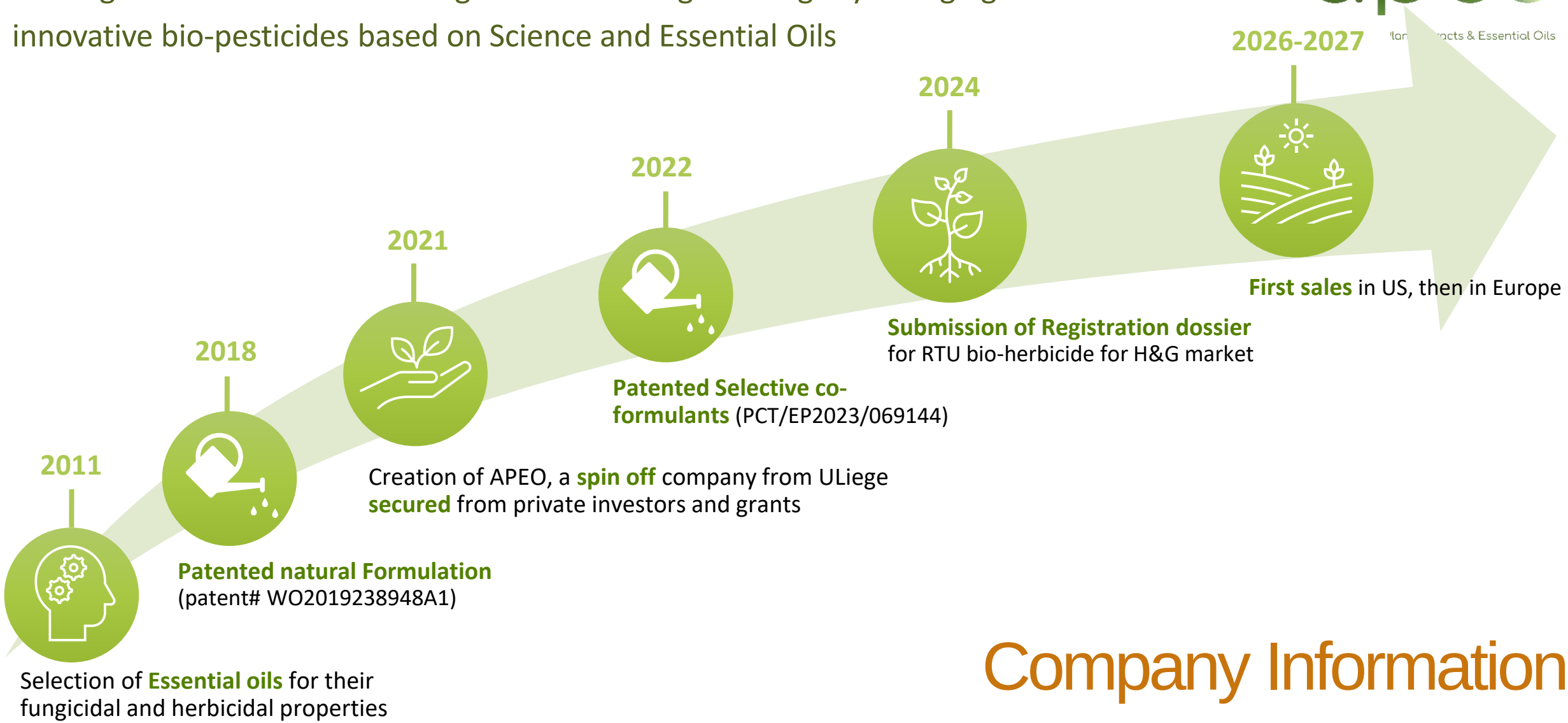
Agronomical Plant Extracts & Essential Oils

Agronomical Plant Extracts & Essential Oils

Developing sustainable Agriculture,
Putting Science and Agronomy at the heart of our activities

Mission

Shifting towards sustainable agriculture and gardening by bringing innovative bio-pesticides based on Science and Essential Oils



Company Information

APEO Team Who/Background

Agronomical Plant Extracts & Essential Oils

A management combining Science and Business

Arnaud Malerbe, CEO

25+ years managing business development teams and PMI in biosolutions for agriculture. International experience: Mexico, Brasil, Spain, Haiti, Europe, South Africa and USA

Pr. Haïssam Jijakli, co-founder & CSO

33 years' experience in biocontrol
Full Professor at ULiège/Gembloux, Phytopathology lab,
Creation of 4 Spin-Offs and 10 patents

Simon Dal Maso, co-founder & Technical director

8 years experiences
Accelerated Management Program/Solvay Business School 2018

The dedicated team and the right support for our stage of development

Experienced managers in the key functions and external support :

- Regulatory
- Technical development
- Supply and ops
- Business development
- Finance and administration

Dynamic young and hybrid R&D team (APEO & ULiège researchers and technicians)

All committed with the APEO Values and project

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From research to first development

2011

- More herbicide-resistance of weeds
- Retailer and consumer reluctance to chemical residues and public concern for environmental safety
- Limitation and withdrawal of authorized active ingredients (Glyphosate, Diquat,…)
- Development of novel practices (e.a. Mechanical weeds killing) or products (Pelargonic acid)

Pre-selection considering plant protection market and EO market

Agronomical Plant Extracts & Essential Oils

- Among 3000 EOs, pre-selection of 91 EOs for fungicidal and herbicidal activities based on :

  - Literature
  - Composition
  - Majority of the chemical families (Terpens, phenol, alcohol)
  - Cost
  - Availability

