Glycomolécules et biostimulants : de la sweet immunité à la sweet biostimulation

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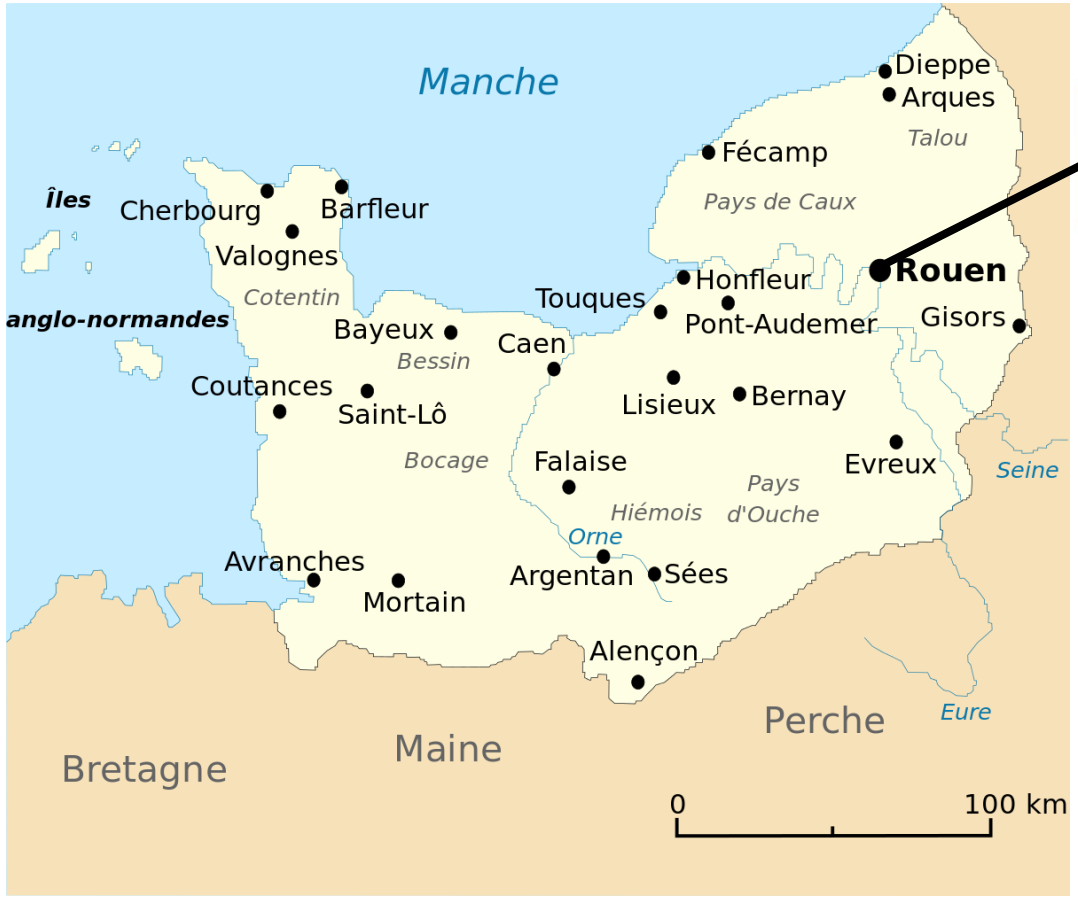
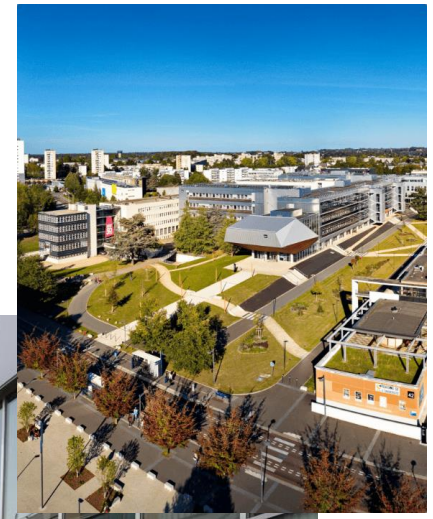
GlycoMEV : Glycobiologie et Matrice Extracellulaire Végétale



UNIVERSITÉ DE ROUEN NORMANDIE



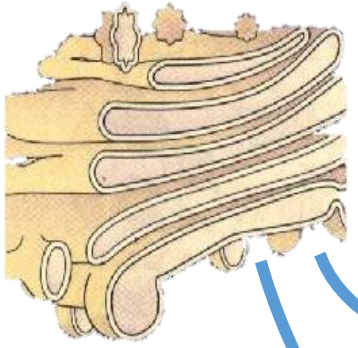
CURIB : Centre de Recherche et d'Innovation en Biologie

http://glycomev.univ-rouen.fr/

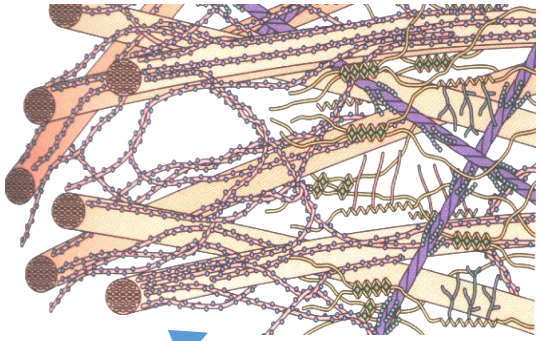
Notre Recherche

Structure, Biosynthèse et Fonctions des Glycomolécules

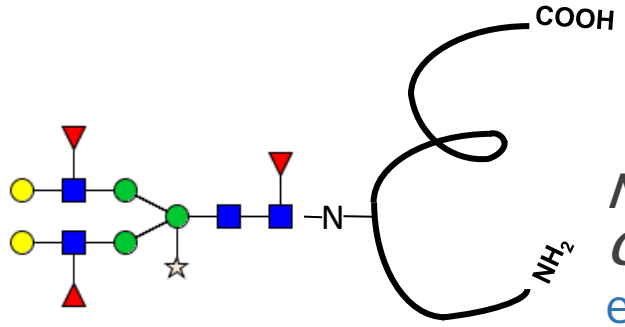
Appareil de Golgi



Intérieur



Polysaccharides complexes
Pectines (HG, RG-I and RG-II)
Hémicelluloses (Xyloglucane, Xylane…)



***N*-Glycoprotéines**
***O*-Glycoprotéines**
extensine, ArabinoGalactan-Protéines (AGPs)

Paroi

Notre Recherche : 1 équipe – 4 thématiques

Thème 1 : Glycomolécules et défense racinaire
(PI. Dr. Marie-Laure Follet-Gueye and Pr. Maïté Vicré)
Fonction des sécrétions racinaires en réponse aux stress abiotiques et aux microorganismes du sol

