



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Département fédéral de l'économie,
de la formation et de la recherche DEFR

Agroscope

Quelques activités du groupe Mycologie d'Agroscope Changins

Pierre-Henri Dubuis, Sylvain Schnée, Katia Gindro et al.

2 octobre 2024 Bordeaux

www.agroscope.ch | une bonne alimentation, un environnement sain



Le groupe Mycologie



8 scientifiques

5 laborants/ines

3 technico-scientifiques

8 doctorants/es

5 post-doctorants/es

5 apprenti(e)s

Etudiants en Bachelor/Master

Startups - 8 *chercheur(e)s* «indépendant(e)s»

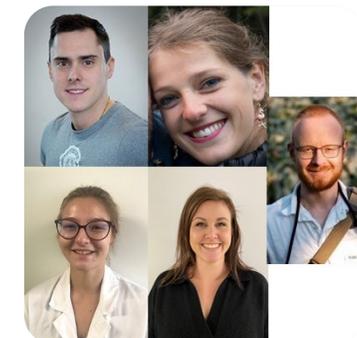


Startups «incubées» dans le groupe de recherche



EFFICACY - INNOCUITY - REMANENCE
HIGH EFFICACY AGAINST A WIDE RANGE OF PATHOGENS
Homebased in Switzerland with lab facilities and approved private research center, Biorem Engineering has discovered innovative biobased chemicals that meet the goals of protecting human health and the environment we live in.

MORE ABOUT US



Nom de la présentation | Conférence
Expéditeur



Orientations stratégiques du groupe de recherche

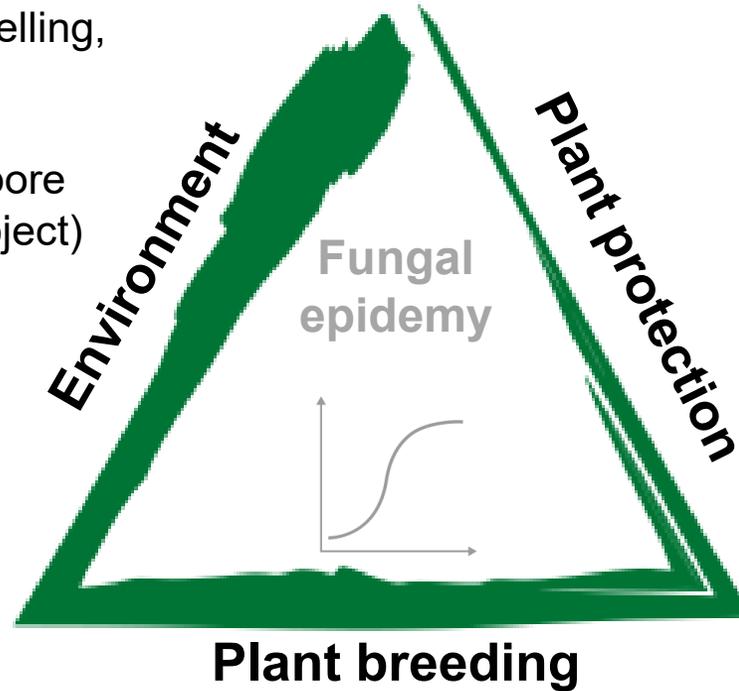
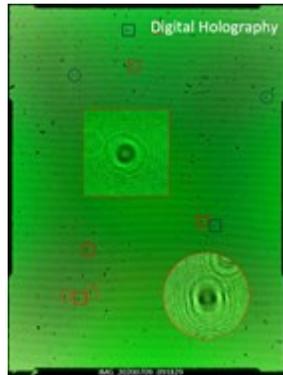
- 📌 Nouveaux fongicides et actifs biosourcés: screening, induction de diversité chimique, biotransformation
- 📌 Epidémiologie et étiologie des maladies fongiques
- 📌 Mycovirus et avantage compétitif (polymycovirus)
- 📌 Communauté fongique complexe et évolution (phylogénie)
- 📌 Interactions hôtes-pathogènes: métabolomique et génomique
- 📌 Mycoscope (mycothèque dynamique, www.mycoscope.bcis.ch)
- 📌 Modèles de prévision des risques (Agrometeo, www.agrometeo.ch)
- 📌 Stratégies de lutte et innovations (drones, capteurs IA)
- 📌 Mycoremédiation
- 📌 Bio-contrôle et expression hétérologue
- 📌 Tâches légales (homologation de l'efficacité des fongicides)



Alternative strategies and discovering alternative products

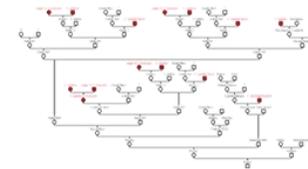


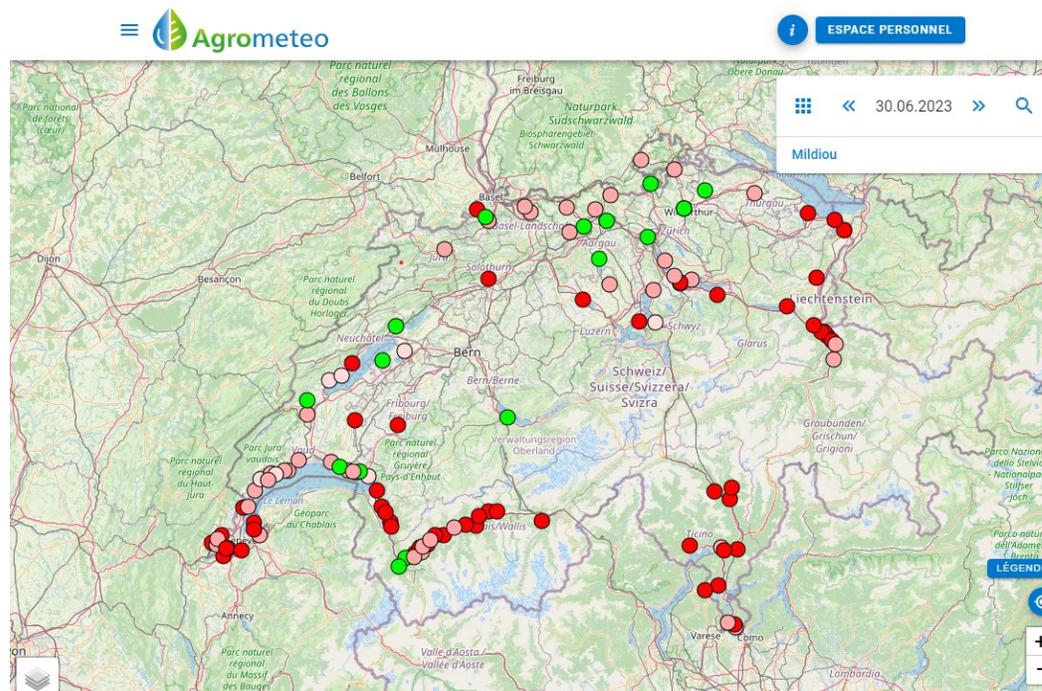
- Diseases and pests modelling, forecasting tools (www.agrometeo.ch)
- Real-time automated spore recognition (SMALA project)



- Screening new active compounds
- Alternative commercial products evaluation
- Innovative control strategies
- Application technology – drone spraying

- Resistant varieties breeding
- Pyramidisation of resistance QTLs



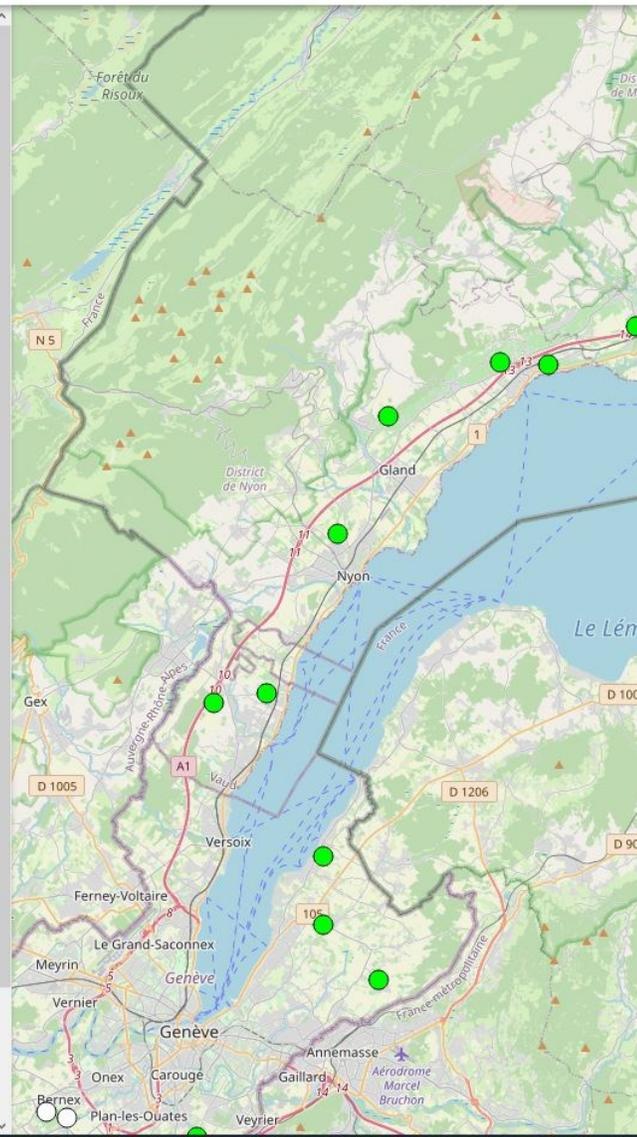
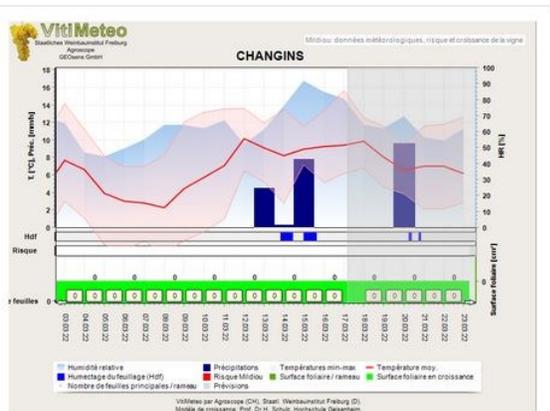
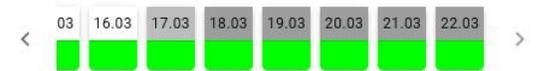


Plant protection platform with:

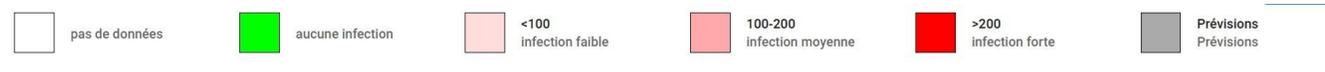
- ~200 microclimatic weather stations including weather forecasts
- Forecasting models (grapevine and fruit growing)
- Monitoring data
- Tools (PPP dosage, irrigation)



Modèles de prédiction des infections

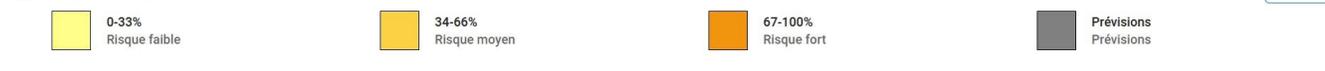


Mildiou de la vigne



Stations	06.07	07.07	08.07	09.07	10.07	11.07	12.07	13.07	14.07	15.07
CHANGINS	279	459	159	277	93	222		237	218	316
DARDAGNY	274	448	208	308	98	243	53	230	224	407
LEYTRON	85	331	249	293		172	170	286	461	343
MARTIGNY-COMBE			242					97	244	168
PULLY	103	109						77	53	133

