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Avenues to reduce copper in organic potato farming with a natural product

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Potato Late Blight and Copper Use

- Copper is used in Swiss organic argiculture to control the oomycete pathogen, potato late blight (*Phytophthora infestans*)
- Copper is a persistant heavy metal that accumulates in the environment. At high dosages, it's toxic to non-target organisms
- Increasing pressure to reduce plant protection products

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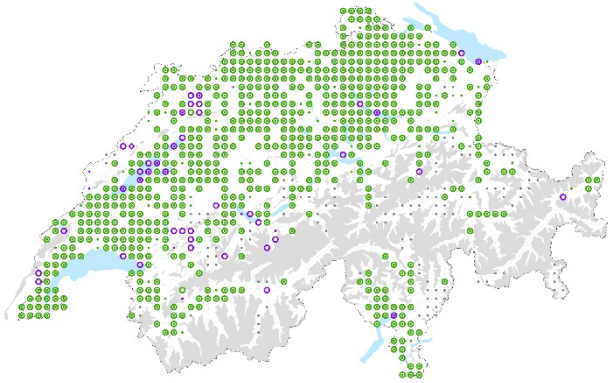
Screening for Alternatives to Copper

- Extensive screening with numerous substances
  (B. Dorn et al., 2007, H.-R. Forrer et al., 2017)

Frangula alnus



www.infoflora.ch

- Laboratory Tests:
  - Mode of action (direct – indirect)
  - Timing of Spraying
- Field Trials:
  - 2019-2021
  - Experimenting with lower dosages

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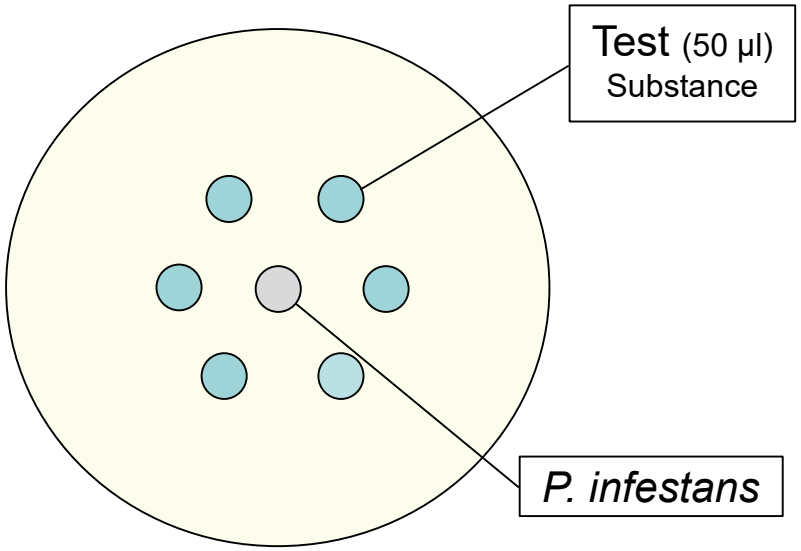
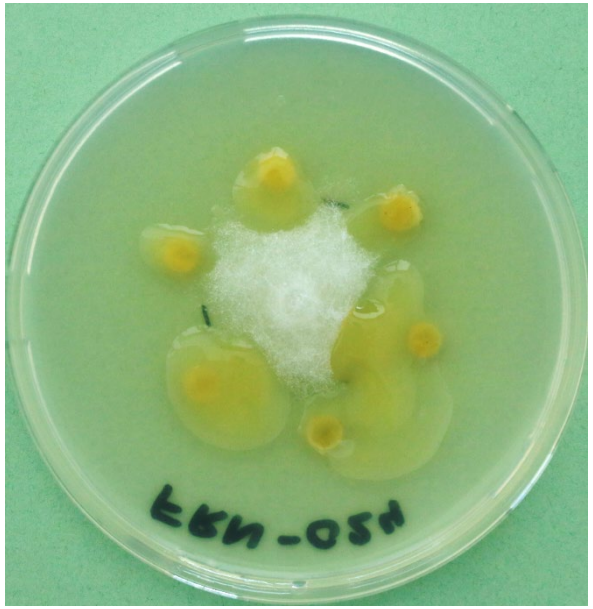
Test for direct mode of action