Thème 2 : Glycomolécules et croissance
(PI. Pr. Arnaud Lehner and Pr. Jean-Claude Mollet)
Localisation et fonctions des polysaccharides de la paroi lors la croissance (adhésion, élongation, signalisation …)

Thème 3 : Biosynthèse et secrétion de glycoprotéines dans les microalgues pour la production de biomédicaments
(PI. Pr. Muriel Bardor)
Caractérisation des acteurs moléculaires impliqués dans la biosynthèse des glycoprotéines chez les microalgues

Thème 4 : Glycomolécules et Biostimulants
(PI. Dr. Isabelle Boulogne)
Etude moléculaire des mécanismes d'action de biostimulants et SNUB à base de glycopolymères en conditions de stress abiotiques

Thème 4 : Glycomolécules et Biostimulants

(PI. Dr. Isabelle Boulogne)

Etude moléculaire des mécanismes d'action de biostimulants et SNUB à base de glycopolymères en conditions de stress abiotiques

Plantes d'intérêts

Soja

Maïs

Tomate

Lin

Zones étudiées

Parties aériennes et racinaires

Stress abiotiques

Déficit hydrique

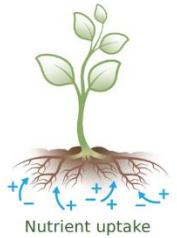
Biostimulants et SNUB

Biostimulants SNUBs

Allégations

Qualité des produits

Efficience de la nutrition ou la disponibilité des éléments nutritifs du sol



Tolérance aux stress abiotiques

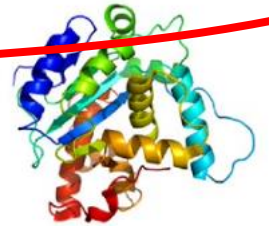
Règlement UE 2019/1009

Décret du 27 avril 2016
Arrêté du 14 juin 2021

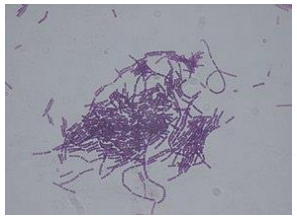
Biostimulants et SNUB

Biostimulants

- **Substances humiques**
- **Aminoacides et dérivés protéiques**



- **Molécules inorganiques non nutritives** Al, Co, Se, Si,…
- **Microorganismes**



- **Extraits de plantes terrestres et d'algues**

Biostimulants d'intéret au sein de l'axe.

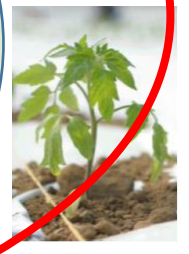
Biostimulants et SNUB

SNUB (substances naturelles à usage biostimulant)

Extraits de plantes terrestres et d'algues

Plantes médicinales de la Pharmacopée française

Plantes de l'alimentation animale ou humaine



Extraits d'origine animale

Extraits d'origine minérale

Décret du 27 avril 2016
Arrêté du 14 juin 2021

SNUB d'intéret au sein de l'axe.

Biostimulants et SNUB

SNUB

Extraits de plantes terrestres et d'algues

Substances humiques

Microorganismes

Biostimulants

Polysaccharides (PS)

- Cellulose
- Non cellulosic PS

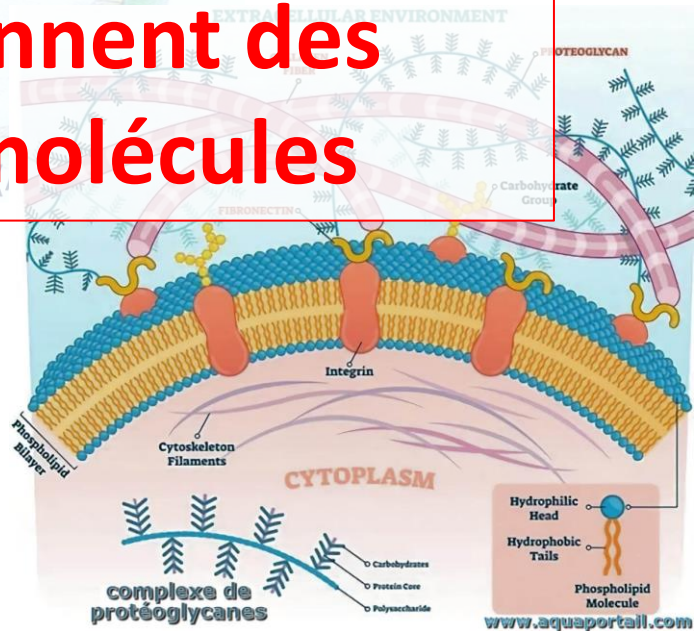
Hemicelluloses (Xyloglucan)

Pectines (HG, RGI et RGII)

Proteoglycanes

- Arabinogala[illegible] proteins (

Contiennent des glycomolécules



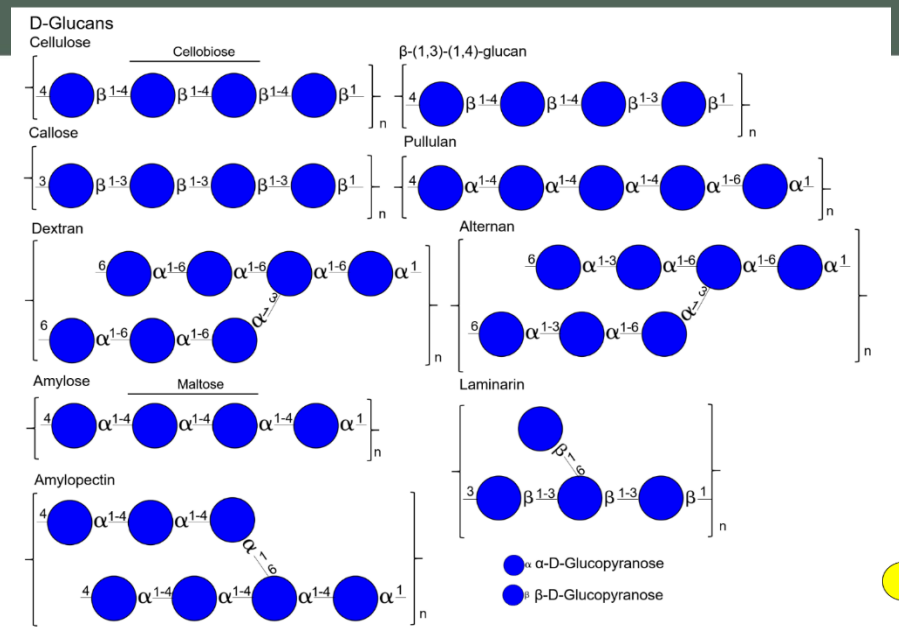
Biostimulants et SNUB d'intéret au sein de la thématique.