Oidium

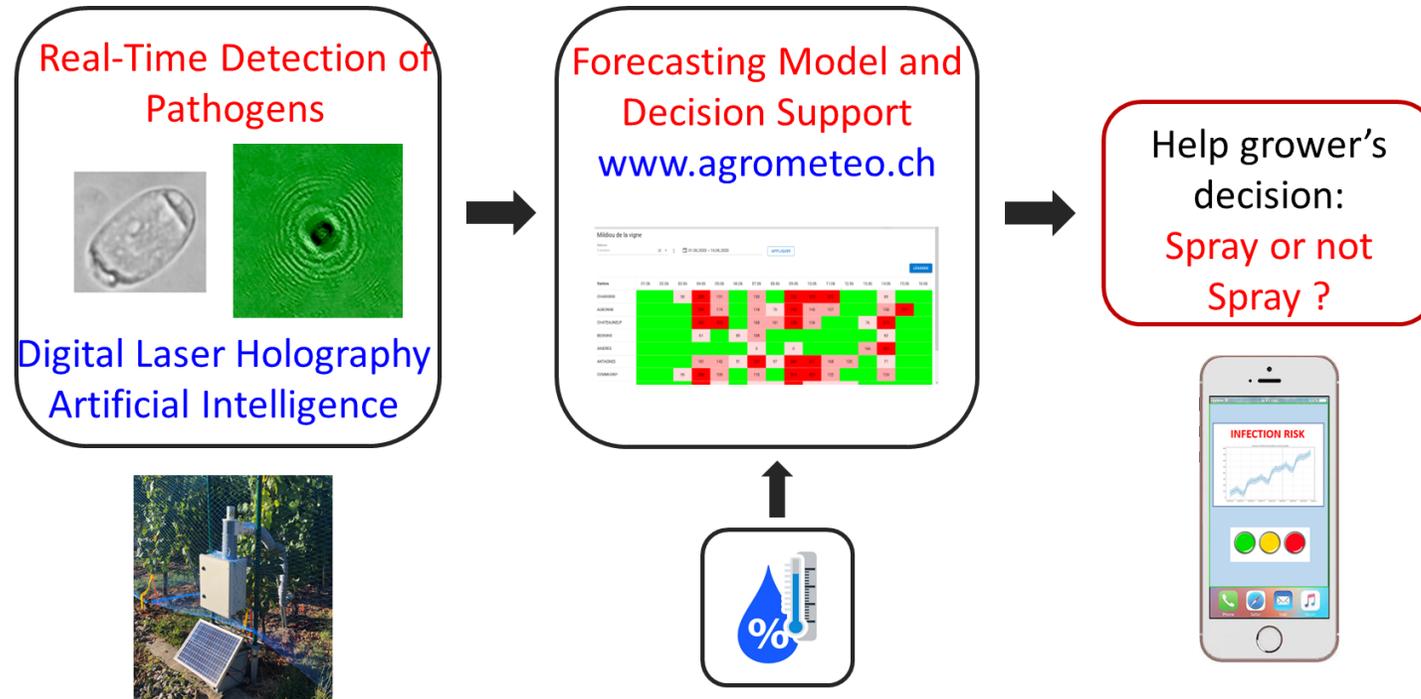


Stations	25.05	26.05	27.05	28.05	29.05	30.05	31.05	01.06	02.06	03.06	04.06	05.06
CHANGINS	39%	46%	45%	51%	51%	46%	42%	45%	54%	62%	72%	64%
DARDAGNY	33%	39%	40%	44%	41%	39%	39%	40%	50%	58%	64%	68%
LEYTRON	62%	61%	59%	57%	62%	59%	55%	54%	62%	71%	73%	63%
MARTIGNY-COMBE	28%	32%	32%	34%	39%	43%	44%	42%	53%	58%	64%	72%
PULLY	31%	32%	34%	42%	46%	46%	45%	46%	55%	62%	64%	58%



SMart Agriculture using Lasers and Artificial intelligence (SMALA)

Diseases Forecasting Improvement



“Spray only where and when it’s really needed !”



GAP : Groupe de Physique Appliquée

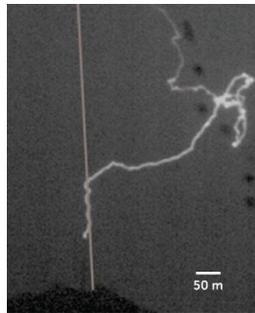


UNIVERSITÉ
DE GENÈVE

FACULTÉ DES SCIENCES



Prof. Jean-Pierre Wolf



→ Etude de la Biophotonique et des Lasers

Utilisation des propriétés de la lumière pour
l'analyse d'images biologiques



Tessa Basso
doctorante

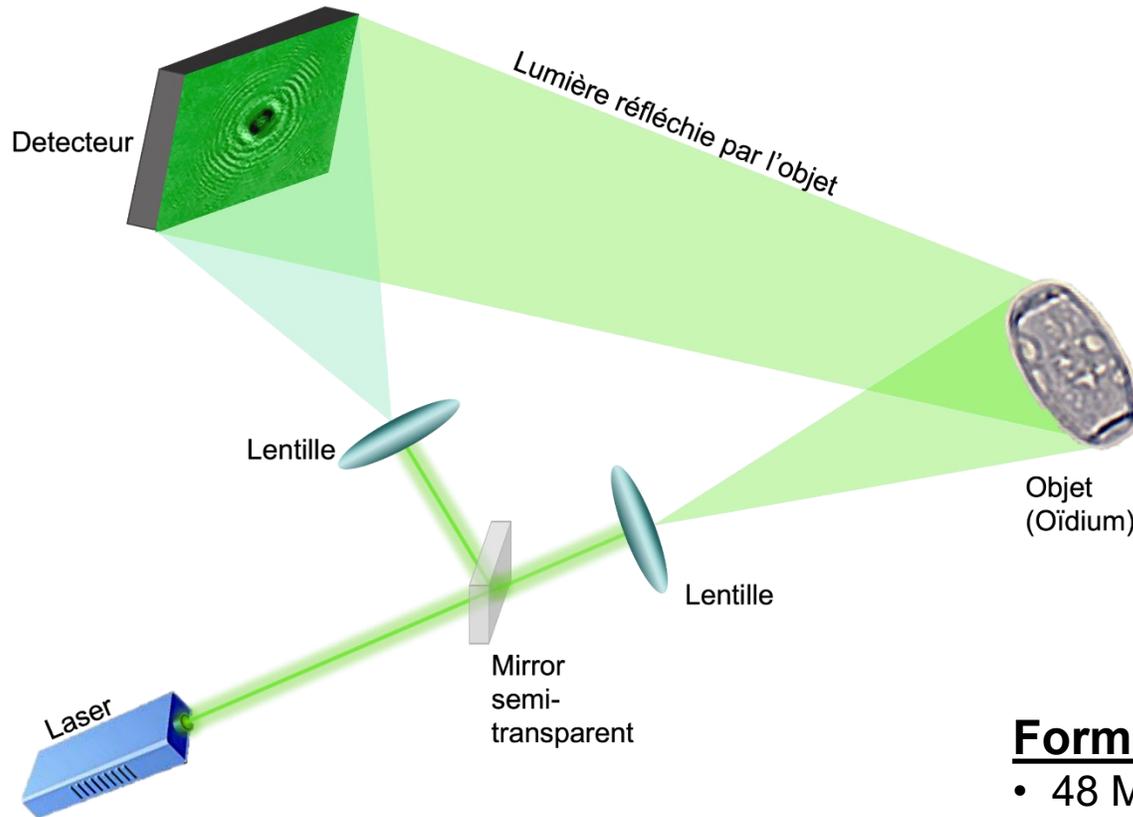


Nicolas Berti
post-doctorant

→ Construction d'un détecteur holographique autonome et à faible
coût capable d'identifier et compter en temps réel les spores



Principes de l'holographie



- Utilisation des propriétés de la lumière
- Enregistrement des fronts d'onde des faisceaux laser
- Reconstruction 3D de l'image
→ informations sur la taille, le poids, la densité, l'épaisseur, etc.
- Haute résolution : 800 nm

Format de l'image:

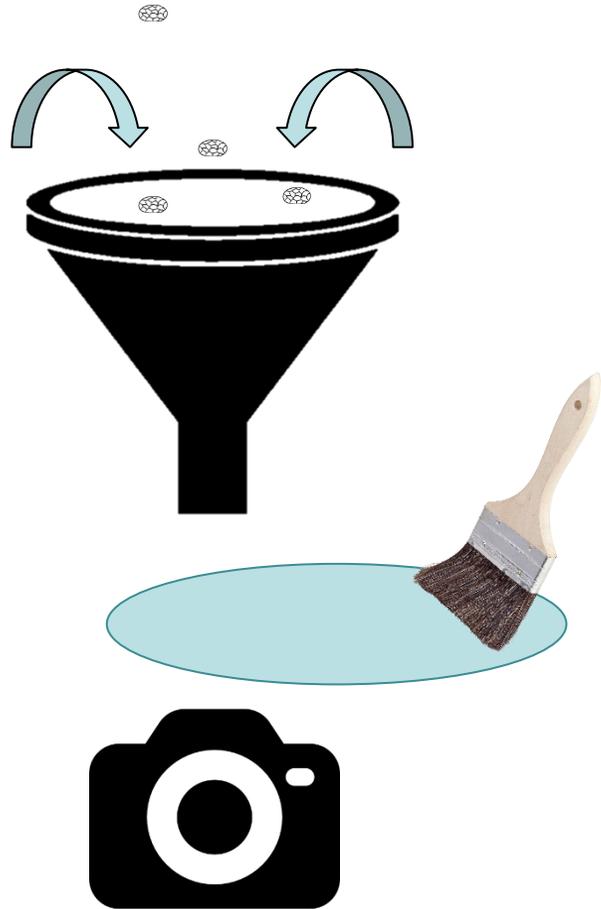
- 48 Mpx en RAW
- ~ 100 Mo par image

Détecteur:

- Dimension : 0.8 $\mu\text{m}/\text{px}$
- Sensor : IMX586



Fonctionnement du détecteur



1) Echantillonnage de l'air par sédimentation



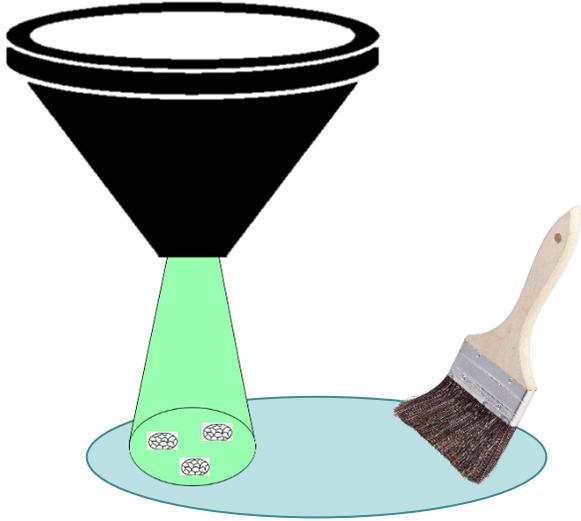
Fonctionnement du détecteur



- 1) Echantillonnage de l'air par sédimentation
- 2) Dépôt des spores



Fonctionnement du détecteur



- 1) Echantillonnage de l'air par sédimentation
- 2) Dépôt des spores
- 3) Enclenchement du laser et capture d'image





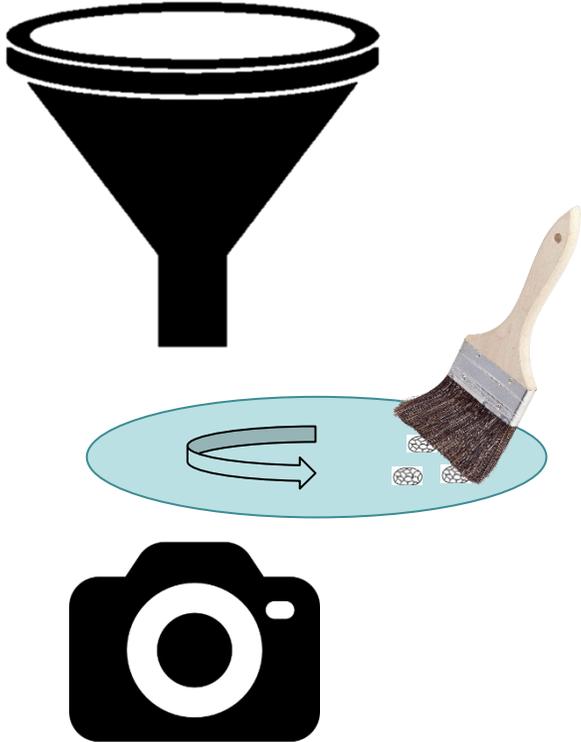
Fonctionnement du détecteur



- 1) Echantillonnage de l'air par sédimentation
- 2) Dépôt des spores
- 3) Enclenchement du laser et capture d'image

