Essential oils as alternative for sustainable management of *Phytophthora infestans* causing potato late blight disease : From *in vitro* to *in vivo* experiments

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01
Introduction

Potato and late bligh disease

Solanum tuberosum L., 1753

Perrenial plant grown for its tubers rich in carbohydrates

1st non-cereal grown worldwide for human consumption

Late blight disease represents on potato an annual loss of ≈ $6B

Phytophthora infestans (Mont.) de Bary, 1876

Eucaryotic microorganism belonging to Oomycota

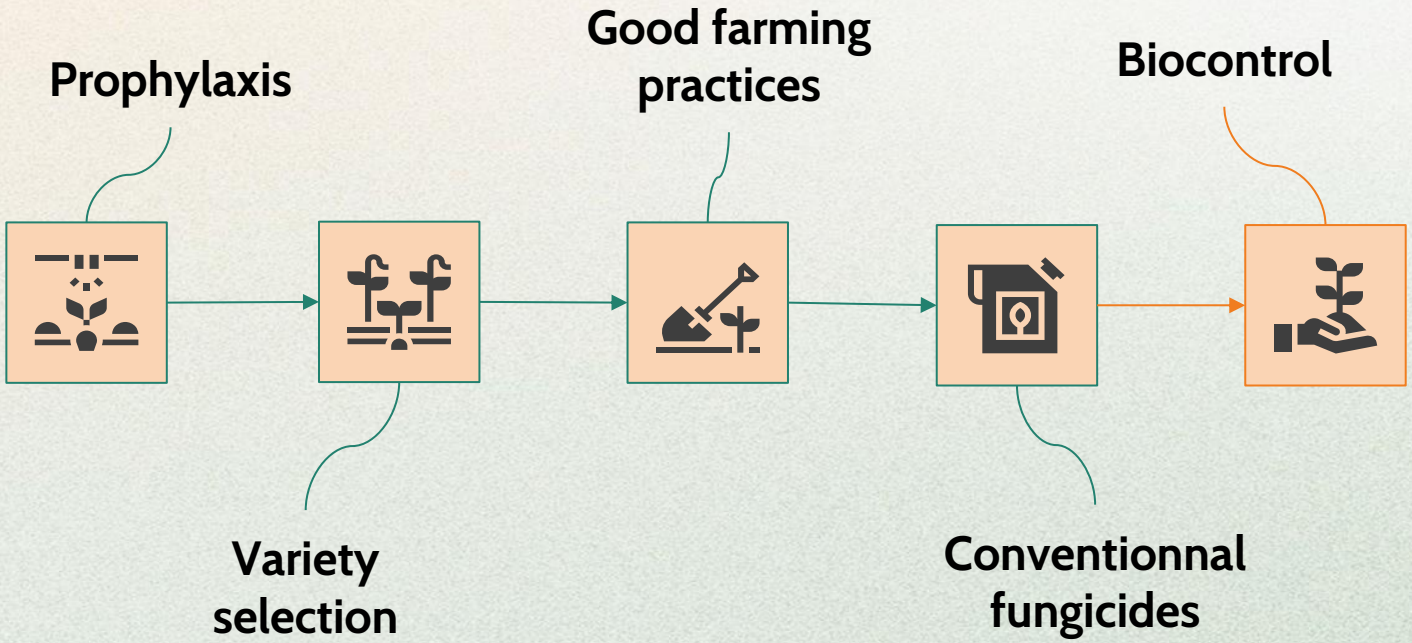
Cellulosic cell wall and membrane without ergosterol

