

Les réseaux mycorhiziens qui relient les plantes : faits et perspectives

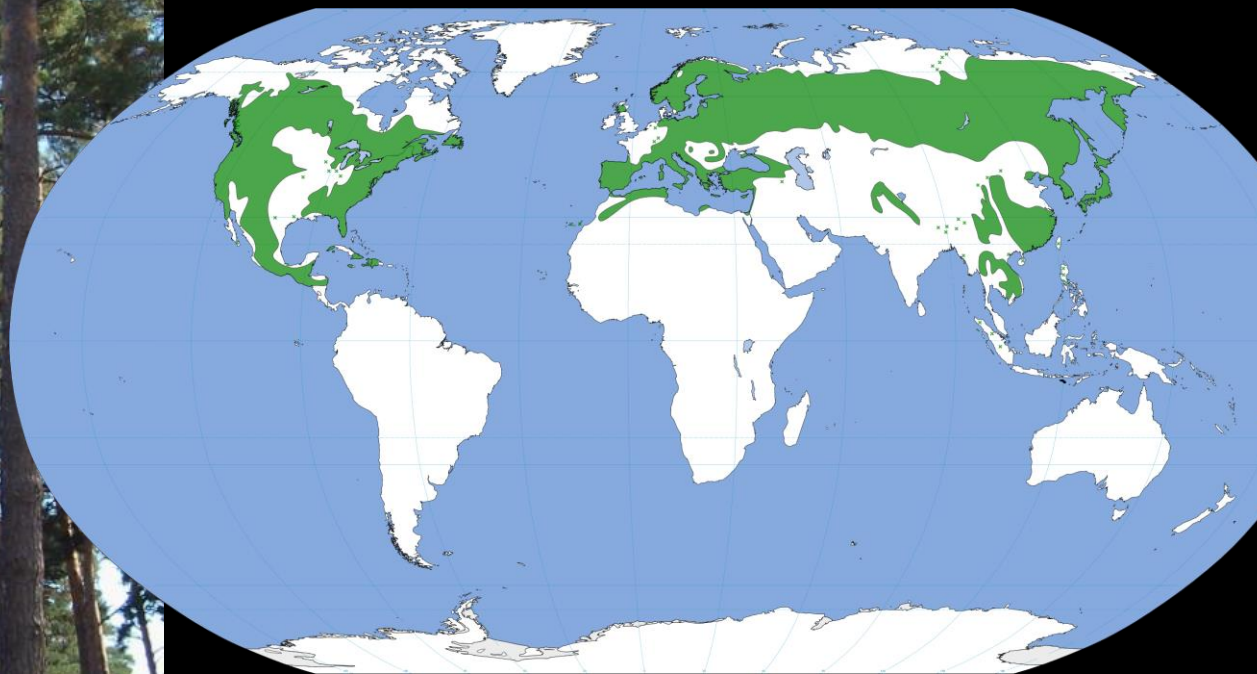
Marc-André SELOSSE

Muséum national d'Histoire naturelle
Universités de Gdansk (Pologne) et Kunming (Chine)

1.

Des champignons
pleins les racines !





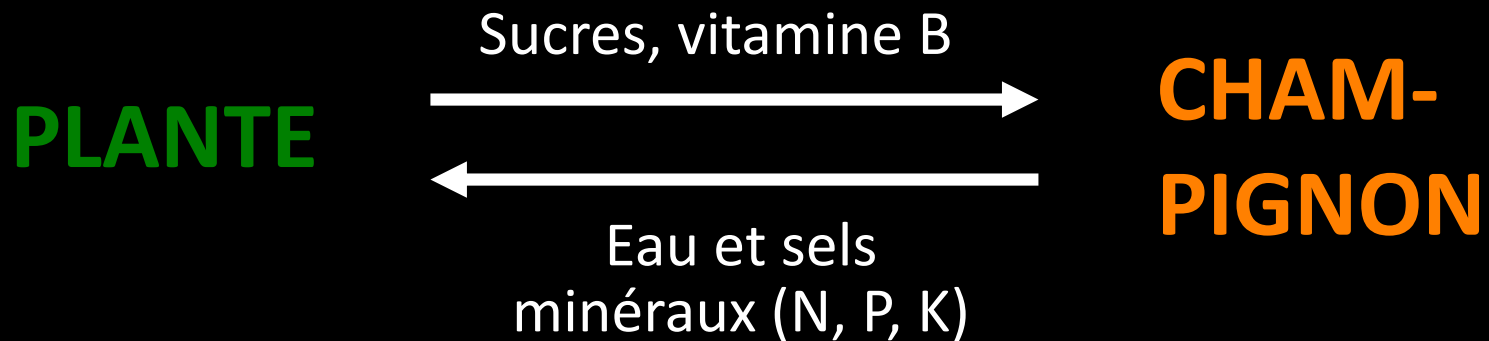




Scleroderma sinnamariense

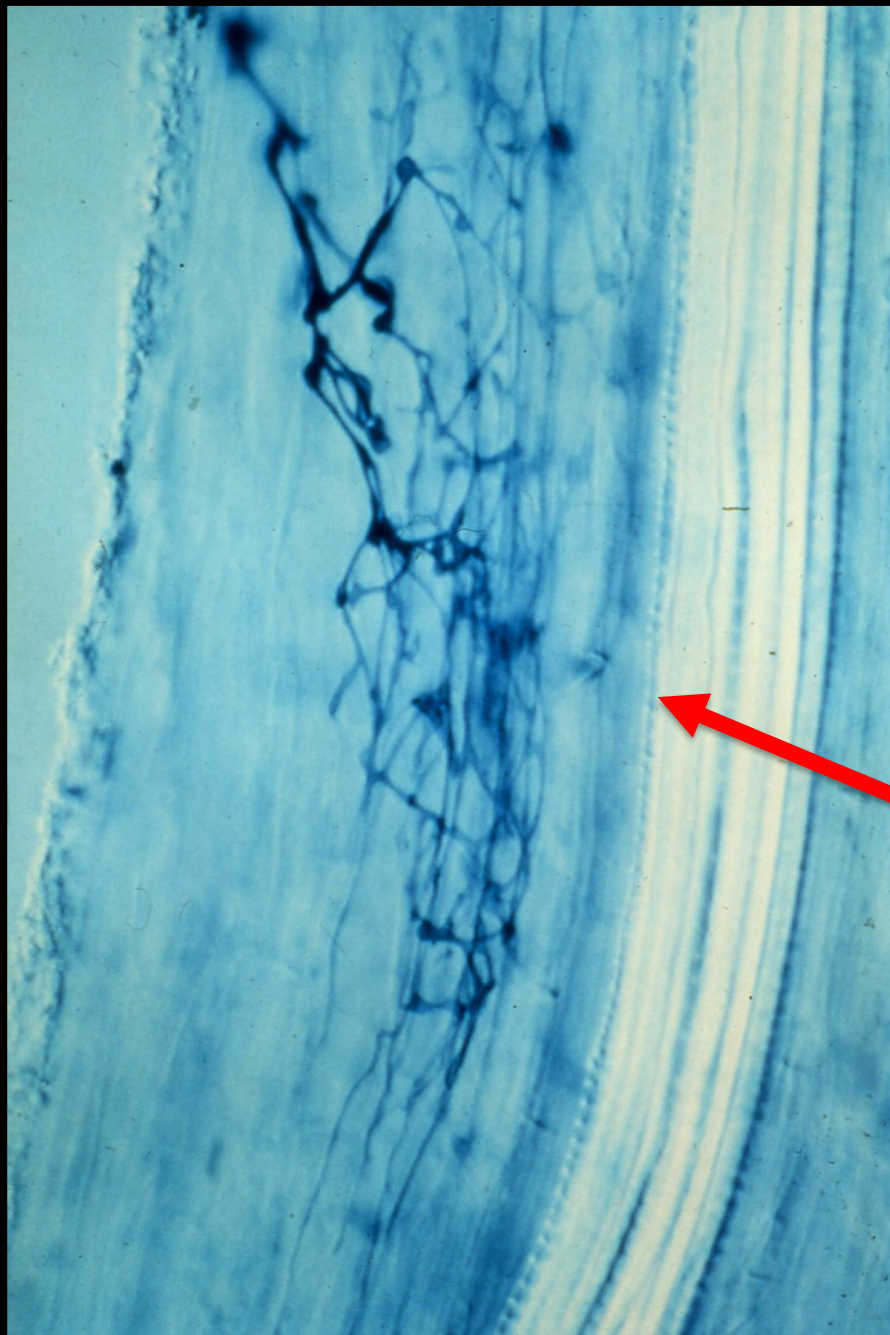
LA MYCORHIZE, UNE SYMBIOSE

Des échanges nutritifs réciproques :



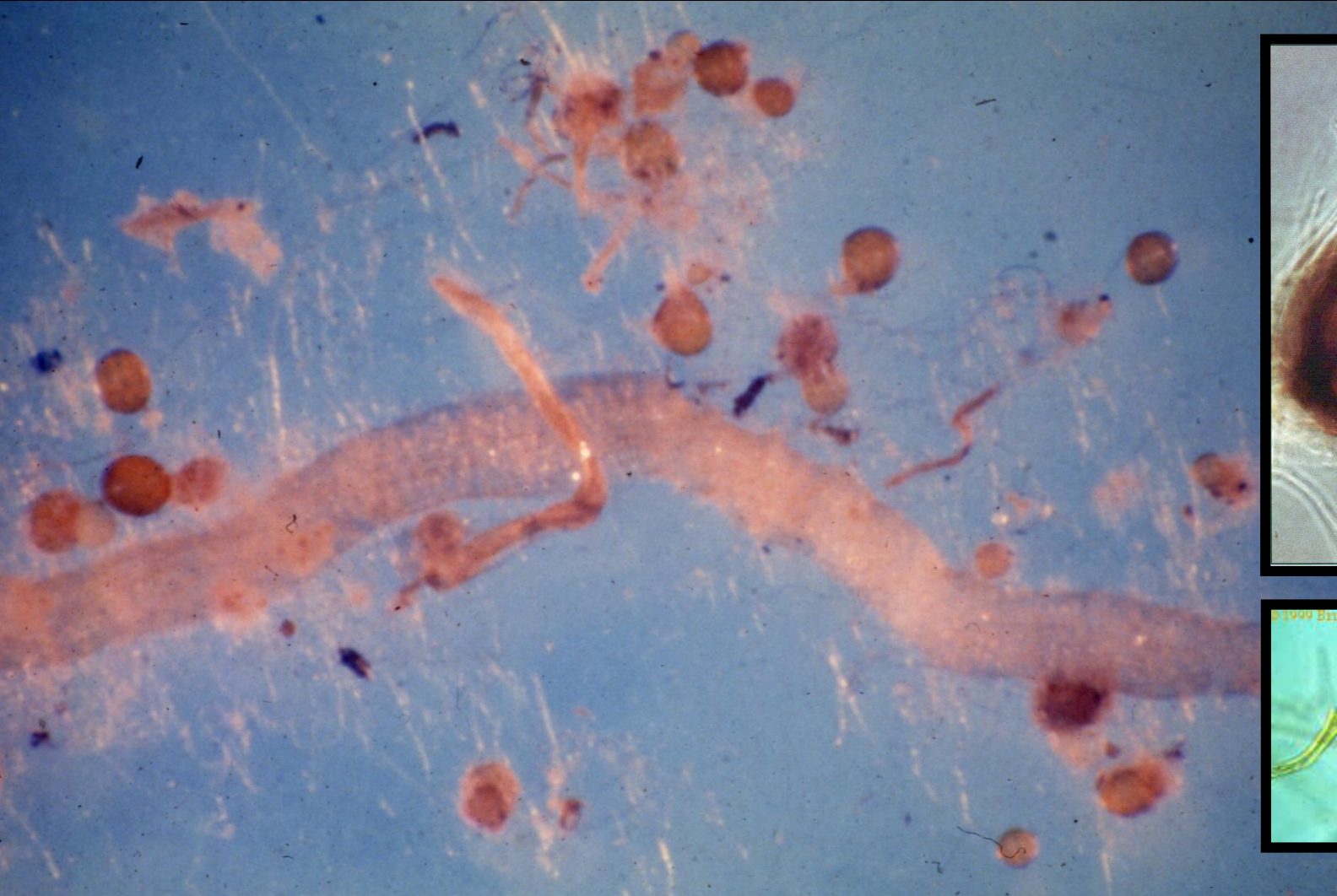
... à table, ensemble !







ENDOMYCORHIZE

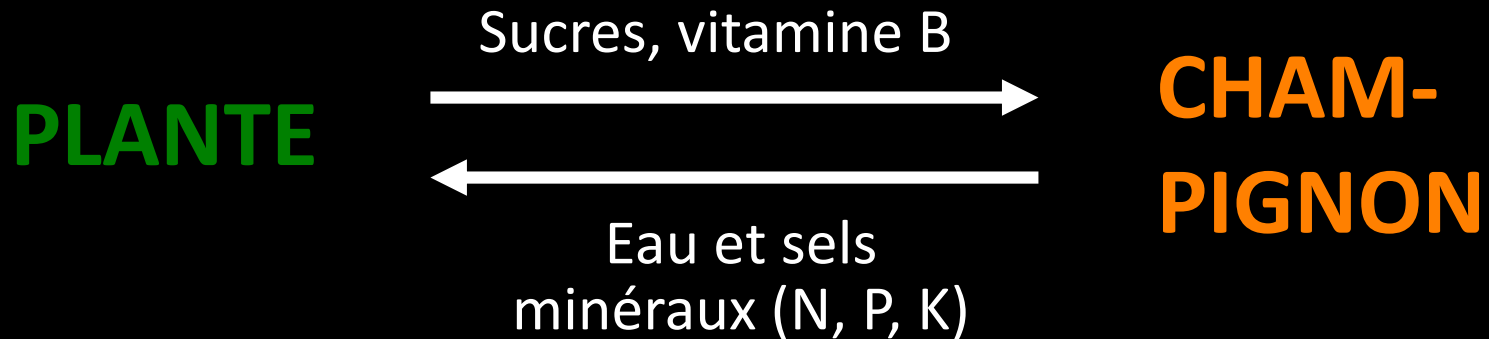


ENDOMYCORHIZE



LA MYCORHIZE, UNE SYMBIOSE

Des échanges nutritifs réciproques :



... à table, ensemble !

2.

Un réseau ...

A close-up photograph of a spider web. The web is a complex, radial structure of fine, light-colored threads. It is set against a dark background. Several small, round, orange-colored objects, likely insect eggs or larvae, are clustered together on the left side of the web. There are also some translucent, white, irregularly shaped objects scattered around the orange ones. The web is stretched between two vertical, light-colored, fibrous structures, possibly plant stems or roots.

Un réseau ...

A photograph of a forest scene. Several large, mature trees with thick, dark trunks and dense green foliage are the main focus. The ground is covered in a thick layer of brown, dry leaves and fallen branches. The scene is captured from a low angle, looking up at the trees. The lighting is natural, suggesting a sunny day with some shade from the canopy.

**Chêne vert
+ arbousier**

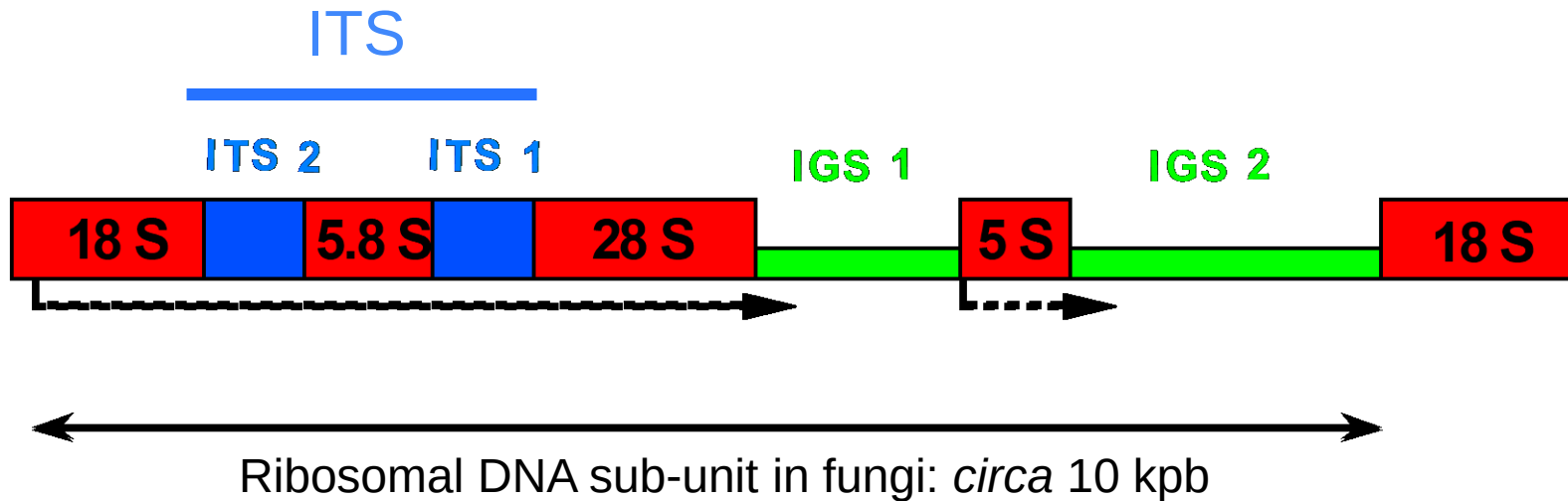


**Chêne vert
+ arbousier**

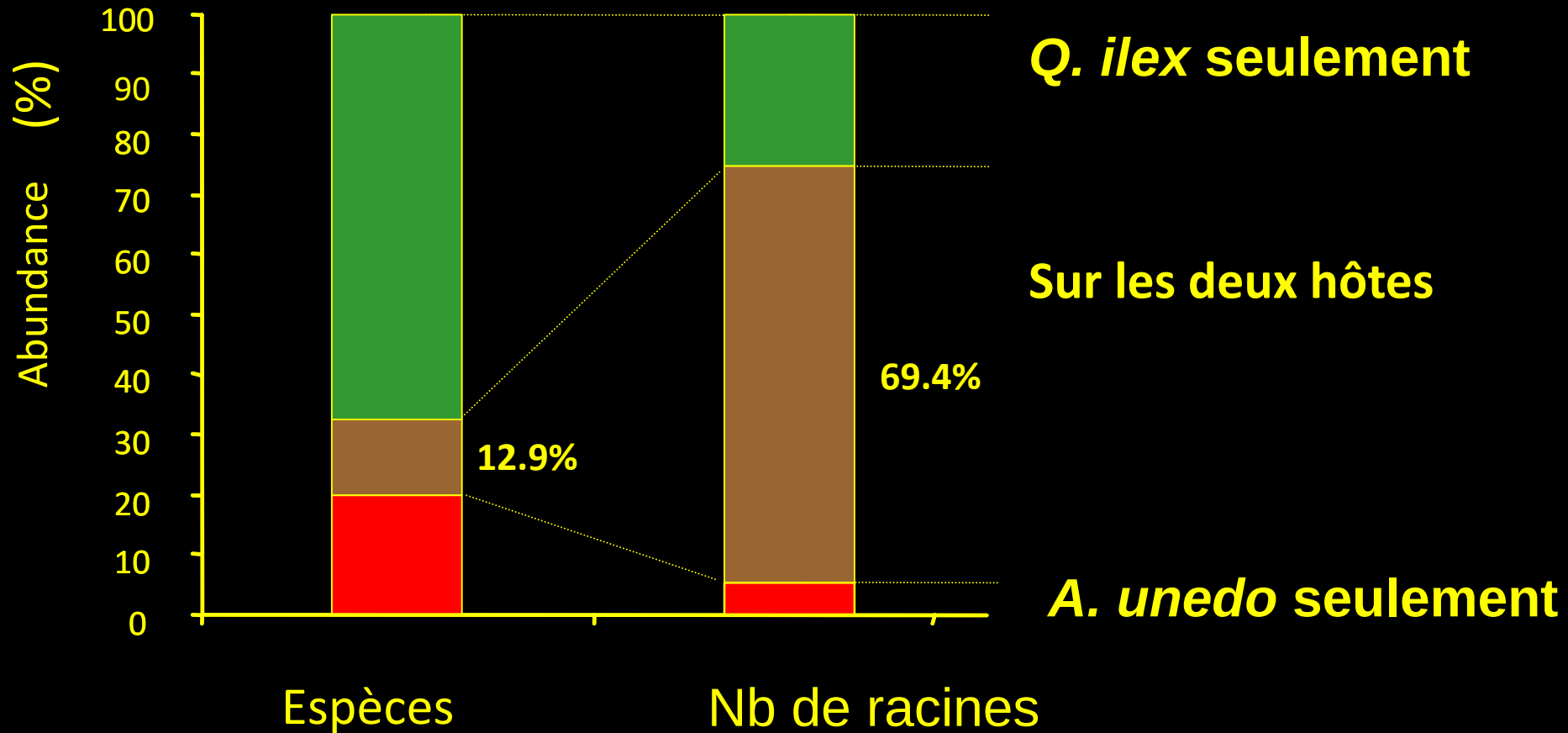
CODE-BARRE ITS

Taxonomic resolution :