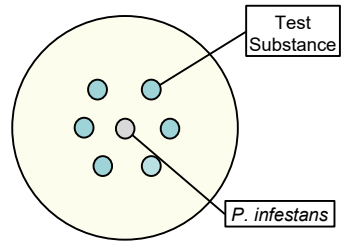
Effect on mycelium development





After 5 days of incubation, photo D. Oswald

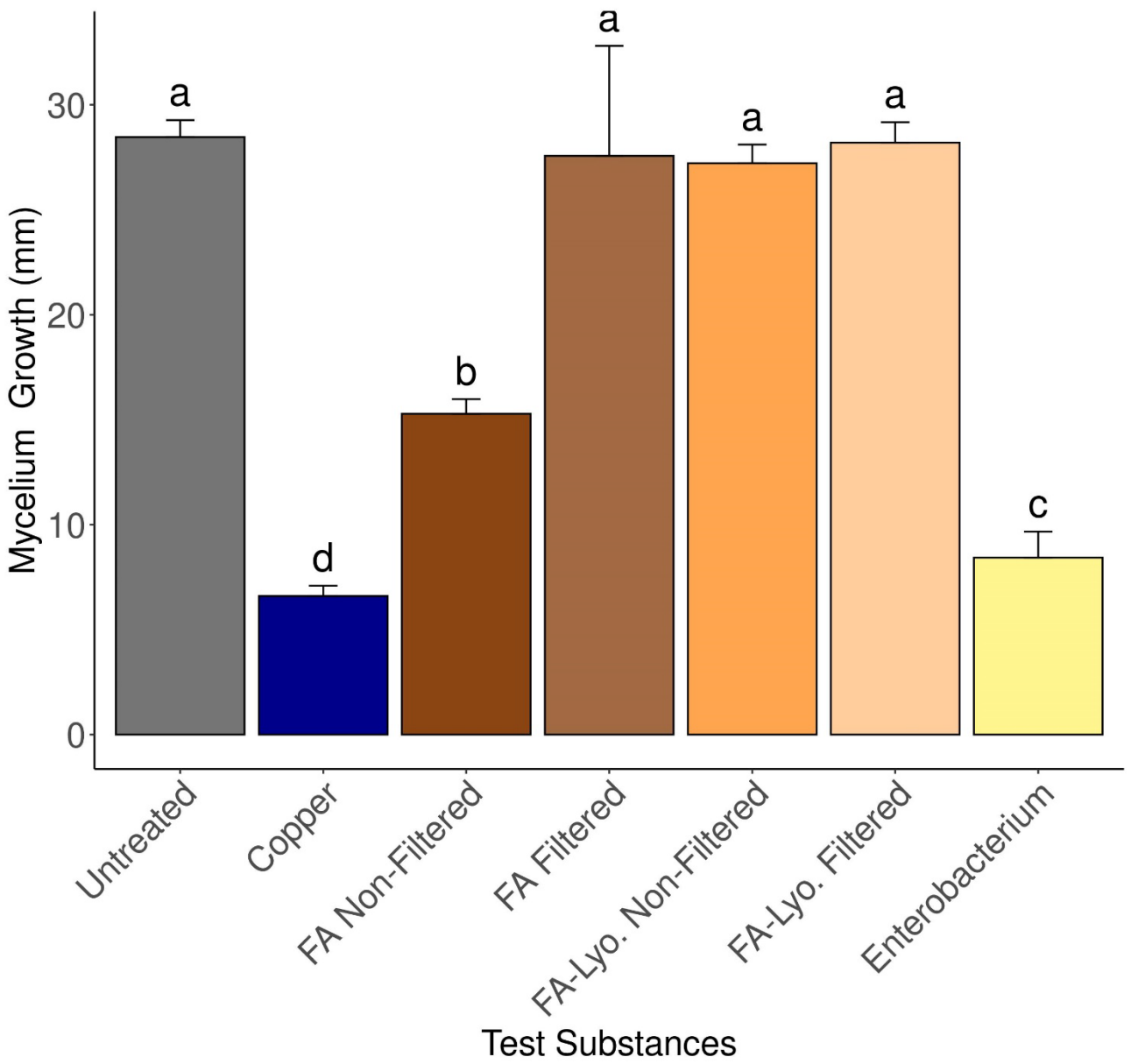
Test for direct mode of action

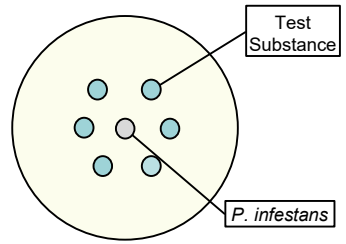


Separate the effects of the *F. alnus* compounds and the bacterium on mycelium development

- Untreated Control (water)
- Copper (0.1%)
- FA non-filtered *F. alnus* – simple suspension with water
- FA filtered *F. alnus,*– with 0.2 µm filtration step
- FA- Lyo. non-filtered: *F. alnus* – with lyophilization step
- FA- Lyo. filtered: *F. alnus,* filtered – with 0.2 µm filtration step
- Enterobacterium – cultured bacteria from *F. alnus*