Phylogenetically closer to Rhodophyta than Fungi

Haverkort *et al*., 2022
Devaux *et al*., 2020

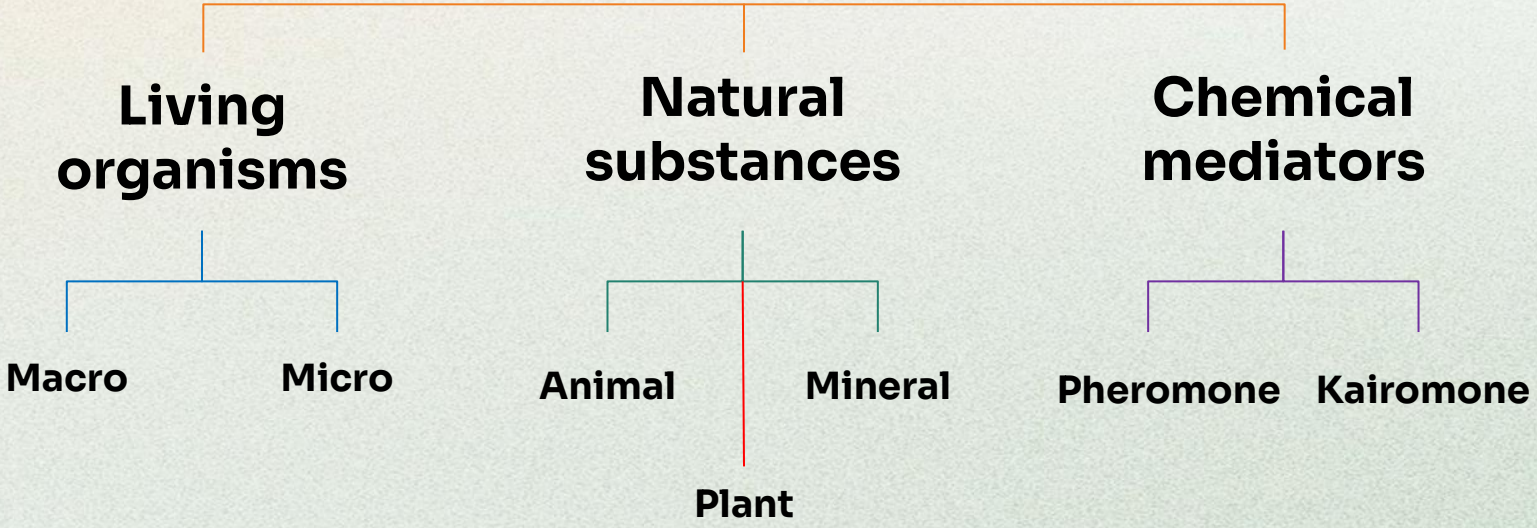
Fry *et al*., 2015
Kazan et al., 2017

Current management of phytopathogens



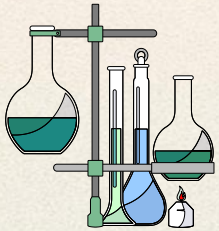
Biocontrol

Any method used to protect plants from pests of any kind
(animals, weeds, bacteria, fungi and viral diseases)
based on naturally existing mechanisms and substances



Amichot *et al.*, 2018
Eilenberg *et al.*, 2001

Essential oils



Essential oils (EO) are complex hydrophobic mixtures mainly composed of volatile organic compounds (VOC's) and exclusively obtained from plant biomass by some extraction methods such as steam distillation or cold pressure

Fometu *et al.*, 2019
Masango *et al.*, 2005

VOC carry many chemical functions and present diverse <u>biological activities</u>

Bassolé *et al.*, 2012

Plant originally use VOC to attract pollinators, fight diseases and communicate

Slavkovic *et al.*, 2019

EO have been used for decades by human in many fields, including <u>plant protection</u>

De Clerck *et al.*, 2021

Research context

State of the art

Many EO have shown promising properties against phytopathogens from *in vitro* to *in planta*

De Clerck *et al.*, 2020

Lack of knoweldege

Molecular mechanisms of EO on *P. infestans* at the cellular scale are still not well understood

Martini *et al.*, 2023

Challenge and constraint

Due to their chemical properties, appropriate formulation is required to optimize EO activities as biofungicide

Maes *et al.*, 2019

02

Results

Experimental material

Host plant

Two varieties of *S. tuberosum* economically important in Europe with high sensitivity to late blight