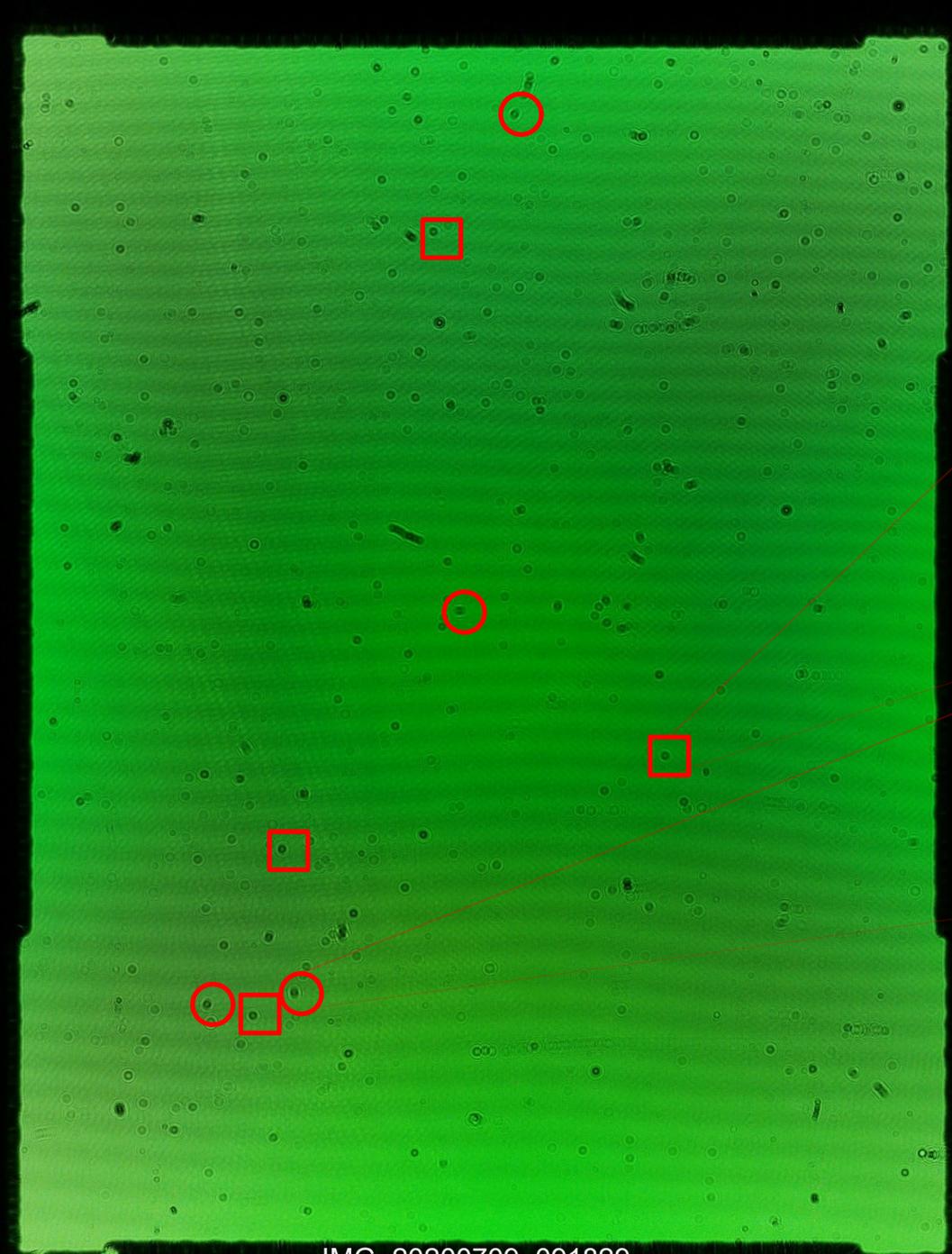


Fonctionnement du détecteur



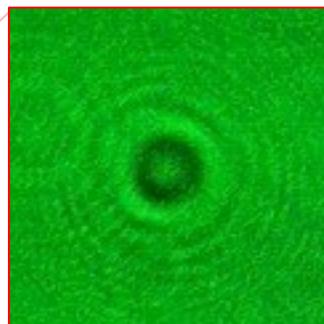
- 1) Echantillonnage de l'air par sédimentation
- 2) Dépôt des spores
- 3) Enclenchement du laser et capture d'image
- 4) Nettoyage

Exemple



IMG_20200709_091829

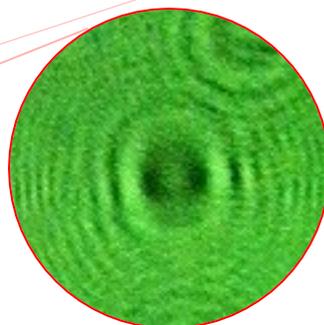
Holographie



Microscopie



P. viticola
~ 10-20 μm



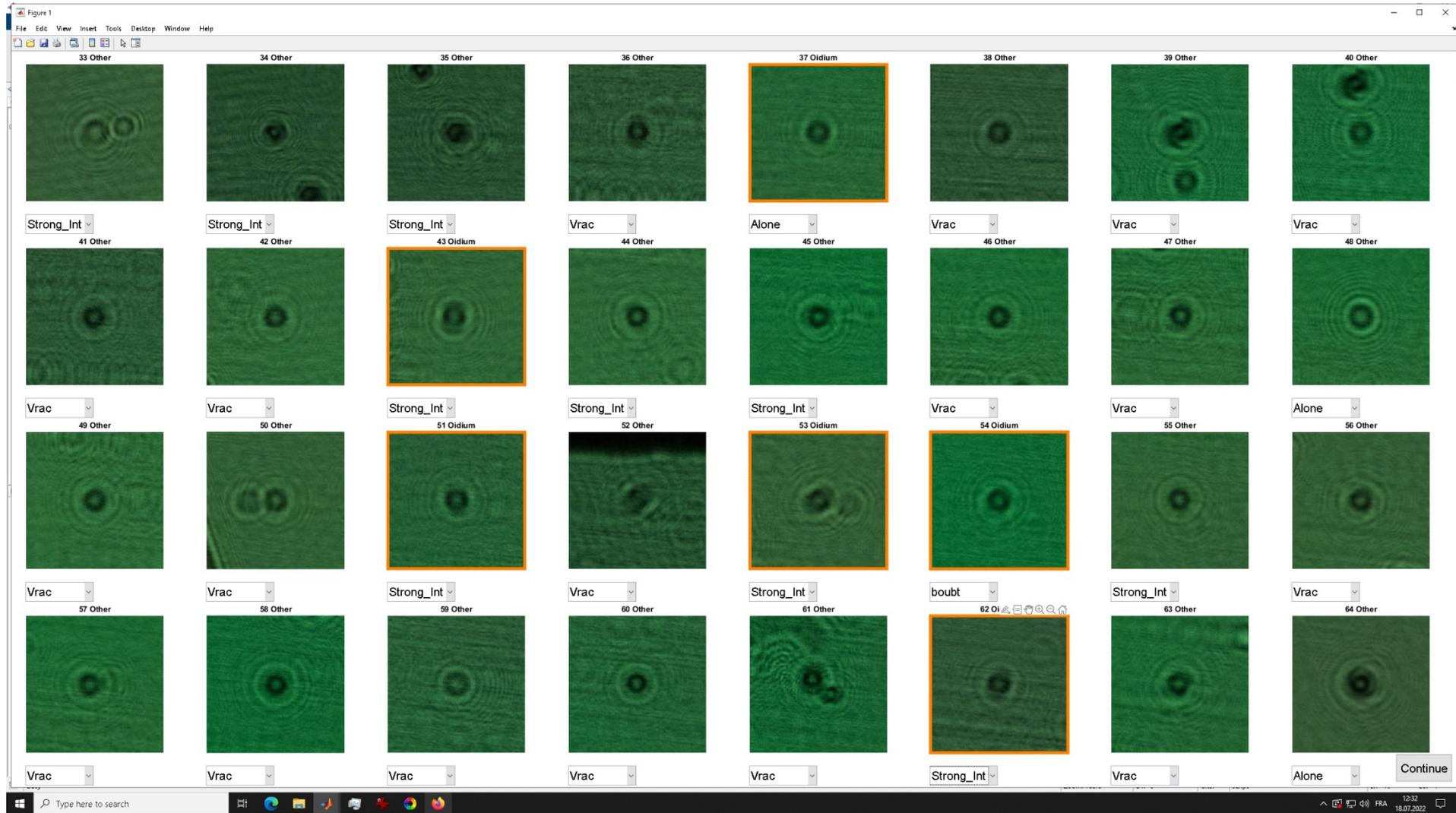
E. necator
~ 15-30 μm

[120x120 px]

-  *P. viticola* spore
-  *E. necator* spore



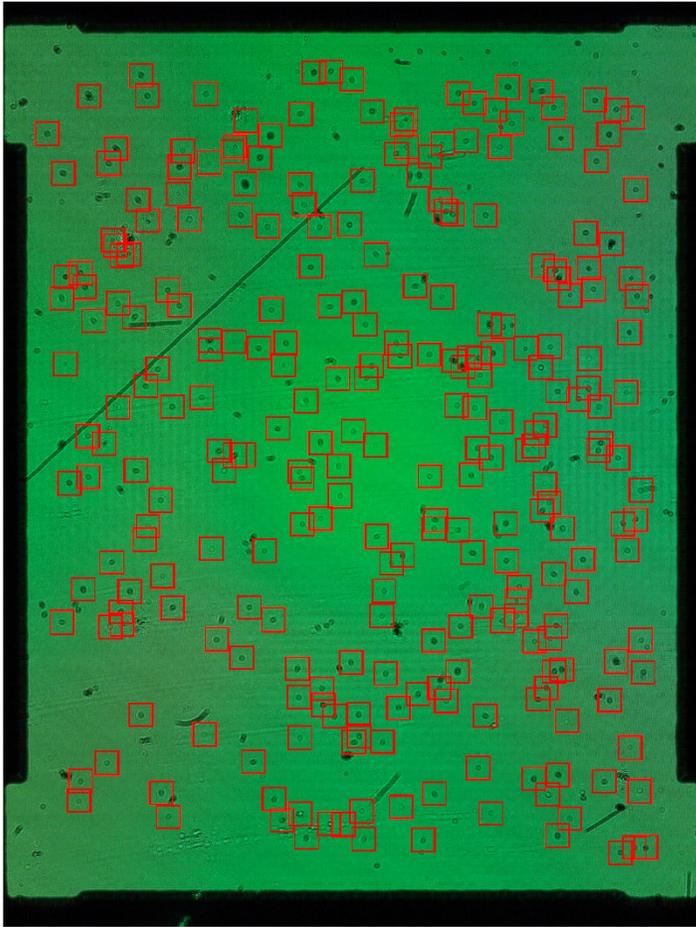
Labellisation



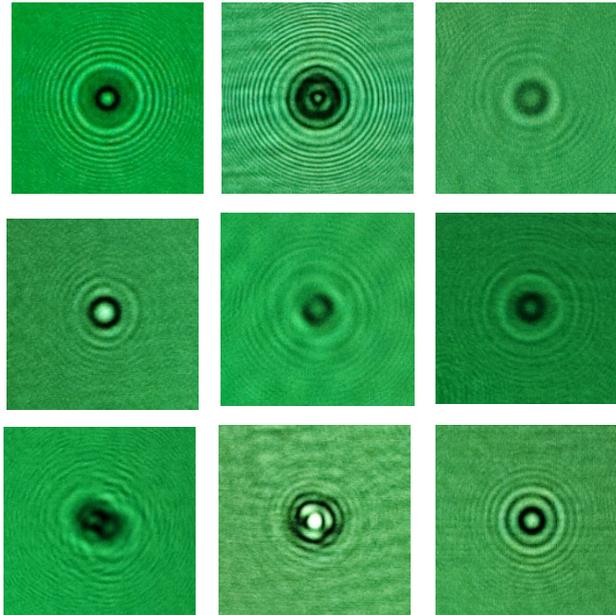


Reconnaissance par Intelligence Artificielle (IA)