- Genus / order
- Species / sub-species
- Sub-species / genet

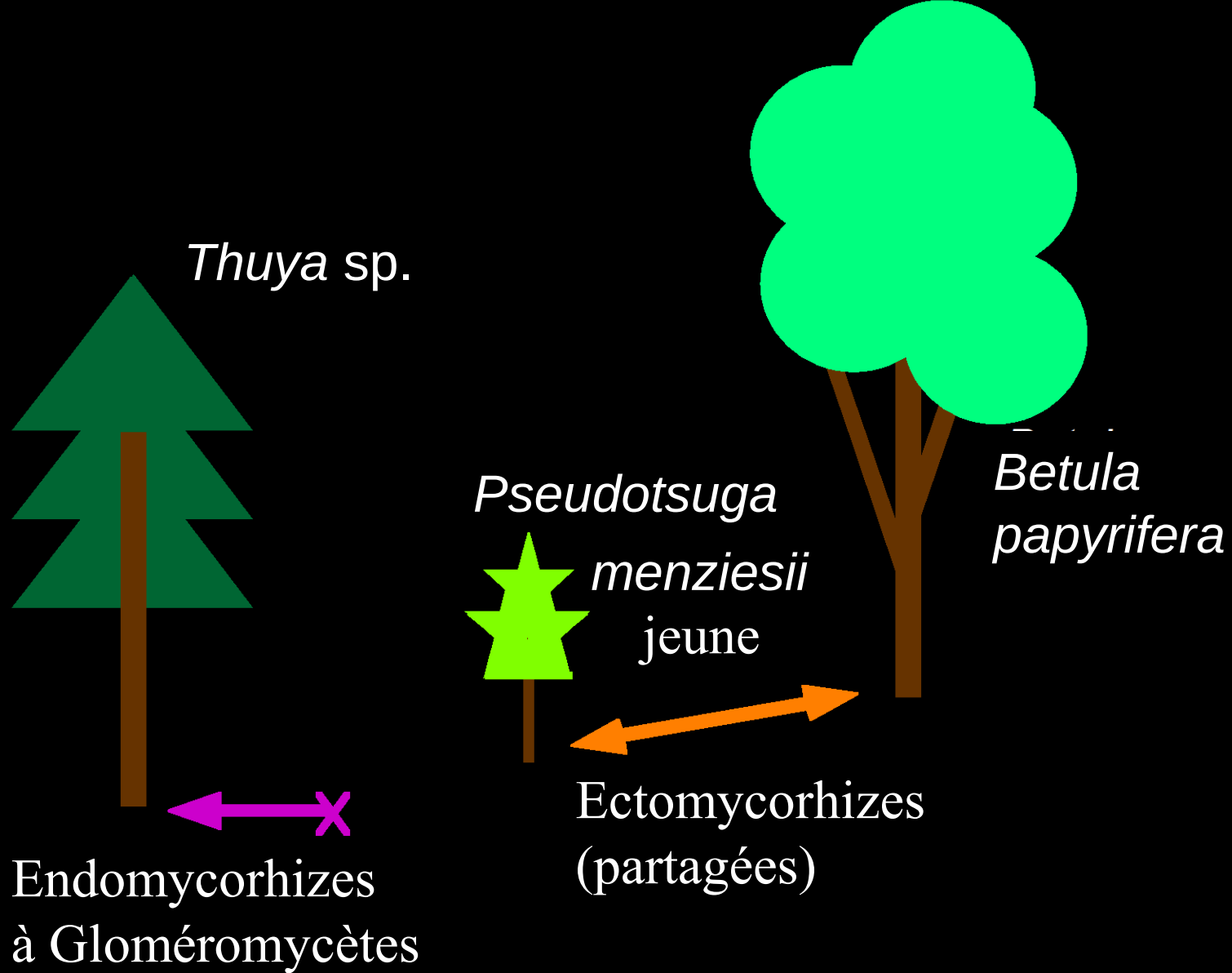


Plus de 520 espèces fongiques ...



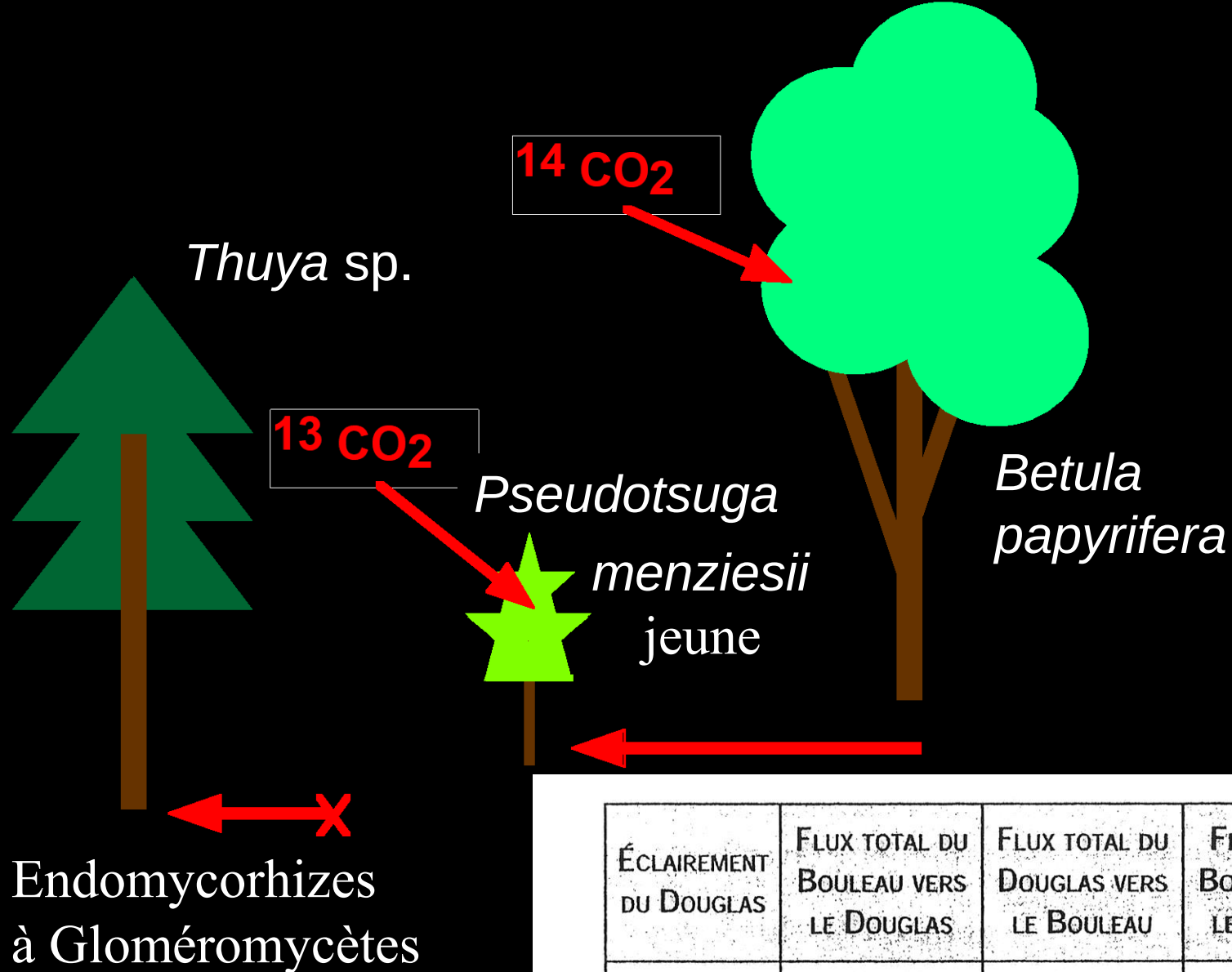
3.

Un réseau nourricier...



Simard *et al.*, 1997





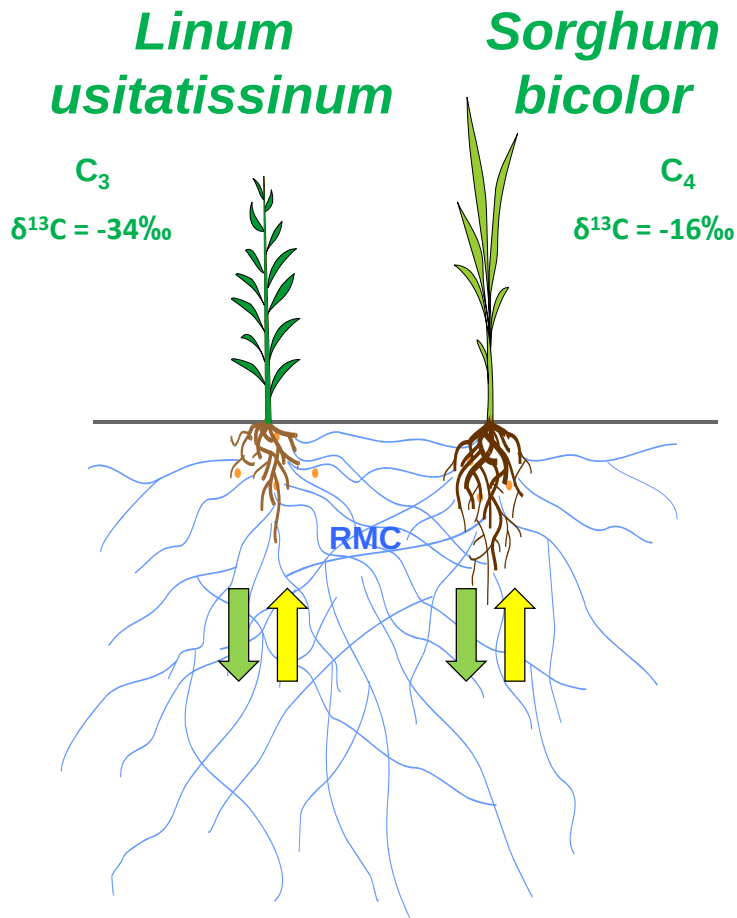
ÉCLAIREMENT DU DOUGLAS	FLUX TOTAL DU BOULEAU VERS LE DOUGLAS	FLUX TOTAL DU DOUGLAS VERS LE BOULEAU	FLUX <u>NET</u> DU BOULEAU VERS LE DOUGLAS
ombre	10,1 %	0,6 %	9,5 %
mi-ombre	4,8 %	0,5 %	4,3 %
lumière	3,3 %	0,5 %	2,7 %

Belowground carbon trade among tall trees in a temperate forest

Tamir Klein,^{1*}† Rolf T. W. Siegwolf,² Christian Körner¹

spheres. Isotope mixing signals indicate that the interspecific, bidirectional transfer, assisted by common ectomycorrhiza networks, accounted for 40% of the fine root carbon (about 280 kilograms per hectare per year tree-to-tree transfer). Although competition for

Le gain indirect, trop peu considéré



Carbone contre ^{33}P

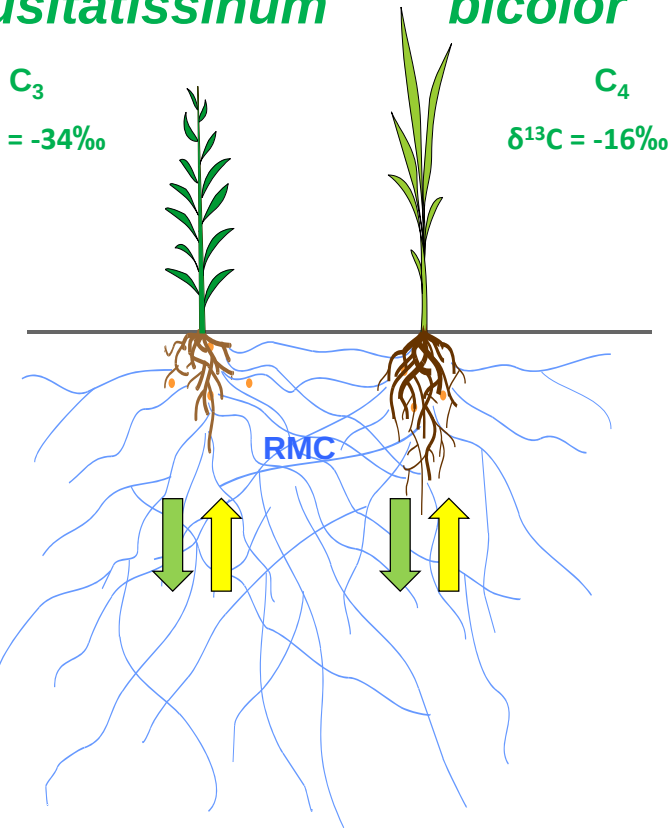
Le gain indirect, trop peu considéré

*Linum
usitatissimum*

*Sorghum
bicolor*

*Rhizophagus
irregularis*

*Funneliformis
mosseae*



Carbone contre ³³P

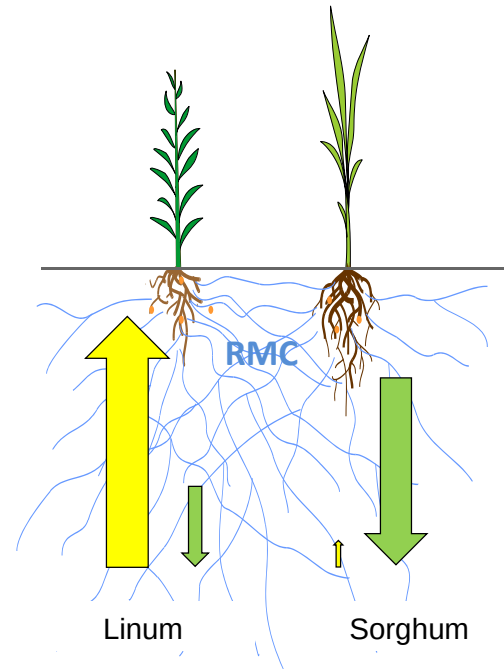
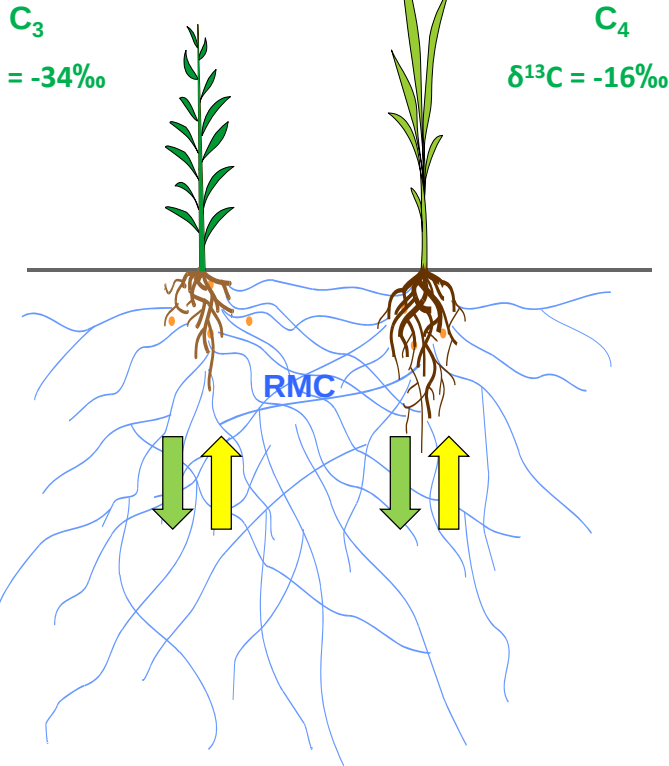
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*Funneliformis
mosseae*



Carbone contre ^{33}P

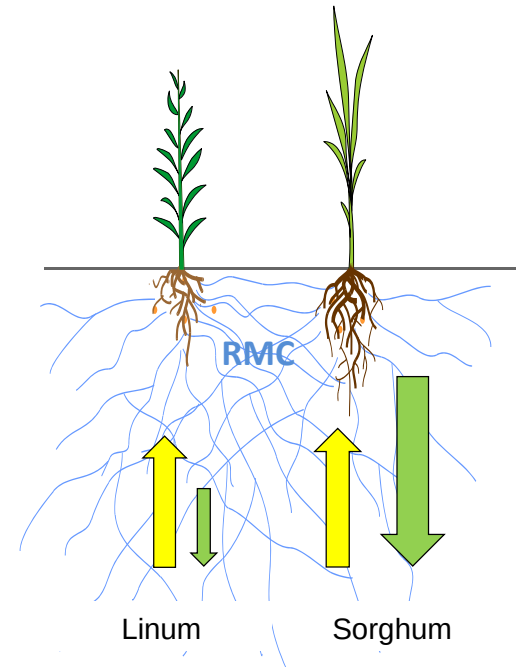
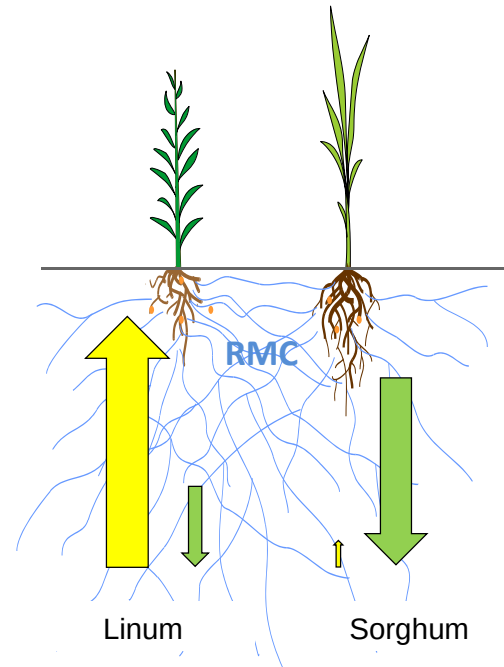
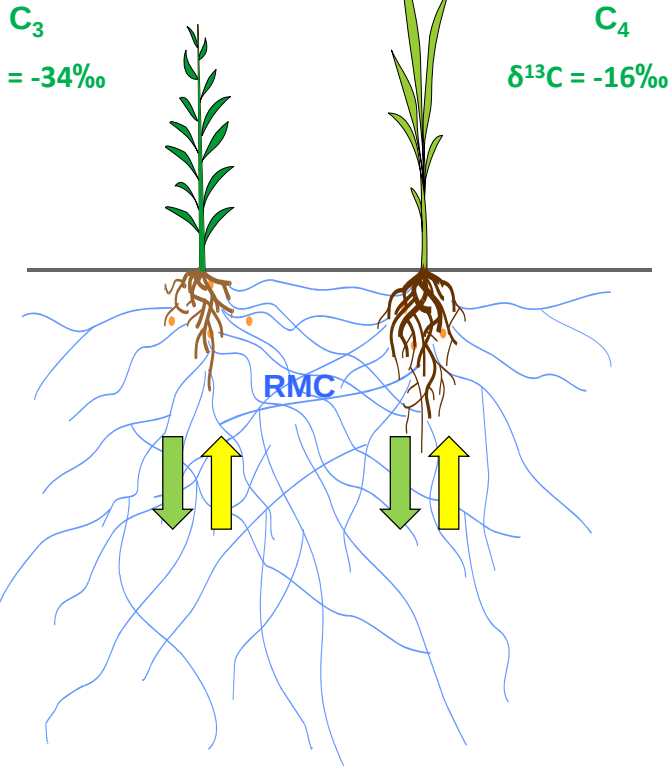
Le gain indirect, trop peu considéré

*Linum
usitatissimum*

*Sorghum
bicolor*

*Rhizophagus
irregularis*

*Funneliformis
mosseae*



Carbone contre ^{33}P

4.

Mais des exploiters...