- Bintje
- Fontane

Pathogen

Three different genotypes of *P. Infestans* causing massive damages in Northern argo-ecosystems

- EU-13-A2
- EU-36-A2
- EU-37-A2

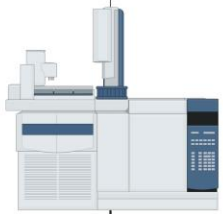
Essential oils

Five essential oils extracted from various sources of biomass and with specific chemical composition

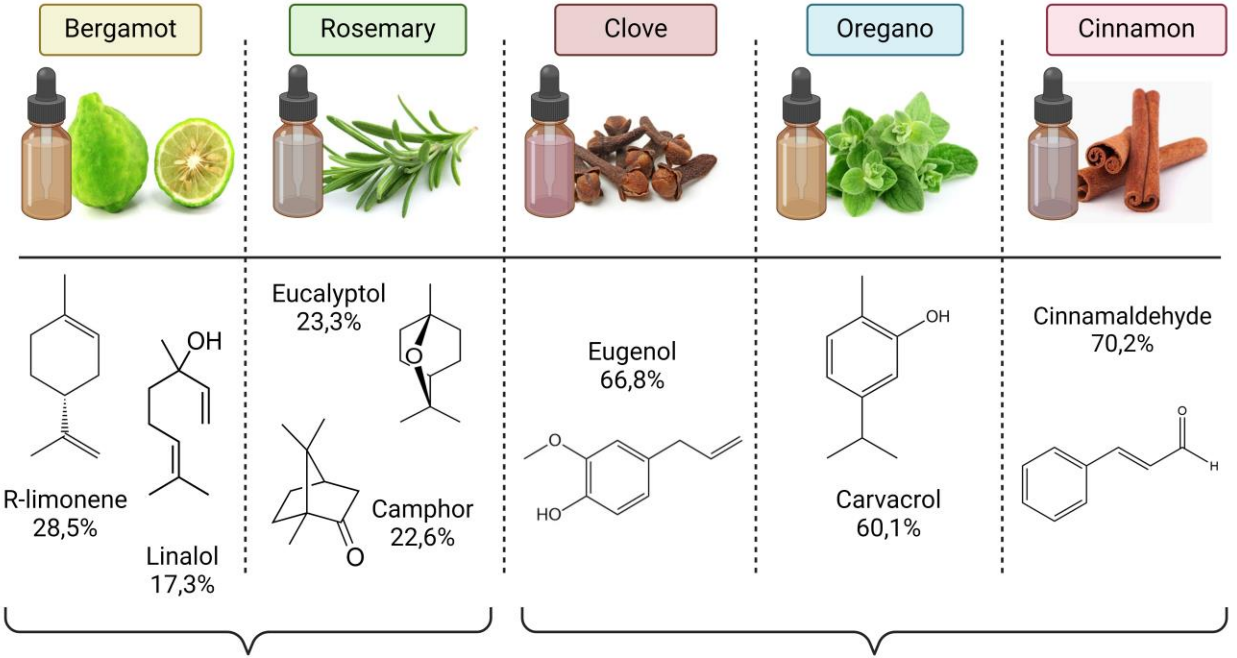
- Rutaceae
- Lamiaceae
- Myrtaceae
- Lauraceae