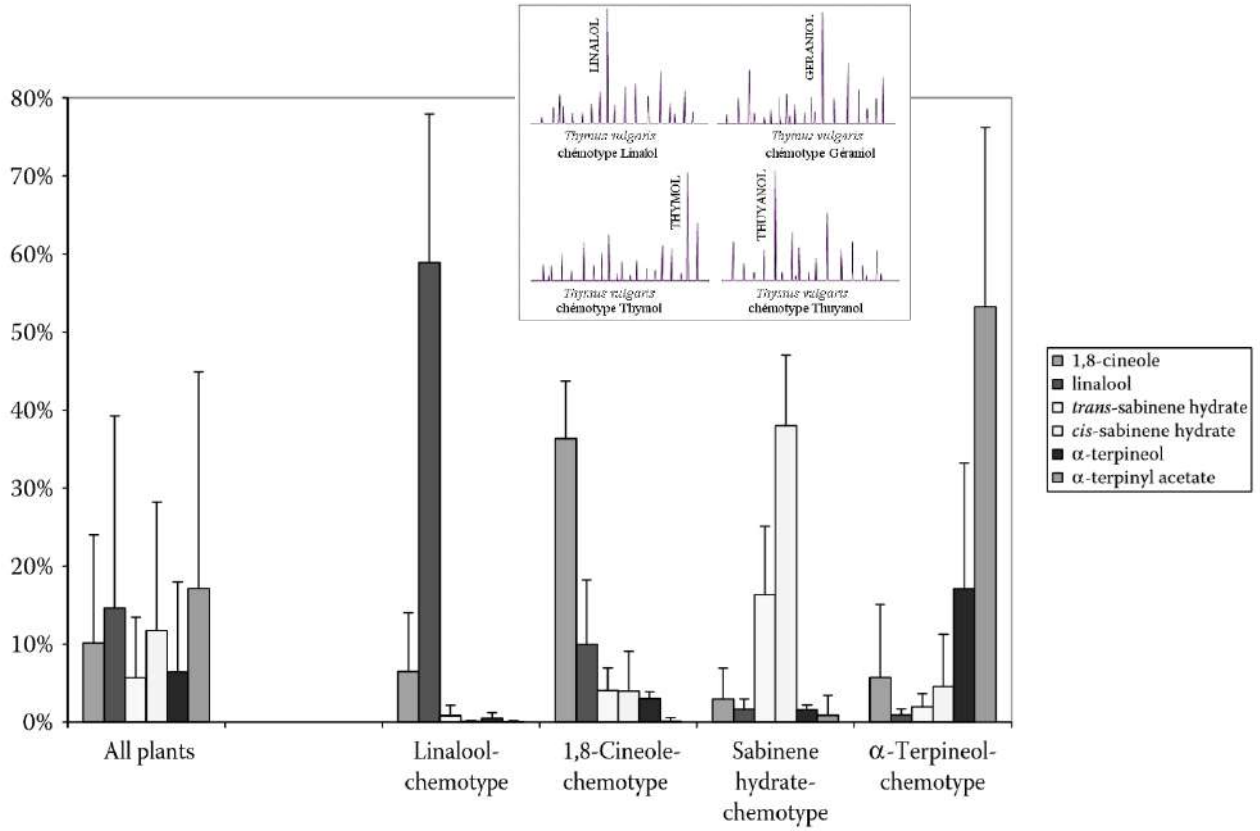
Pre-selection considering plant protection market and EO market

Agronomical Plant Extracts & Essential Oils

Chemotype

Chemotype = intraspecific variation
Chemotype of *Thymus vulgaris*

Selection of our suppliers according to the right chemotype and its stable composition



Source graph : Baser, K. H. C., & Buchbauer, G. (2015). *Sources of essential oils*. *Handbook of Essential Oils: Science, Technology, and Applications, Second Edition,* p.52 . https://doi.org/10.1201/b19393

Selection under greenhouse conditions

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Preselection of **22 EOs for herbicidal action** and test on :

- Monocotyledons : grass
(Festuca 70%, Lolium 30%)


- Bryophyte

- Dicototyledons : *Urtica dioica, Chenopodium, Papaver, Trifolium incarnatum*




- Pteridophyte

Selection under greenhouse conditions

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Activity against

	Type of major peak	Monocotyledon	Dicotyledon	Mosses	Horsetail
EO1	Aromatic	+++	++++	++++	++++
EO2	Aromatic	++++	++++	undertermined	undertermined
E03	Terpenic	++++	+	undertermined	undertermined

Efficacy of EO1

EO2

EO3

Untreated

Untreated

Efficacy of EO1

Importance of the formulation

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- Influences the modes of action
- Protects the EOs against the environment
- Influences the stability

And it strongly affects the efficacy

Formulation for stable emulsion

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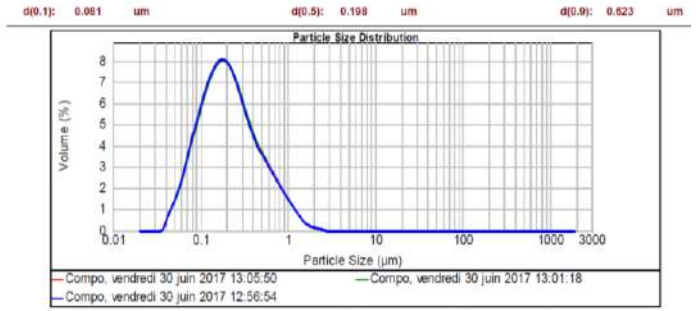
Type	Droplet size	appearence	Stability
Marco emulsion	2-20µm	Milky white	Instable
Mini emulsion	0.1-0.3µm	Bluish white	Several week
Micro emulsion	<0.1µm	translucent	Several months

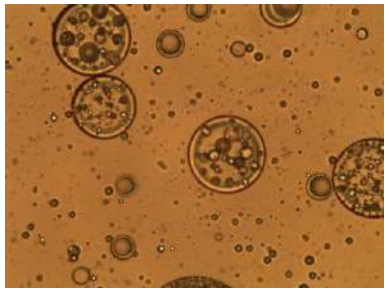
Laser granulometry



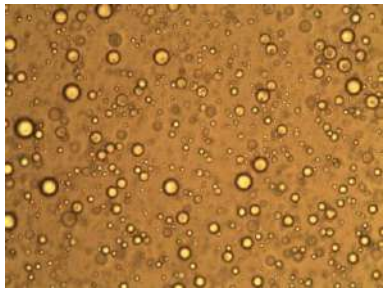
Formulation from chemical to biological adjuvants