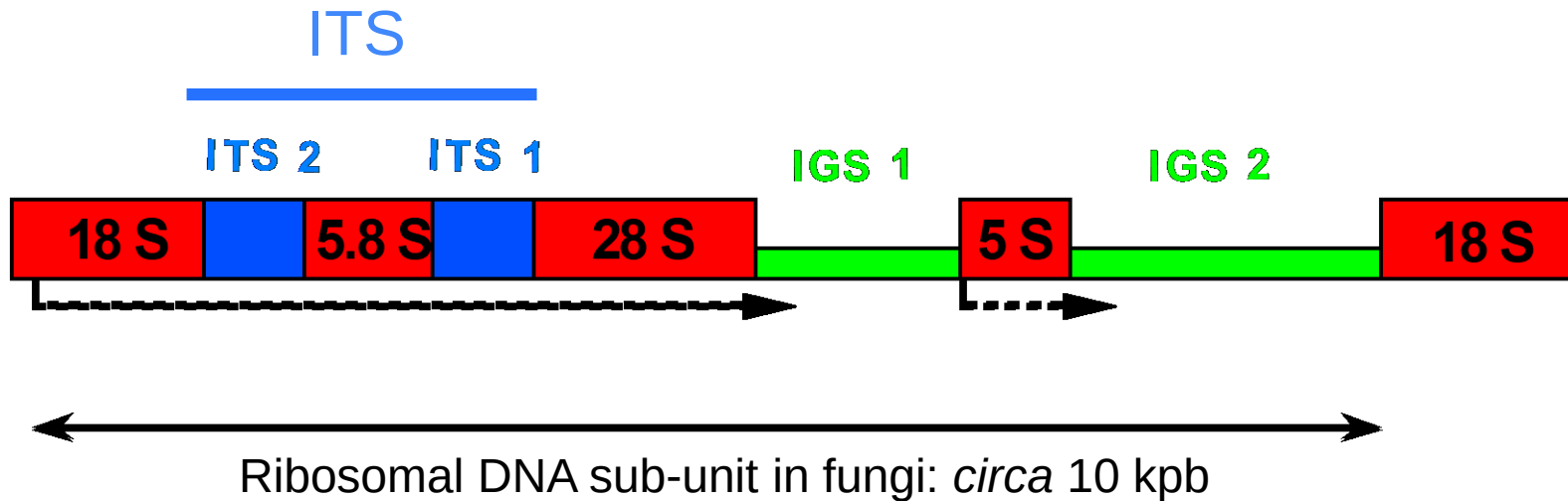
*Neottia
nidus-avis*



CODE-BARRE ITS

Taxonomic resolution :

- Genus / order
- Species / sub-species
- Sub-species / genet



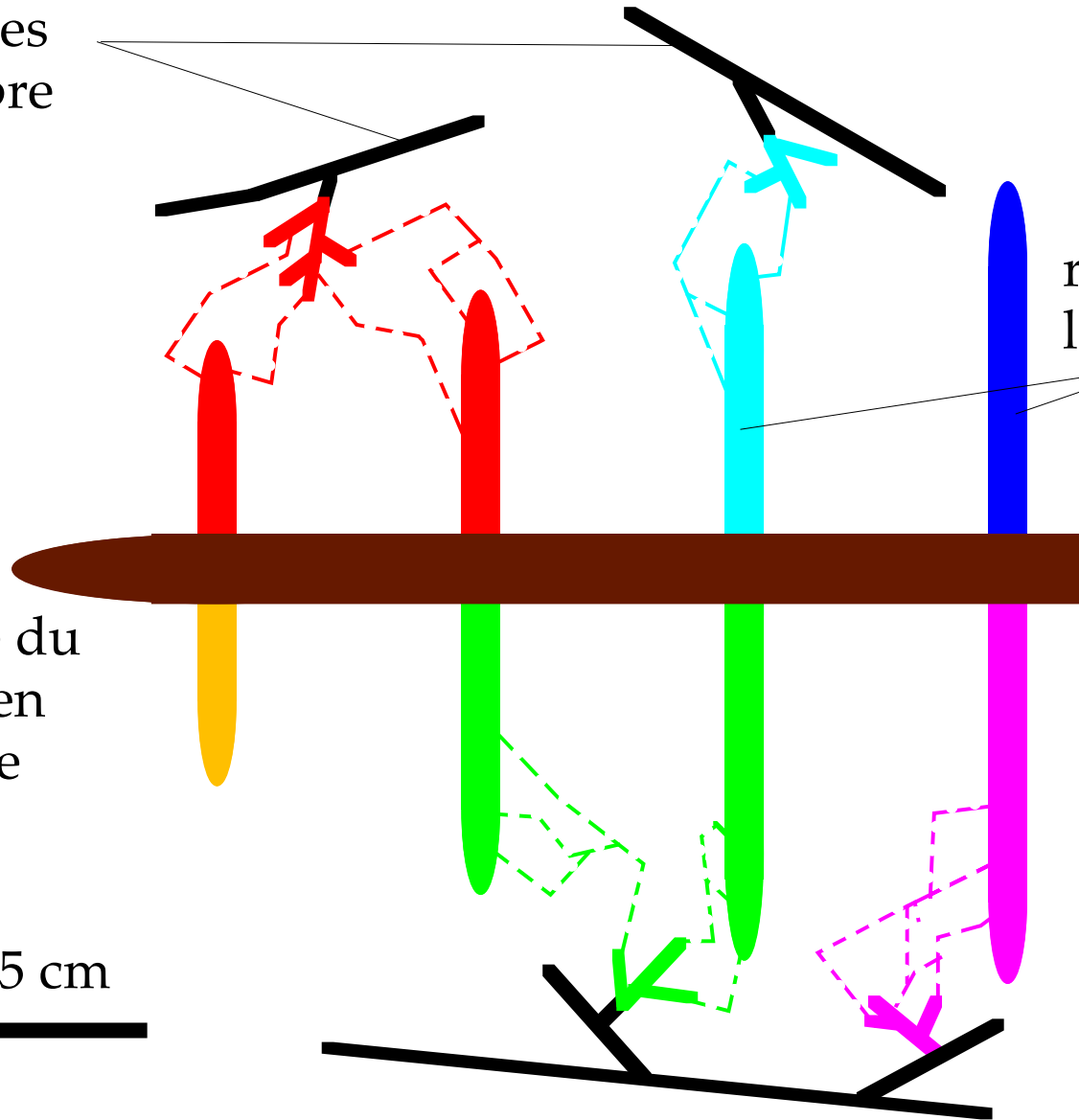
racines
d'arbre

racines de
la Néottie

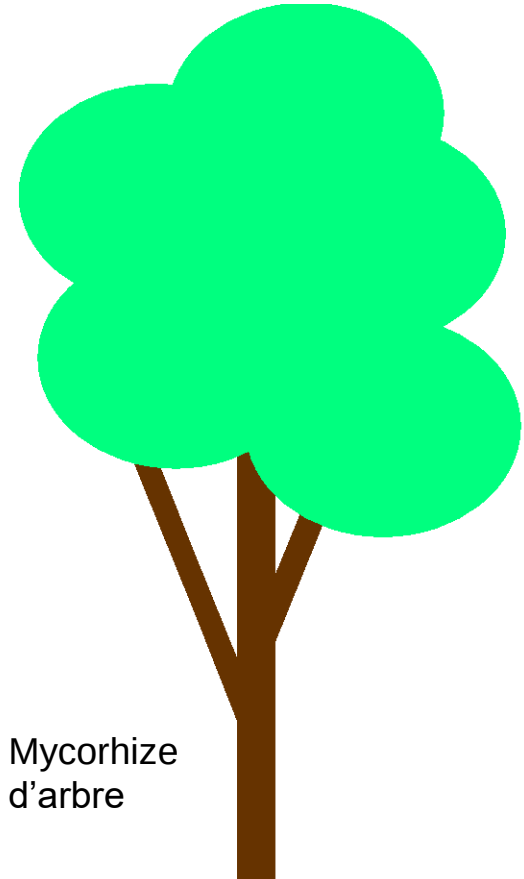
extrémité du
rhizome en
croissance

rhizome
de la Néottie

0,5 cm



ARBRE

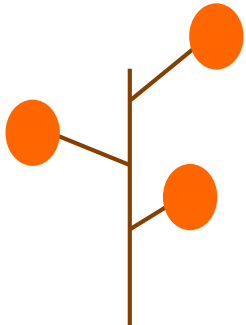


Mycorhize
d'arbre



CHAMPIGNON

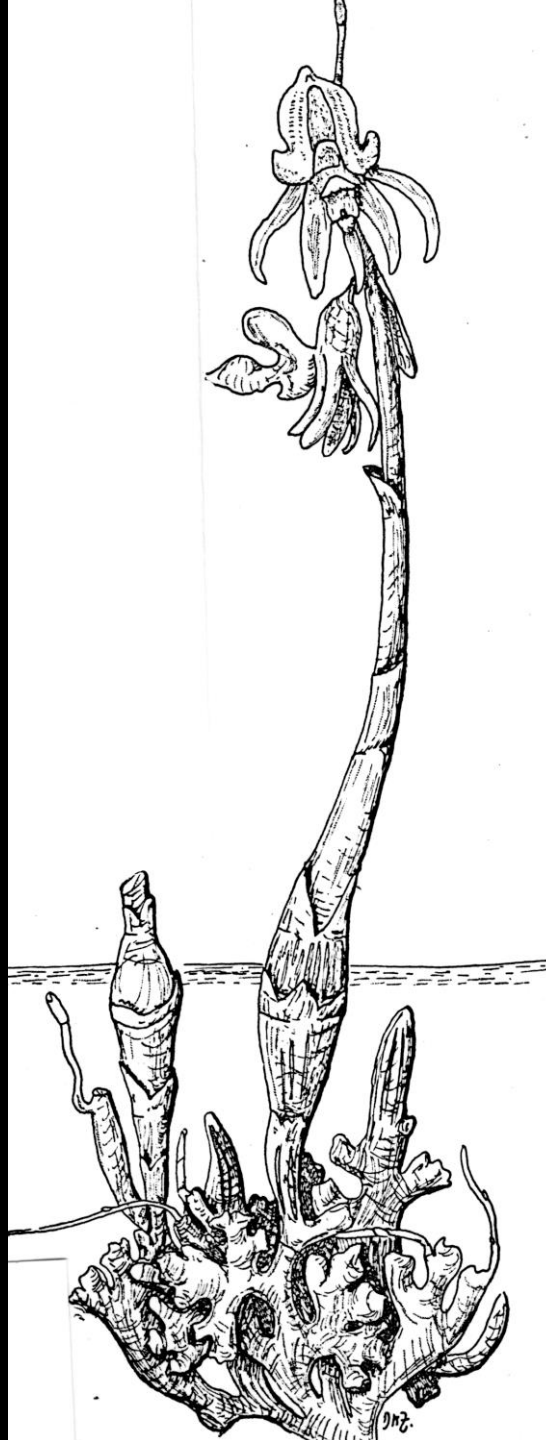
**PLANTE NON
CHLORO-
PHYLLIENNE**



Mycorhize
d'orchidée

Flux de sucre

***Epipogium
aphyllum***
+ *Inocybe*



*Hypopytis
monotropa*



*Sarcodes
sanguinea*



Voyria aphylla



Gymnosiphon sp.



*Apteria
aphylla*





*Limnorchis
abortivum*



Russula groupe *delica*

Epipactis microphylla



Divers chamignons
ectomycorhiziens
(*Tuber* spp.)





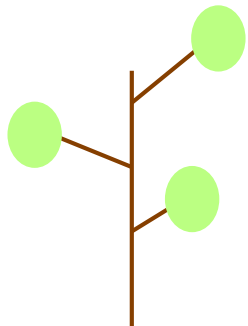
*Cephalanthera
damasonium*





Pyrolas

**PLANTE
CHLORO-
PHYLLIENNE**

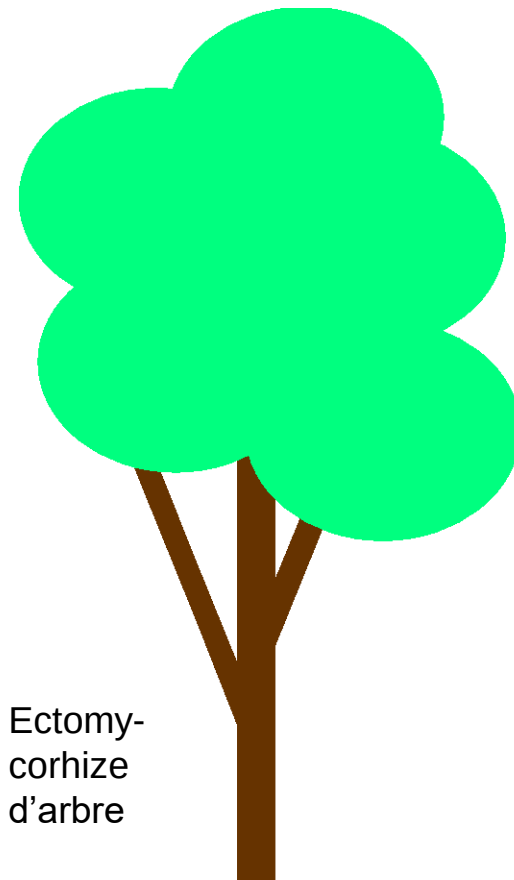


Lumière



CHAMPIGNON

ARBRE



Mycorhize
d'orchidée

Ectomy-
corhize
d'arbre



Flux de sucre

5.

Des signaux ?

Puceron : *Acyrtosiphon pisum*
Prédateur : *Aphidius ervi*

Sur la fève

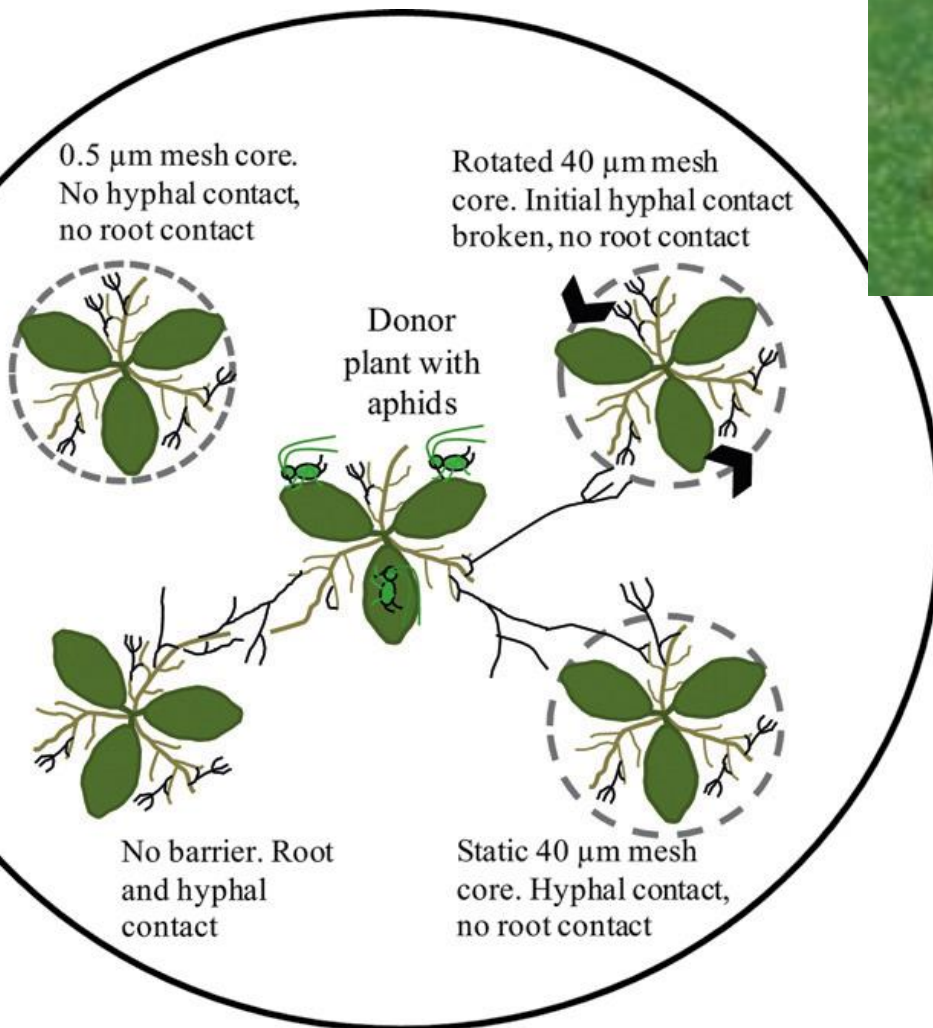


2013 07 25

Fairer Mall

大商場

Puceron : *Acyrtosiphon pisum*
 Prédateur : *Aphidius ervi*

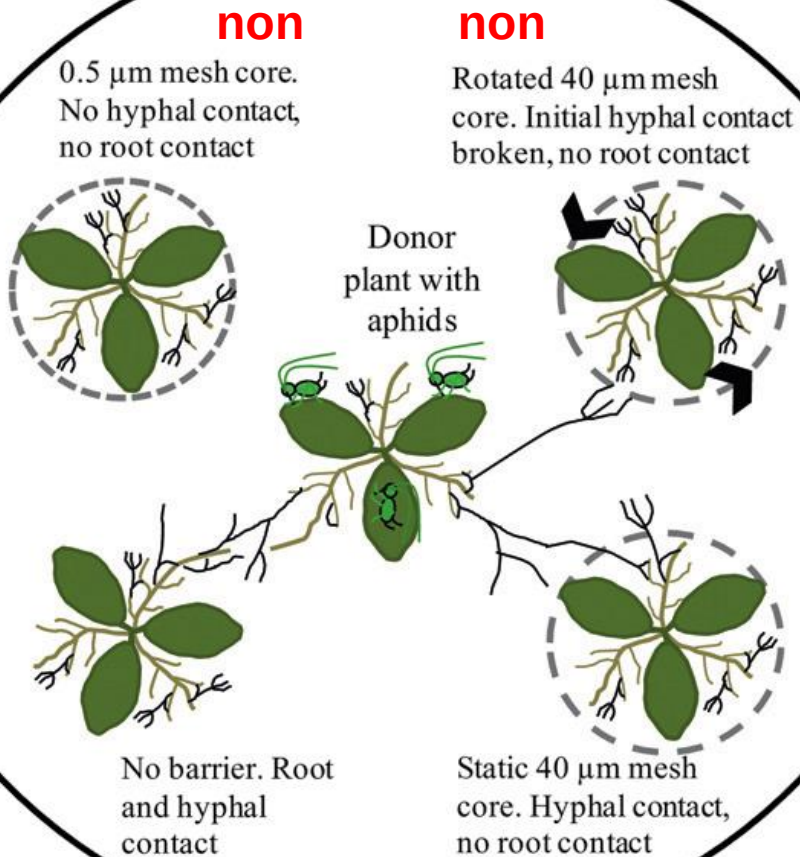


Roots  Mycorrhizal fungi  Aphids  | — | = 5 cm

Puceron : *Acyrtosiphon pisum*

Prédateur : *Aphidius ervi*

Réseau :

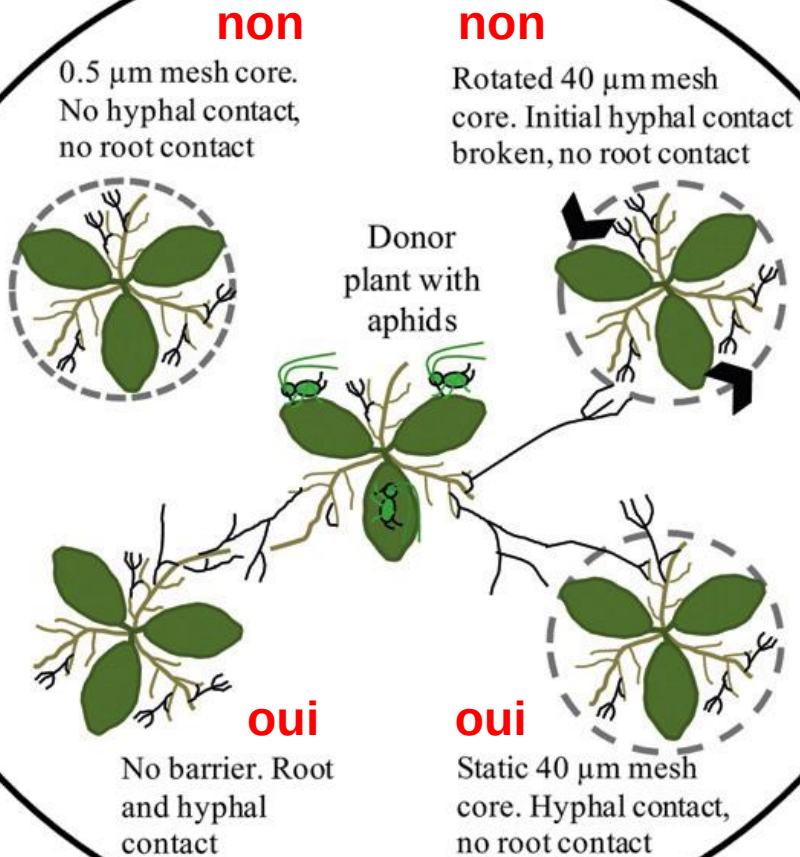


Roots  Mycorrhizal fungi  Aphids  |—| = 5 cm

Puceron : *Acyrtosiphon pisum*

Prédateur : *Aphidius ervi*

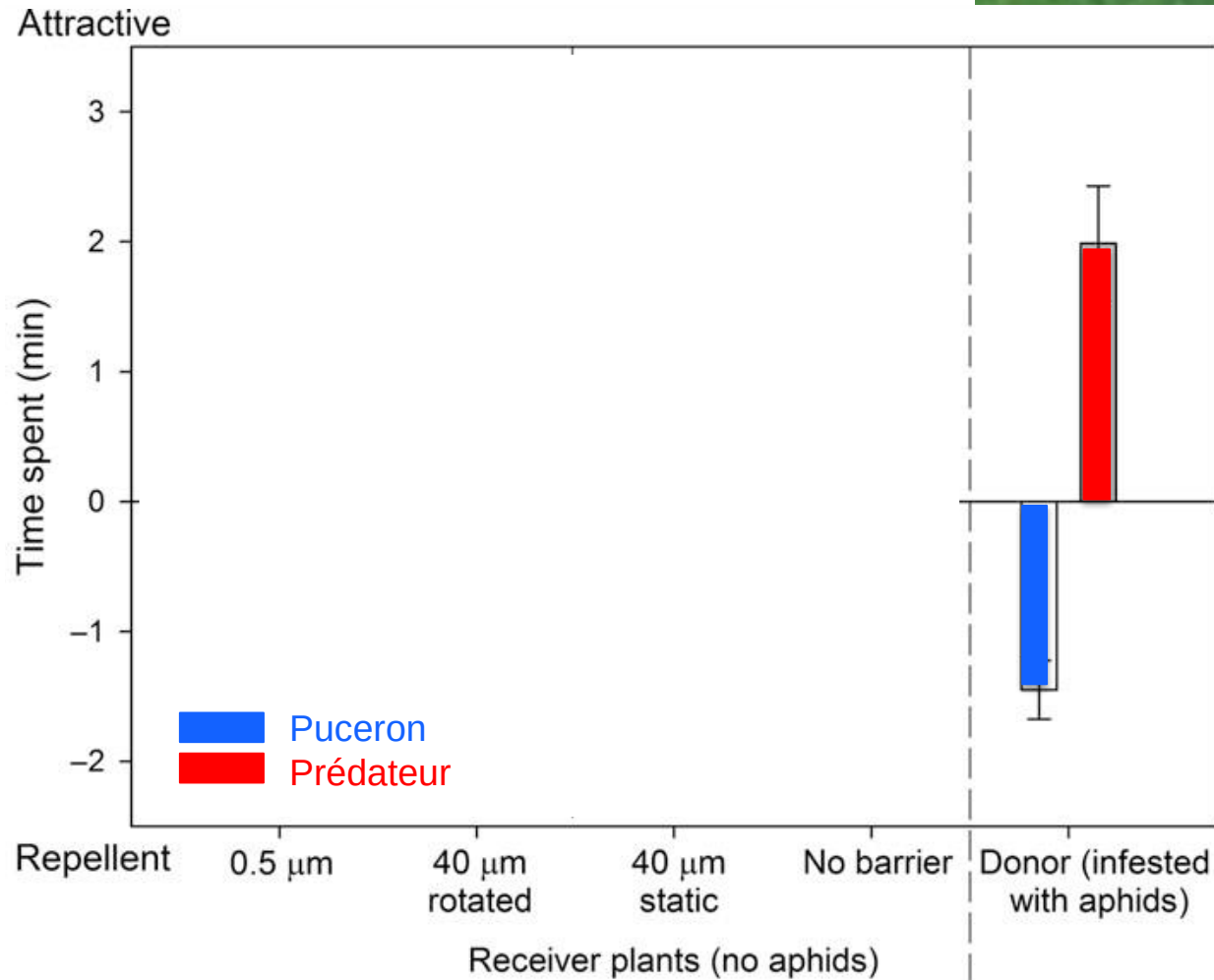
Réseau :