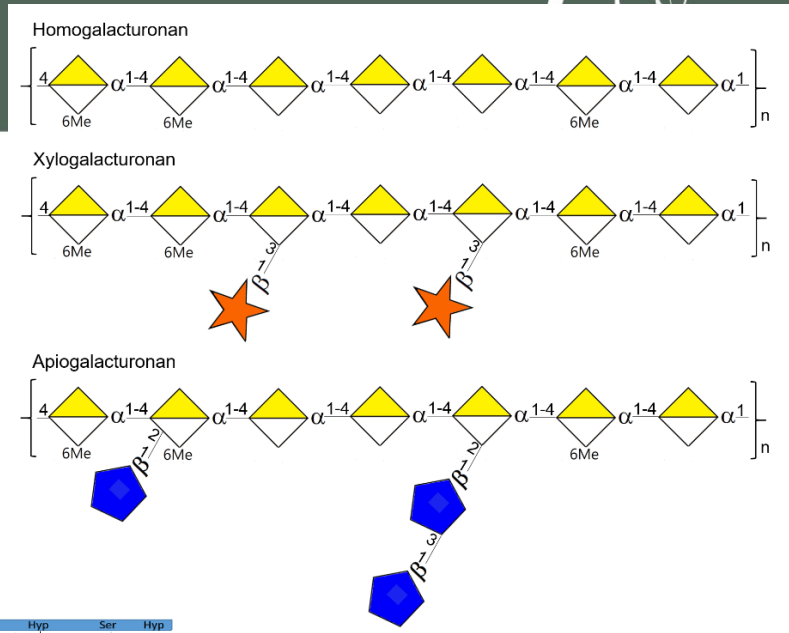
Glycomolécules

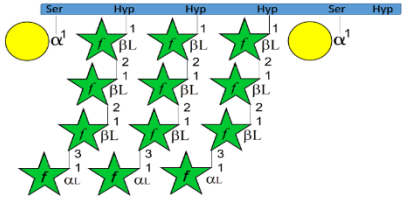
Polysaccharides

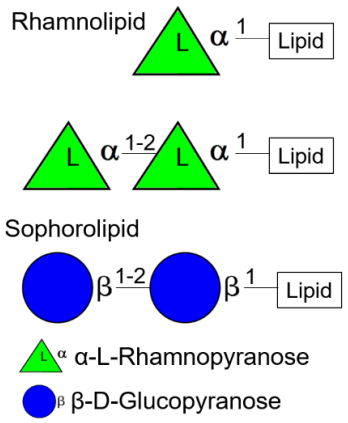
Glycoproteins

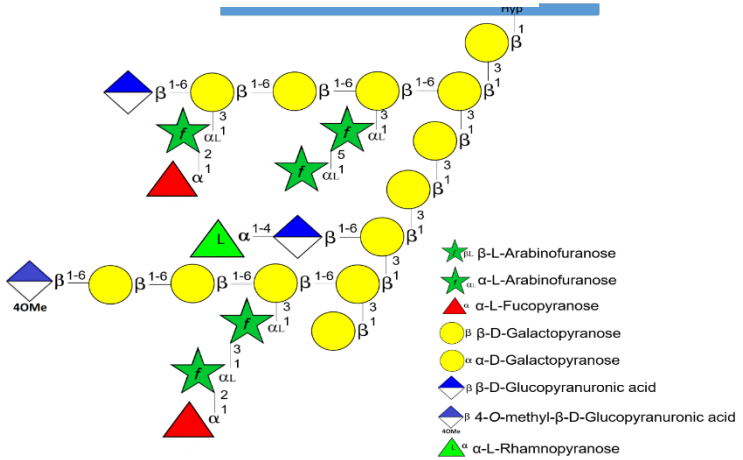
Glycolipids











Glycomolécules et biostimulants

Glycomolécules en tant que biostimulants:

- Peu d’études disponibles
- Surtout sur les polysaccharides algaux

Glycomolécules et biostimulants

Polysaccharides algaux

Laminaran

Alginate and oligoalginates

Ulvan

Fucoidan

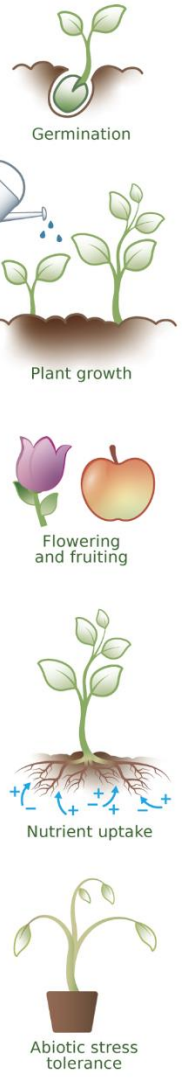
Carrageenan

Agar

Foliar spraying

Seed, fruit and flower coating

Culture substrate incorporation



Glycomolécules et biostimulants

Glycomolécules en tant que biostimulants:

- Peu d'études disponibles
- Surtout sur les polysaccharides algaux
- Sans afficher la notion de "biostimulant", études sur les effets sur l'efficience de la nutrition, sur la croissance des plantes ou la tolérence aux stress abiotiques.

Glycomolécules et biostimulants

Autres polysaccharides

EPS

Gellan and oligo-gellan

Chitosan et chitin

Starch

Cellulose and oligomer

Oligoxyloglucans

Xylo-oligosaccharides

Pectins and derived oligosaccharides

Foliar spraying

Seed, fruit and flower coating

Culture substrate incorporation

Glycomolécules et biostimulants

Glycoprotéines

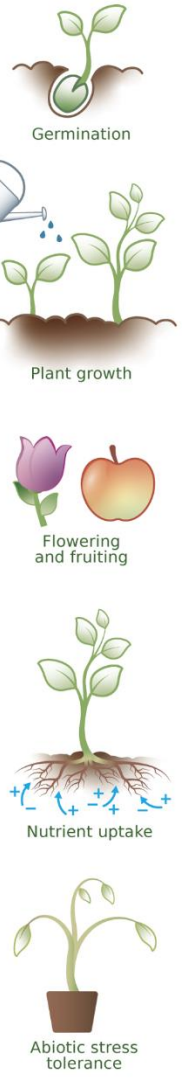
Fungal N-linked glycoproteins (glomalin-related soil protein)