Agronomical Plant Extracts & Essential Oils

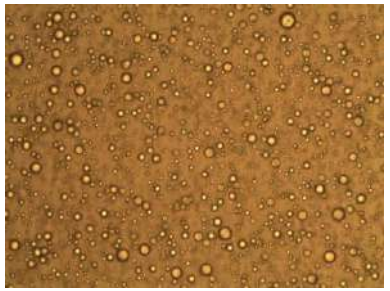
Microscopy



Basic Formulation

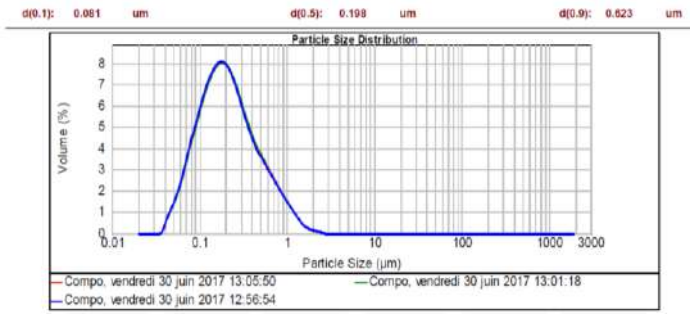


chemical Formulation



Biological Formulation

Laser granulometry



Formulation from chemical to biological adjuvants

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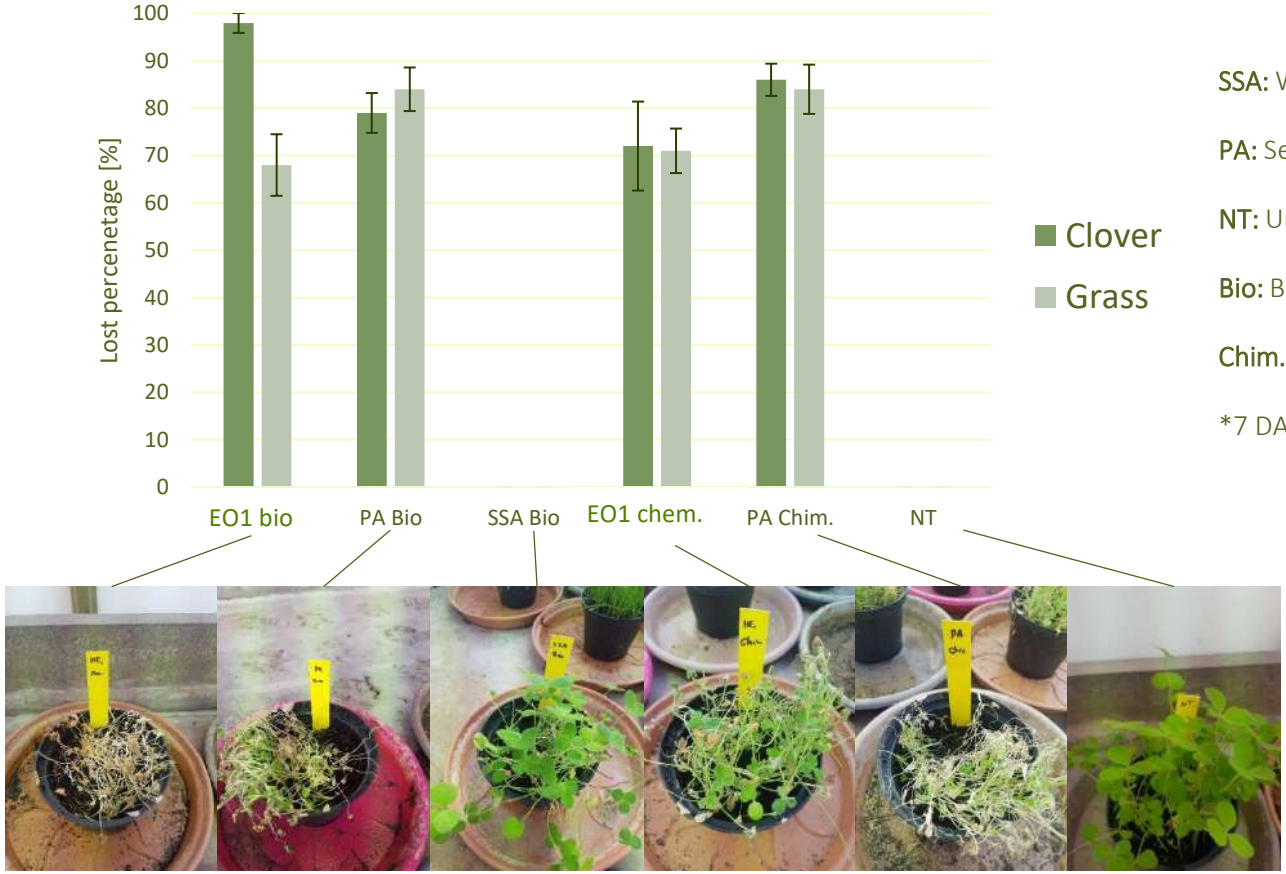
Efficacy on clover and grass



SSA: Without active substance

PA: Self formulated Pelargonic Acid

NT: Untreated

Bio: Biological formulation

Chim.: Chemical formulation

*7 DAA

Improvement and validation of the biological formulation with efficacy trials at different scales

Patented formulation

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From development to first products

Characteristics of EO1 - Marketing

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- ✓ EO1 is a unique novel biosourced biocontrol herbicide active ingredient based on essential oil
- ✓ As such, EO1 has a general positive perception form the public and essential oils are also known in other positive applications (medical, para-medical, cosmetic,…)
- ✓ RTU (Ready to use) and 5 x concentrated formulations are fully from natural organic ingredients
- ✓ PLEASANT ODOR
- ✓ Fully, steadily biodegradable
- ✓ (Will be) OMRI certified and certified as biocontrol
  - ✓ All ingredients are OMRI certified

Efficacy trials under field conditions 2019

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June 2019 in Belgium

Sown weeds in fields (4 monocotyledons and 12 dicotyledons)

Application of EO1 with final formulation

2 applications (10 days between applications)