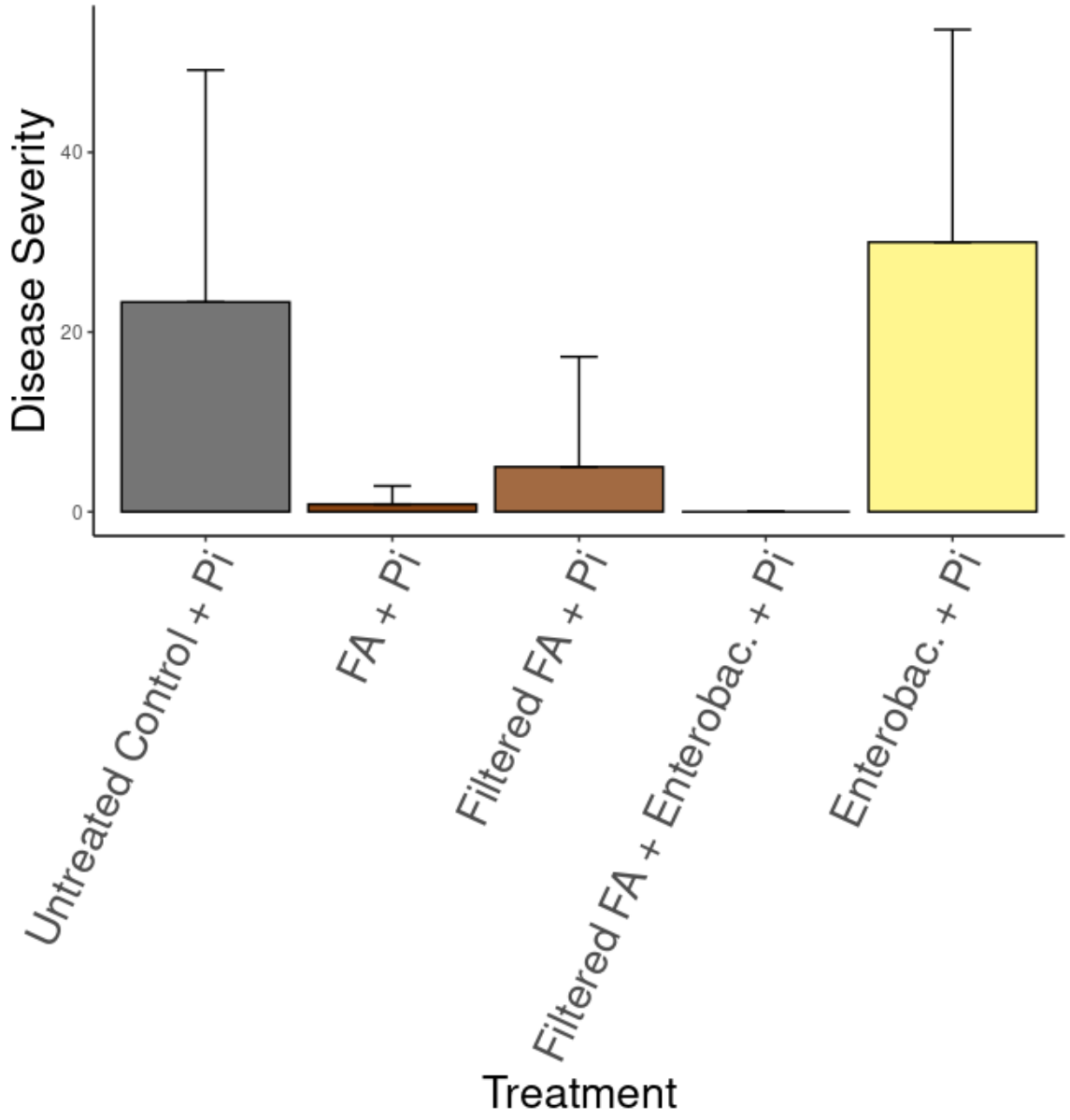
Test for direct mode of action





- No or weak direct effect of *F. alnus* suspension
- Enterobacterium alone showed direct inhibition
- FA-Lyo. extractions showed no bacterial growth