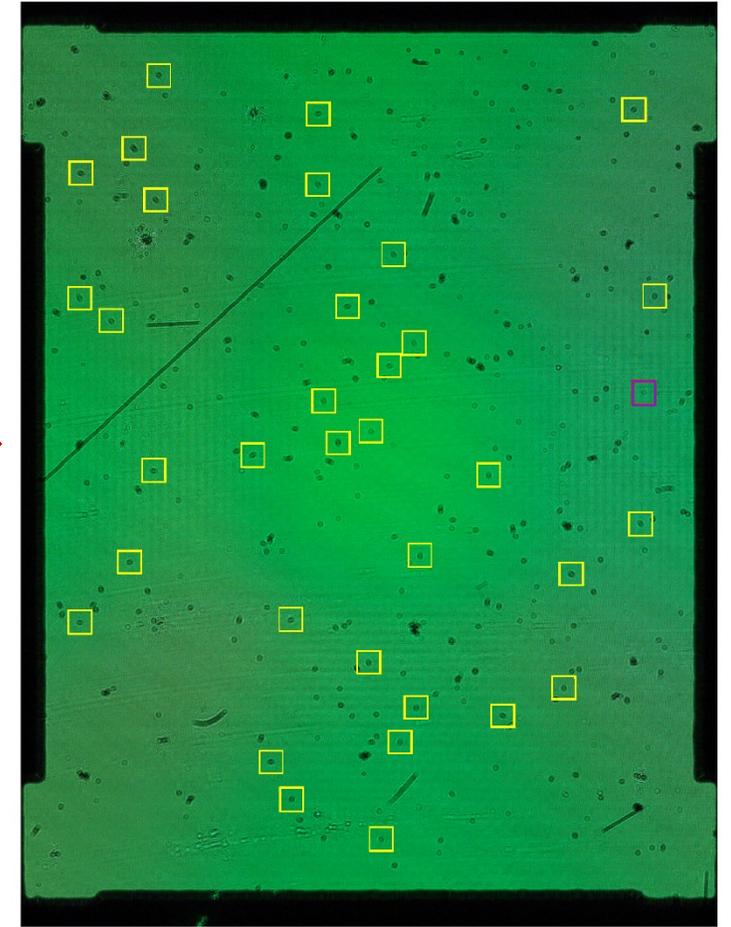
188 particules



Analyse des différents segments par IA



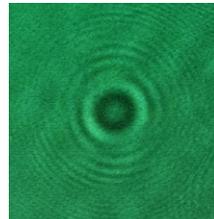
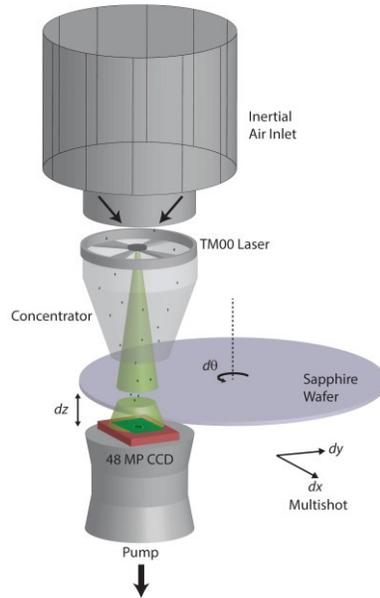
Résultat →  Oïdium : 34
 Mildiou : 1



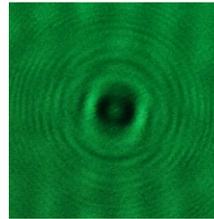


Holographic Detector of Airborne Pathogen Spores

Identification of Downy and Powdery Mildew by AI



Downy Mildew



Powdery Mildew

Patents: EP 19 170
073.1(2019),
PCT/EP2020/060873 (2020)

Discrimination of interferents

		Confusion Matrix									
		Agglomerate F. S.	Alnus Glutinosa	Castanea Sativa	Fagus Sylvatica	Downy Mildew	Powdery Mildew	Taraxacum O. Populus T.	Quercus Robur		
Output Class	Agglomerate F. S.	294 4.2%	0 0.0%	0 0.0%	6 0.1%	0 0.0%	2 0.0%	0 0.0%	1 0.0%	97.0% 3.0%	
	Alnus Glutinosa	0 0.0%	397 5.6%	1 0.0%	0 0.0%	1 0.0%	4 0.1%	6 0.1%	38 0.5%	88.8% 11.2%	
	Castanea Sativa	0 0.0%	0 0.0%	382 5.4%	0 0.0%	23 0.3%	3 0.0%	0 0.0%	0 0.0%	93.6% 6.4%	
	Fagus Sylvatica	6 0.1%	0 0.0%	0 0.0%	1058 15.0%	0 0.0%	2 0.0%	2 0.0%	16 0.2%	97.6% 2.4%	
	Downy Mildew	0 0.0%	4 0.1%	67 1.0%	0 0.0%	1102 15.6%	14 0.2%	0 0.0%	0 0.0%	92.8% 7.2%	
	Powdery Mildew	0 0.0%	2 0.0%	4 0.1%	0 0.0%	4 0.1%	1351 19.2%	10 0.1%	2 0.0%	98.4% 1.6%	
	Taraxacum O. Populus T.	0 0.0%	0 0.0%	1 0.0%	0 0.0%	0 0.0%	7 0.1%	1348 19.1%	1 0.0%	99.3% 0.7%	
	Quercus Robur	1 0.0%	27 0.4%	0 0.0%	14 0.2%	0 0.0%	15 0.2%	5 0.1%	826 11.7%	93.0% 7.0%	
			97.7% 2.3%	92.3% 7.7%	84.0% 16.0%	98.1% 1.9%	97.5% 2.5%	96.6% 3.4%	98.3% 1.7%	93.4% 6.6%	95.9% 4.1%
			Data base	Target Class						Accuracy	
		35 000 Images							95,9%		



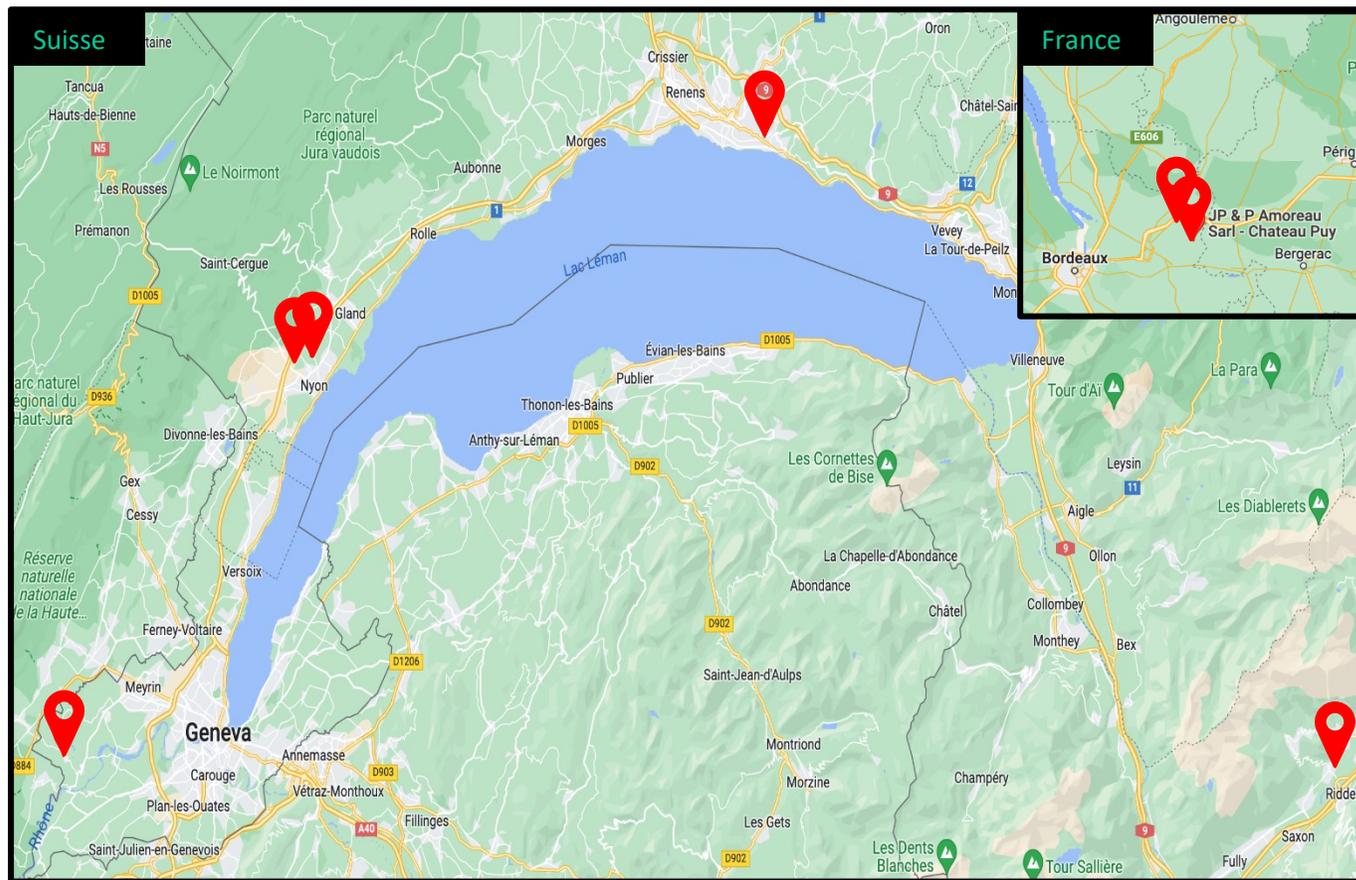
Sites 2021-2024

En Suisse :

- Dardagny (Genève)
- Changins (Nyon)
- Pully (Lavaux)
- Leytron (Valais)
- Fully (Valais)

En France :

- Bordeaux, Château Le Puy
- Bourgogne, Domaine de Villaine
- Champagne, Epernay (CIVC)



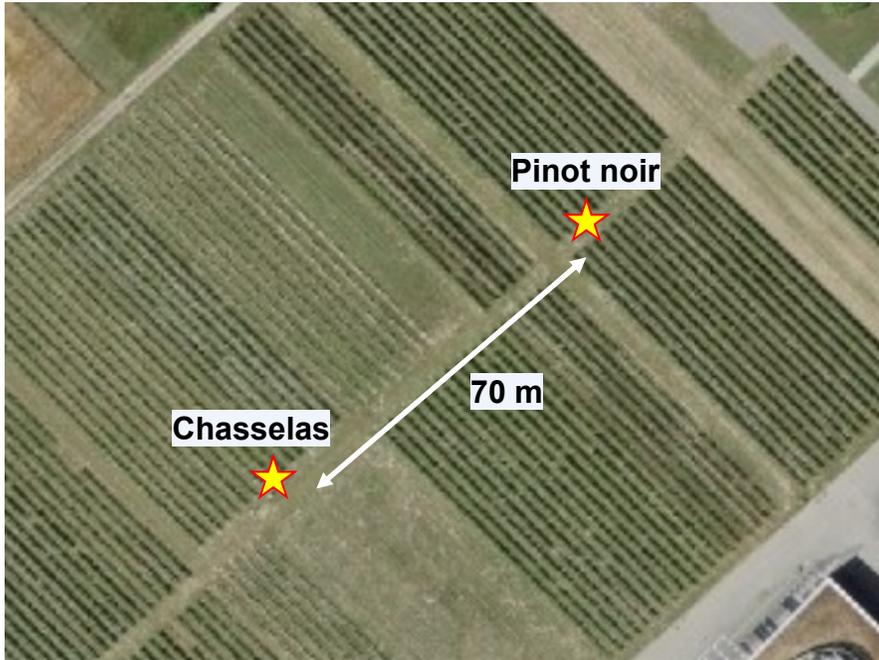
*12 détecteurs autonomes en 2024 !
+ test d'un nouveau capteur sur pommier*