4 replicates

Efficacy trials under field conditions 2019

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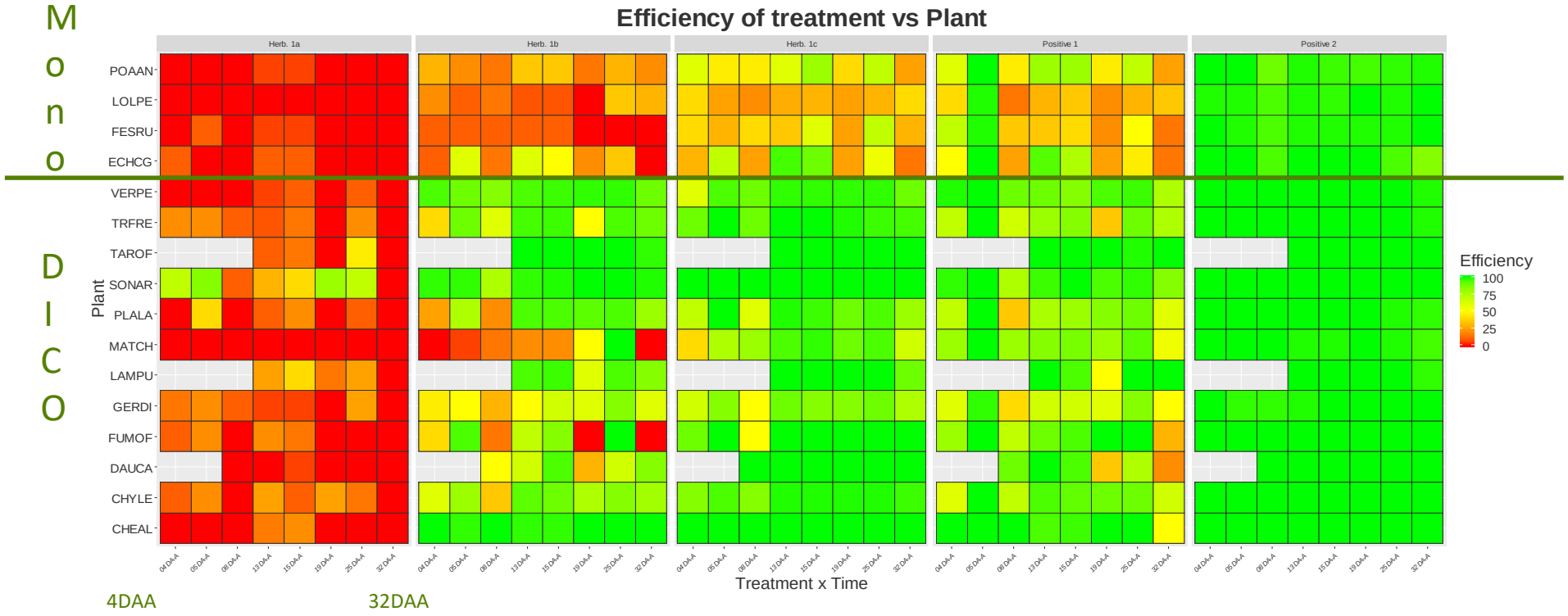
EO1 – Belgium

Mono

Dico



4DAA

32DAA

EO1 Dose 1

EO1 Dose 2

EO1 Dose 3

Positive control 1

Positive control 2

Efficacy trials under field conditions 2019

Agronomical Plant Extracts & Essential Oils

EO1 – Belgium

Mono

DICO

EO1 Dose 1

EO1 Dose 2

EO1 Dose 3

Positive control 1

Positive control 2

Untreated control

Characteristics of EO1 – EFFICACY on permeable soil

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Belgium in 2021
Sown weeds in fields

APEO

Fatty Acid

Characteristics of EO1 – EFFICACY after 5 years of GEP trials

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- ✓ EO1 has a **broader and higher global efficacy against DICOT** than products based on Pelargonic Acid (AP)
  - ✓ EO1 has a higher efficacy on 29/40 species of DICOT
- ✓ EO1 has a **global similar efficacy against MONOCOT** than products based on AP
  - ✓ EO1 has a higher efficacy on 4/7 species of MONOCOT
- ✓ EO1 has a **global similar activity in comparison with US market reference** products based on
  - ✓ Fatty acids + hydrazide maleic (chemical)
- ✓ Residual activity
  - ✓ better than Pelargonic Acid
- ✓ Germicidal action
  - ✓ No regrowth of seeds produced by the treated plant

Characteristics of EO1 – EFFICACY on permeable soil

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- Permeable soil – 21-25 Days after treatment

Plant	Trial Num.	APEO	Fatty Acid
GERRO	1	100.0	12.5
LAMPU	1	100.0	12.5
MATCH	3	100.0	75.0
STEME	1	100.0	15.0
THLAR	1	100.0	12.5
VERPE	1	100.0	100.0
GERDI	2	99.5	75.0
POROL	2	99.0	90.0
PLALA	1	97.5	40.0
TRFRE	2	94.0	52.5
SETVI	1	92.5	87.5
CONAR	1	80.0	22.5
GLNPU	1	80.0	17.5
MATIN	1	75.0	25.0
ECHCG	2	75.0	35.0
POAAN	4	72.5	62.5
DAUCA	1	60.0	30.0
NNNGA	2	55.0	70.0
LOLPE	1	50.0	15.0
CHEAL	3	30.0	35.0
HOLMO	1	30.0	10.0
EPIAD	1	20.0	0.0
PTLAN	1	17.5	17.5
TAROF	3	12.5	10.0

Classification by level of efficacy

The product is applied on young plants

(BBCH 00-30)

- Permeable soil – 61-70 Days after treatment

Plant	Trial Num.	APEO	Fatty Acid
PLALA	1	100.0	30.0
POROL	1	100.0	98.5
TRFRE	1	100.0	98.0
VERPE	1	100.0	100.0
CHEAL	1	98.0	80.0
GERDI	1	95.5	30.0
ECHCG	1	95.0	55.0
NNNGA	1	75.0	77.5
CONAR	1	70.0	12.5
POAAN	1	70.0	50.0
TAROF	2	50.0	55.0
DAUCA	1	10.0	5.0
CIRAR	1	5.0	12.5
GGGGG	1	5.0	7.5
GERRO	1	0.0	0.0
PTLAN	1	0.0	0.0