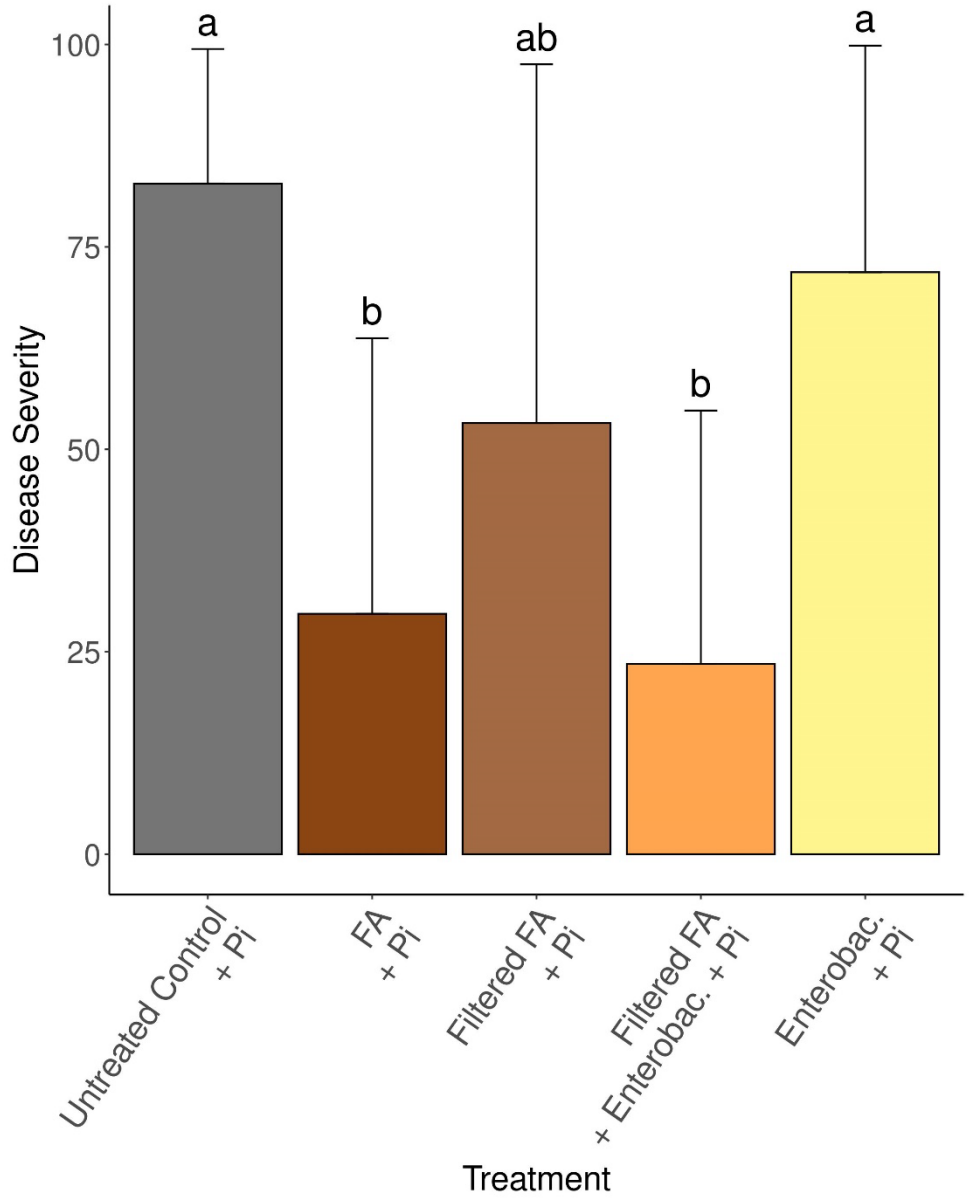
Detached leaf assay



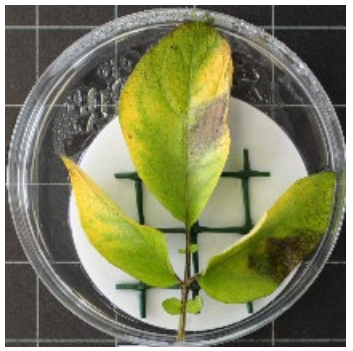
Agria
6 reps/treatment
OD=0.6
$5x10^5$ spores/ml

- Too much variation – low infection achieved, in general
- Suggests that the treatment of Enterobacterium alone does not inhibit *P. infestans* on the leaves, but *F. alnus* (FA) does