AGPs and plant gum polysaccharides

Foliar spraying

Seed, fruit and flower coating

Culture substrate incorporation



Glycomolécules et biostimulants

Glycolipides

LPS

Rhamnolipids

Sophorolipids

Foliar spraying

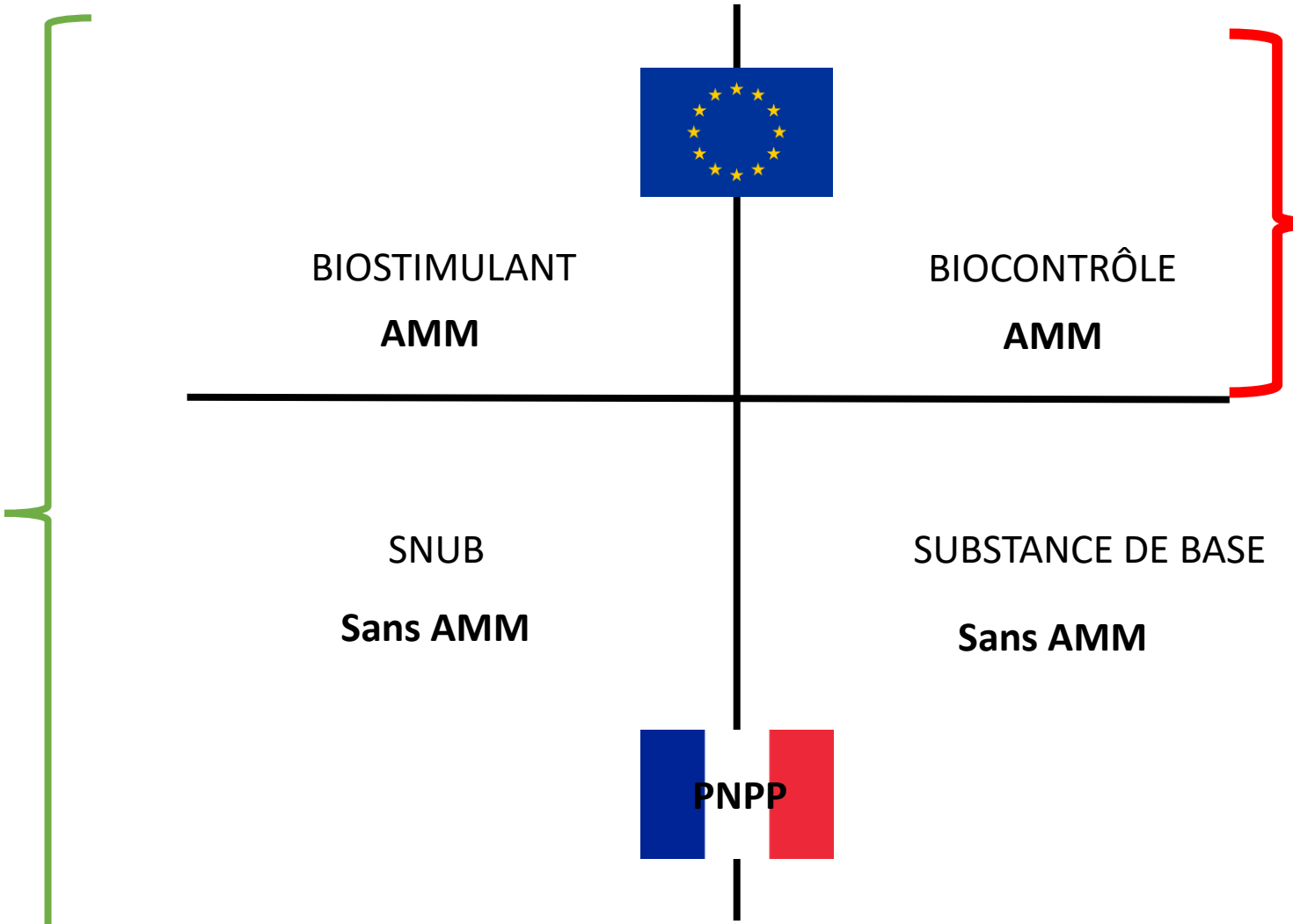
Seed, fruit and flower coating

Culture substrate incorporation

Mode d'action glycomolécules?

- Nombreuses glycomolecules connues pour activité SDP
- β-glucans, laminarin, chitin and chitosan, oligogalacturonides, alginates, carrageenans,…
- Mode d'action glycomolécules biostimulantes ≠ des glycomolécules SDP?

Point réglementaire actuel



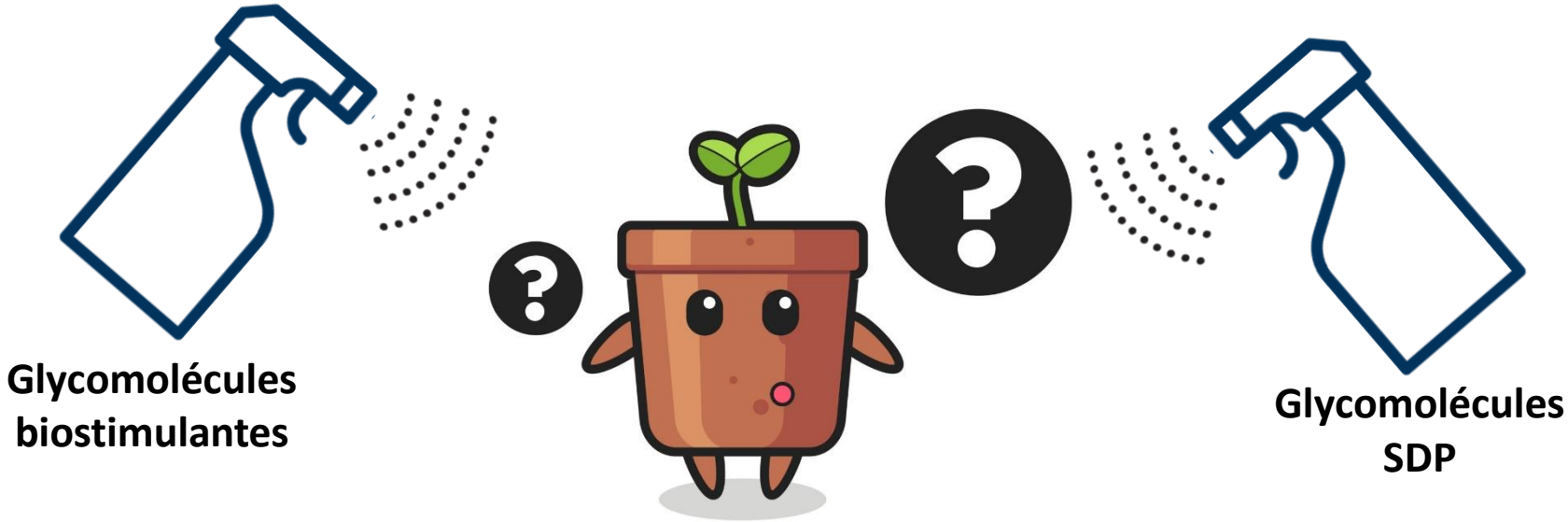
Substances à activité biostimulante

- Macroorganismes
- Microorganismes
- Médiateurs chimiques
- Biocides
- **SDP (ou SDN)**

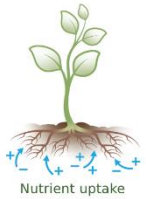
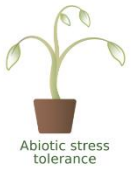
Substances à activité biocontrole

Mode d'action glycomolécules?