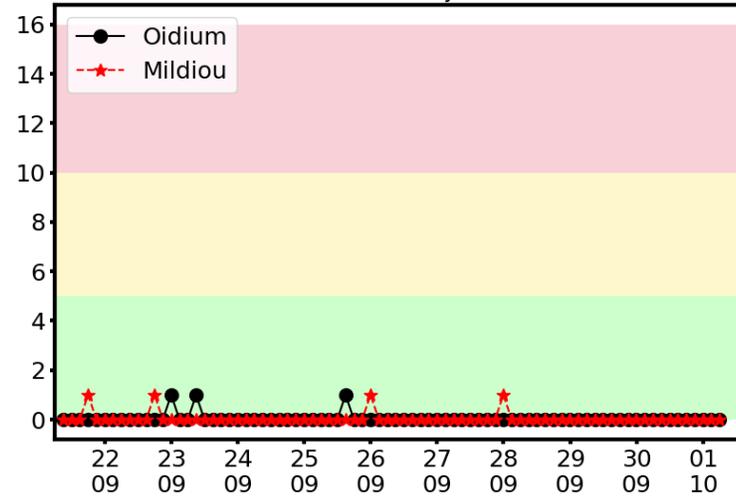
Suivi en temps réel

Chasselas

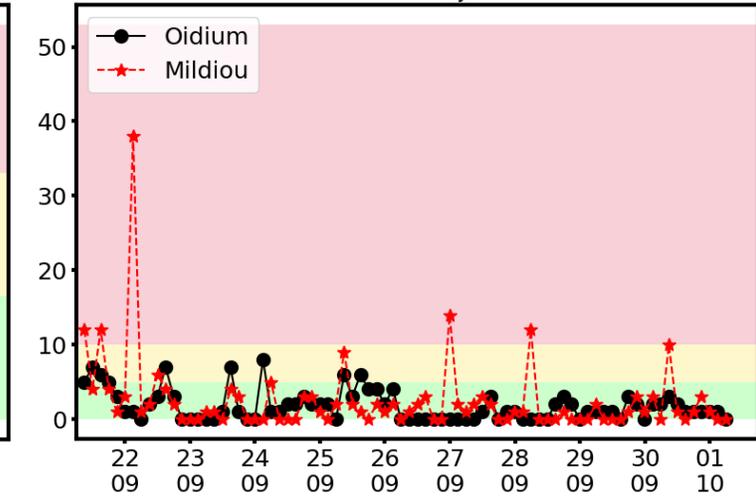
Pinot Noir



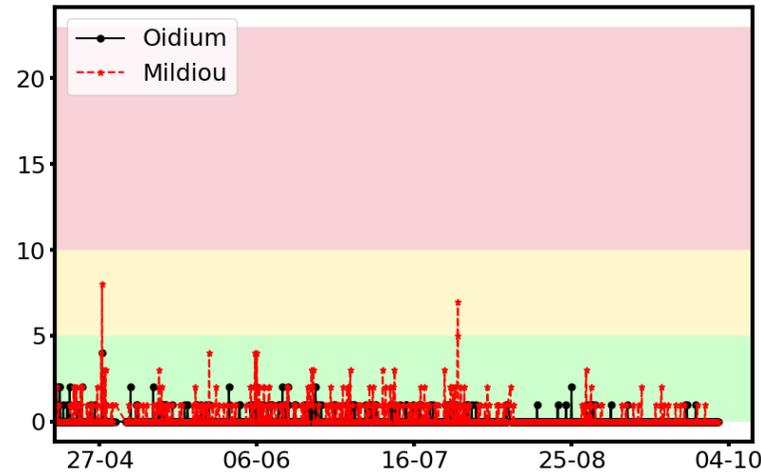
10 derniers jours



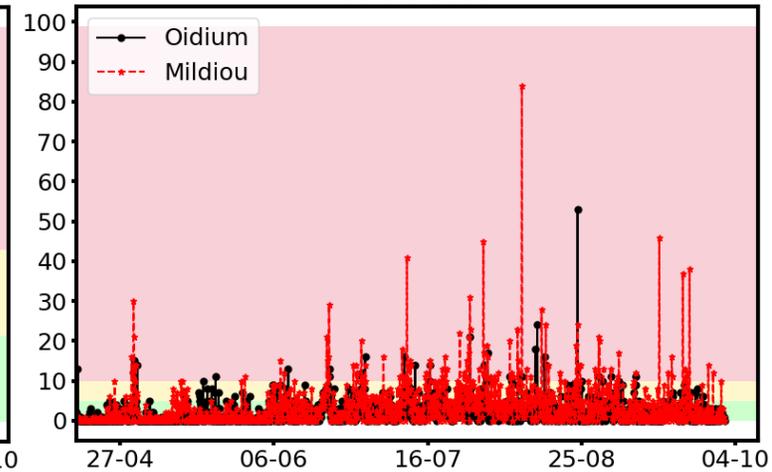
10 derniers jours



Toute la saison



Toute la saison

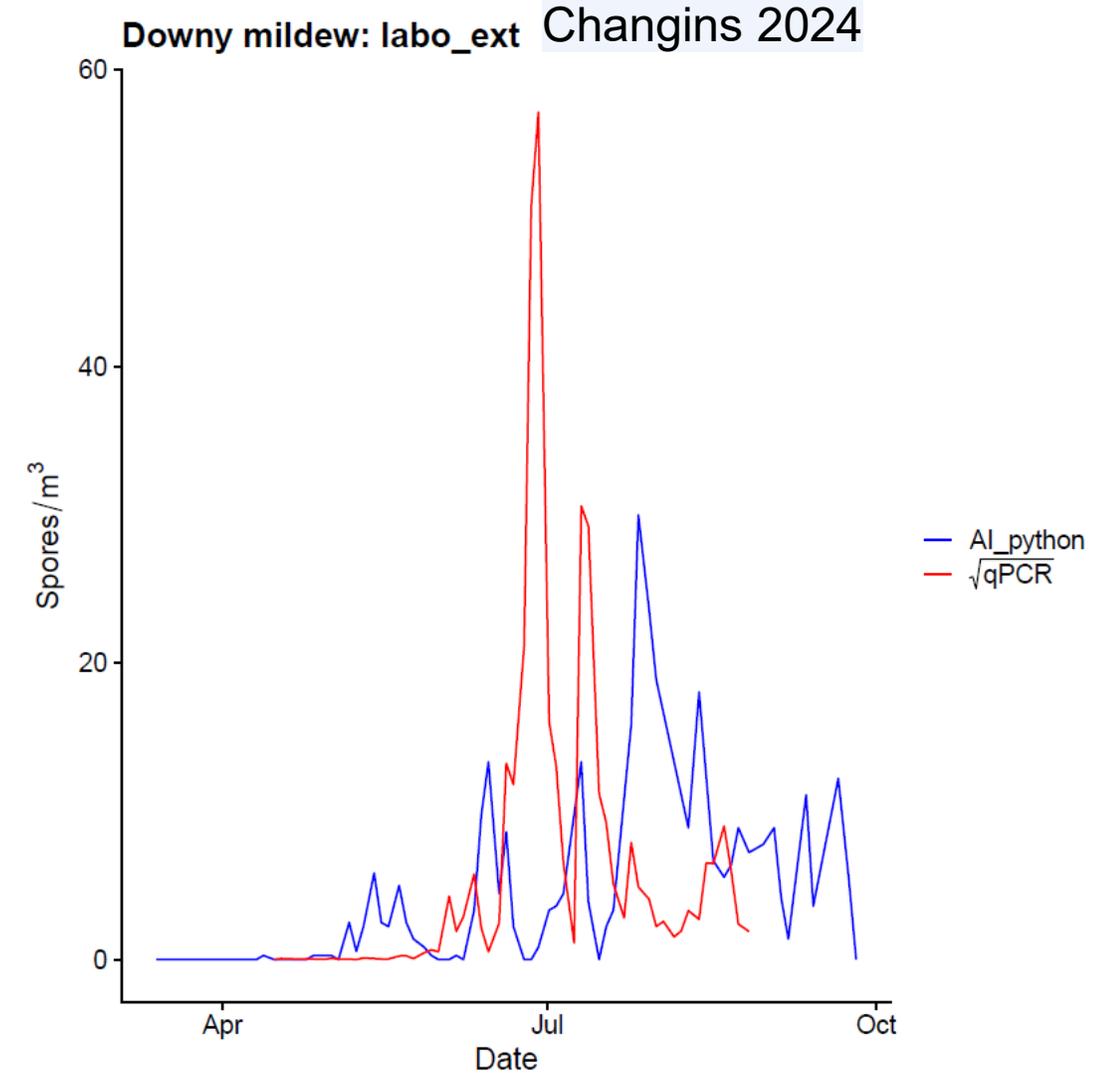
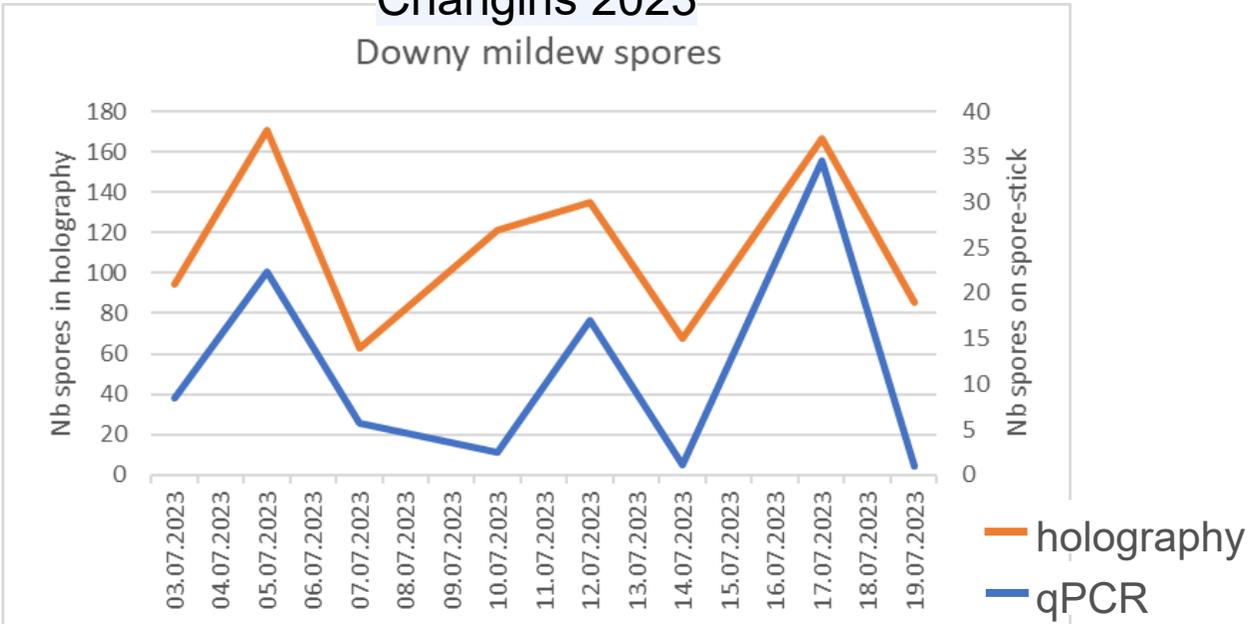




Comparison holography VS qPCR



Changins 2023
Downy mildew spores



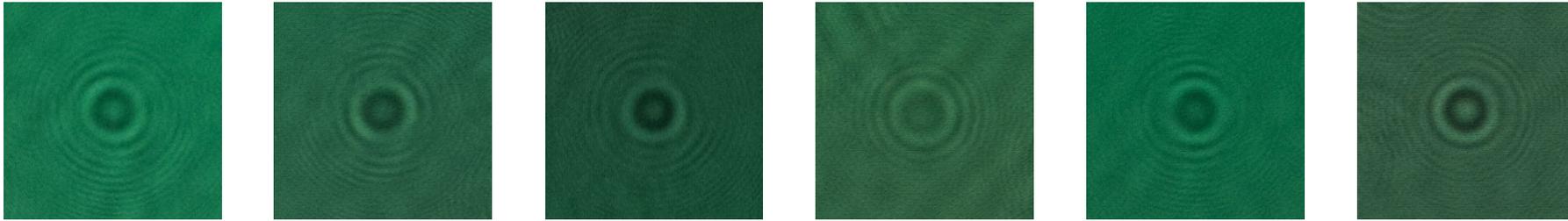


Problèmes de reconnaissance, exemples

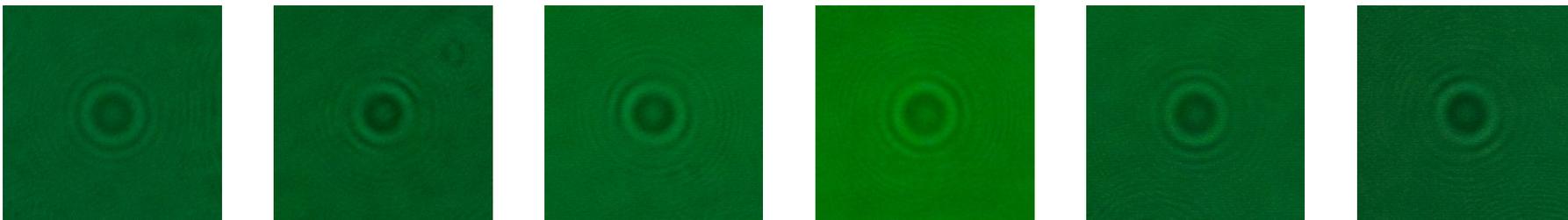
Mildiou / Pollen de châtaignier:

Deux particules ayant des patronnes de diffraction vraiment très proches. Difficile de les différencier à l'œil nu ! Néanmoins, le Mildiou semble avoir le deuxième anneau de diffraction plus espacé du premier...

Mildiou (Changins)



Castanea Sativa





2024 Downy mildew trial – spray decision on spore load

Changins, sur chasselas



treatment	A
03.05.2024	
10.05.2024	
24.05.2024	
05.06.2024	
19.06.2024	
04.07.2024	

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2024 Downy mildew trial – spray decision on spore load

Changins, sur chasselas

B: Threshold > 10 spores count during 3 days



treatment	A	B
03.05.2024		
10.05.2024		
24.05.2024		
05.06.2024		
19.06.2024		
04.07.2024		

Nom de la présentation | Conférence
Expéditeur



2024 Downy mildew trial – spray decision on spore load

Changins, sur chasselas

B: Threshold > 10 spores count during 3 days

C: Threshold > 50 spores count during 3 days



treatment	A	B	C
03.05.2024	Yellow		
10.05.2024	Yellow		
24.05.2024	Yellow	Yellow	
05.06.2024	Yellow		
19.06.2024	Yellow	Yellow	Yellow
04.07.2024	Yellow	Yellow	Yellow

→ 3 sprays saved with the threshold > 10 spores last 3 days



Suite

- Traitement des données afin d'établir **une valeur seuil** de danger d'infection
- Ajout de la donnée **quantité de spores** au modèle mildiou (VM-Plasmopara) sur Agrometeo
- Amélioration de la spécificité de l'IA
- Développement de l'identification par IA de nouvelles spores sur **d'autres maladies** (ex : black rot, tavelure du pommier, mildiou de la pomme de terre, etc.)