Efficacy Dicots all surfaces 3 years BBCH 30

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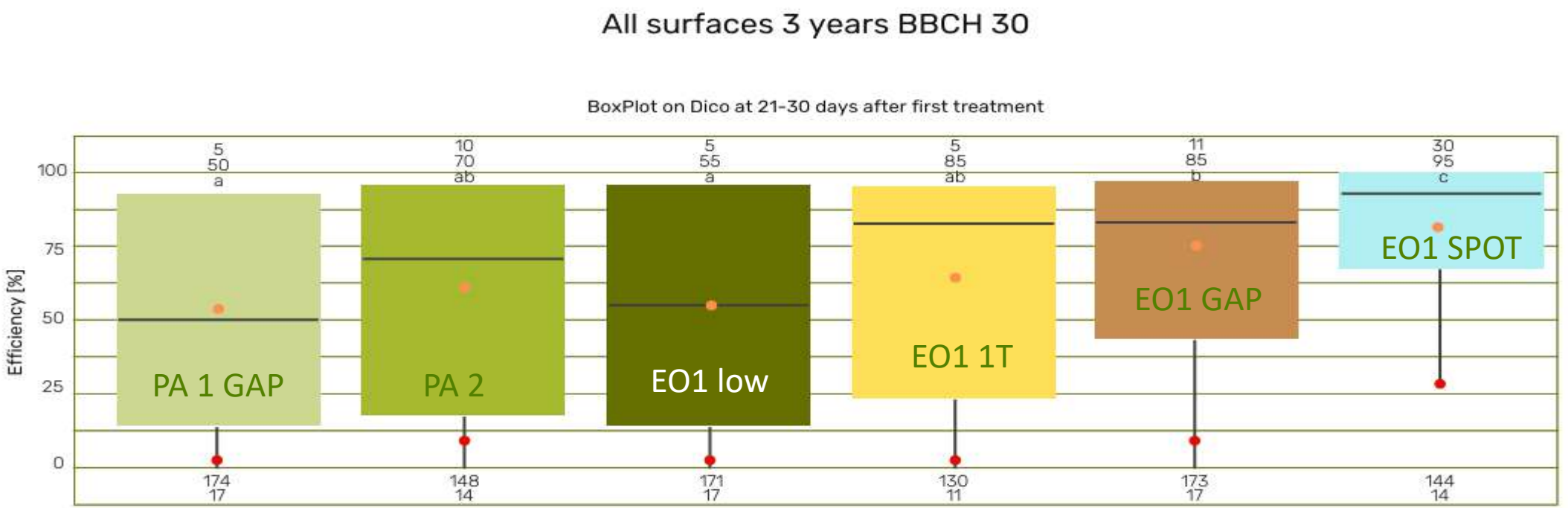

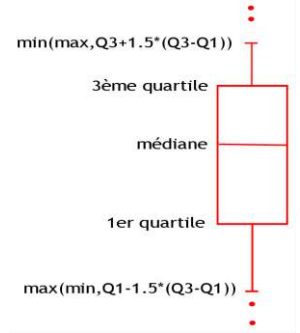

Efficacy, permeable soil, 3 years Dicots BBCH30

20 trials | 14 trials | 8 trials | 12 trials | 10 trials | 8 trials

8 to 20 trials and 53 to 320 observations for each point on the curves

8 to 20 trials and 53 to 320 observations for each point on the curves

Efficacy benchmark EO1 vs PA

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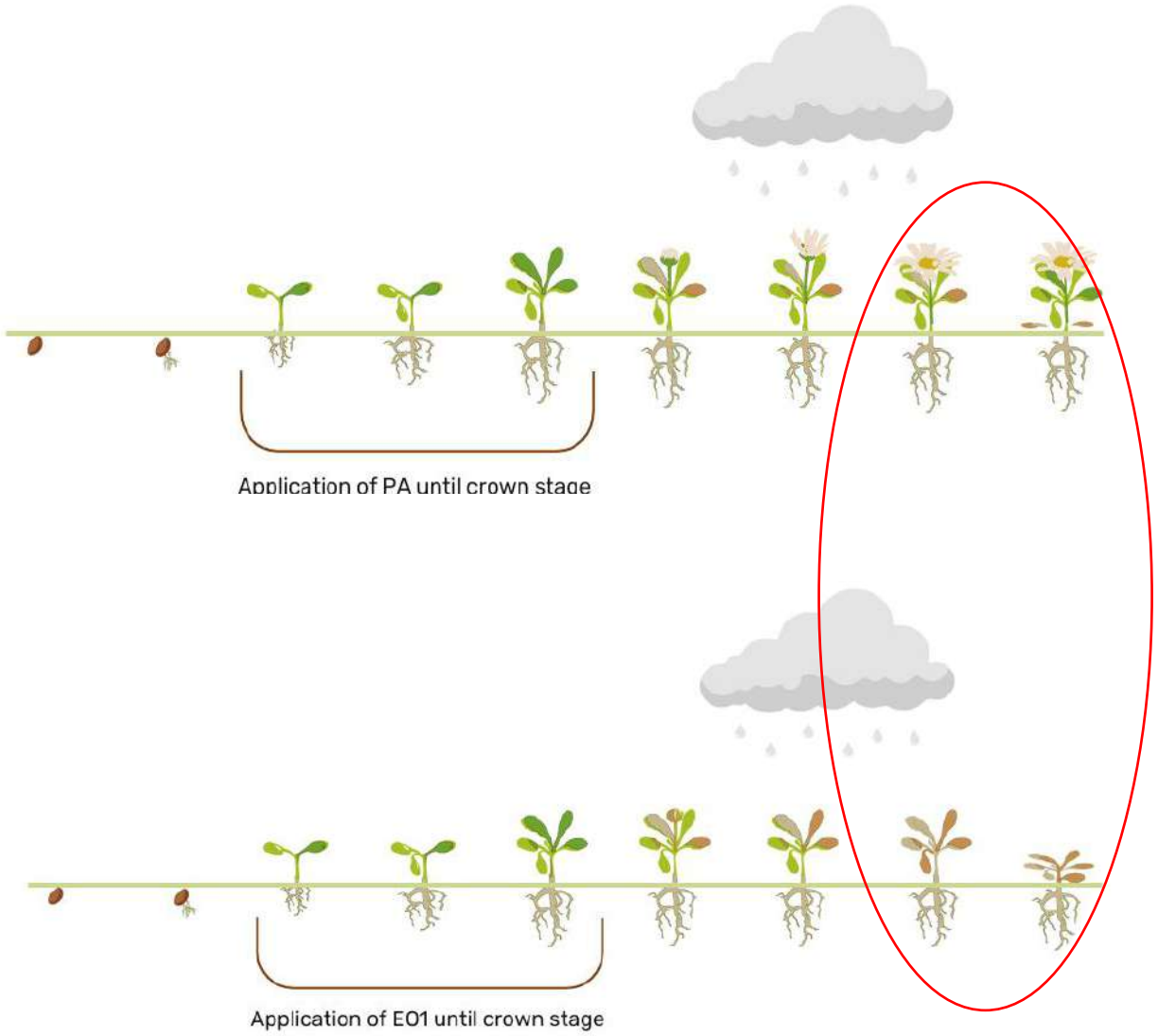
PA