Results : essential oils chemical profile

Selection of promising essential oils



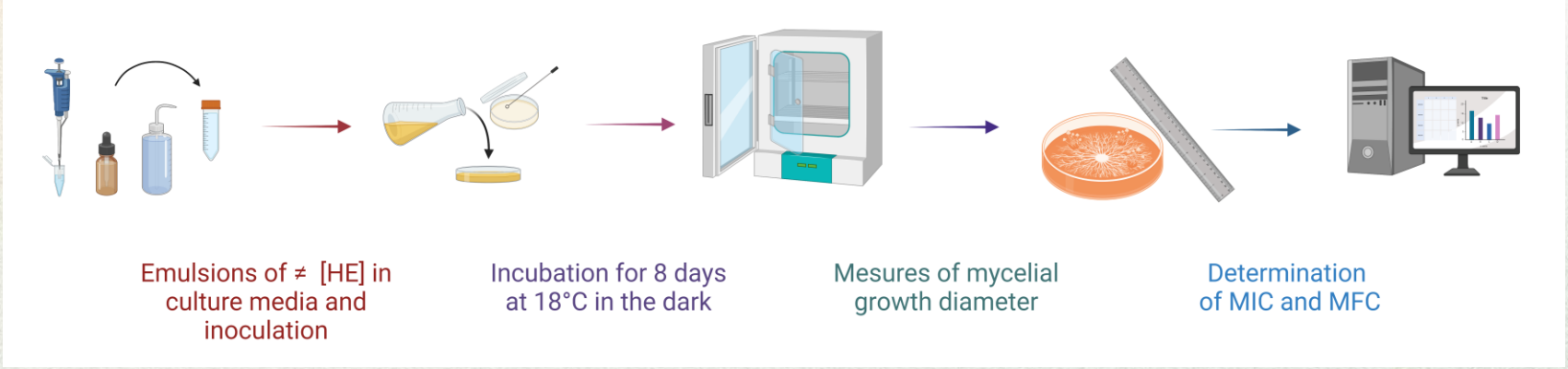
GC-MS analysis for chemical profile identification