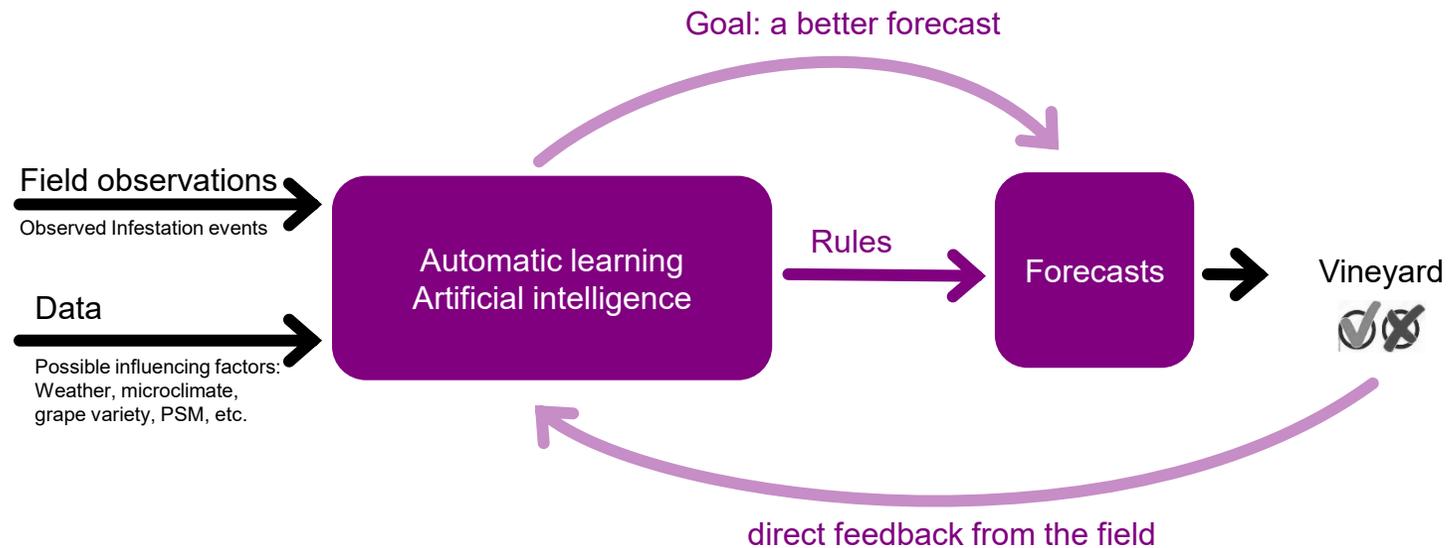
Détecteur à Leytron 2023



Vitiprotec project

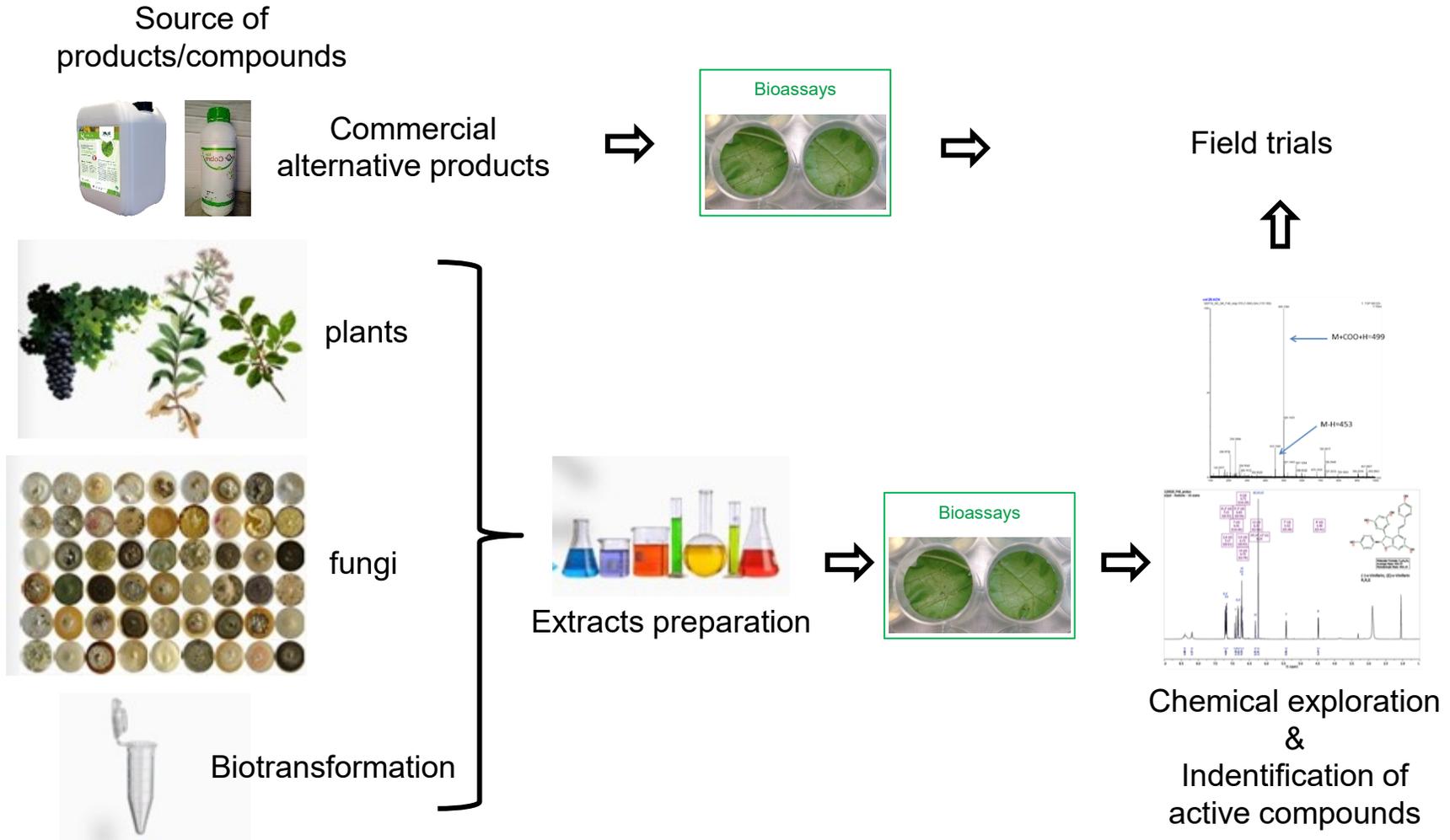
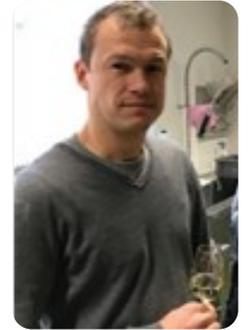


- Use of AI and deep learning to develop a new Downy Mildew model
- Project from Weinbauzentrum Wädenswil and the company Databaum
- Challenge: monitor epidemic development of Downy Mildew in different conditions and location in Switzerland (2024 90 plots monitored)





Discovering and testing alternatives fungicides



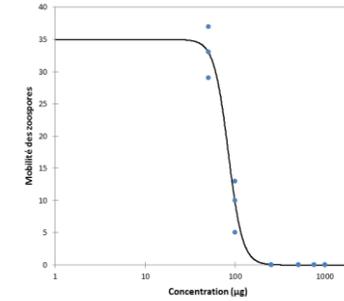


Assessment of antifungal activity - bioassays



Plasmopara viticola

- Mobility of zoospores
- Sporulation (7 dpi)

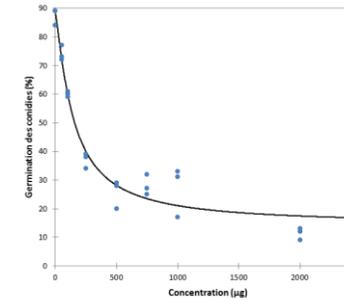


Determination of CI_{50}



Erysiphe necator

- Conidial germination rate (48 hpi)

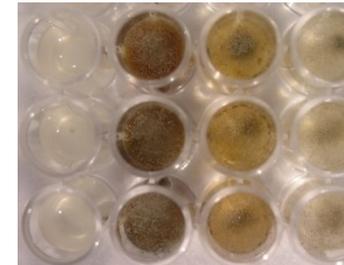


Determination of CI_{50}



Botrytis cinerea

- Mycelium development (5 dpi)



Determination of CI_{50}



Example 1: protecting vines with vines



- Valorisation of waste products derived from grapevine and developing a natural active extract formulated to control diseases in grapevine
- Cane/wood extract => **AGROSCOPE PATENT**

SARMENTS DE VIGNE



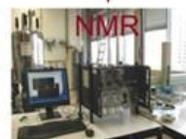
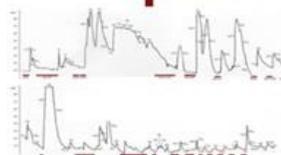
Broyage