Roots  Mycorrhizal fungi  Aphids  |—| = 5 cm

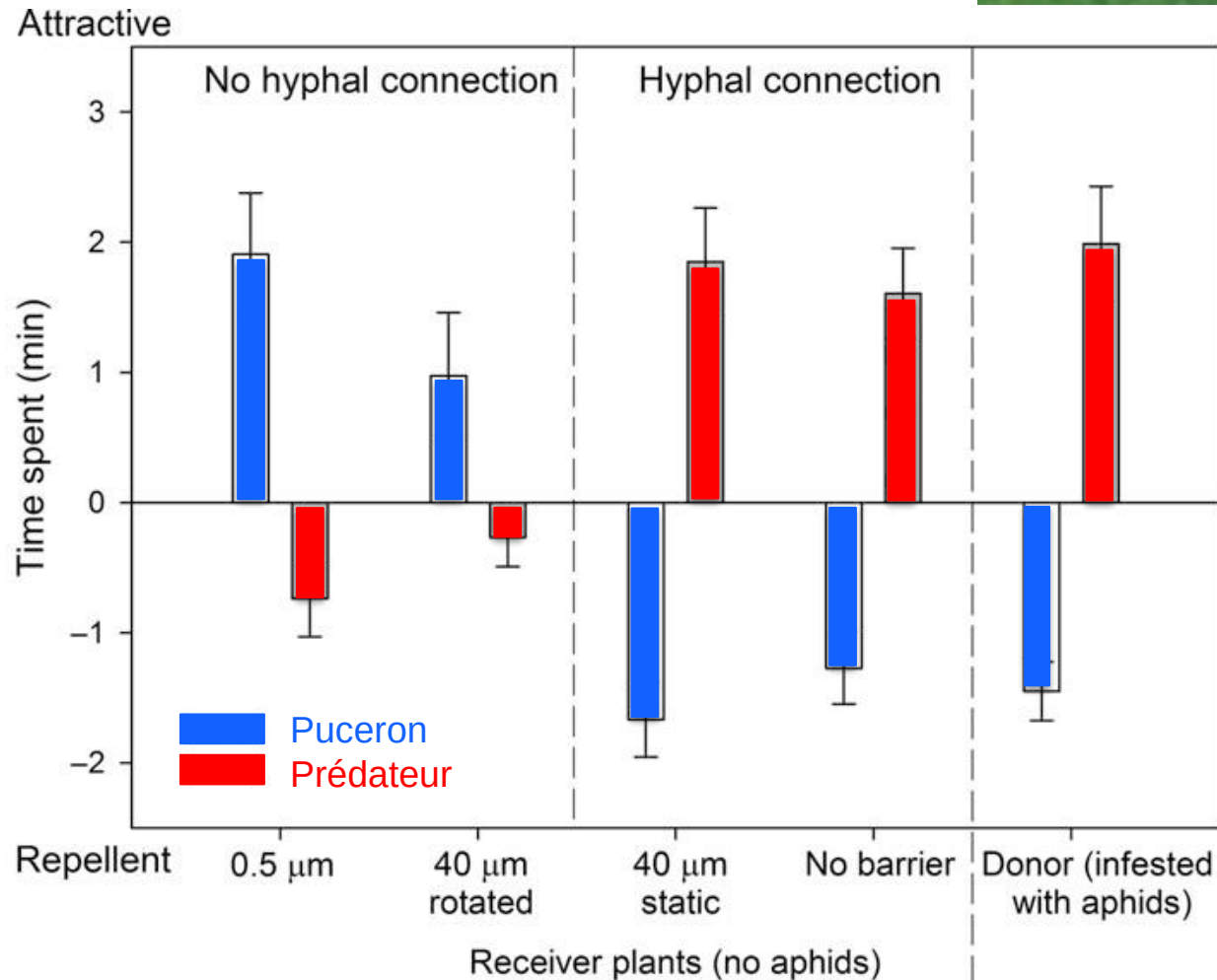
Puceron : *Acyrtosiphon pisum*

Prédateur : *Aphidius ervi*

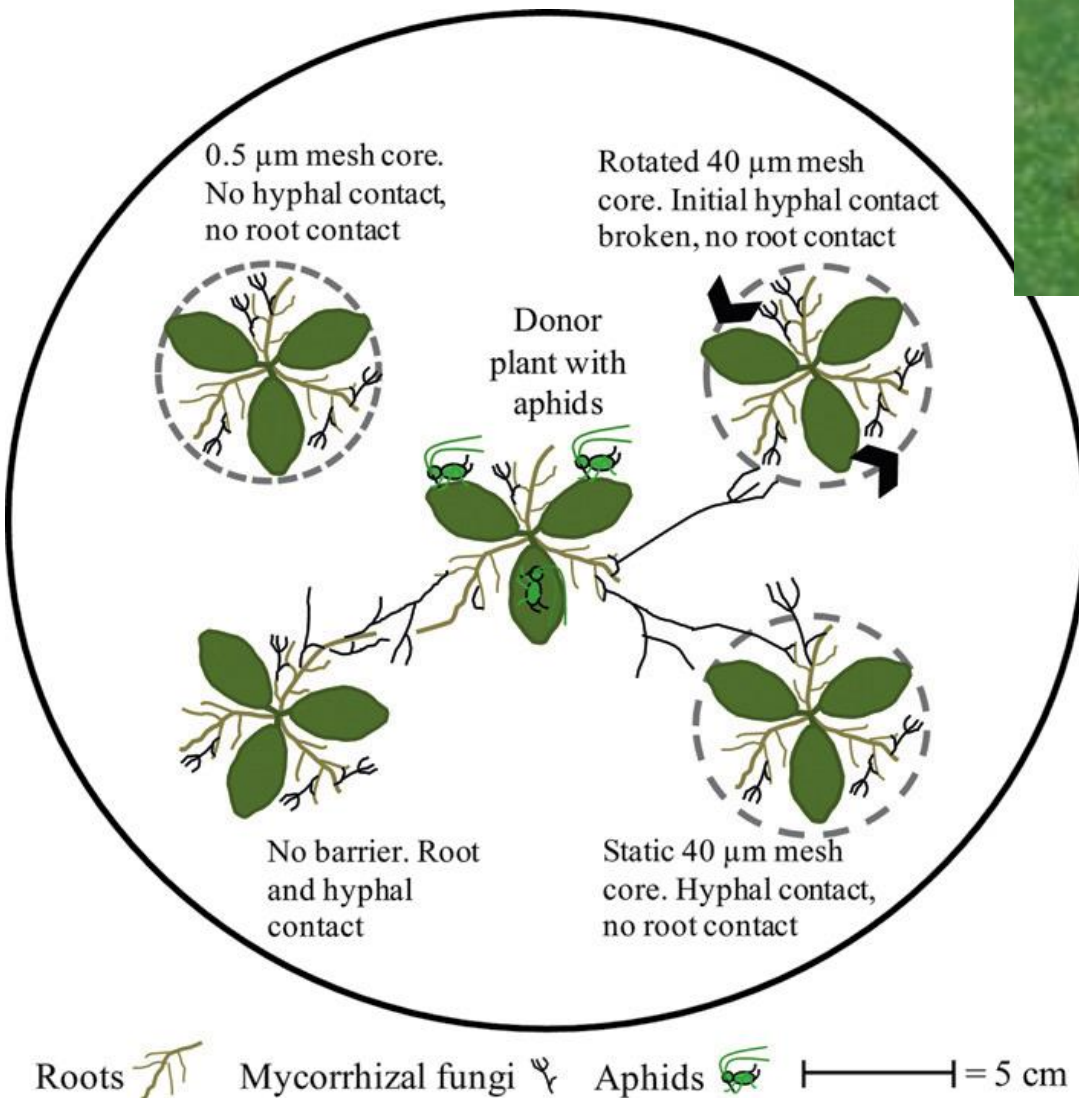


Puceron : *Acyrtosiphon pisum*

Prédateur : *Aphidius ervi*



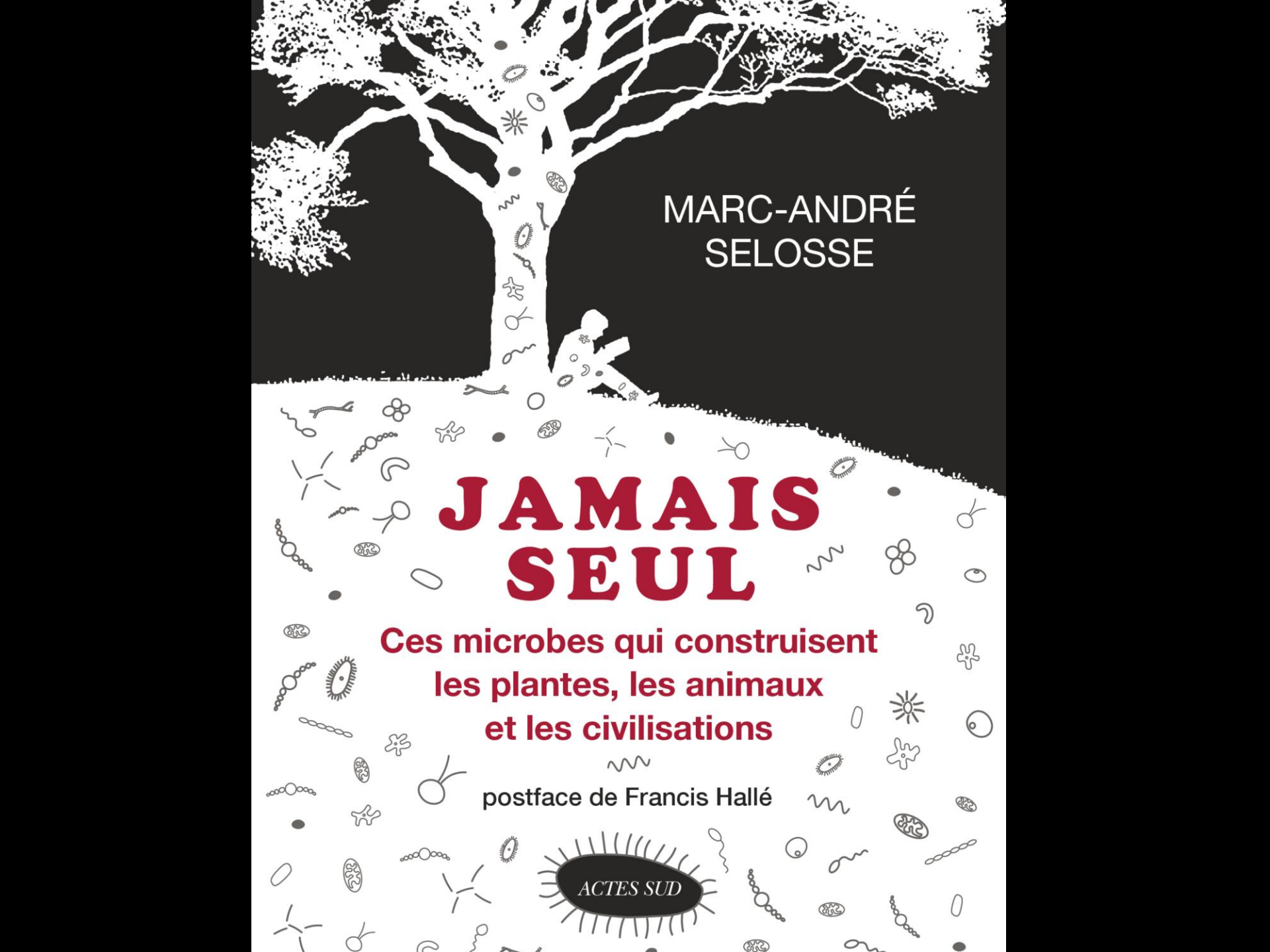
Puceron : *Acyrtosiphon pisum*
 Prédateur : *Aphidius ervi*



**Et dans les
écosystèmes ?**

A photograph of a man standing in a dense forest of tall, thin trees. The ground is covered with dry pine needles and some green moss. A white rectangular box with a torn-edge effect is overlaid on the bottom half of the image, containing the text "JAMAIS SEUL" in red, bold, serif capital letters. The box is decorated with small, hand-drawn black doodles like stars, circles, and squiggles.

**JAMAIS
SEUL**



MARC-ANDRÉ
SELOSSE

JAMAIS SEUL

**Ces microbes qui construisent
les plantes, les animaux
et les civilisations**

postface de Francis Hallé

ACTES SUD

La Forêt et le Bois en France en 100 Questions

Accueil

Le livre en bref

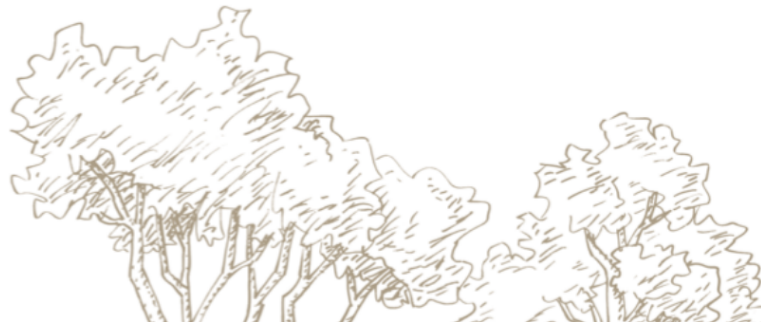
Chapitres

Contact

Chapitres » [Chapitre 2](#) » [Fiche 2.12](#)

2.12 Les arbres sont-ils connectés par les réseaux mycorhiziens ?

Francis Martin et Marc-André Sélosse



2.

Des champignons
nourriciers...