- **Dans la réalité cellulaire/moléculaire de la plante, la distinction est probablement moins tranchée….**



Mode d'action glycomolécules?

Level Phenological	
1. Seed germination	
2. Plant growth	
3. Flowering and fruiting	
4. Nutrient Uptake	
5. Abiotic stress tolerance	

Mode d'action glycomolécules?

Level Phenological	
1. Seed germination	
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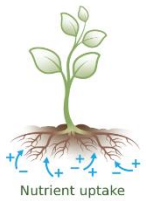
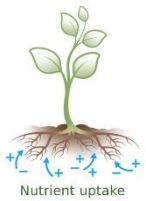
4. Nutrient Uptake	
5. Abiotic stress tolerance	

Sweet Biostimulant
1. rhamnolipids, chitosan, chitin, laminaran, alginates and oligo-alginates, ulvans, pectins and derived oligosaccharides
2. EPS, gellan gum and oligo-gellan, LPS, rhamnolipids, chitosan, chitin, laminaran, ulvans, agar, starch, fungal glycoproteins, sophorolipids, laminaran, alginates and oligo-alginates, ulvans, carrageenans, microalgal polysaccharides, oligomers of cellulose, oligoxyloglucans, xylooligosaccharides, pectins and derived oligosaccharides, AGP-rich extracts
3. alginate and oligoalginates, xylooligosaccharides, fungal glycoproteins, xylooligosaccharides
4. gellan gum and oligo-gellan, chitosan, chitin, ulvans, carrageenans, microalgal polysaccharides, pectins and derived oligosaccharides
5. EPS, gellan gum and oligo-gellan, chitosan, chitin, fungal glycoproteins, sophorolipids, laminaran, alginates and oligo-alginates, ulvans, fucoidans, carrageenans, agar, microalgal polysaccharides, oligoxyloglucans, xylooligosaccharides

Mode d'action glycomolécules?

Level Phenological		Sweet Immunity	Sweet Biostimulant
1. Seed germination		No data	1. rhamnolipids, chitosan, chitin, laminaran, alginates and oligo-alginates, ulvans, pectins and derived oligosaccharides
2. Plant growth			2. EPS, gellan gum and oligo-gellan, LPS, rhamnolipids, chitosan, chitin, laminaran, ulvans, agar, starch, fungal glycoproteins, sophorolipids, laminaran, alginates and oligo-alginates, ulvans, carrageenans, microalgal polysaccharides, oligomers of cellulose, oligoxyloglucans, xylooligosaccharides, pectins and derived oligosaccharides, AGP-rich extracts
3. Flowering and fruiting			3. alginate and oligoalginates, xylooligosaccharides, fungal glycoproteins, xylooligosaccharides
4. Nutrient Uptake			4. gellan gum and oligo-gellan, chitosan, chitin, ulvans, carrageenans, microalgal polysaccharides, pectins and derived oligosaccharides
5. Abiotic stress tolerance			5. EPS, gellan gum and oligo-gellan, chitosan, chitin, fungal glycoproteins, sophorolipids, laminaran, alginates and oligo-alginates, ulvans, fucoidans, carrageenans, agar, microalgal polysaccharides, oligoxyloglucans, xylooligosaccharides

Mode d'action glycomolécules?

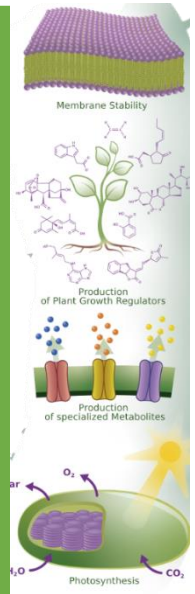
Level Tissular/Cellular

6. Membrane Stability

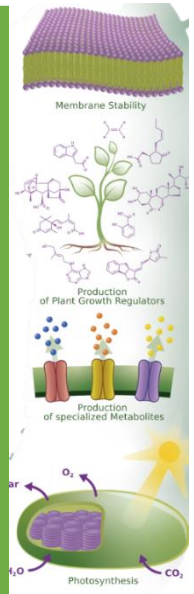
7. Production of specialized Metabolites

8. Production of Plant Growth Regulators

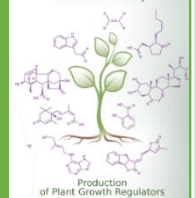
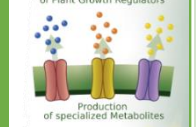
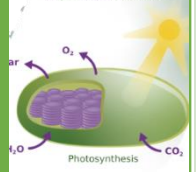
9. Photosynthetic Pigments and Photosynthesis



Mode d'action glycomolécules?

Level Tissular/Cellular		Sweet Biostimulant
6. Membrane Stability		6. oligoxyloglucans, xylooligosaccharides
7. Production of specialized Metabolites		7. gellan gum and oligo-gellan, alginate, carrageenans, chitosan, oligoxyloglucans
8. Production of Plant Growth Regulators		8. alginates and oligo-alginates
9. Photosynthetic Pigments and Photosynthesis		9. gellan gum and oligo-gellan, alginates and oligo-alginates, microalgal polysaccharides, oligoxyloglucans, pectins and derived oligosaccharides

Mode d'action glycomolécules?