Mainly composed of **terpenoids**

Mainly composed of **phenylpropanoids**

Method : mycelium growth inhibition



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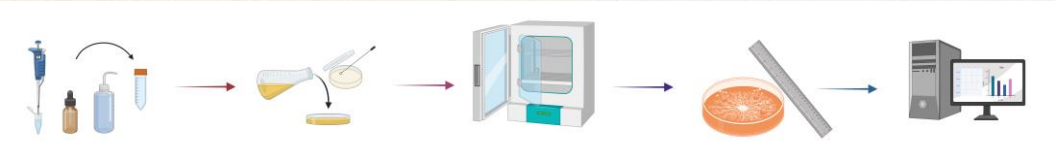
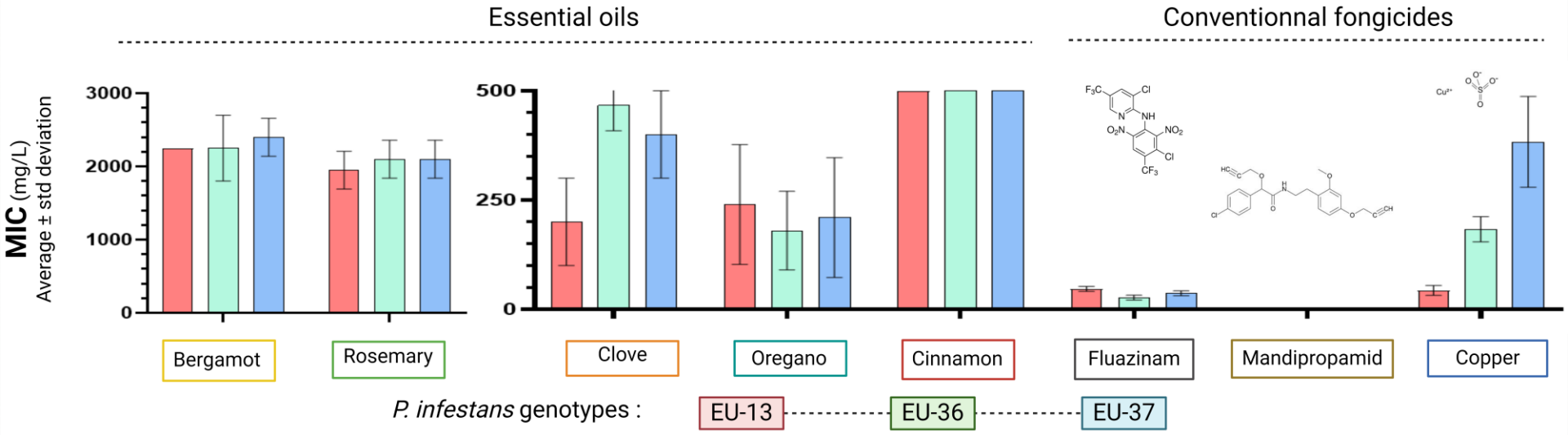
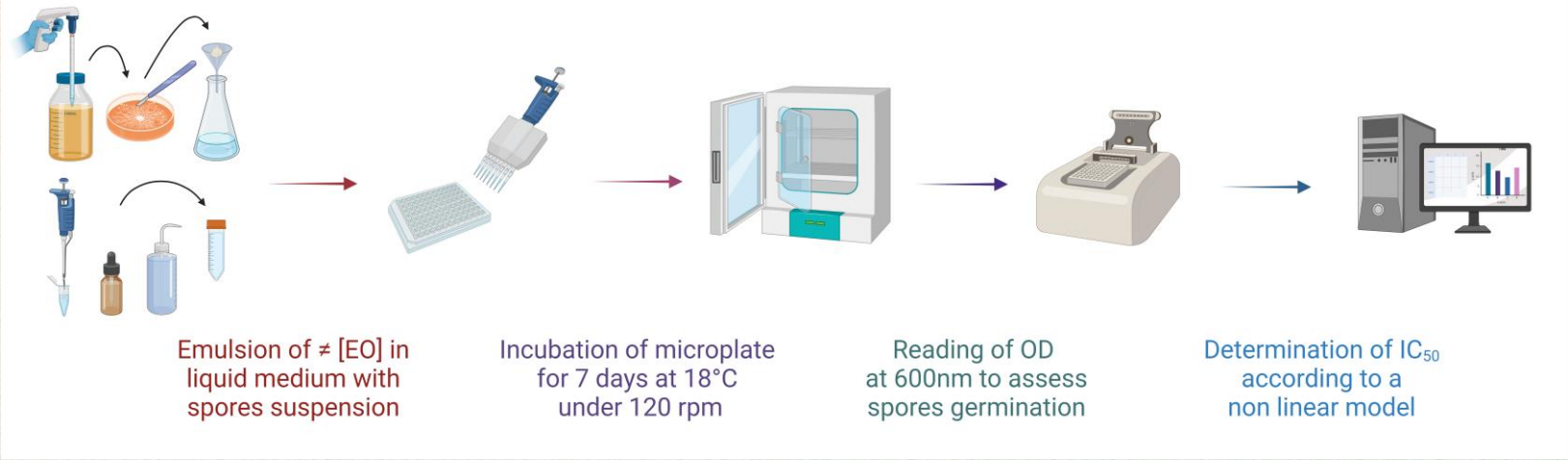


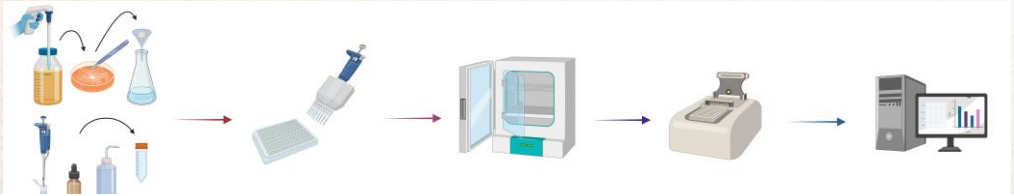
Minimum inhibitory concentrations (MIC) of chemical substances on mycelial growth of 3 *P. infestans* genotypes in Petri dish



Method : spore germination inhibition



Results : spore germination inhibition



Median inhibitory concentrations of chemical substances on spores germination of 3 *P. infestans* genotypes in microplates