Trends in Plant Science

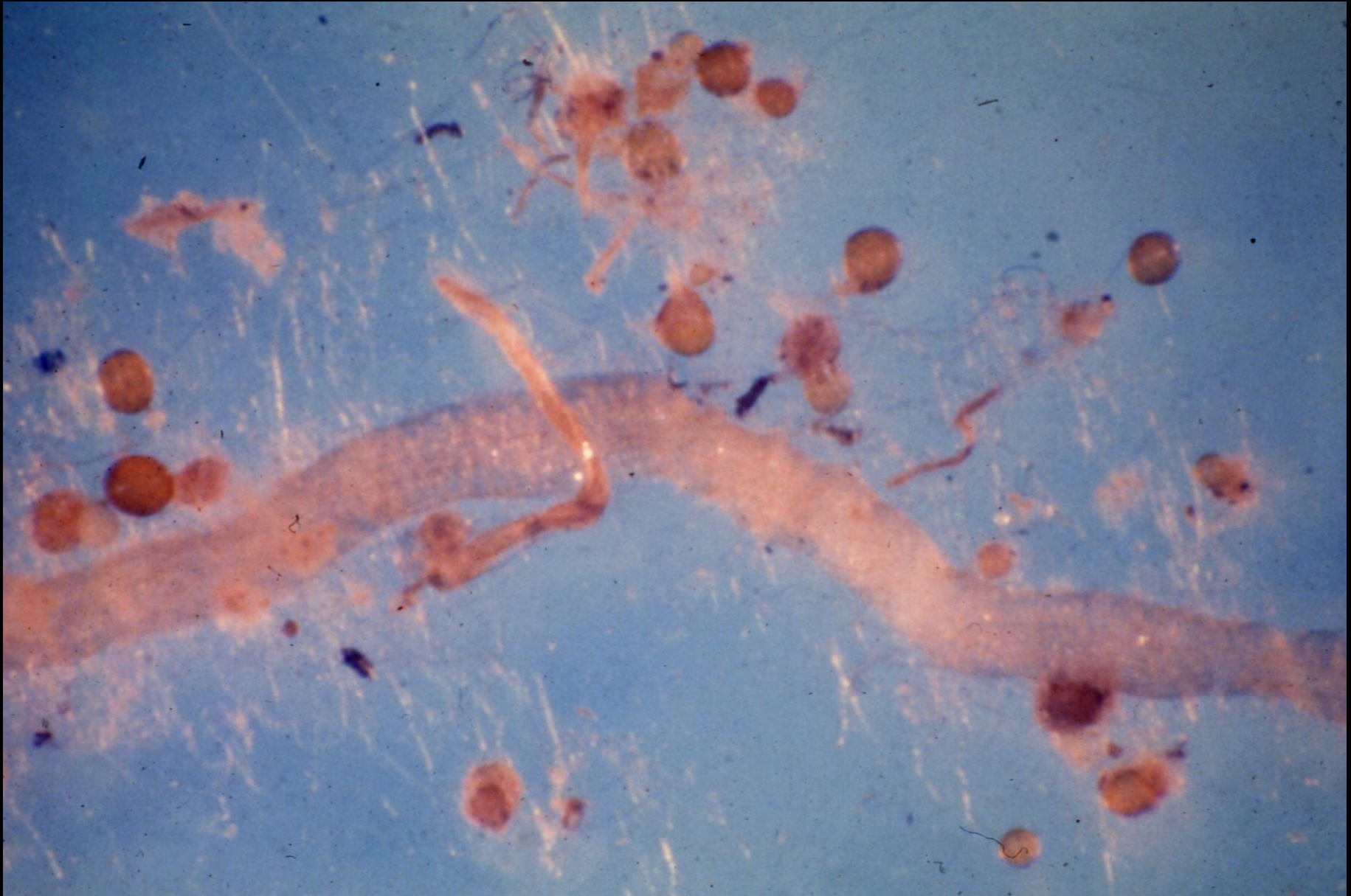


Green plants that feed on fungi

ENDOMYCORHIZE



ENDOMYCORHIZE



LA MYCORHIZE, UNE SYMBIOSE

1 km d'hyphes / m de racine

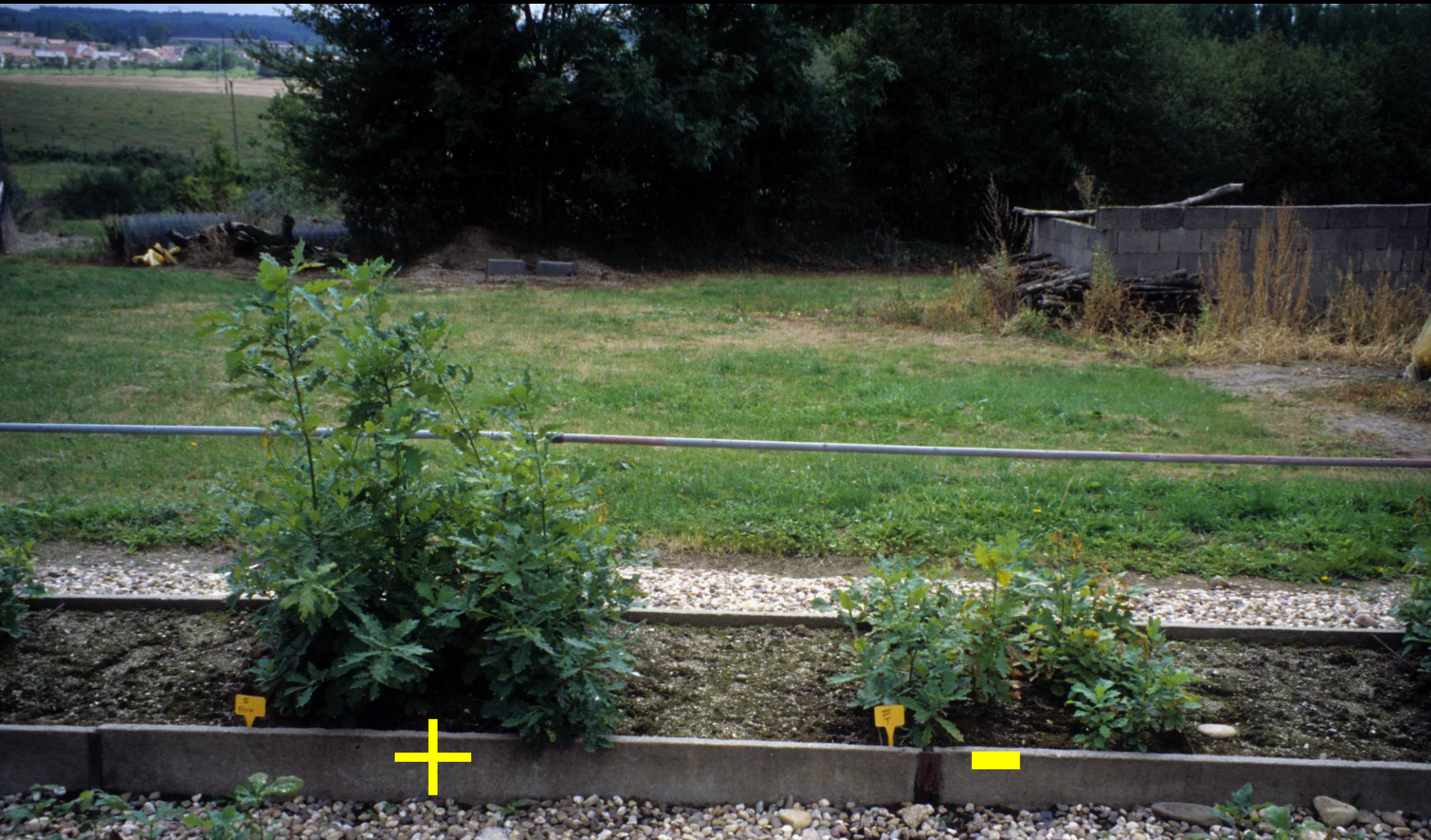
100 m d'hyphes / cm³ de sol

une interface accrue 10 000 x

... pour un coût 100 x moindre

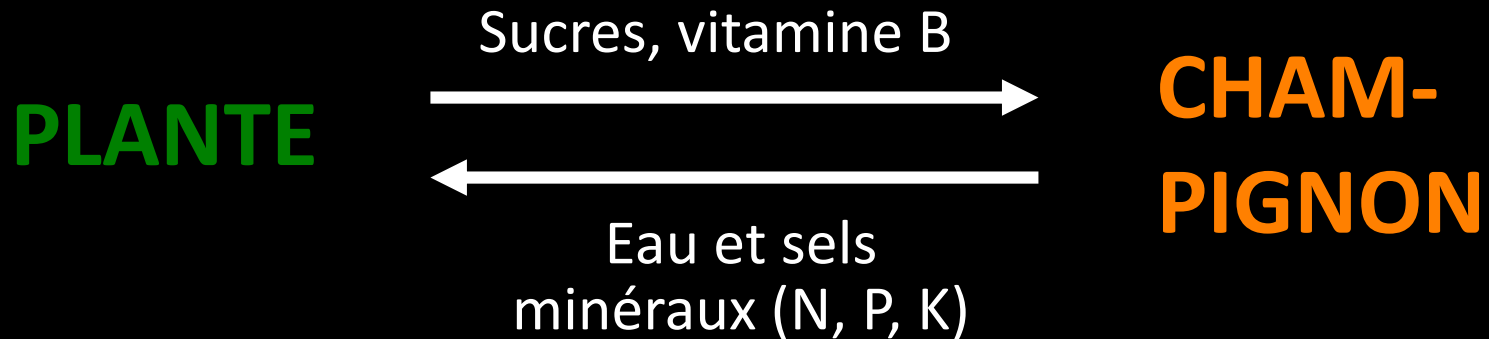


ECTOMYCORHIZE



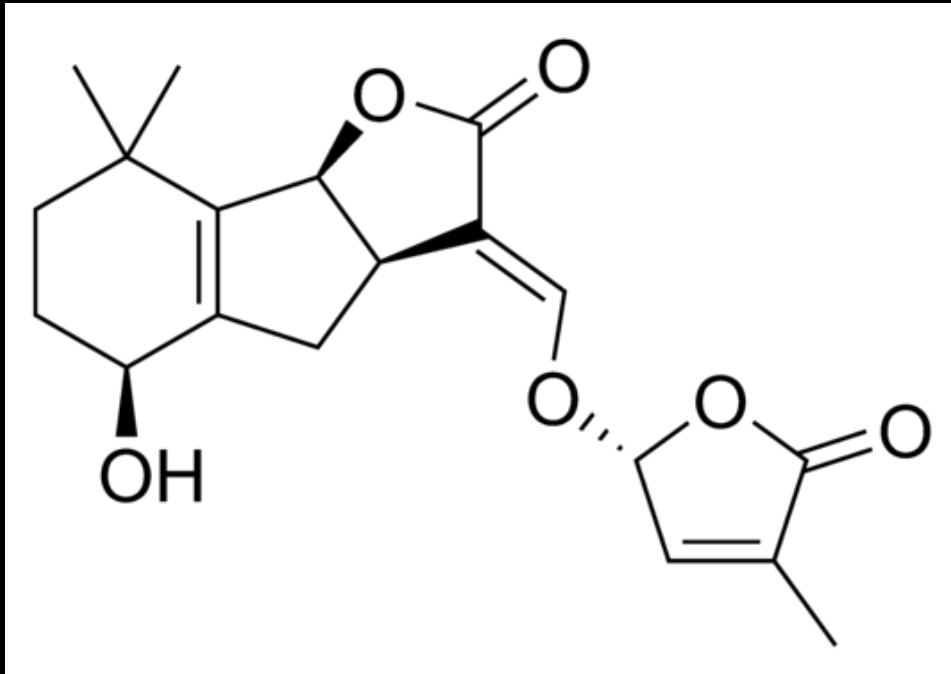
LA MYCORHIZE, UNE SYMBIOSE

Des échanges nutritifs réciproques :



... à table, ensemble !



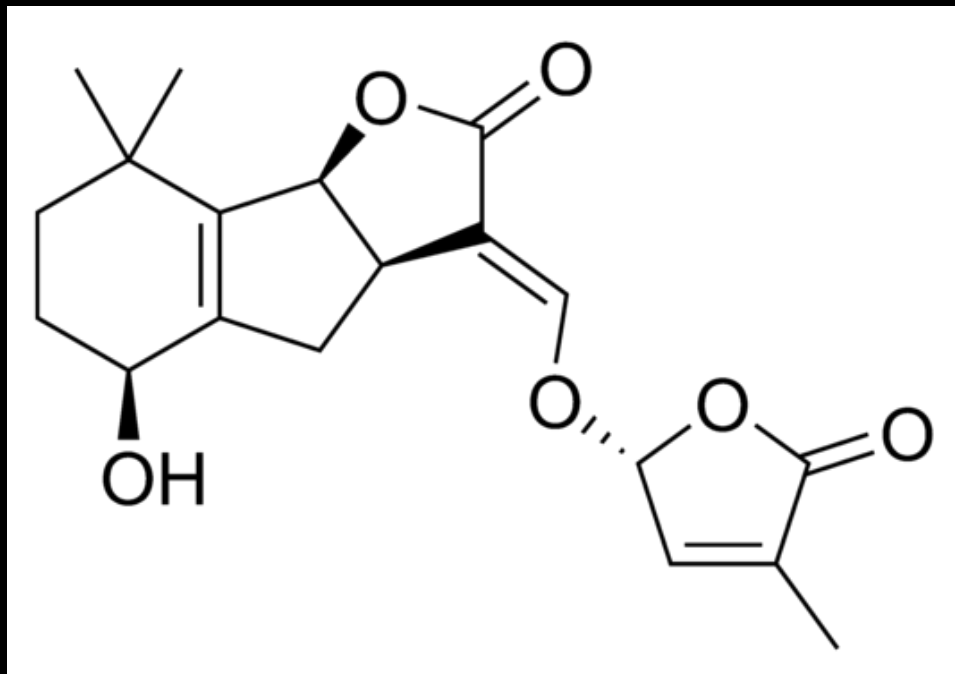


strigolactones

PLANTE

**CHAM-
PIGNON**



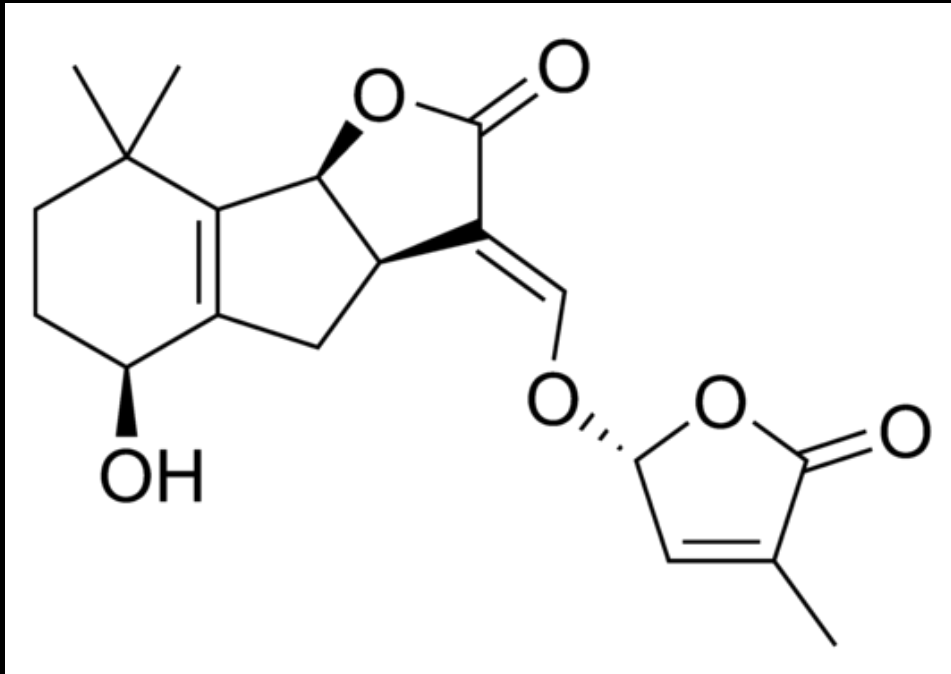


PLANTE

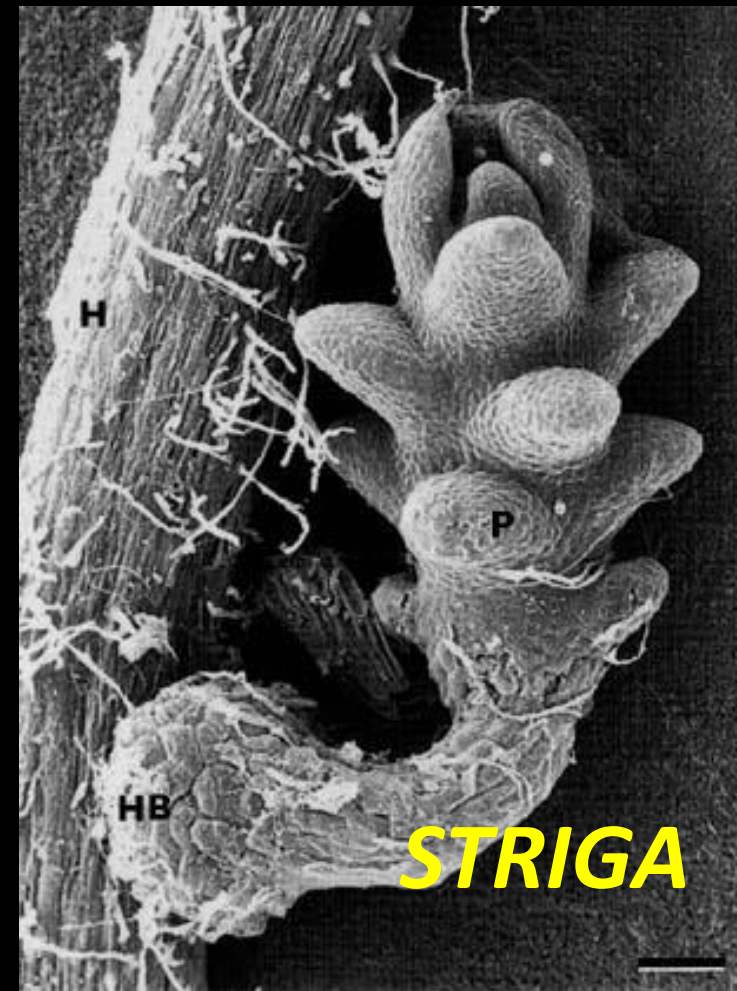


STRIGA

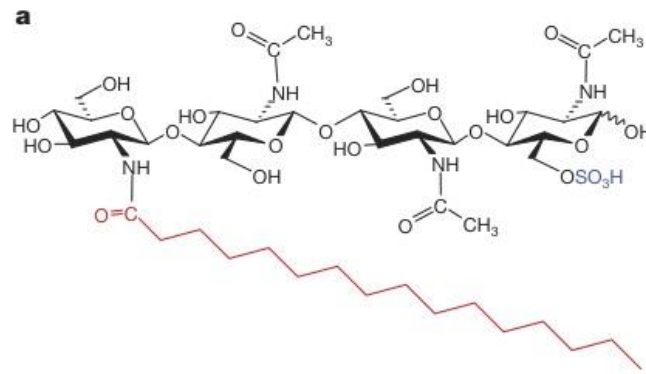




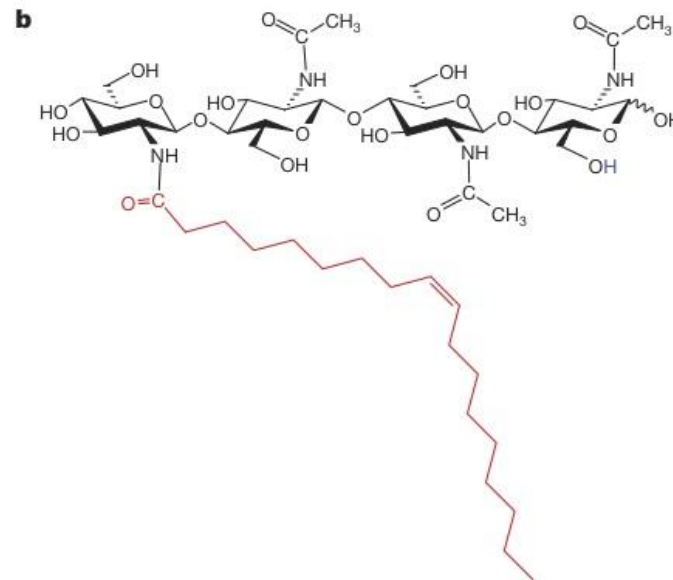
PLANTE



STRIGA



**Facteurs
Myc**



**CHAM-
PIGNON**

PLANTE



LA MYCORHIZE, UNE SYMBIOSE

Des échanges nutritifs réciproques ?

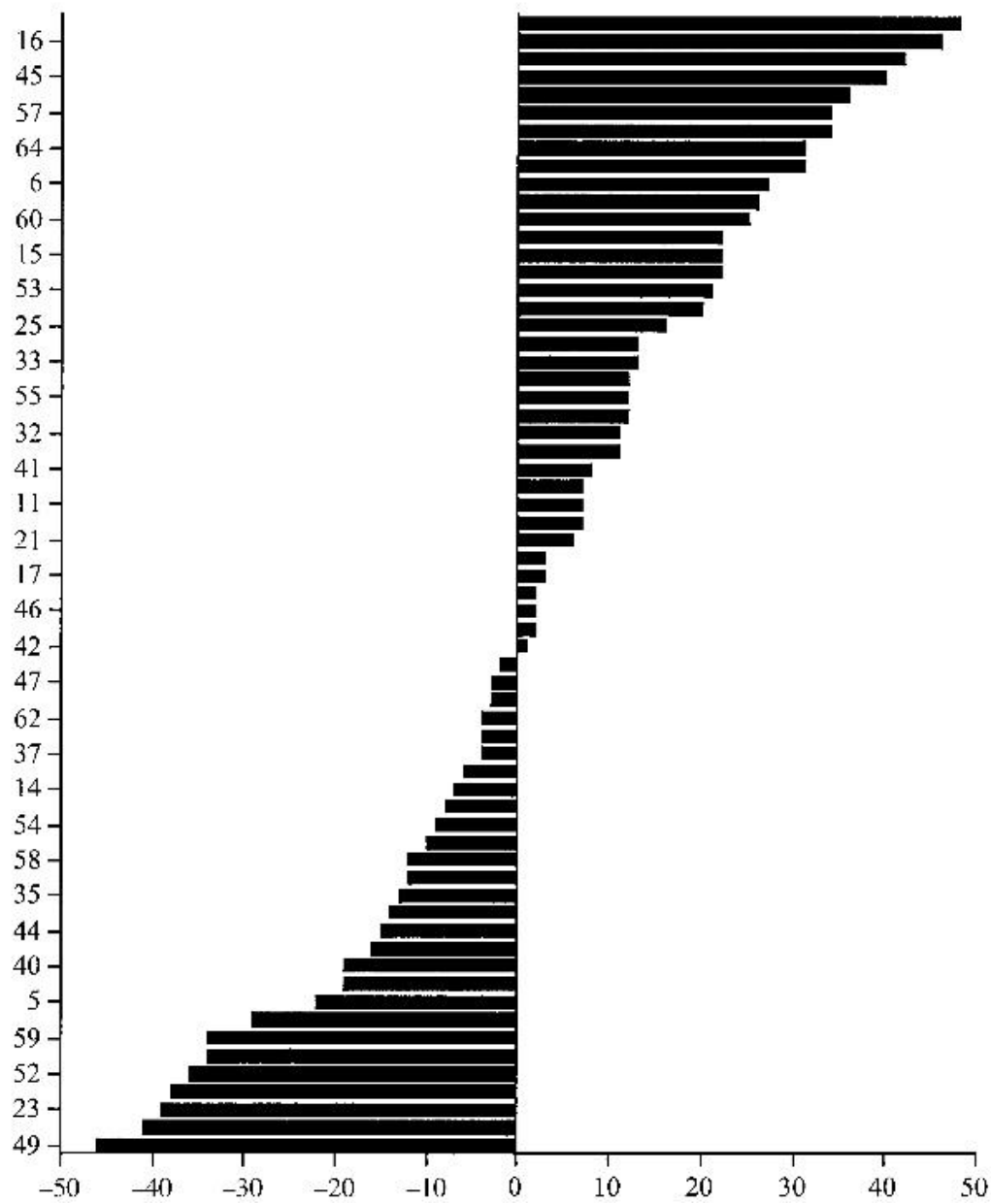
DIVERSES
PLANTES



Glomus
etunicatum

?