Level Tissular/Cellular		Sweet Immunity	Sweet Biostimulant
6. Membrane Stability		6. No data	6. oligoxyloglucans, xylooligosaccharides
7. Production of specialized Metabolites		7. bacterial and fungal D-glucans, rhamsan, PGN, LPS, **chitosan**, fungal glycoproteins, starch, **alginates** and oligo-alginates, oligomers of cellulose, AGP-rich extracts	7. gellan gum and oligo-gellan, **alginates**, carrageenans, **chitosan**, oligoxyloglucans
8. Production of Plant Growth Regulators		8. EPS, rhamnolipids, laminaran, ulvans, fucoidans, carrageenans, algal AGP-like fraction, xyloglucans, xylooligosaccharides, pectins and derived oligosaccharides	8. alginates and oligo-alginates
9. Photosynthetic Pigments and Photosynthesis		9. No data	9. gellan gum and oligo-gellan, alginates and oligo-alginates, microalgal polysaccharides, oligoxyloglucans, pectins and derived oligosaccharides

Level Molecular

10. Reactive Oxygen Species (ROS)

11. Nitric oxide (NO)

12. Mitogen-activated protein kinases (MAPK)

13. Ca2+ signaling

14. SA and ET/JA-mediated signaling pathways

15. Others phytohormones (abscisic acid (ABA), auxins and cytokinins)

16. Protein phosphorylation

17. Antimicrobial (phytoalexin, defensin,…)

18. Pathogenesis-related protein (PR protein)

19. Antioxidant enzymes (SOD, CAT, APX, POD, GR, …)

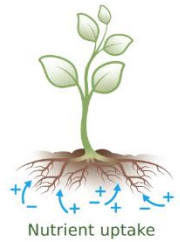
20. Phenylpropanoids pathways (PAL, PPO, LOX,…)

Level Molecular	Sweet Biostimulant
10. Reactive Oxygen Species (ROS) 	10. laminaran
11. Nitric oxide (NO)	11. No data
12. Mitogen-activated protein kinases (MAPK)	12. No data
13. Ca2+ signaling	13. No data
14. SA and ET/JA-mediated signaling pathways	14. No data
15. Others phytohormones (abscisic acid (ABA), auxins and cytokinins)	15. alginates and oligo-alginates
16. Protein phosphorylation	16. No data
17. Antimicrobial (phytoalexin, defensin,…)	17. No data
18. Pathogenesis-related protein (PR protein)	18. No data
19. Antioxidant enzymes (SOD, CAT, APX, POD, GR, …)	19. alginates and oligo-alginates, oligoxyloglucans, xylooligosaccharides
20. Phenylpropanoids pathways (PAL, PPO, LOX,…)	20. pectins and derived oligosaccharides

Level Molecular	Sweet Immunity	Sweet Biostimulant
10. Reactive Oxygen Species (ROS) 	10. EPS, PGN, LPS, rhamnolipids, chitosan, **laminaran**, alginates and oligo-alginates, ulvans, microalgal polysaccharides, oligomers of cellulose, xylooligosaccharides, arabinoxylan-oligosaccharides and mixed-linked glucans, oligomannans, pectins and derived oligosaccharides	10. **laminaran**
11. Nitric oxide (NO)	11. PGN, LPS, chitosan, alginates and oligo-alginates, xylooligosaccharides, pectins and derived oligosaccharides	11. No data
12. Mitogen-activated protein kinases (MAPK)	12. PGN, chitin, oligomers of cellulose, xyloglucans, arabinoxylan-oligosaccharides and mixed-linked glucans, oligomannans	12. No data
13. Ca2+ signaling	13. PGN, LPS, rhamnolipids, laminaran, microalgal polysaccharides, oligomers of cellulose, arabinoxylan-oligosaccharides and mixed-linked glucans, oligomannans	13. No data
14. SA and ET/JA-mediated signaling pathways	14. EPS, rhamnolipids, laminaran, ulvans, fucoidans, carrageenans, algal AGP-like fraction, xyloglucans, xylooligosaccharides, pectins and derived oligosaccharides	14. No data
15. Others phytohormones (abscisic acid (ABA), auxins and cytokinins)	15. rhamnolipids, pectins and derived oligosaccharides	15. alginates and oligo-alginates
16. Protein phosphorylation	16. PGN	16. No data
17. Antimicrobial (phytoalexin, defensin,…)	17. bacterial and fungal D-glucans, rhamsan, chitosan, fungal glycoproteins, laminaran, alginates and oligo-alginates, ulvans, fucoidans, xyloglucans, pectins and derived oligosaccharides	17. No data
18. Pathogenesis-related protein (PR protein)	18. LPS, rhamnolipids, fungal D-glucans, chitosan, chitin, laminaran, fucoidans, oligomers of cellulose, xyloglucans	18. No data
19. Antioxidant enzymes (SOD, CAT, APX, POD, GR, …)	19. xanthan, fungal glycoproteins, **alginates and oligo-alginates**, ulvans, microalgal polysaccharides, fructans	19. **alginates and oligo-alginates**, oligoxyloglucans, xylooligosaccharides
20. Phenylpropanoids pathways (PAL, PPO, LOX,…)	20. bacterial and fungal D-glucans, chitin, fucoidans, microalgal polysaccharides	20. pectins and derived oligosaccharides