IC_{50} (mg/L) [confidence range]	Essential oils					Conventional fungicides		
	Bergamot	Rosemary	Clove	Oregano	Cinnamon	Mandipropamid	Fluazinam	Copper
EU-13	9100 [7500 ; 13000]	9810 [7920 ; 12060]	500 [400 ; 600]	1620 [990 ; 1890]	130 [90 ; 200]	0.010 [0.03 ; 0.21]	0.35 [0.1 ; 1.3]	6 [1 ; 23]
EU-36	9900 [6300 ; 15300]	2160 [1080 ; 3330]	100 [60 ; 140]	270 [180 ; 360]	120 [50 ; 280]	0.012 [0.02 ; 0.32]	0.25 [0.05 ; 3.2]	14 [2 ; 27]
EU-37	4400 [3500 ; 5580]	5940 [4770 ; 7560]	400 [300 ; 600]	360 [180 ; 540]	80 [50 ; 130]	0.015 [0.06 ; 0.20]	0.29 [0.01 ; 6.2]	80 [30 ; 220]

Results : phytotoxicity on detached leaves

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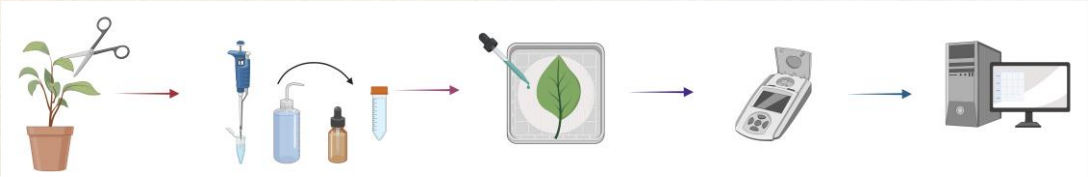
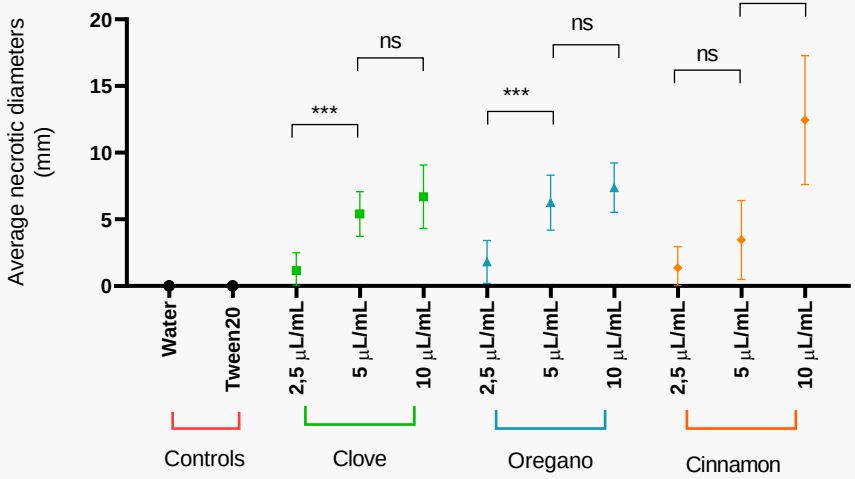
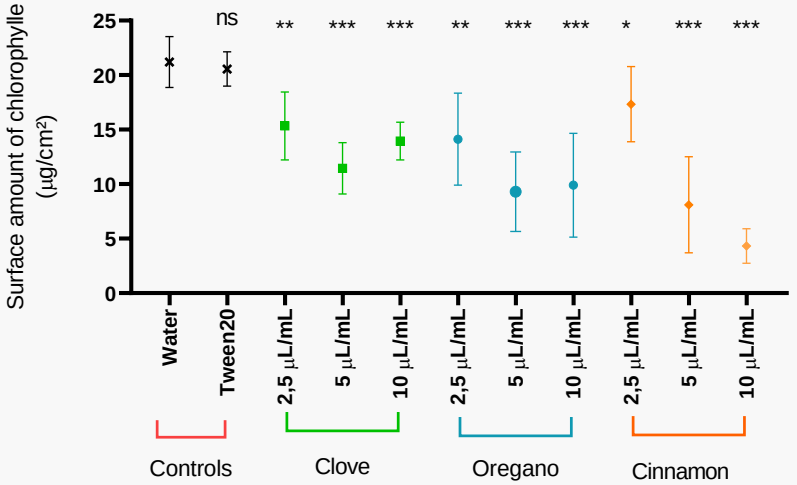