**Espèce
de plante
hôte**



Effet (biomasse)



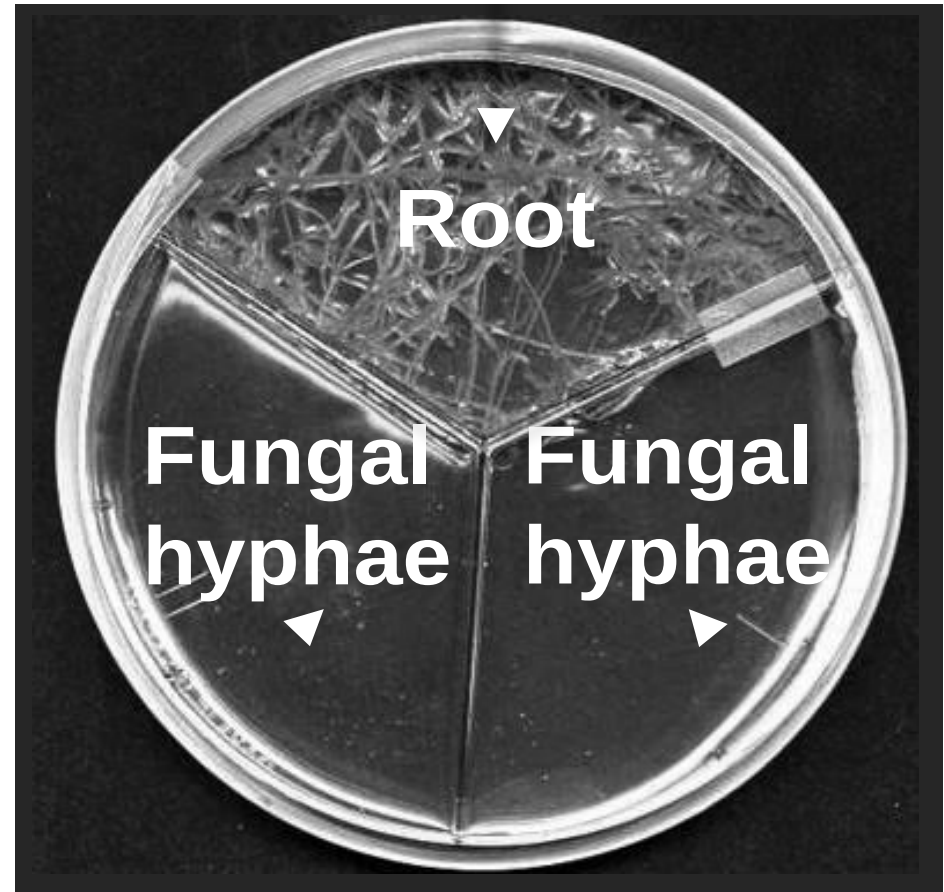
^{14}C - saccharose



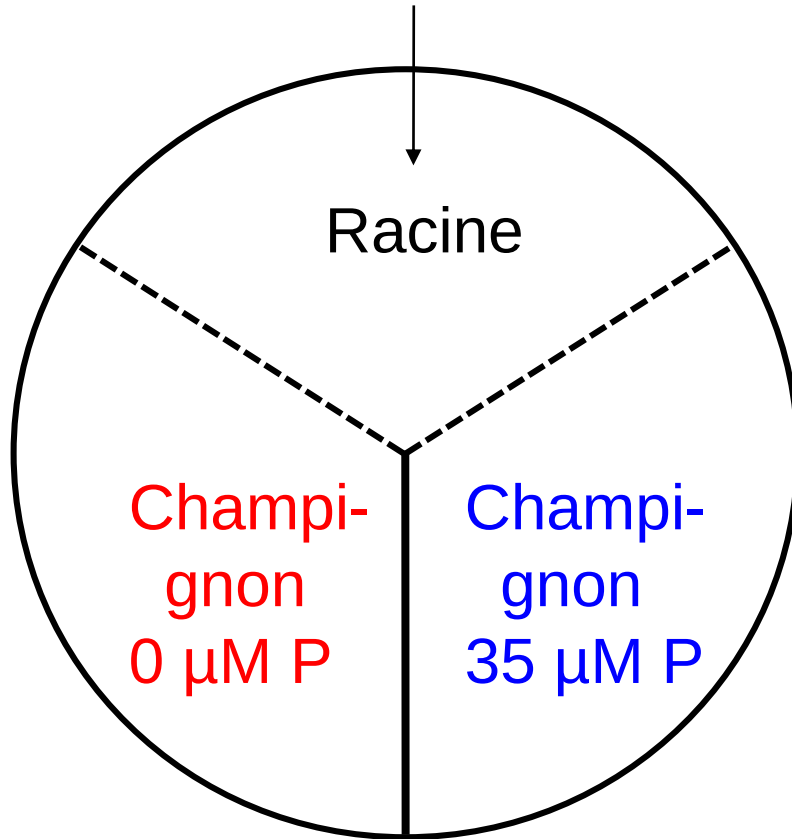
Racine

Champi-
gnon
0 $\mu\text{m P}$

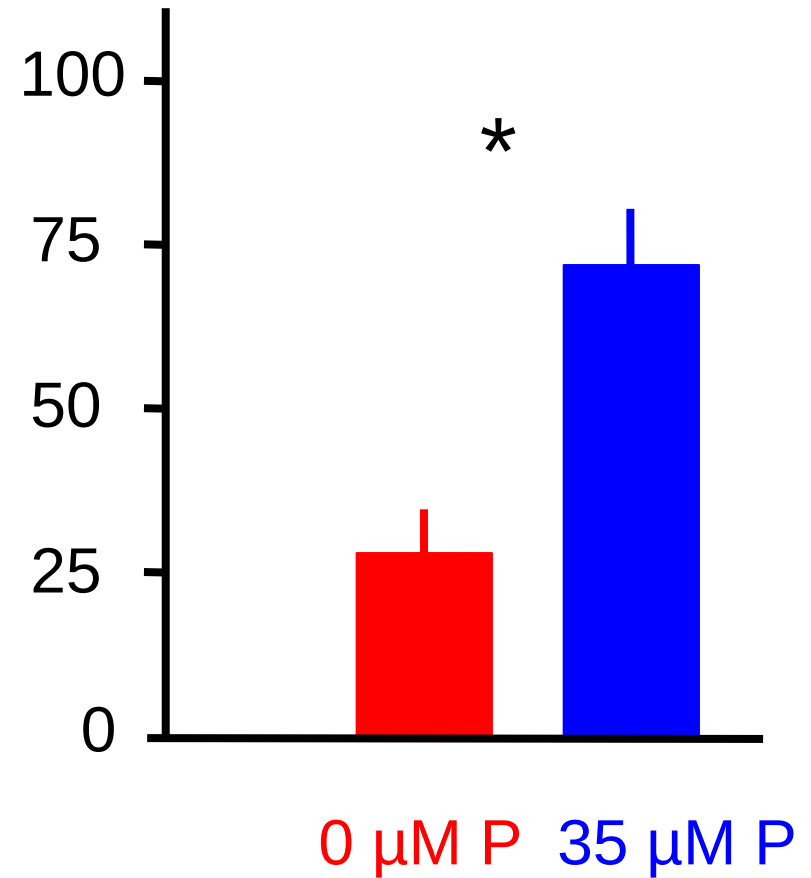
Champi-
gnon
35 $\mu\text{m P}$



^{14}C - saccharose



^{14}C alloué à chaque champignon
(% du total transféré)



^{33}P

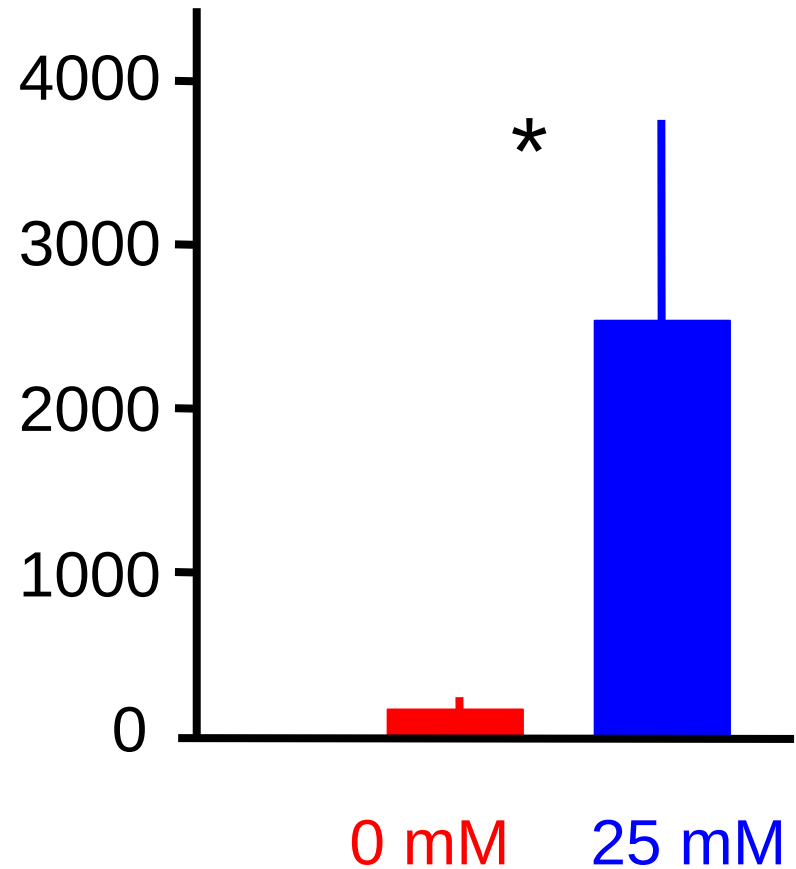


Champignon

Racine
0 mM
saccha-
rose

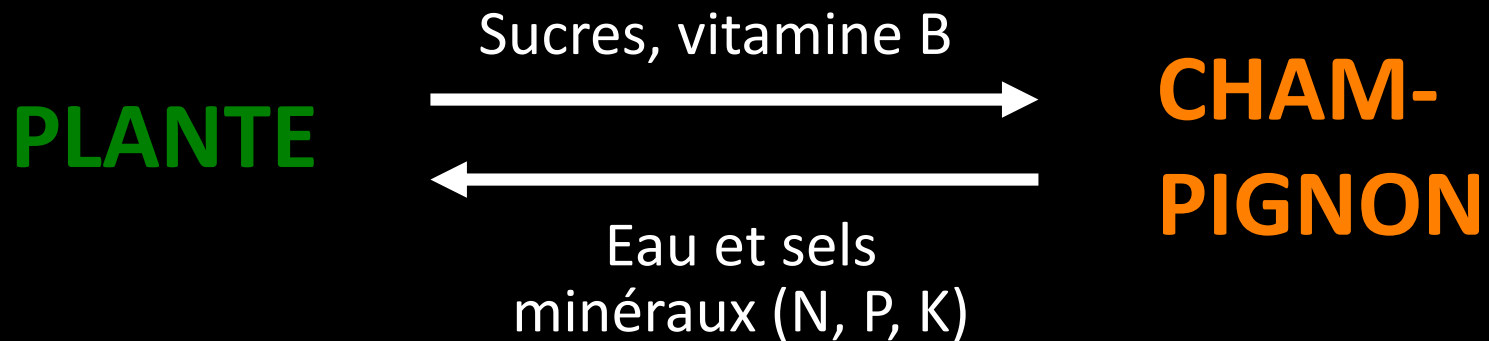
Racine
25 mM
saccha-
rose

^{33}P intégré dans les racines
(dpm mg^{-1})



LA MYCORHIZE, UNE SYMBIOSE

Des échanges nutritifs réciproques :



... à table, ensemble,
mais pas à n'importe quel prix !

3.

Des champignons
depuis toujours !

L'ENDOMYCORHIZE

80% des plantes
terrestres

&

des champignons microscopiques du groupe des
Gloméromycètes





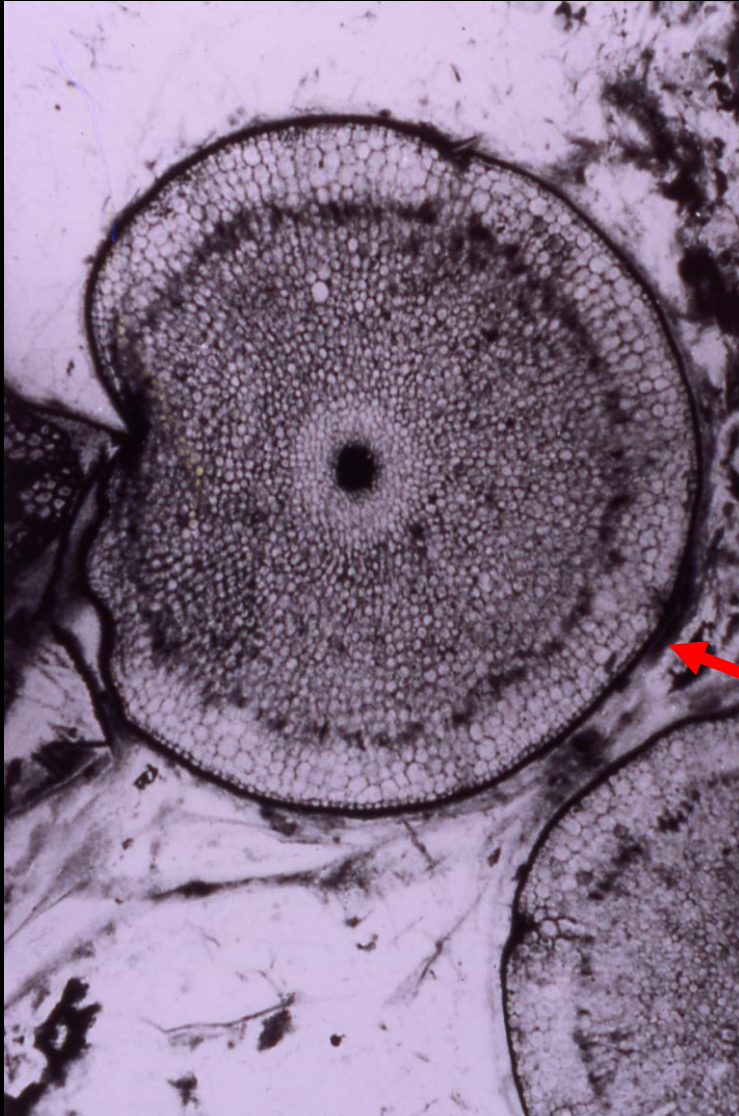
RHYNIE

Drive slowly



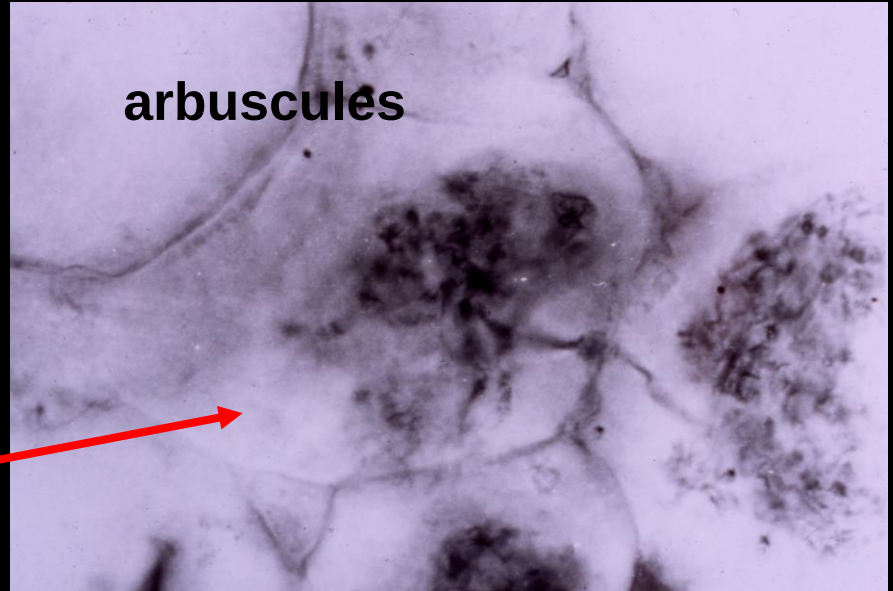


DES LE SILURIEN...



Aglaophyton, flore de Rhynie
(400 millions d'années)

DES LE SILURIEN...



APRES LE SILURIEN...



APRES LE SILURIEN...



ECTOMYCORHIZE



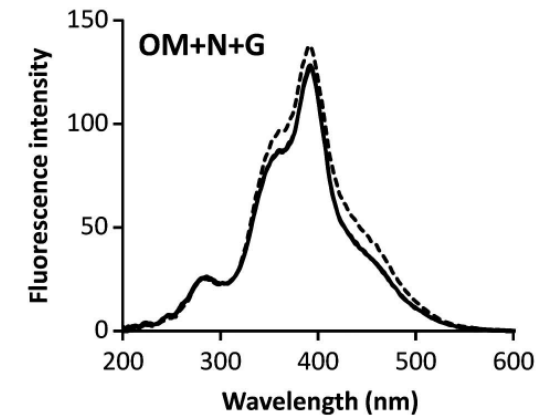
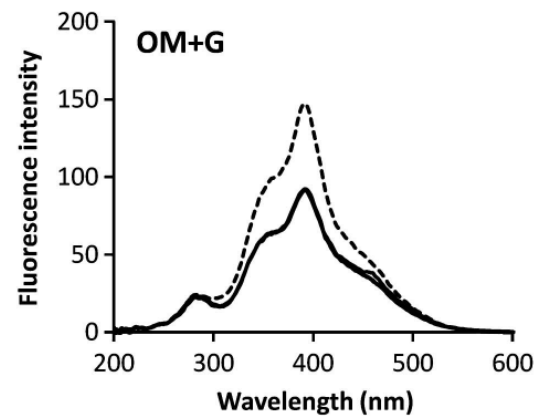
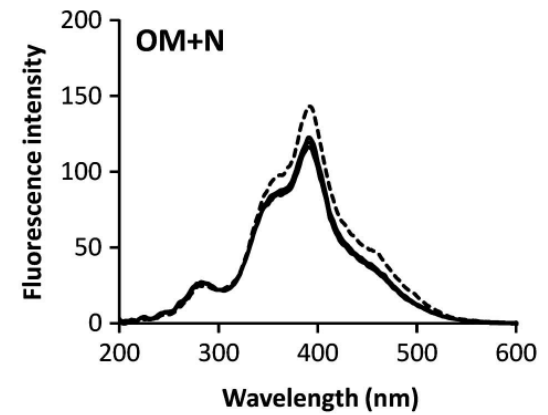
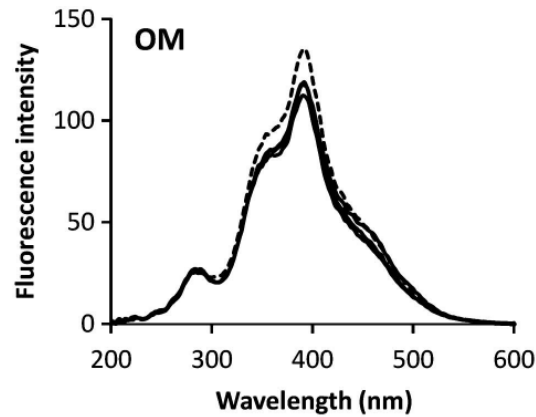
ECTOMYCORHIZE