Sweet biostimulation

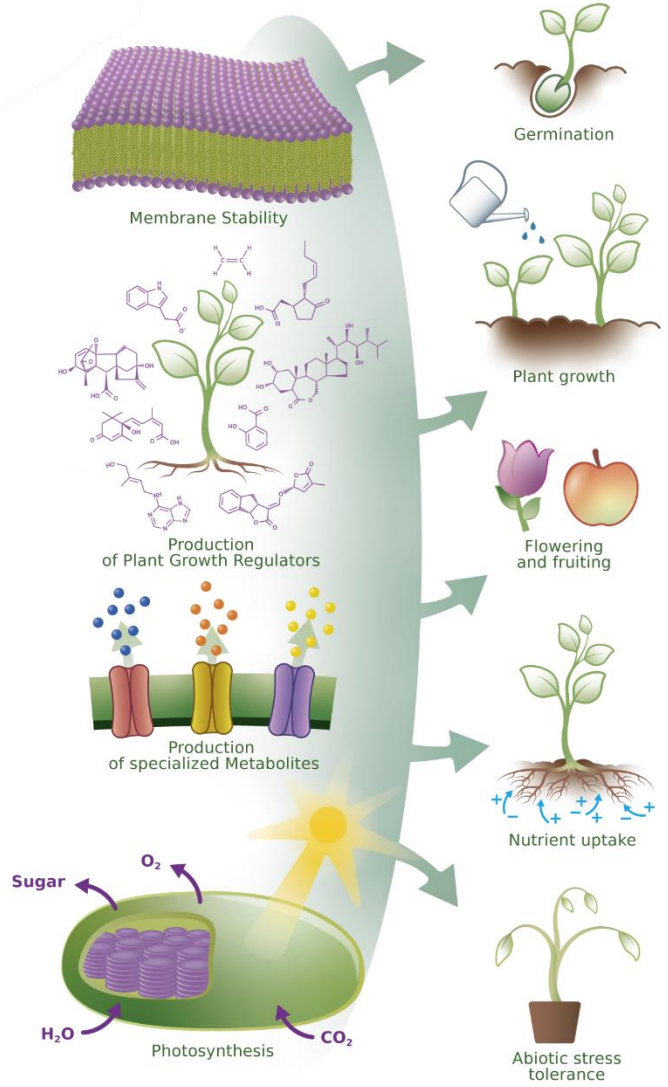
Au niveau phénologique



Sweet biostimulation

Au niveau phénologique

Au niveau cellulaire/tissulaire

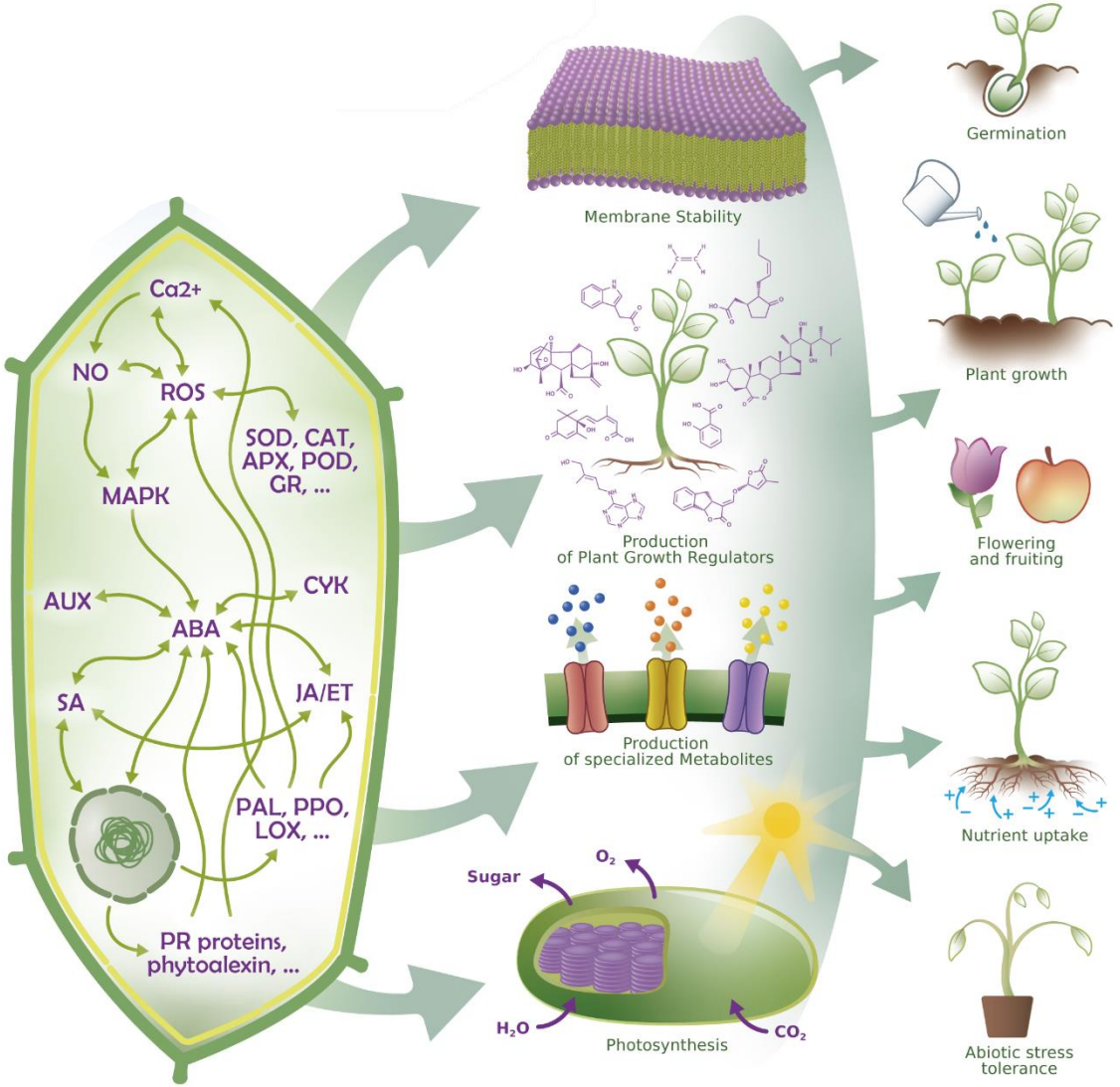


Sweet biostimulation

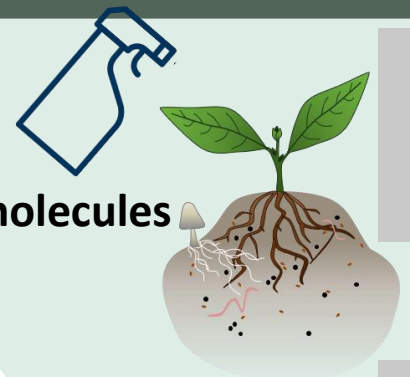
Au niveau phénologique

Au niveau cellulaire/tissulaire

Au niveau moléculaire



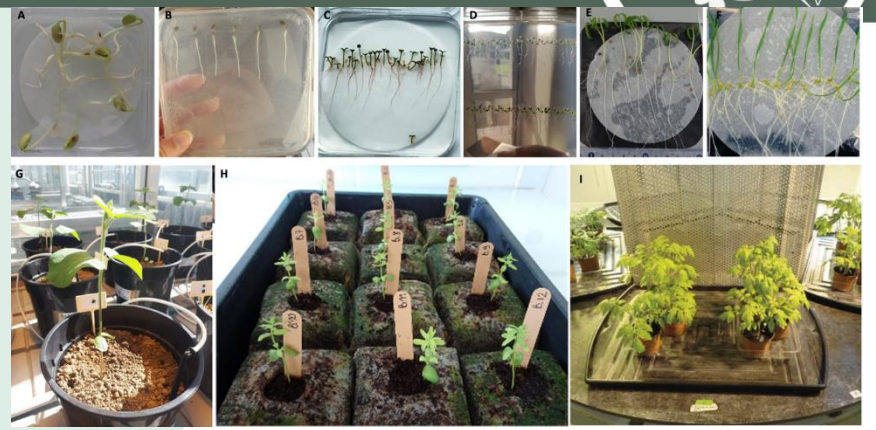
Sweet biostimulation

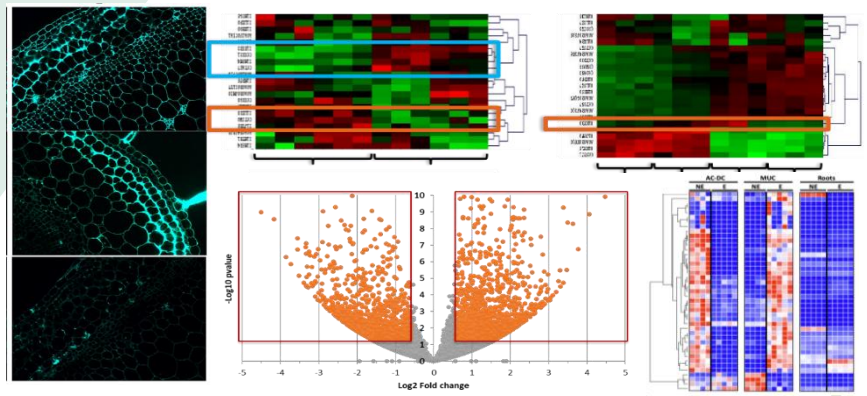


Glycomolecules

in vitro and semi-controlled culture devices

- **Phenomics**
- **Glycomics**
- **Metabolomics**
- **Proteomics**
- **Transcriptomics**
- **Ionomics**