Necrotic diameters on potato detached leaves after drop treatments of various concentrations of essential oils emulsions



Surface amount of chlorophyll on potato detached leaves after drop treatments of various concentrations of essential oils emulsions

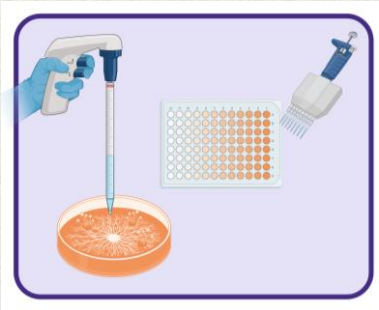


03 Conclusion and Perspectives

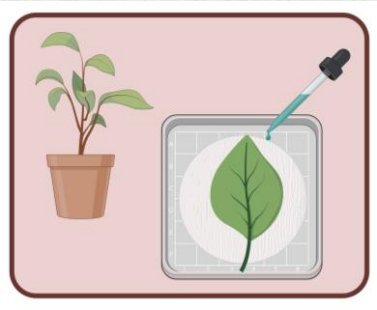
Conclusion : From *in vitro* to *in vivo*

1 → **2** → **3**

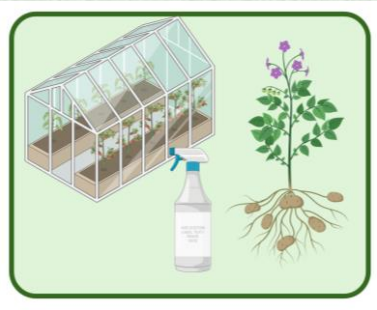
In vitro tests showed promising anti-oomycete properties of specific EO's



Ex vivo assays gave phytoxicity tresholds on potato detached leaves



In planta experiments must be carried out to confirm EO protective properties against late blight

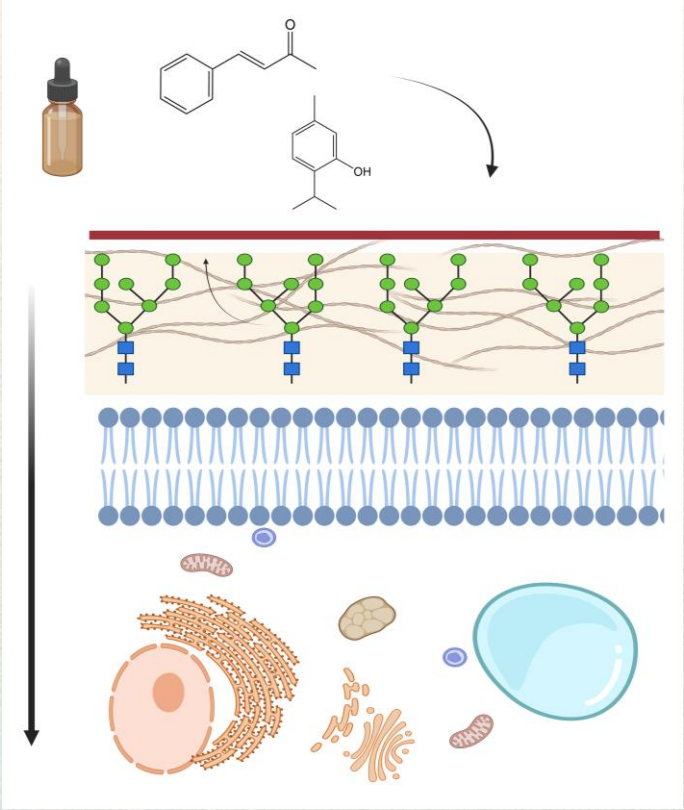


Perspectives : Cellular site of action

Successive extractions with different solvants on treated *P. infestans* biomass followed by GC-MS analysis should help determine :