Detached leaf assay

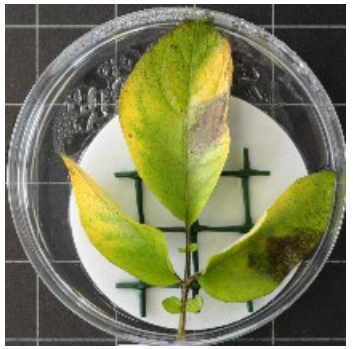


Bintje
16 reps/treatment
OD=0.6
5x10^5 spores/ml



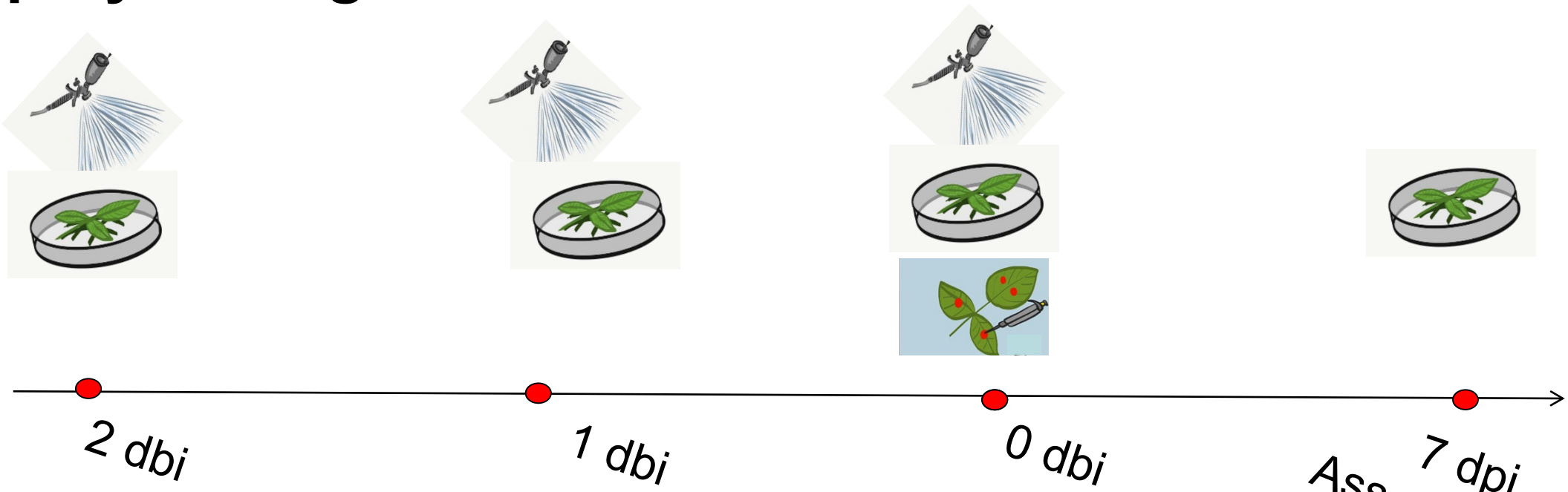
- Rerun with Bintje (preliminary results)
- Filtering steps were involved and time consuming – degradation of FA?

Gene Expression Results



- No differences in gene expression detected in salicylic acid (PR1b, PR2) and jasmonic pathway (LOX) between control, FA and Enterobacterium treatments
- High variation in gene expression among all treatments
- Off on the timing of induction?