EO1



Characteristics of EO1 – EFFICACY on permeable soil

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Germany in 2021
Natural weeds

APEO

Fatty Acid

Modes of Action of EO1

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Contact

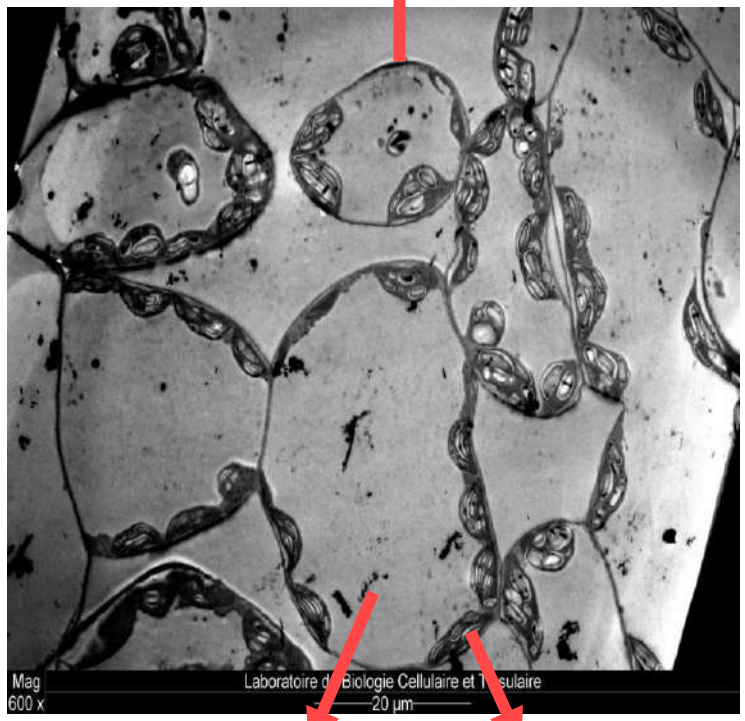
Multisite actions and more modes of actions than AP

No impact on germination if sowing few days after application

Characteristics of APEO EO1 – MODES OF ACTION

Effect on plant cells

Cell wall/membrane



Vacuole

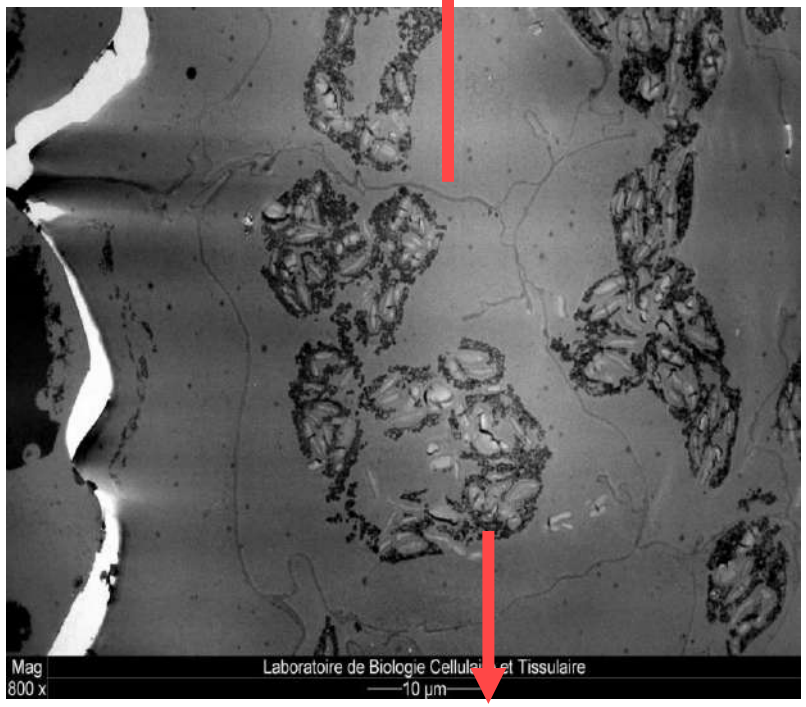
Cytoplasm

Normal plant cell

Contact

No impact on germination if sowing few days after application

Cell wall/membrane



Cytoplasm

Plant cell after application of APEO EO1

Effect on roots

Characteristics of APEO EO1 – MODES OF ACTION

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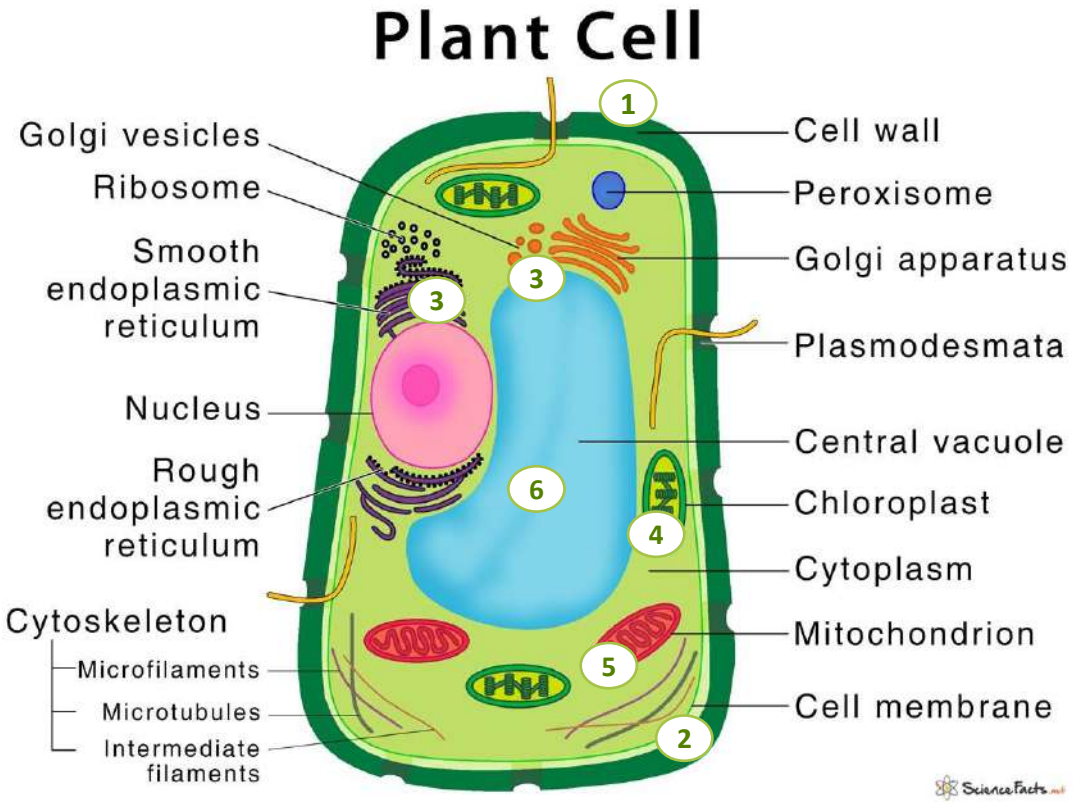
Multisite effect