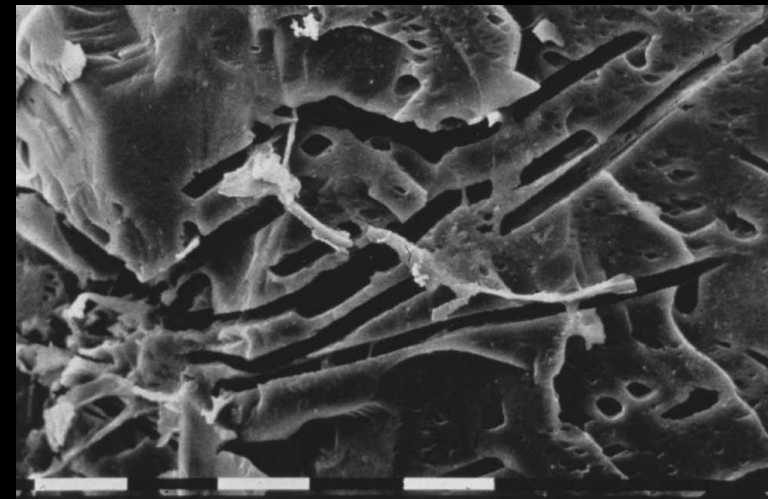
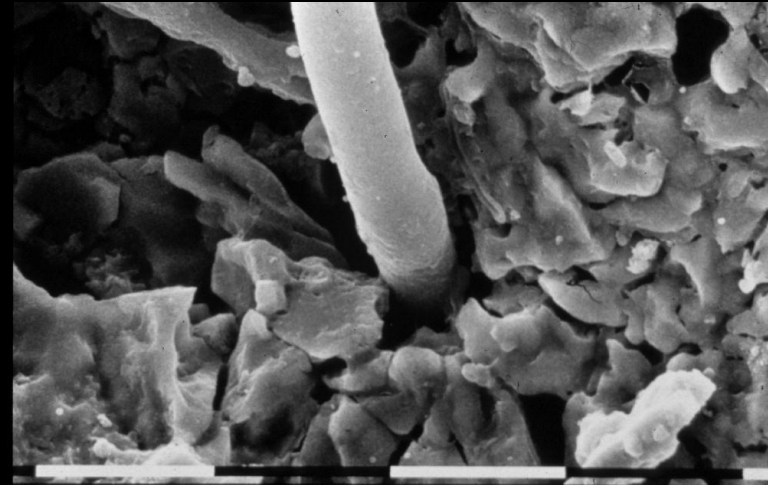
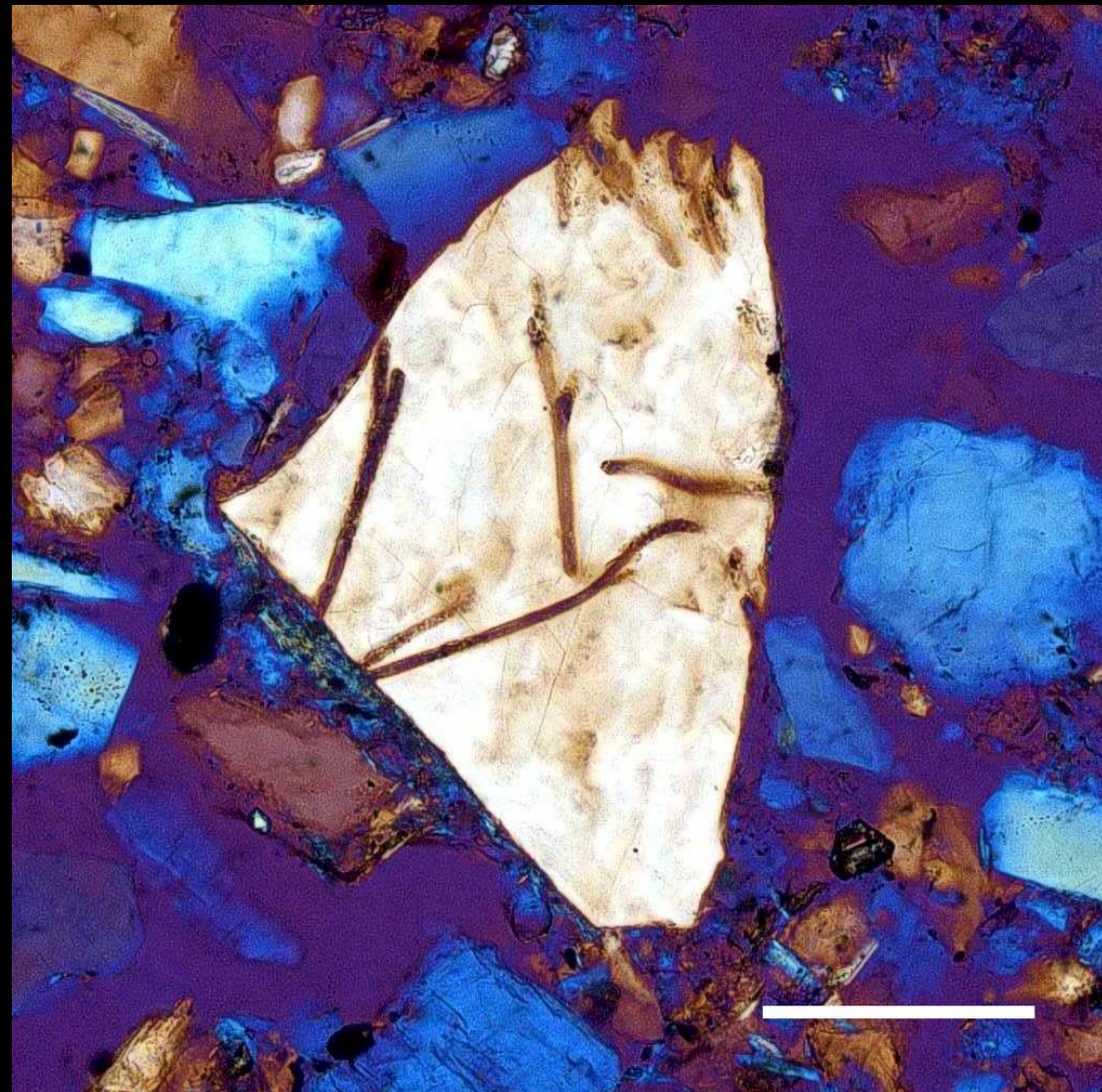
ECTOMYCORRHIZE



ECTOMYCORRIZE



ECTOMYCORRHIZE





-  Arctic tundra - ERICOID
-  Coniferous forest, temperate forest - ECTO - some VA
-  Tropical forest, sub-tropical seasonal forest - VA or ECTO
-  Moist savannah and Miombo woodland - ECTO (trees) VA (grasses)

-  Temperate grassland, steppe, dry scrub and desert - VA
-  Tropical and sub-tropical savannah grassland, scrub and desert - VA
-  Mediterranean vegetation : - Mixed ECTO, ERICOID & VA
-  ^ ^ Mountains



**10% de plantes
non mycorhizées
(milieux pionniers,
humides et/ou
riches)**

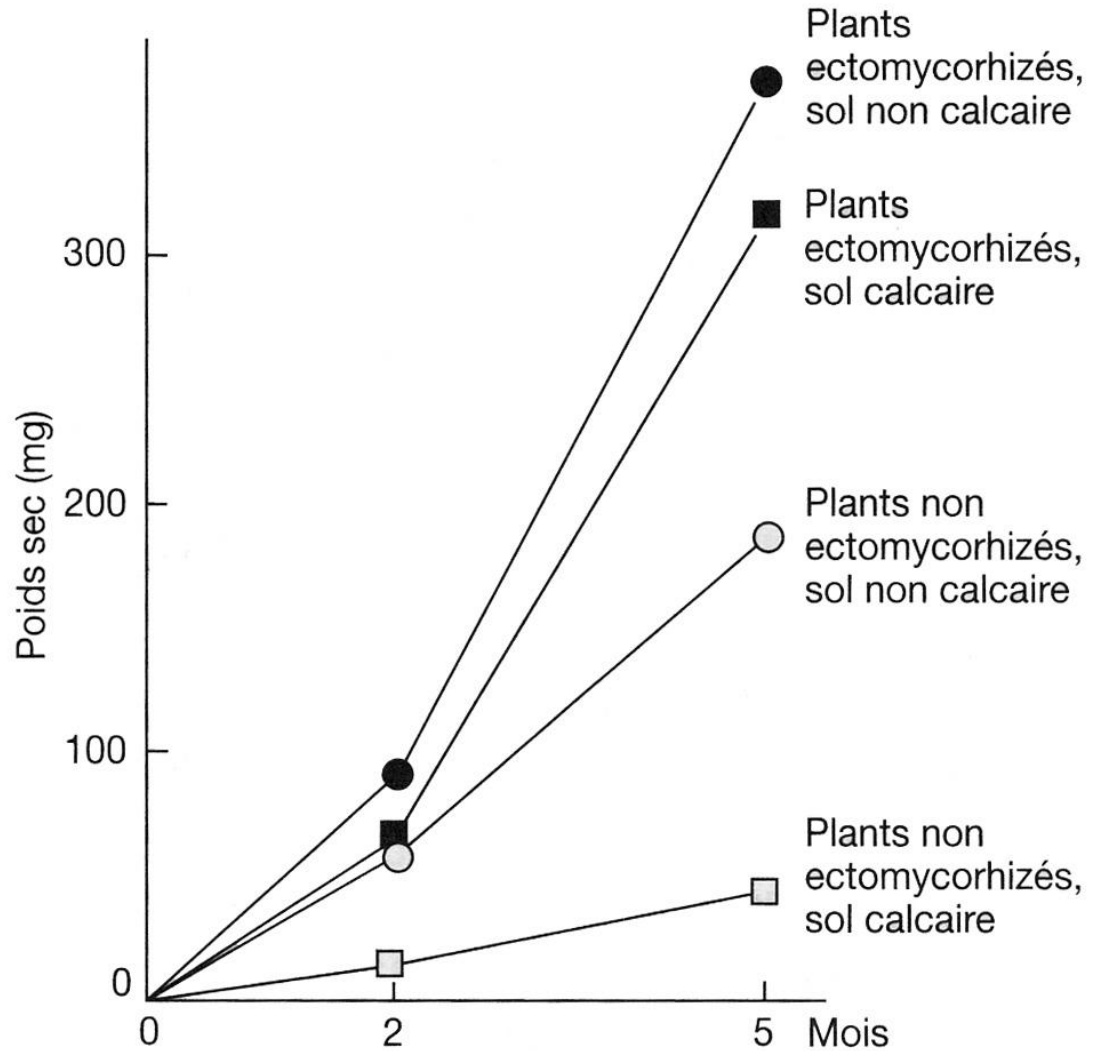
**dont les
Brassicacées**

Arabidopsis thaliana

4.

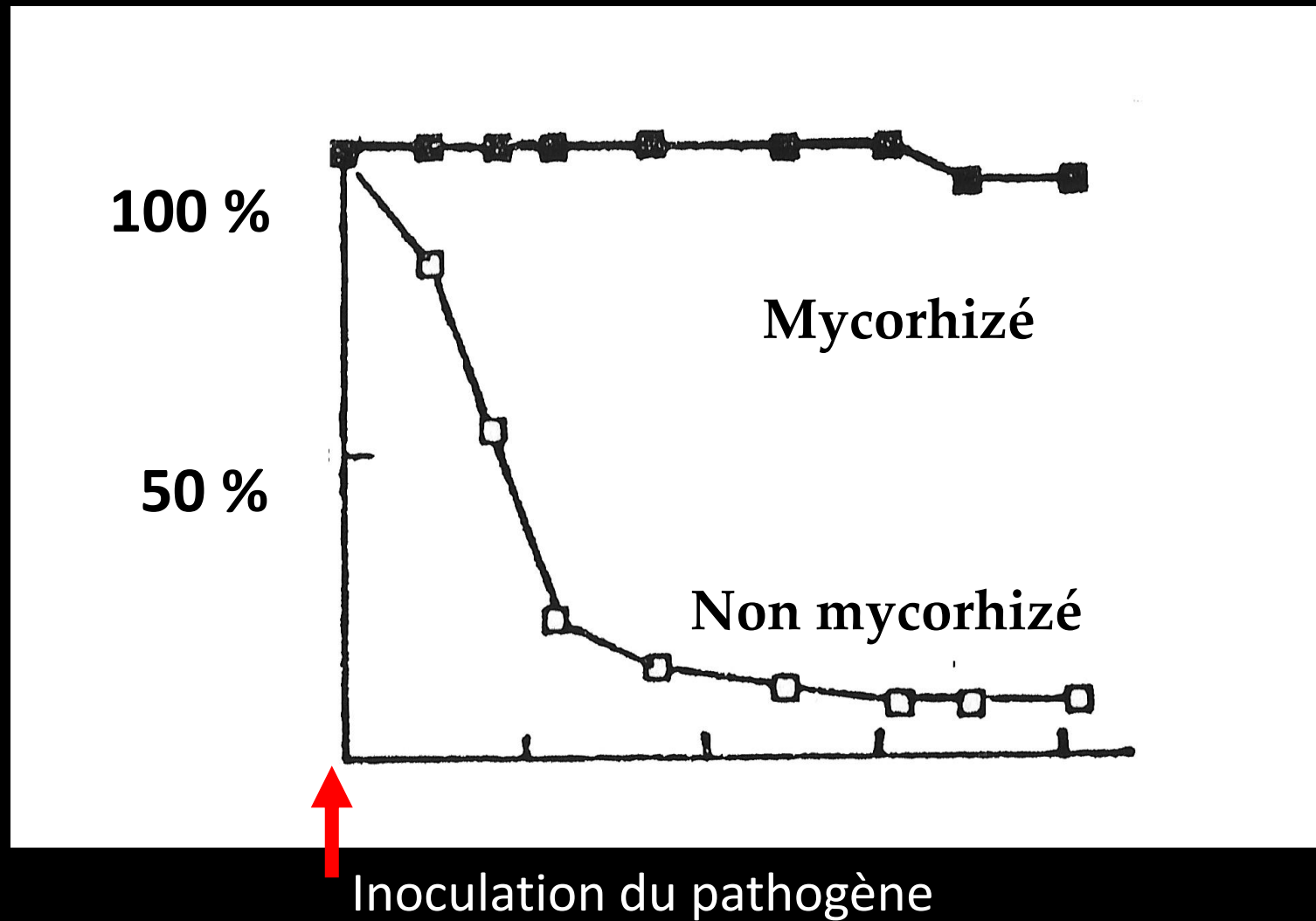
... et protecteurs!

Tolérance au calcaire d'*Eucalyptus globulus*, mycorhizé ou non

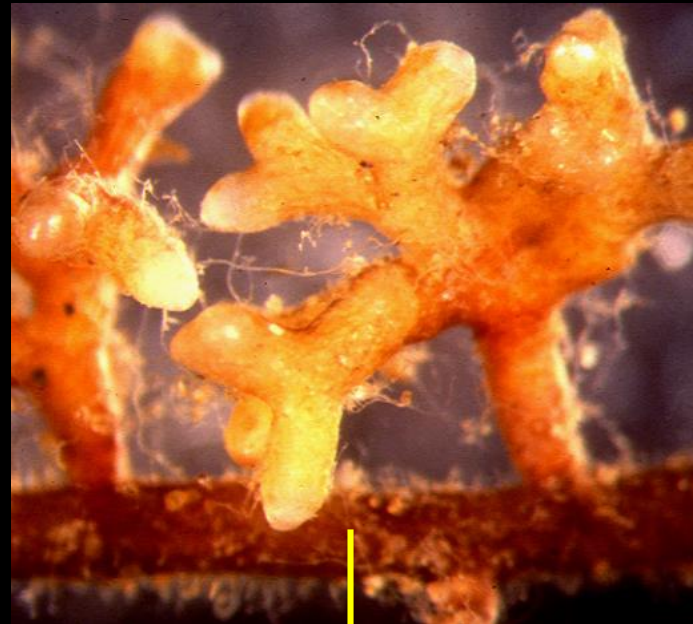


Cenococcum geophilum





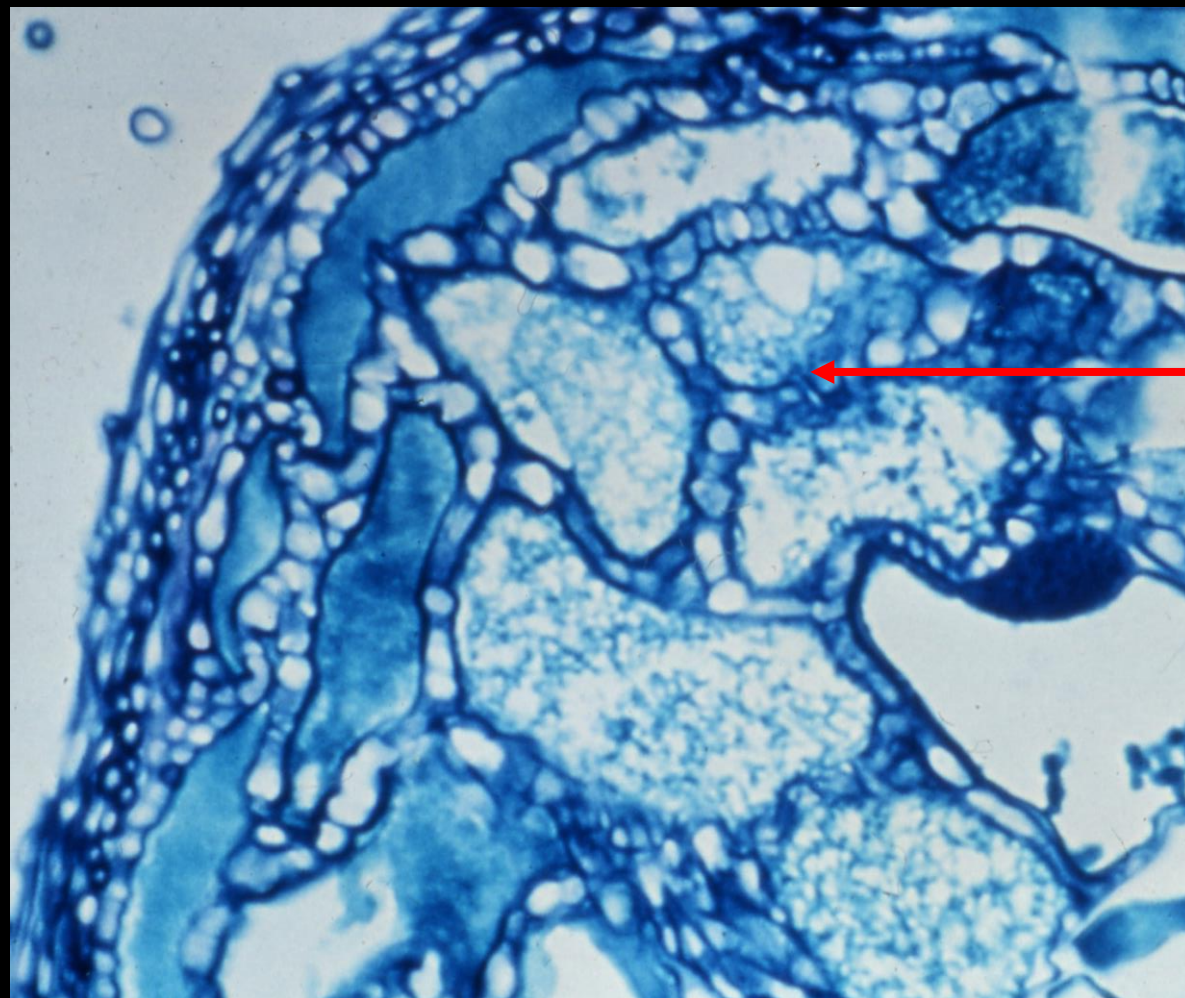
Survie de *Chamaecyparis lawsoniana* mycorhizé ou non à l'inoculation du pathogène racinaire *Phytophthora cinnamomi*.



ECTOMYCORHIZE



ECTOMYCORRHIZE



Protection contre *Botrytis cinerea*

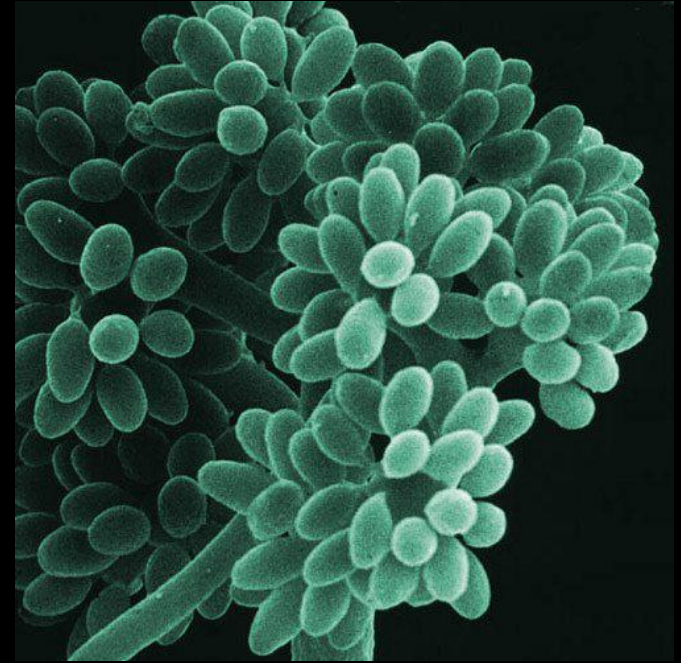
INOCULATION



Non
mycorrhizé



+ *Glomus
margarita*



Protection contre *Botrytis cinerea*

INOCULATION

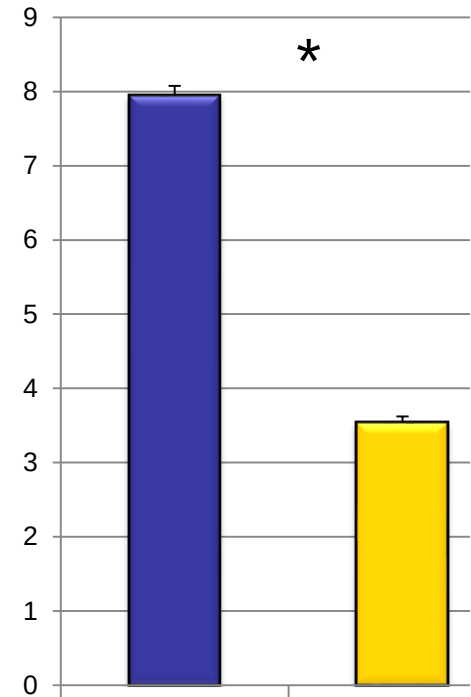


Non
mycorrhizé



+ *Glomus
margarita*

% des feuilles endommagées



Non
mycor.