BIOMOLECULE

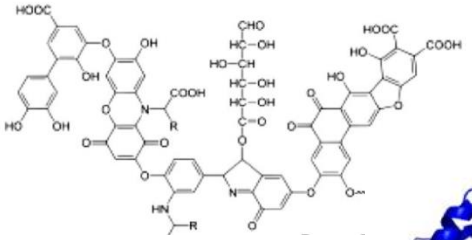
anr

- BIOstimulants and GlycoMOLECULEs: implication and tools for plant biostimulation
- Février 2023 – Février 2026
- Etudier les activités biostimulantes de glycomolécules en cultures *in vitro* et semi controlées → Etude des modes d'action des substances choisies en multi-omics (glycomics, metabolomics, proteomics, transcriptomics et ionomics)

Objectifs

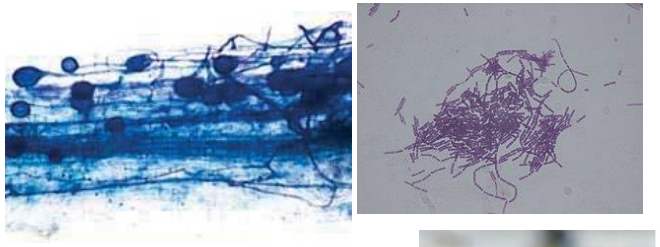
Biostimulants

- Substances humiques



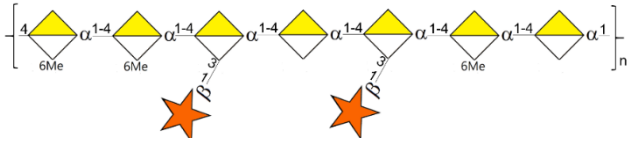
- Aminoacides et dérivés protéiques

- Molécules inorganiques non nutritives **Al, Co, Se, Si,…**
- Microorganismes



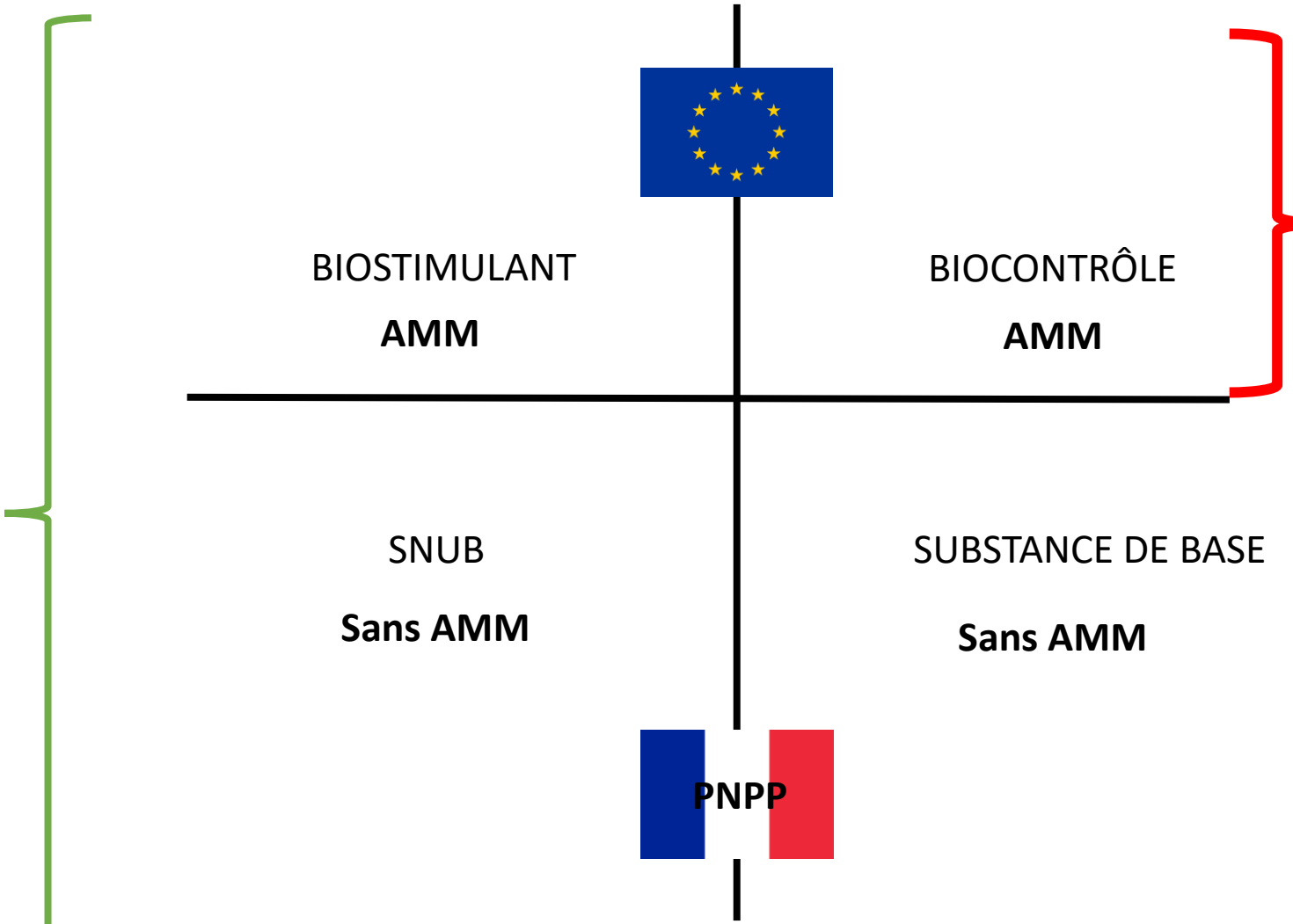
- Extraits de plantes terrestres et d'algues

- **Glycomolécules**



Objectifs

Contribuer à une évolution réglementaire ?



Substances à activité biostimulante **et SDP (SDN)**

- Macroorganismes
- Microorganismes
- Médiateurs chimiques
- Biocides
- ~~SDP (ou SDN)~~

Substances à activité biocontrôle

To be continued…

Des questions?