Extraction



Extrait actif

ANALYSES



ACTIVITES FONGICIDES BIOTESTS



Mildiou de la vigne



Oïdium de la vigne



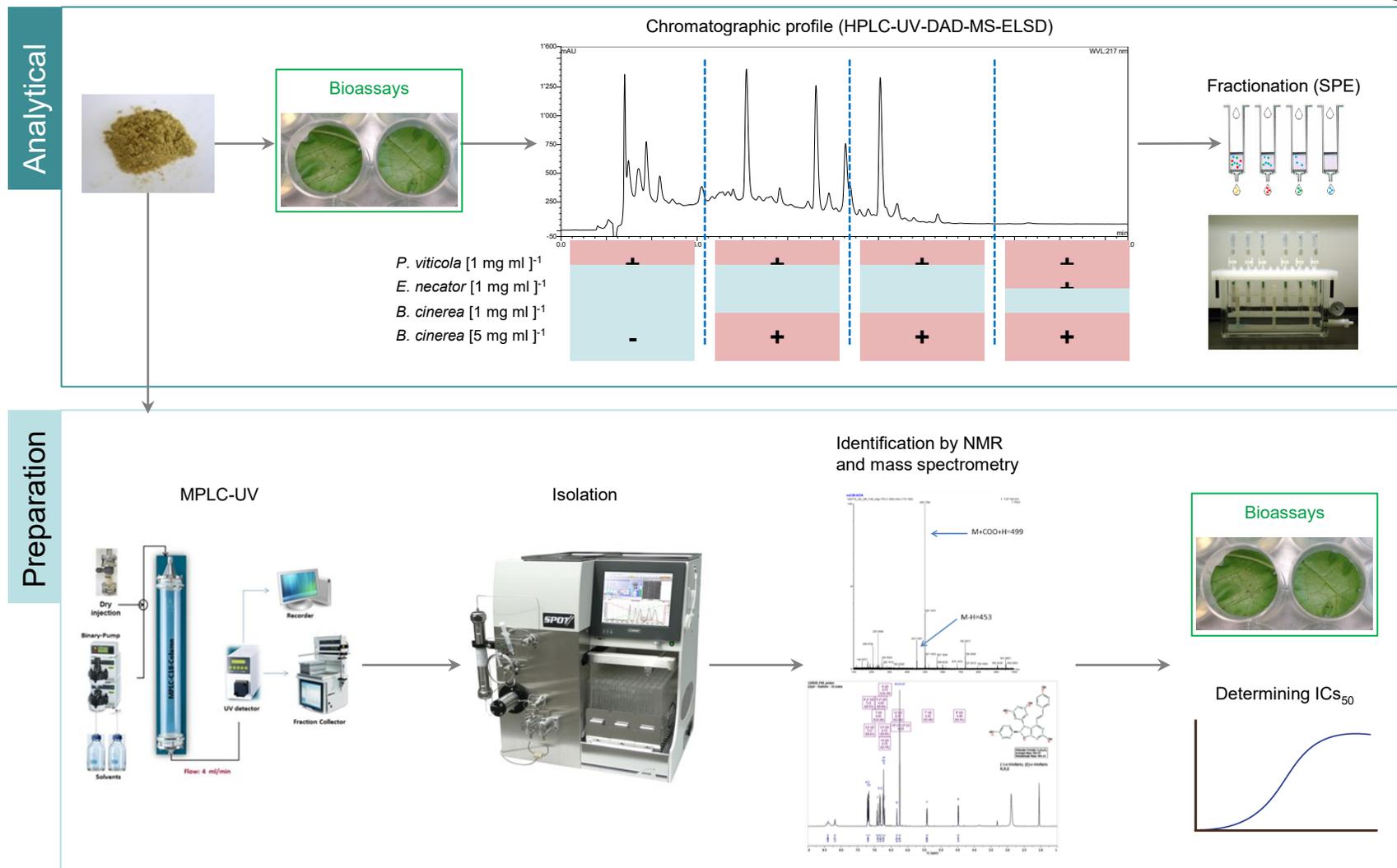
Pourriture grise
de la vigne

Forte activité fongicide

**EXTRAIT DE VIGNE POUR
UNE VITICULTURE DURABLE**



Ex. 1: «Bio-guided» strategy

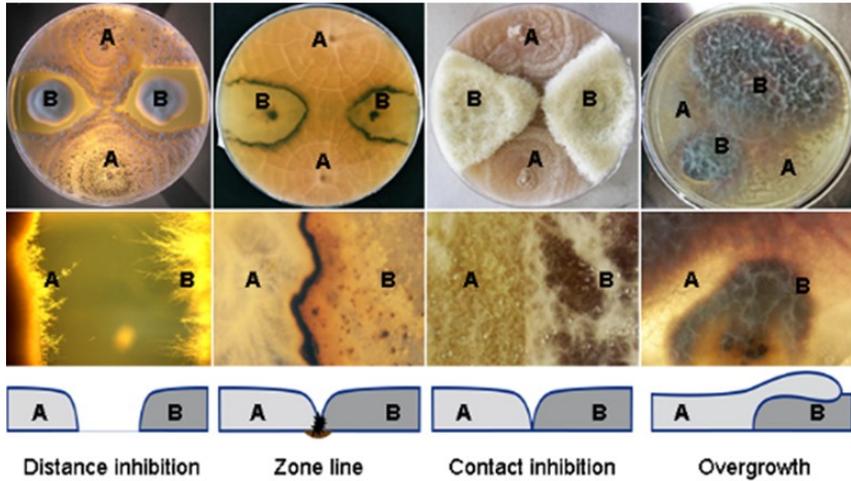




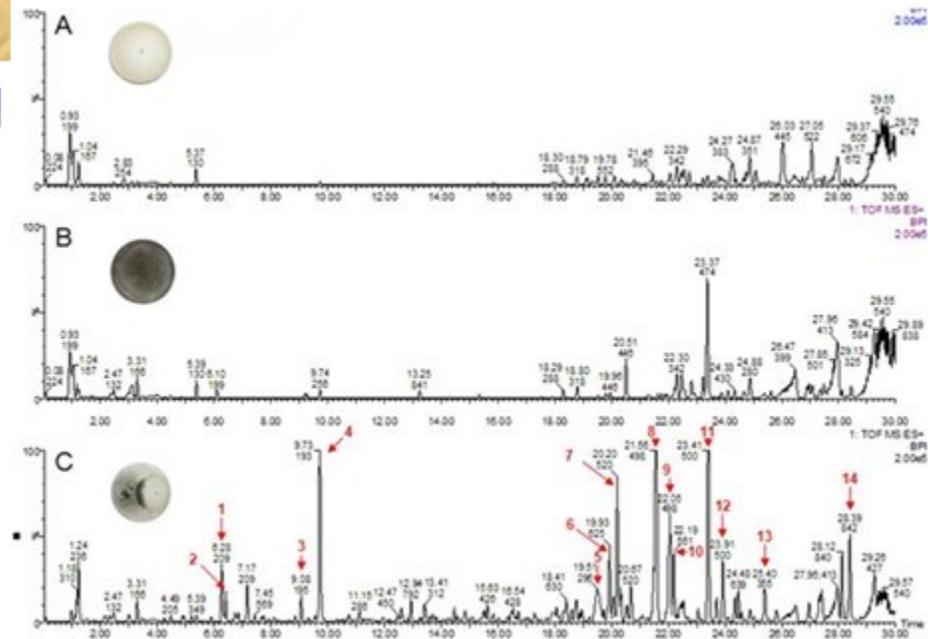
Ex. 2: Induced secondary metabolites



Fungal confrontations : «chemical war»



Metabolites produced - induced



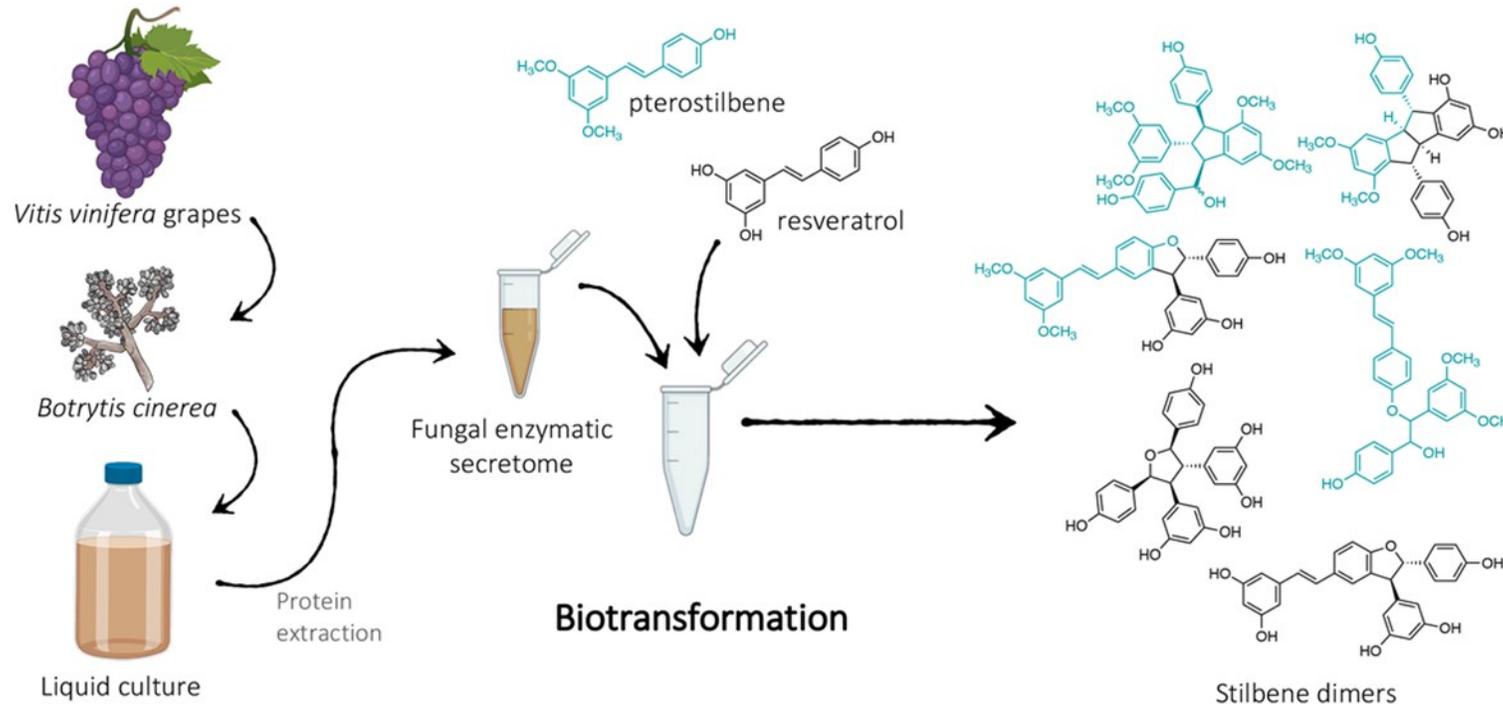


Ex. 3: Biotransformation

New strategy to generate chemical diversity



Biotransformation use of an organism or enzymes purified from that organism to induce chemical modifications in an selected organic compound.

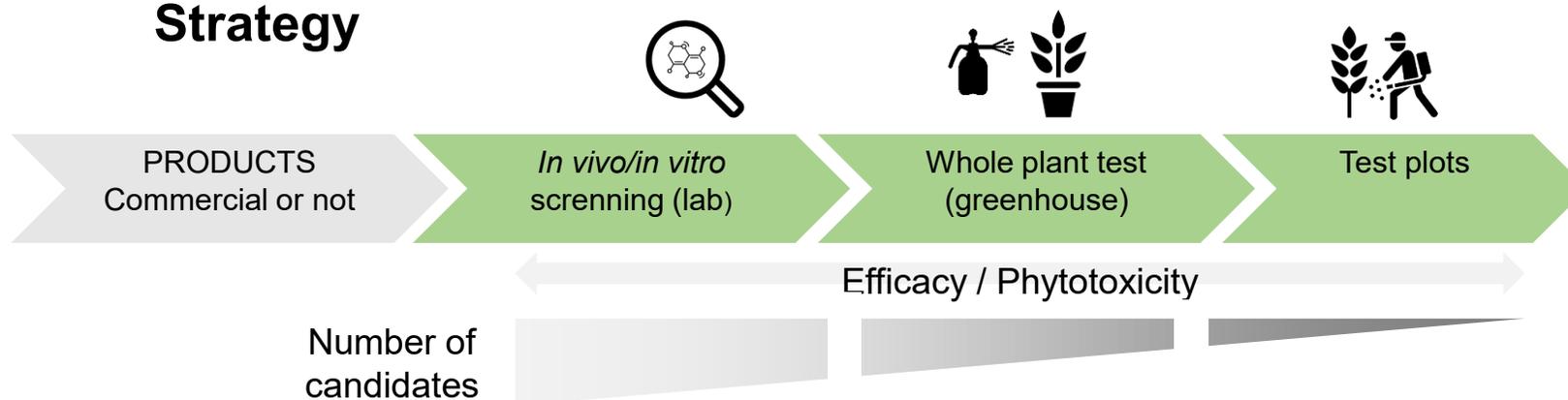




Ex 4: evaluation of commercial alternatives products

- experimentation with alternative solutions but need of a valid experimental system, to avoid generating biased data on efficacy and possible side effects
→ Generating scientifically validated and robust data
- 4 pathogens studied: Downy mildew PRIORITY / (human pathogens)

Strategy



Chemodiversity of natural products



- Substances
- Extracts
- Prototypes
- Formulated products

Identify/generate/characterise chemical diversity using innovative approaches

- **Biotransformation** Gindro K, and Queiroz EF (SNSF project N° 205321_182438/1)
- **MycoMediX** Jean-Luc Wolfender, Thilo Köhler and Sylvain Schnée (SNSF project N°40B2-0_211759/1)



Ex 4: Screening Black-Rot (or Botrytis)

Objective → Determination of the **minimum inhibitory concentration (MIC)**
6 concentrations tested, surrounding the recommended dose

Biotest **optimisation**: polymorphism + growth 4-5 weeks → 1 week!



Fungal growth is assessed at 7, 14 and 21 days after inoculation (→ discrimination of fungistatism and fungitoxicity).

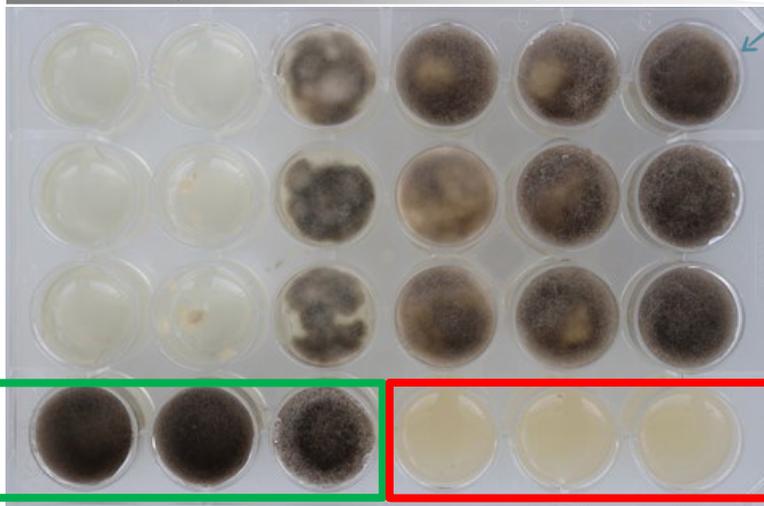
B. cinerea: suspension of conidia
G. bidwellii: agar plug + mycelium



Increasing concentration of the product tested

Triplicate

Positive control
(culture medium alone)



Negative control
(Registered fungicide)



Ex 5: *In vivo/in vitro* screening (laboratory)



Biotrophic pathogens: Downy Mildew and Powdery Mildew

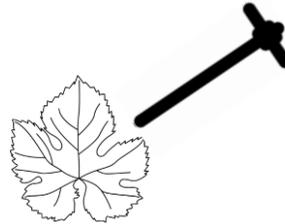
Objective → Determination of the **effective preventive concentration**
5 concentrations tested: 4N, 2N, N, ½N, 0.2N - Controls: water / Kocide Opti



① Cabernet-Sauvignon cuttings at 10-15 leaf stage

② Harvest young leaves and wash them down with water to remove all traces of treatment.