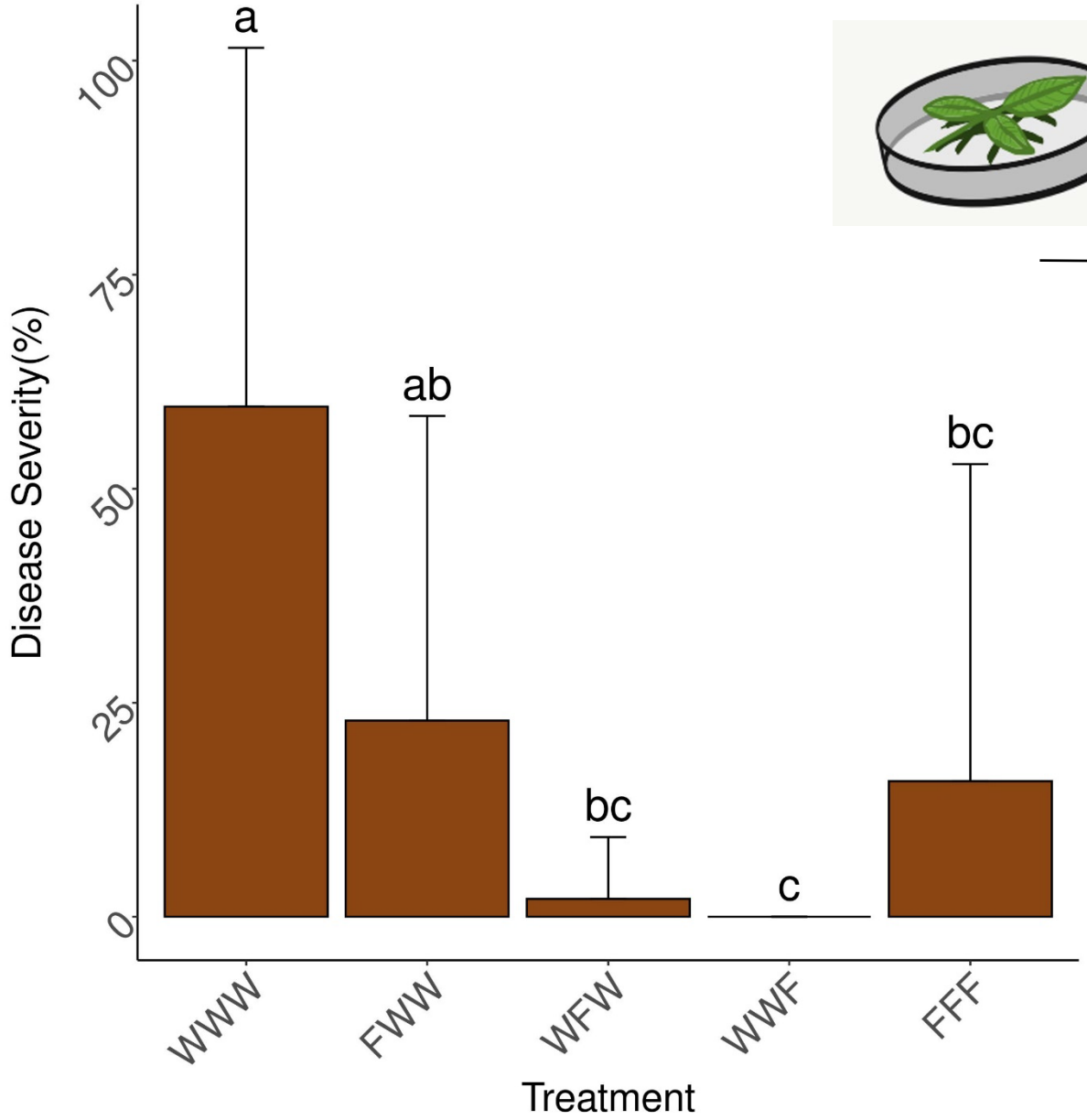
Spray Timing Trial

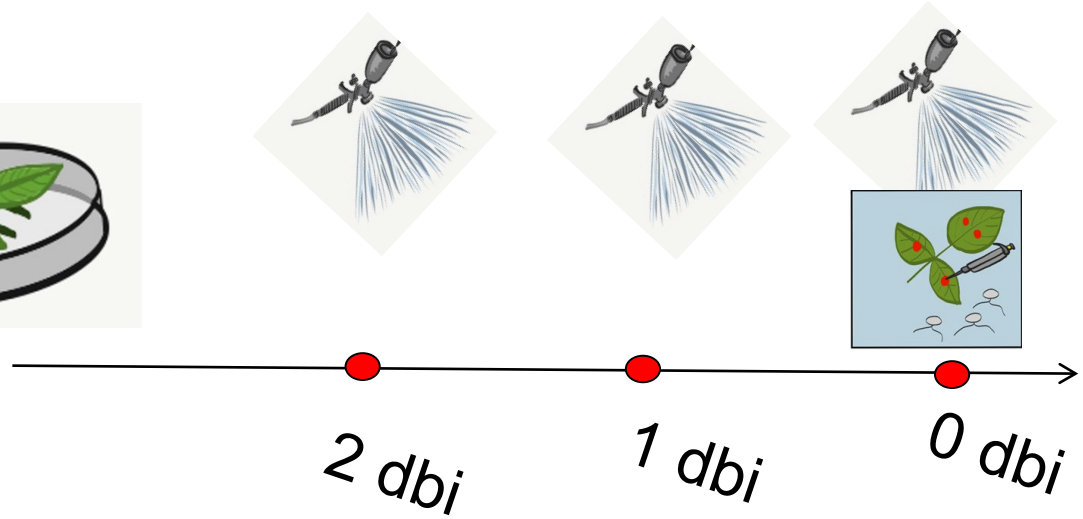


Treatments

Control	Water	Water	Water
FWW	FA	Water	Water
WFW	Water	FA	Water
WWF	Water	Water	FA
FFF	FA – 1/3rd	FA – 1/3rd	FA – 1/3rd

Spray Timing Trial

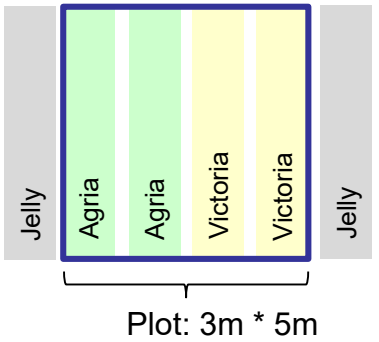




- Better efficacy if reduced time in between spraying and inoculation?
- Potentially missed signal with gene expression analysis

Field Trials 2019-2021

– Varieties Agria and Victoria



Treatments (amount/appl.):

2019 2020 2021

1. Control
2. Copper (0.4 kg Cu/ha)
3. Copper (0.2 kg Cu/ha)
4. FA High dosage (40 kg/ha – 1X)
5. FA Medium dosage (25 kg/ha – 0.6X)
6. FA Low dosage (2.5 kg/ha – 0.06X)
7. FA-Lyo. Low (0.5 kg/ha – 0.06X)
8. FA Low (2.5 kg/ha) + Copper (0.2 kg Cu/ha)