1. Inhibition of membrane cell synthesis
2. Alteration of membrane proteins,
3. Destabilization of lipid organization and electrolyte leakage
4. Destabilization of protein synthesis
5. Inhibition of photosynthesis (Chloroplast)
6. Inhibition of cellular respiration
7. Total disappearance of the vacuole



Conclusions for bioherbicides

Agronomical Plant Extracts & Essential Oils

- **APEO E01**
  - ✓RTU formulation for H&G, water based
  - ✓Ongoing submission of regisration dossier
  - ✓Ongoing distributorship investigation

RTU herbicide by spraying application

- **APEO E04**
  - ✓One formulation for professional use under development
  - ✓Non-selective weed control
  - ✓Potato leaf kill
  - ✓Vines shoot control

Suckering test – France 2021

APEO EO4

Untreated

Perspectives for bioherbicides

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Agronomical Plant Extracts & Essential Oils

Code	Market	USES	Formulation	First Sales	
APEO EO1	H&G	Non-selective Herbicide on permeable an non- permable soil	RTU	2026	Herbicides
APEO EO2	H&G	Non-selective Herbicide on permeable an non- permable soil	Concentrated	2027	
APEO EO3	H&G	Algicide on semi and non-permeable soil/material	RTU	2027	Biocide
APEO EO4	PRO	Non-selective Herbicide Grapes, Fruit trees, Potatoes	Concentrated	2028	Herbicides
APEO EO5	H&G	Selective Herbicide on permeable an non- permable soil	RTU	2028	
APEO EO6	H&G	Selective Herbicide on permeable an non- permable soil	Concentrated	2028	
APEO EO7	PRO	Selective Herbicide Cereals	Concentrated	2030	

Agronomical Plant Extracts & Essential Oils

From research to first biofungicide development

2011

- Fungi are responsible of yield decrease worldwide
- Chemical fungicide-resistance of fungal populations
- Public is concerned about human health and environmental pollution
- Biofungicides is one of the most dynamic market due to no residue and resistance strategy
- Difficult to control fungal diseases without fungicides

Pre-selection considering plant protection market and EO market

Agronomical Plant Extracts & Essential Oils

- Among 3000 EOs, pre-selection of 91 EOs for fungicidal and herbicidal activities based on :

  - Literature
  - Composition
  - Majority of the chemical families (Terpens, phenol, alcohol)
  - Cost
  - Availability

Pathosystem selection

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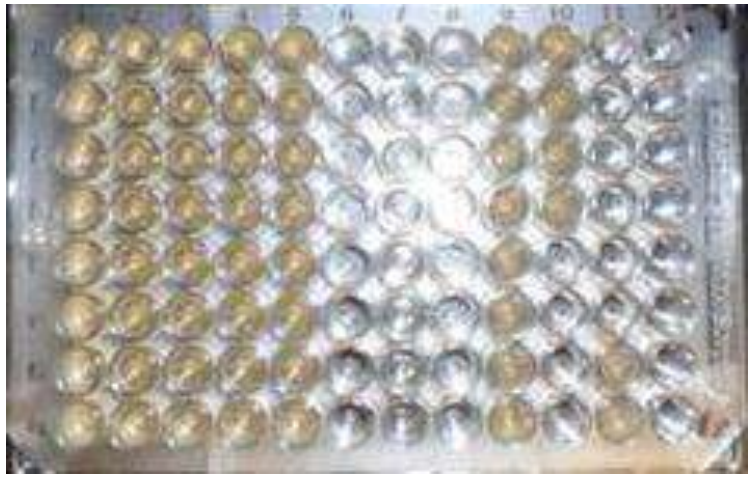
Cultures	Pathogens
Wheat	*Septoria tritici*
	Puccinia striiformis
	Fusarium graminearum / F culmorum
Sugar Beet	*Cercospora beticola*
	Erysipahe betae
	Rhizoctonia solani
Potato	*Phytophthora infestans*
	Erwinia carotovora/ E. atrospetica.
Apple (tree)	*Venturia inaequalis*
Apple and Pears	*Botrytis cinerea*
	Penicillium expansum
	Gloesporium perennans
Strawberry	*Xanthomonas fragariae*
	Podosphaera aphanis
	Botrytis cinerea

Cultures	Pathogens
Bean	Colletotrichum lindemuthianum
Vineyard	Plasmopara viticola (mildiou)
	Uncinula necator (oïdium)
Soils	Pythium ultimum

In vitro screening of best EOs

Agronomical Plant Extracts & Essential Oils



- 92 extracts (emulsion)
- 2 [EOs]

=184 objects/pathogen * 8 reps

=36 plates/pathogen

- Measure of OD /24 h
  - 120h
- Measure of OD /2 h
  - 24h

In vitro screening of best EOs

Agronomical Plant Extracts & Essential Oils

Cultures	Pathogens	In vitro
Wheat	Septoria tritici	☺
	Puccinia striiformis	--
	Fusarium graminearum / F culmorum	☺
Sugar Beet	Cercospora beticola	☺
	Erysipahe betae	--
	Rhizoctonia solani	☺
Potato	Phytophthora infestans	☺
	Erwinia carotovora/ E. atrospetica.	☺
Apple (tree)	Venturia inaequalis	--
Apple and Pears	Botrytis cinerea	☺
	Penicillium expansum	☺
	Gloesporium perennans	☺
Strawberry	Xanthomonas fragariae	☺
	Podosphaera aphanis	--
	Botrytis cinerea	☺
Bean	Colletotrichum lindemuthianum	☺
Vineyard	Plasmopara viticola (downy mildew)	--
	Uncinula necator (powdery mildew)	--
Soils	Pythium ultimum	☺