- in which cellular compartment
- how long

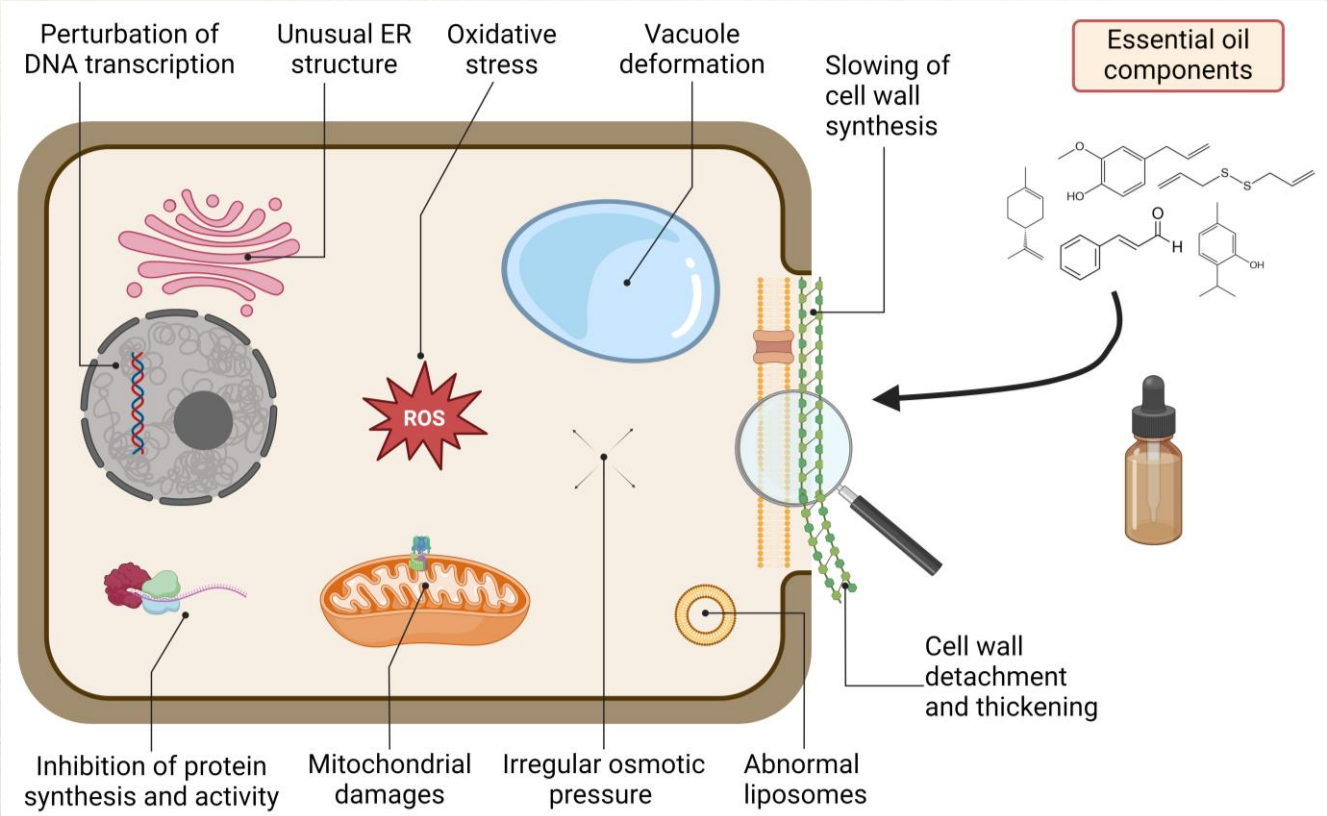
EO are retained.



Perspectives : Mechanisms of action

Many mechanisms have been described on how EO's perturb cellular activities.

Our hypothesis :
→ Focus on plasma membrane



Thanks for listening!

I'd be happy to answer any questions!

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