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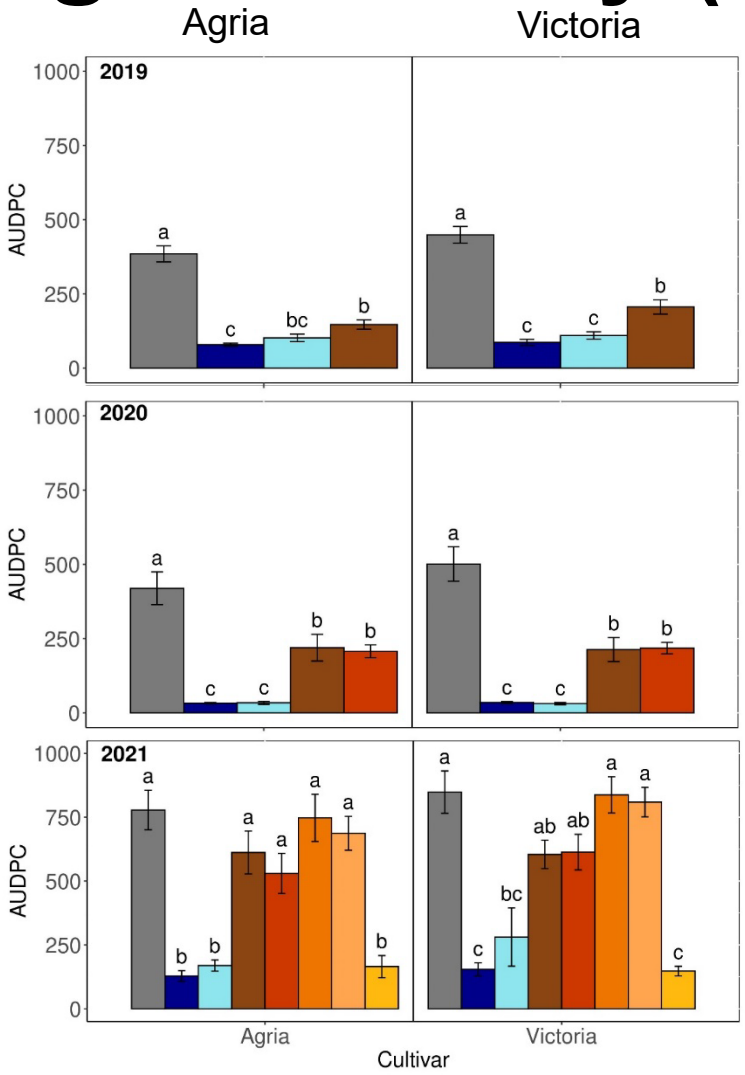
Late Blight Severity (AUDPC) 2019-2021

2019

2020

2021

Infection Pressure (due to weather conditions)

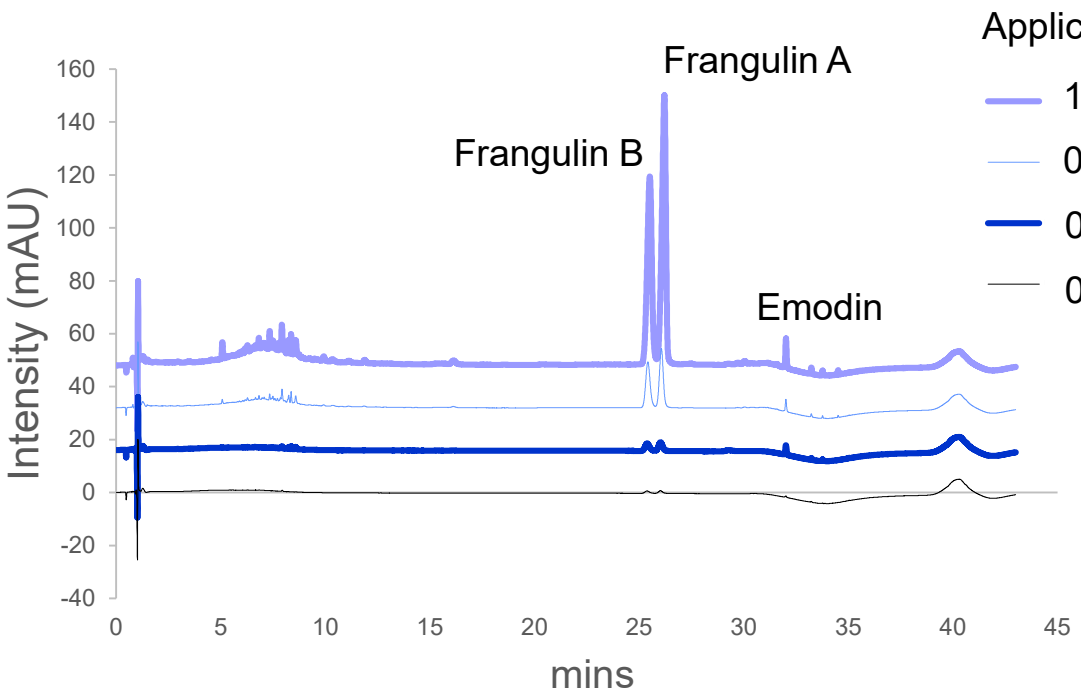


Treatment

- Untreated
- Copper (Full)
- Copper (Reduced)
- Frangula (High)
- Frangula (Medium)
- Frangula (Low)
- Frangula Lyo. (Low)
- Frangula (Low) + Copper (Reduced)