Phytotoxicity screening

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- Importance of the formulation
  - Concentration of EOs
  - Formulation

Basic Formulation



Elaborated Formulation



In vivo screening of best Eos on sugar beet

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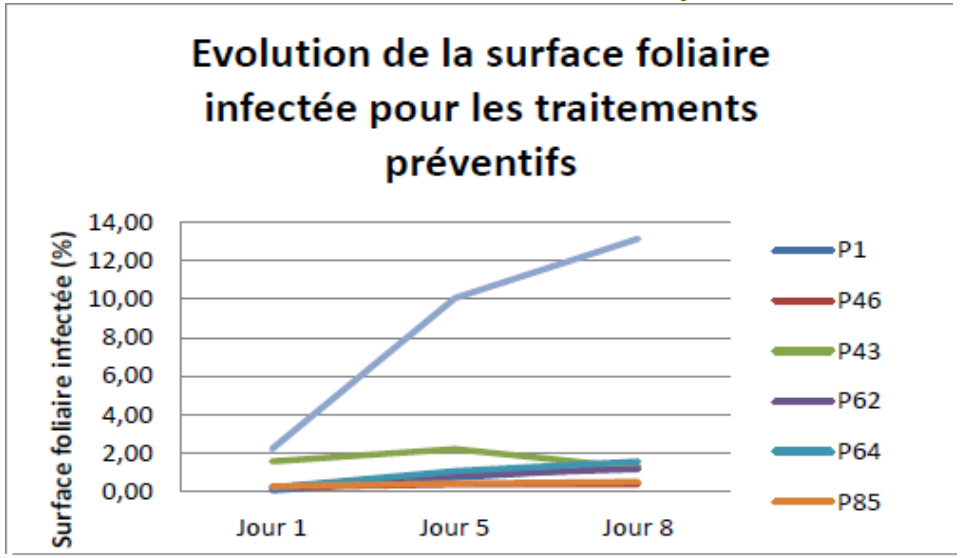
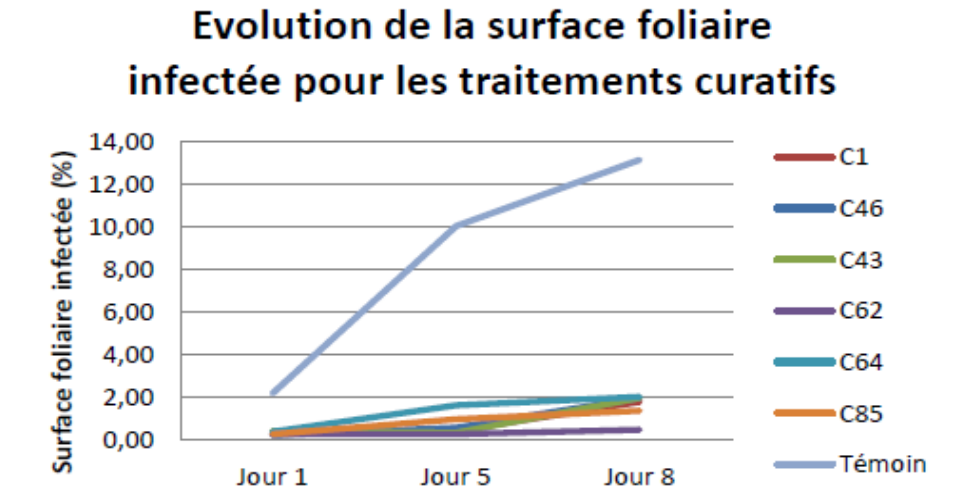
- *Set up*
  - Preventive treatment
    - 2-3 Hours before inoculation
    - By spraying EOs on plants
  - Curative treatments
    - 24 hours after inoculation
    - By spraying EOs on plants





In vivo screening of best Eos on strawberry

Agronomical Plant Extracts & Essential Oils

- *Set up*
  - Curative treatments
    - After natural inoculation
    - By 2 successive spraying treatments with 1 week interval

Control

1rst treatment

2nd treatment

In vivo screening of best EOs

Plant	Pathogen	Efficacy
Sugar beet	*Cercospora beticola*	☺☺
	Erysiphae betae	☺☺
	Rhizoctonia solani	☺
Potato	*Phytophthora infestans*	☺ (☺)
Apple(tree)	*Venturia inaequalis*	☺☺
Strawberries	*Podosphaera aphanis*	☺☺
	Xanthomonas fragariae	☺
Apple-Pear	*Botrytis cinerea*	☹(☺)
	Penicillium expansum	☹(☺)
	Gloesporium perennans	😐(☺)
Wheat	*S. tritici, P. striiformis. Fusarium sp.*	😐
Soil	*P. Ultimum*	☺☺

From research to first biofungicide development

2023

→ Undergoing Post-doc

→ Undergoing PhD

→ Undergoing PhD

→ PhD starting in Sept 2024

Perspectives for biofungicides

Agronomical Plant Extracts & Essential Oils

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APEO EO5	H&G	Selective Herbicide on permeable an non- permable soil	RTU	2028	
APEO EO6	H&G	Selective Herbicide on permeable an non- permable soil	Concentrated	2028	
APEO EO7	PRO	Selective Herbicide Cereals	Concentrated	2030	
APEO EO8	PRO	Fungicide against Potato mildew	Concentrated	2029	**Fungicides**
APEO EO9	PRO	Fungicide against Apple scab	Concentrated	2029	
APEO EO10	PRO	Fungicide against Septoriose on wheat	Concentrated	2030	
APEO EO11	PRO	Fungicide against Cercospora leaf spot on sugar beet	Concentrated	2030	

Thank you for your attention

apeo
Plant Extracts & Essential Oils

2011
Selection of **Essential oils** for their fungicidal and herbicidal properties

2018
Patented natural Formulation
(patent# WO2019238948A1)

2021
Creation of APEO, a **spin off** company from ULg **secured** from private investors and grants

2022
Patented Selective co-formulants (PCT/EP2023/069144)

2024
Submission of Registration dossier
for RTU bio-herbicide for H&G market

2026-2027
First sales in US, then in Europe

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