+ *Glomus
margarita*

Protection contre *Manduca sexta*



Photo: Hans van Pelt

Protection contre *Manduca sexta*



0



1

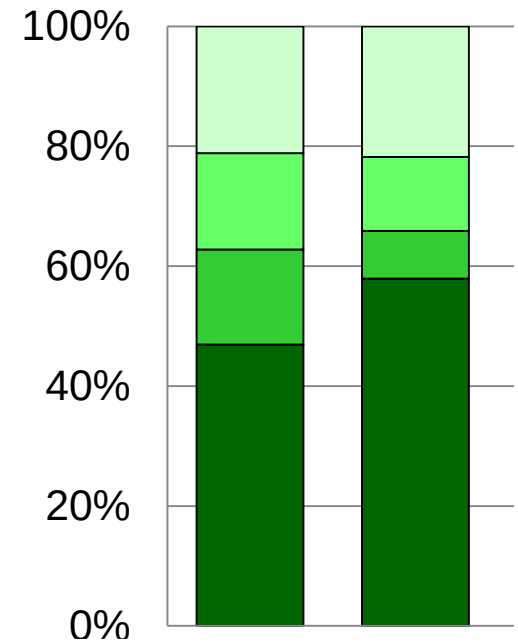


2



3

Catégories
de dommages



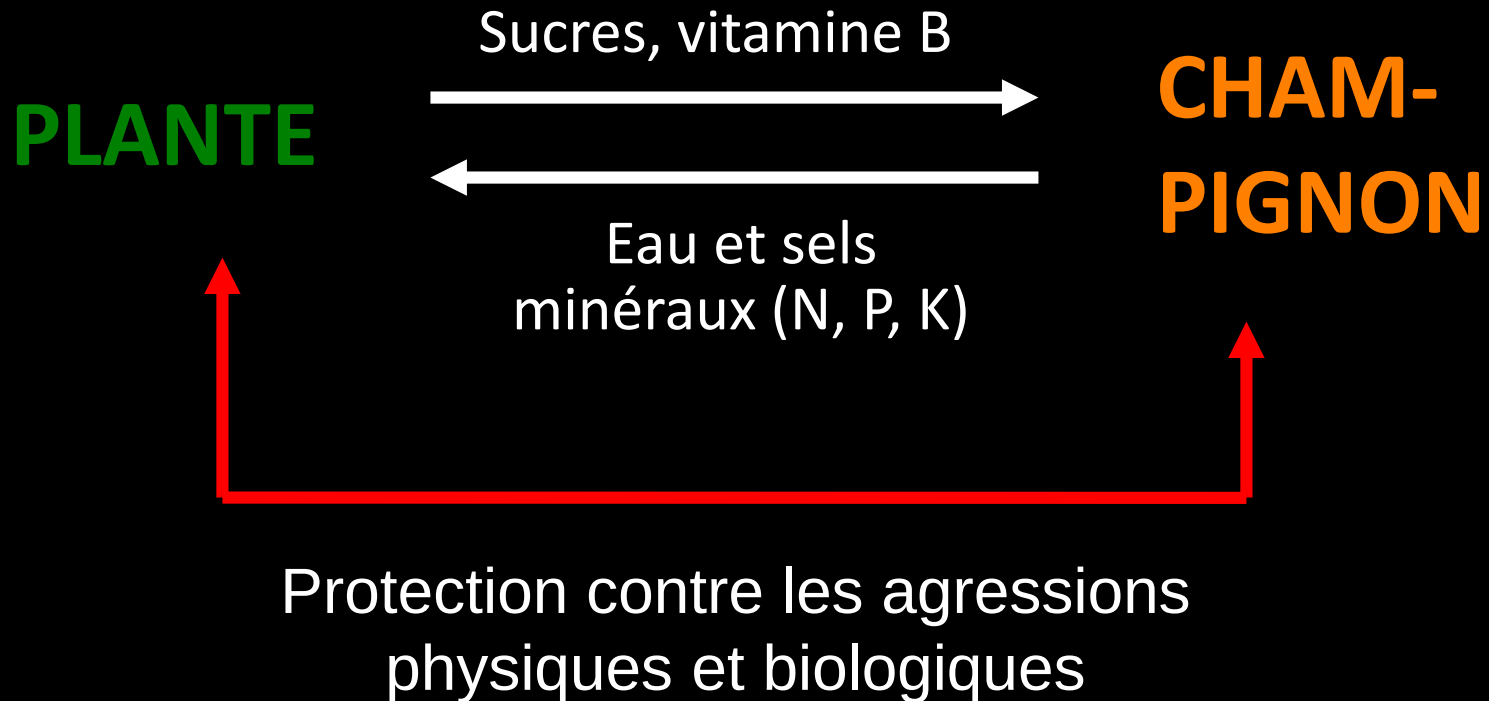
Non
mycorrhizal

+ *Glomus
margarita*



LA MYCORHIZE, UNE SYMBIOSE

Echanges nutritifs et protection réciproques :

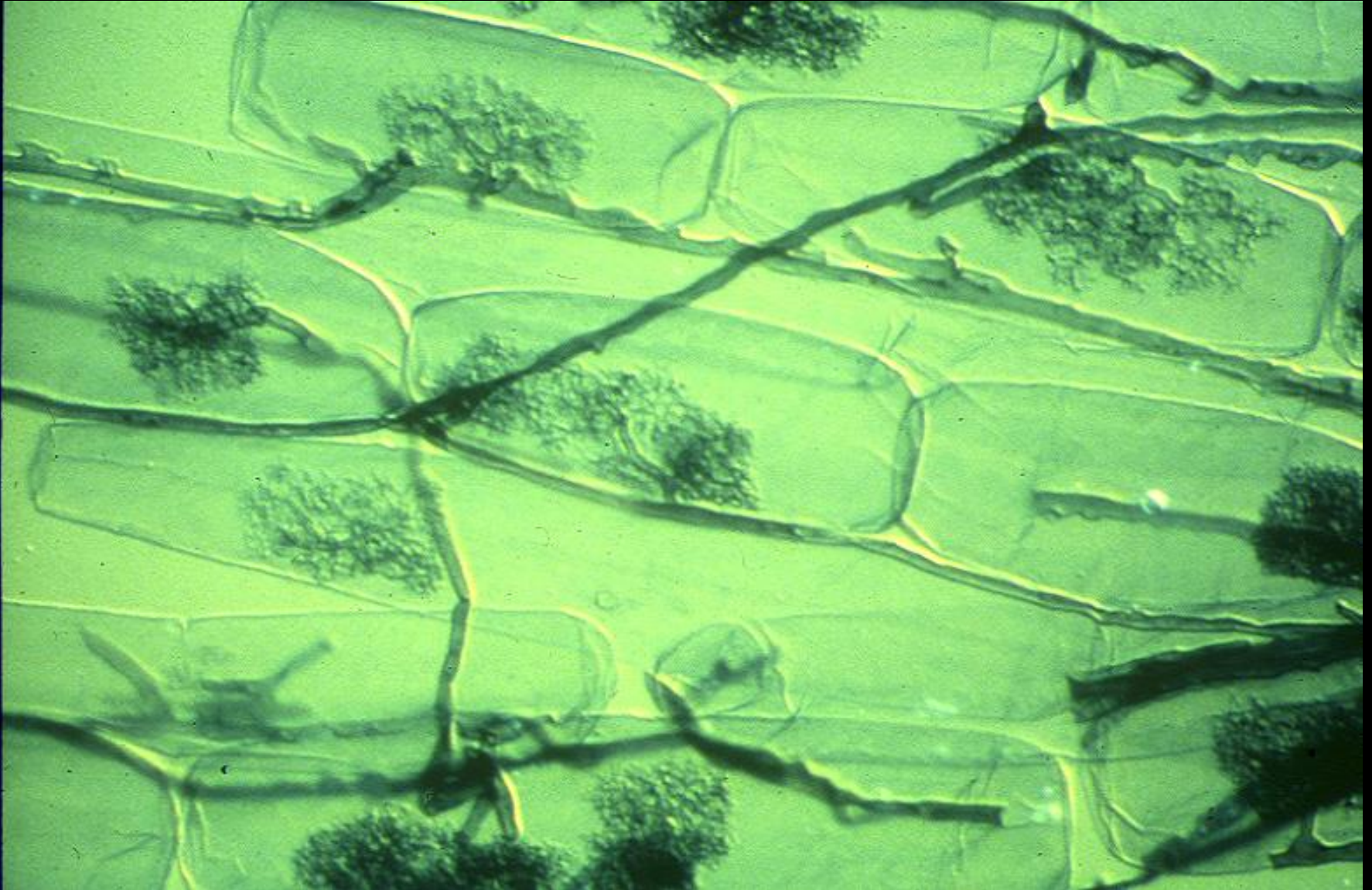


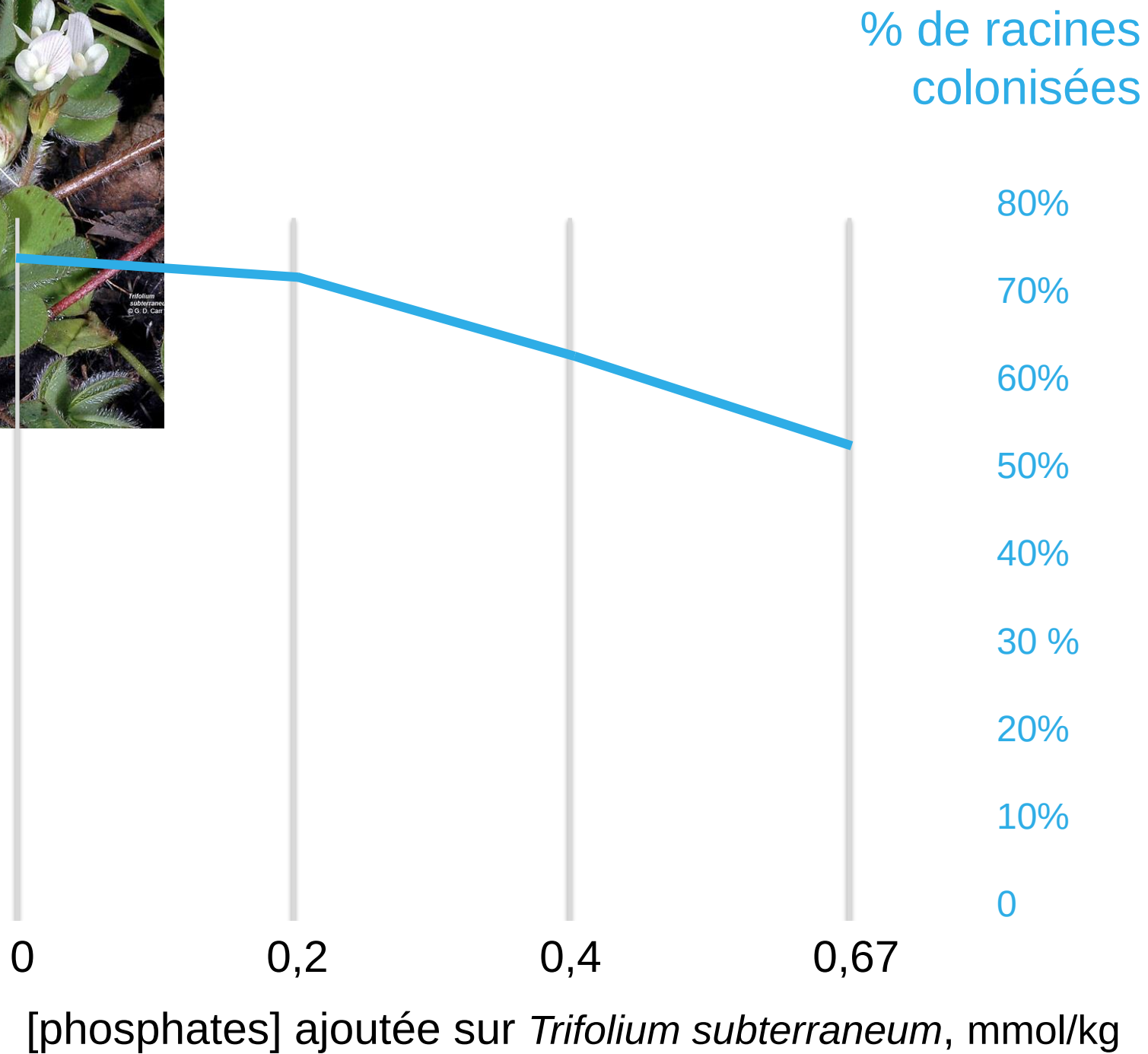
5.

D'étranges dérives...

Pour finir...

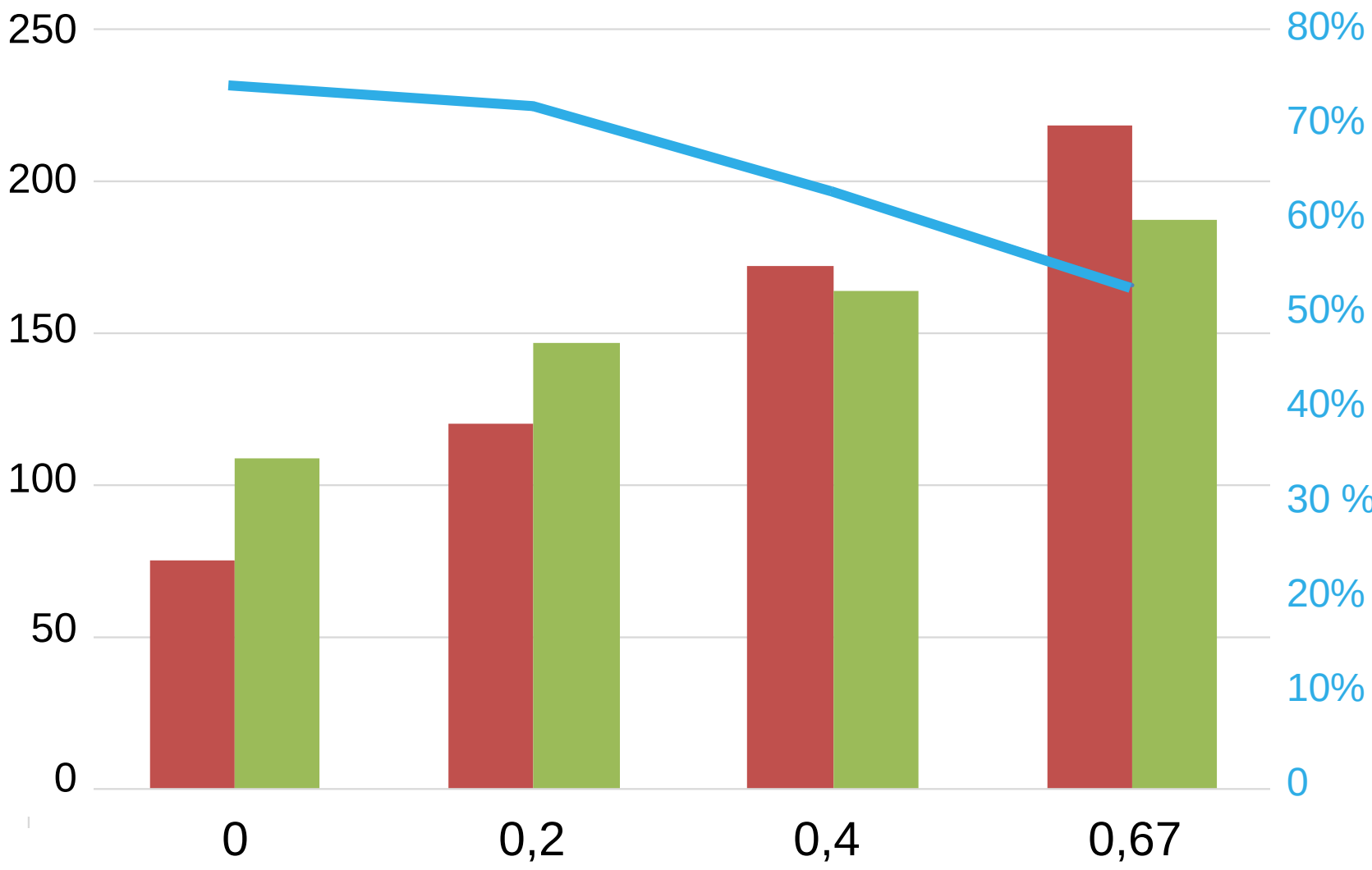
ENDOMYCORHIZE





Croissance non mycorhizée
Croissance mycorhizée
(en mg/plante, poids sec)

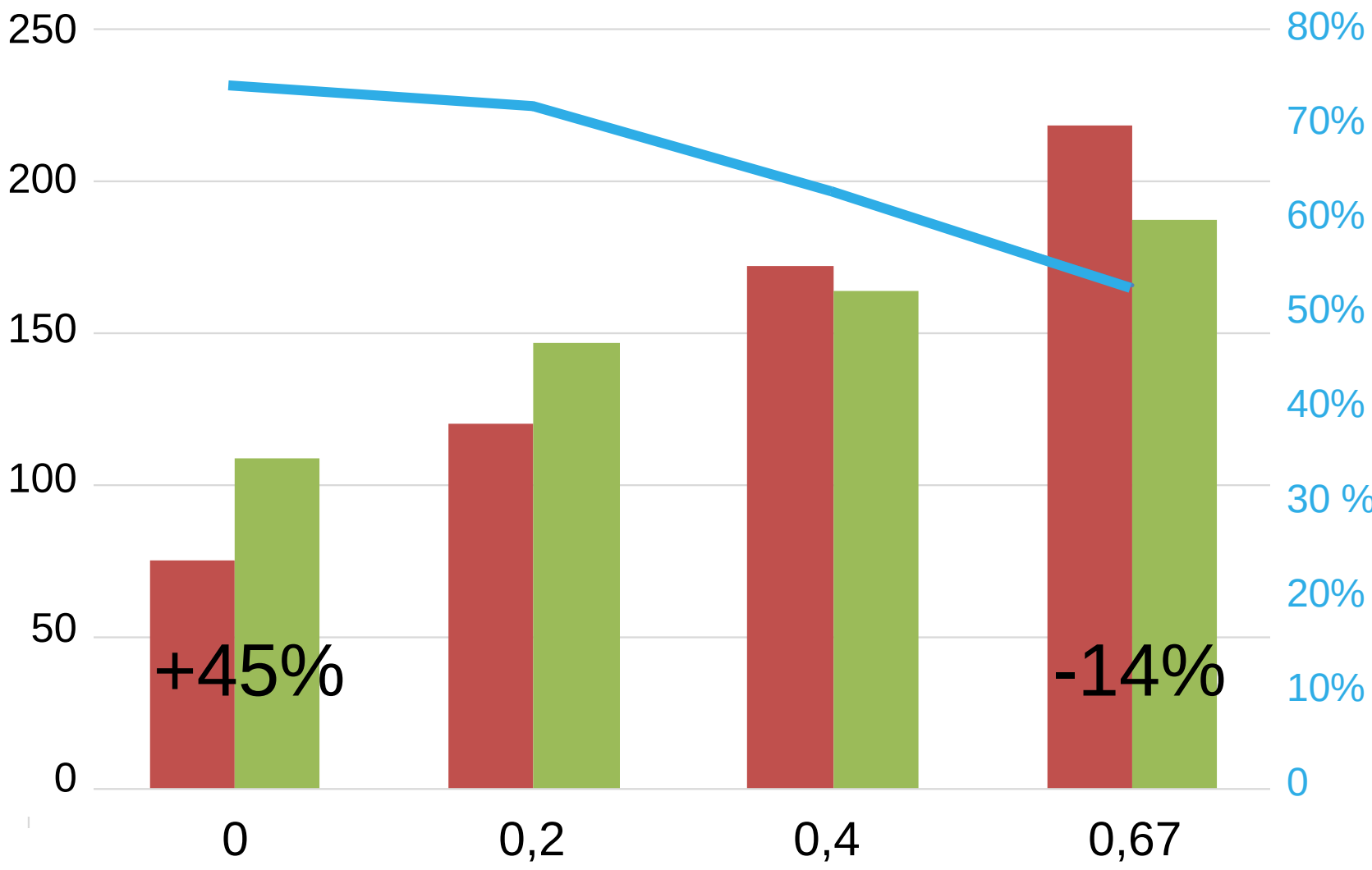
% de racines
colonisées



[phosphates] ajoutée sur *Trifolium subterraneum*, mmol/kg

Croissance non mycorhizée
Croissance mycorhizée
(en mg/plante, poids sec)

% de racines colonisées



+45%

-14%

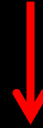
[phosphates] ajoutée sur *Trifolium subterraneum*, mmol/kg

ENGRAIS



Diminution du taux
de mycorhization

PESTICIDES



Diminution du pouvoir
inoculant du sol

ENGRAIS



Diminution du taux
de mycorhization



PESTICIDES



Diminution du pouvoir
inoculant du sol



Perte des mycorhizes et de l'interaction

```
graph TD; ENGRAIS --> D1[Diminution du taux de mycorhization]; D1 --> P1[Perte des mycorhizes et de l'interaction]; P1 --> D2[Dépendance accrue aux engrais]; D2 --> ENGRAIS; PESTICIDES --> D3[Diminution du pouvoir inoculant du sol]; D3 --> P1; P1 --> D4[Dépendance accrue aux pesticides]; D4 --> PESTICIDES;
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ENGRAIS

PESTICIDES

Diminution du taux
de mycorhization

Diminution du pouvoir
inoculant du sol

Perte des mycorhizes et de l'interaction

Dépendance accrue
aux engrais

Dépendance accrue
aux pesticides



JAMAIS SEUL

Actes Sud

14 juin 2017