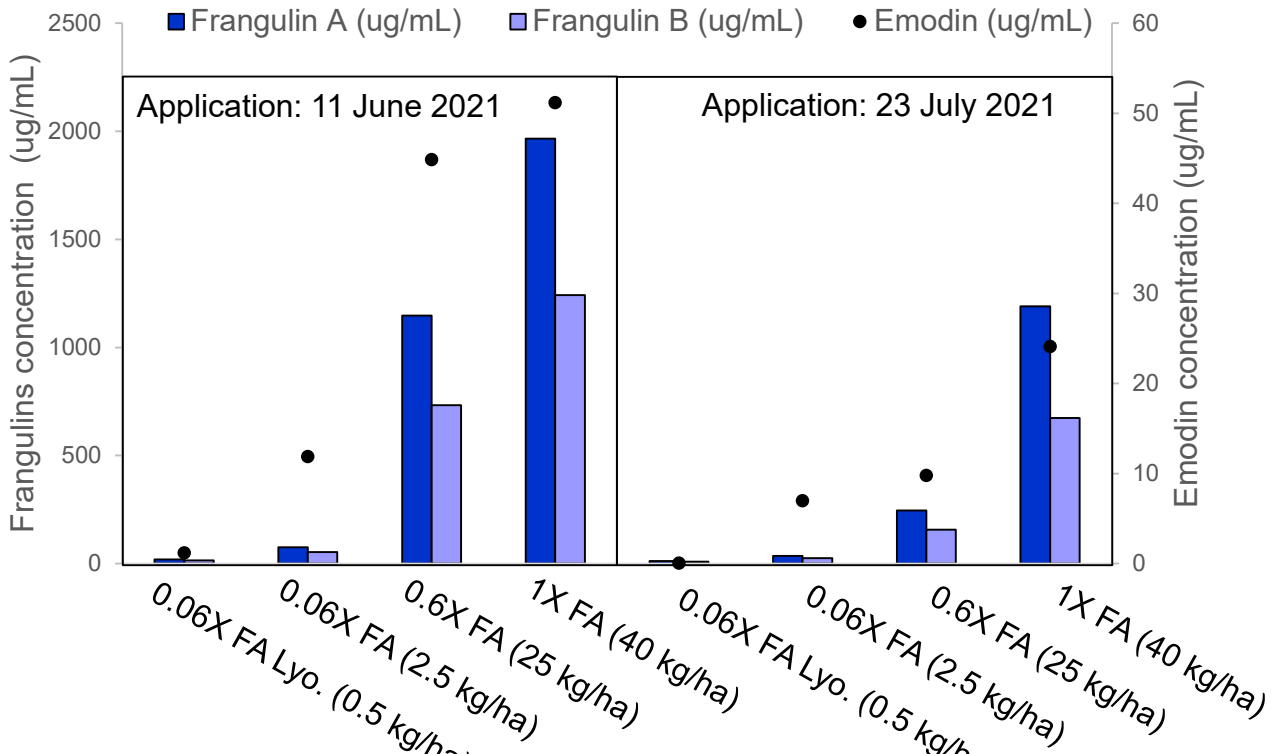
Chromatogram of Frangula Extracts

UHPLC chromatogram of extracts used in the field in 2021



Frangulins concentration 20-30x greater at highest field application

Emodin concentration 3-5x greater at highest field application



Anthraquinones show antifungal activity against plant pathogens (i.e. powdery mildew of cereals) at concentrations of 10 – 50 µg/mL (Hildebrandt *et al.*; 2018, Ma *et al.*, 2009; Yang *et al.*, 2007).

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Summary and Conclusions

- *F. alnus* reduces late blight infection - comparable with a reduced amount of copper in certain conditions (low infection pressure, cultivar)
- High infection pressure - the effect of F. alnus alone is not sufficient
- 2 kg Cu/ha generally offers same effectiveness as 4 kg Cu/ha
- Combination *F. alnus* followed by copper applications could contribute to further copper reduction (1.2 kg/ha)

Acknowledgements

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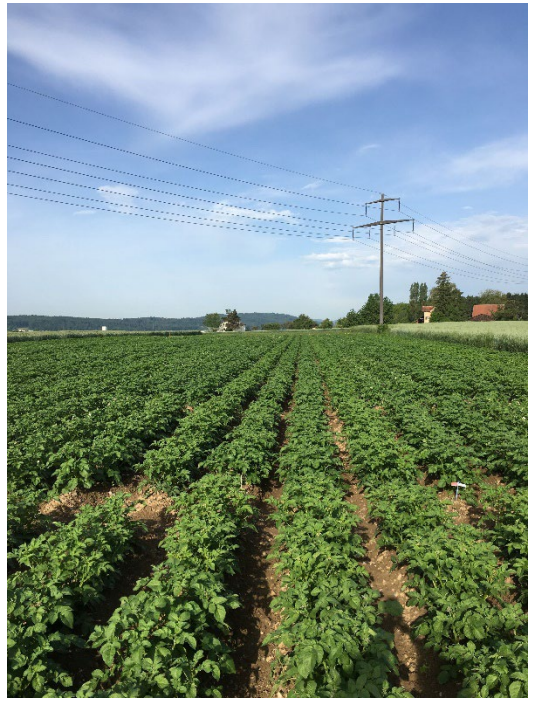
















Thank you for your attention

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