④ Random boxing of discs



③ Production of leaf discs (Ø 1.8 cm)

⑤ Treatment using a spray robot



⑥ Inoculation (1.10^5 sporanges.ml⁻¹) 24 hours after treatment

⑦ Incubation 7 days (22°C, natural photoperiod)



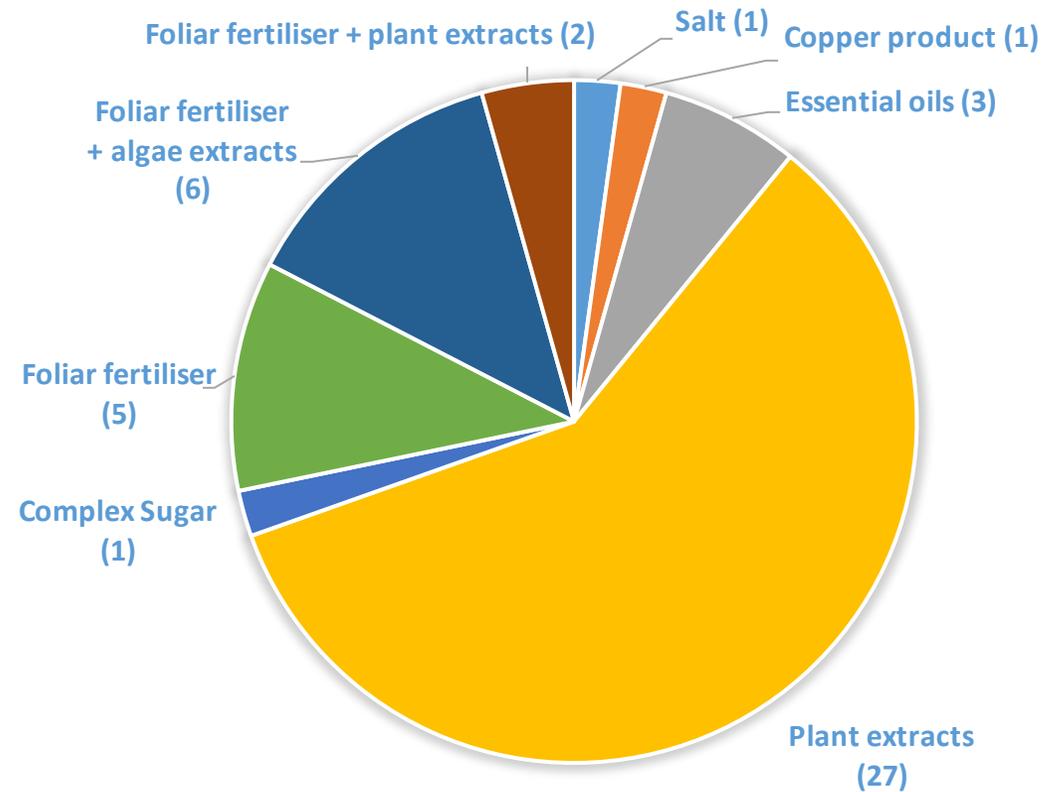
⑧ Assessment of the severity and symptoms of phytotoxicity



Ex 5: Downy Mildew Screening



→ 46 commercial alternative products evaluated against





Field trial at Changins (2023) - Downy mildew



Changins experimental facility

N° cep \ Ligne	1	2	3	4	5	6	7	8	9	10
62	6a	7a	3b	11b	4c	10c	1d	9d		
51	5a	8a	1b	9b	2c	12c	5d	7d		
50										
41	4a	9a	5b	12b	6c	8c	2d	11d		
40										
31	3a	10a	2b	7b	1c	11c	6d	12d		
30										
21	2a	11a	6b	8b	3c	9c	4d	10d		
20										
11	1a	12a	4b	10b	5c	7c	3d	8d		
10										
1										

Ligne tampon : Référence biologique

Programme conventionnel (Viticulture)

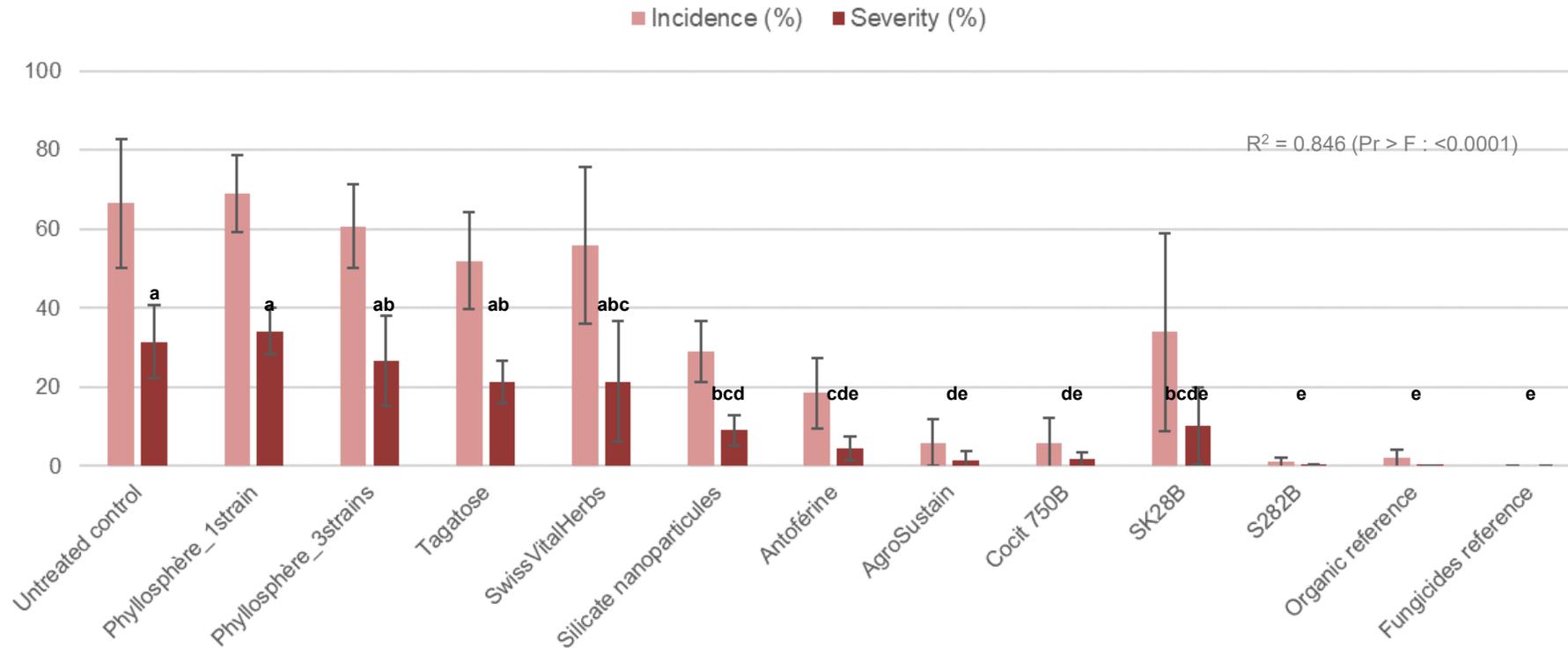
Experimental design – tested variants

1. TNT
2. Organic reference (BIO)
3. Reference Conventional fungicides
4. Phyllosphere_bacteria *antiPv*
5. Phyllosphere_complex 3 bacteria
6. Tagatose
7. SwissVitalHerbs (plant extract)
8. Silicate nanoparticles
9. Antoferin®
10. Agrosustain®
11. Copper citrate 750B (16.7% Cu)
12. Copper silicate SK28B (13.14% Cu)
13. Copper silicate S282B (22.34% Cu)



Field trial at Changins (2023) - Downy mildew

Severity on **bunches** in the untreated control: **31.5%**.





Conclusion and outlook

Identifying active substances/extracts (fungicide)

Efficacy
comparable to references



No phytotoxicity

LEAD



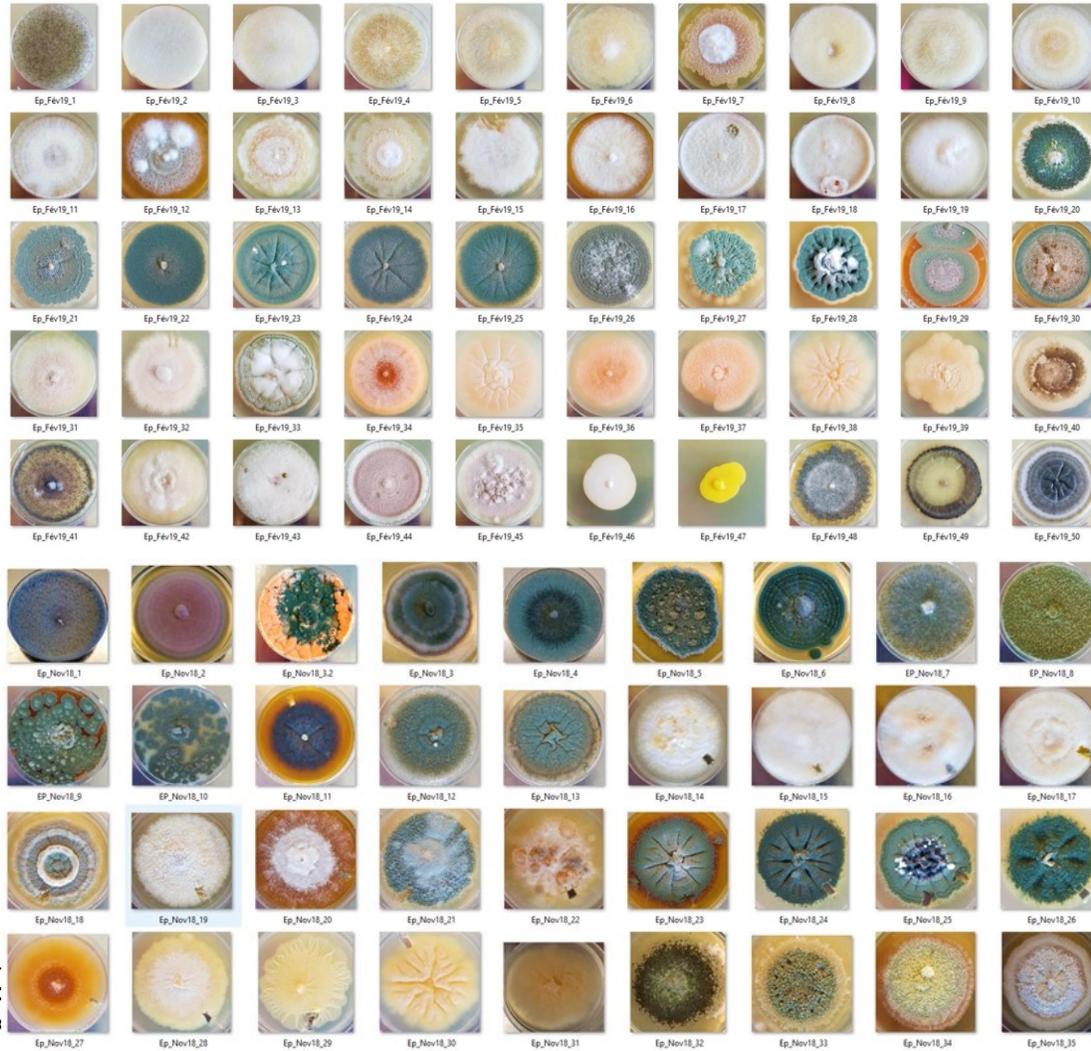
- **Broad spectrum** activity
- Mode of action does not induce **resistance**
- **No residues** on treated products
- No impact on **beneficial organisms**

Partnerships





2. Par la découverte de nouvelles communautés fongiques

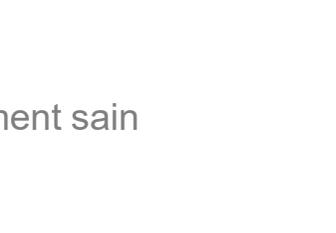


— No
Ex



Projet Stratospore: quelles spores dans la stratosphère?





Merci pour votre attention

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