IPM 2.0

Towards future-proof crop protection in Europe

Agricultural practices and Ecology of soil-borne plant pathogenic microorganisms

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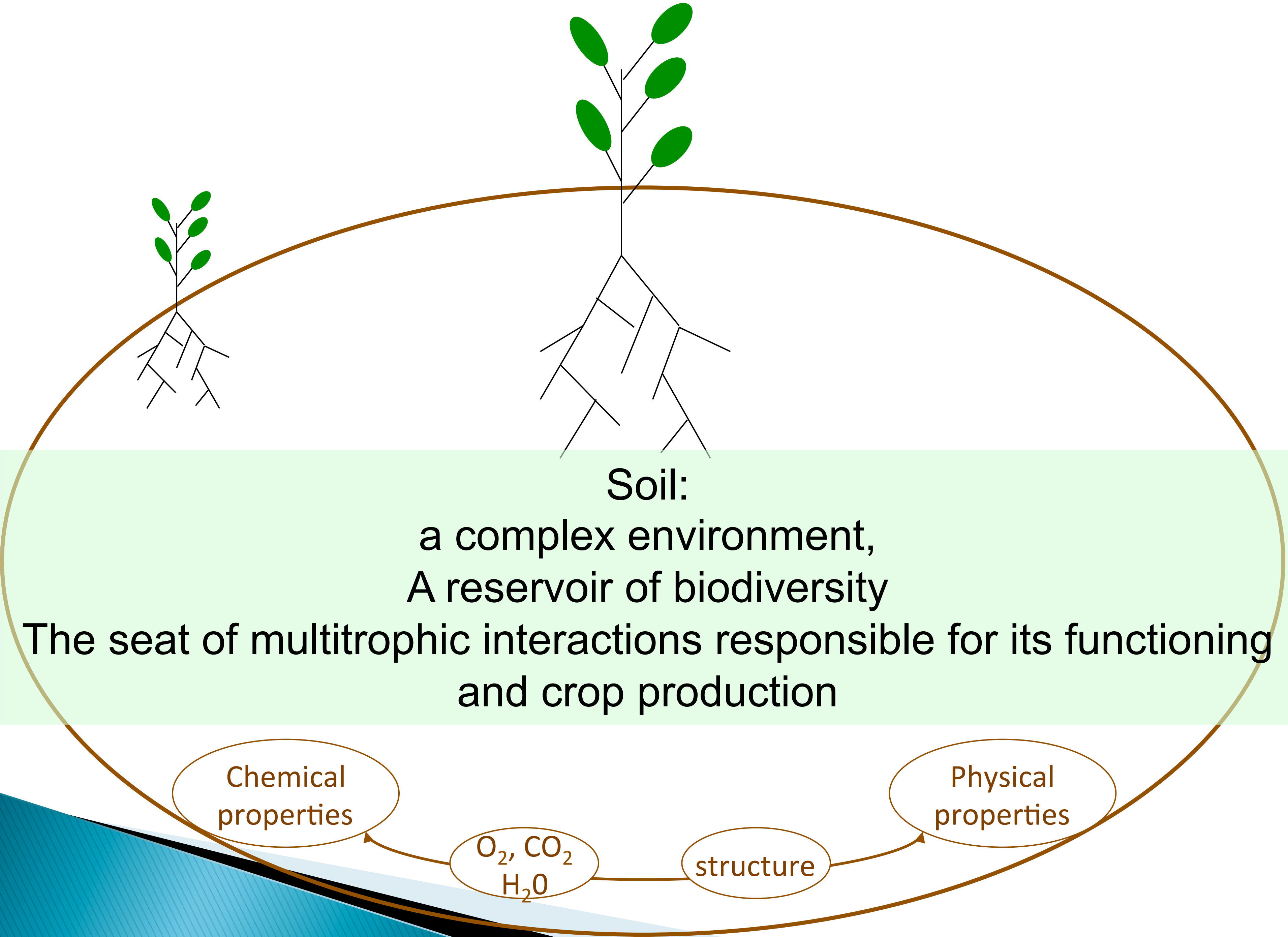
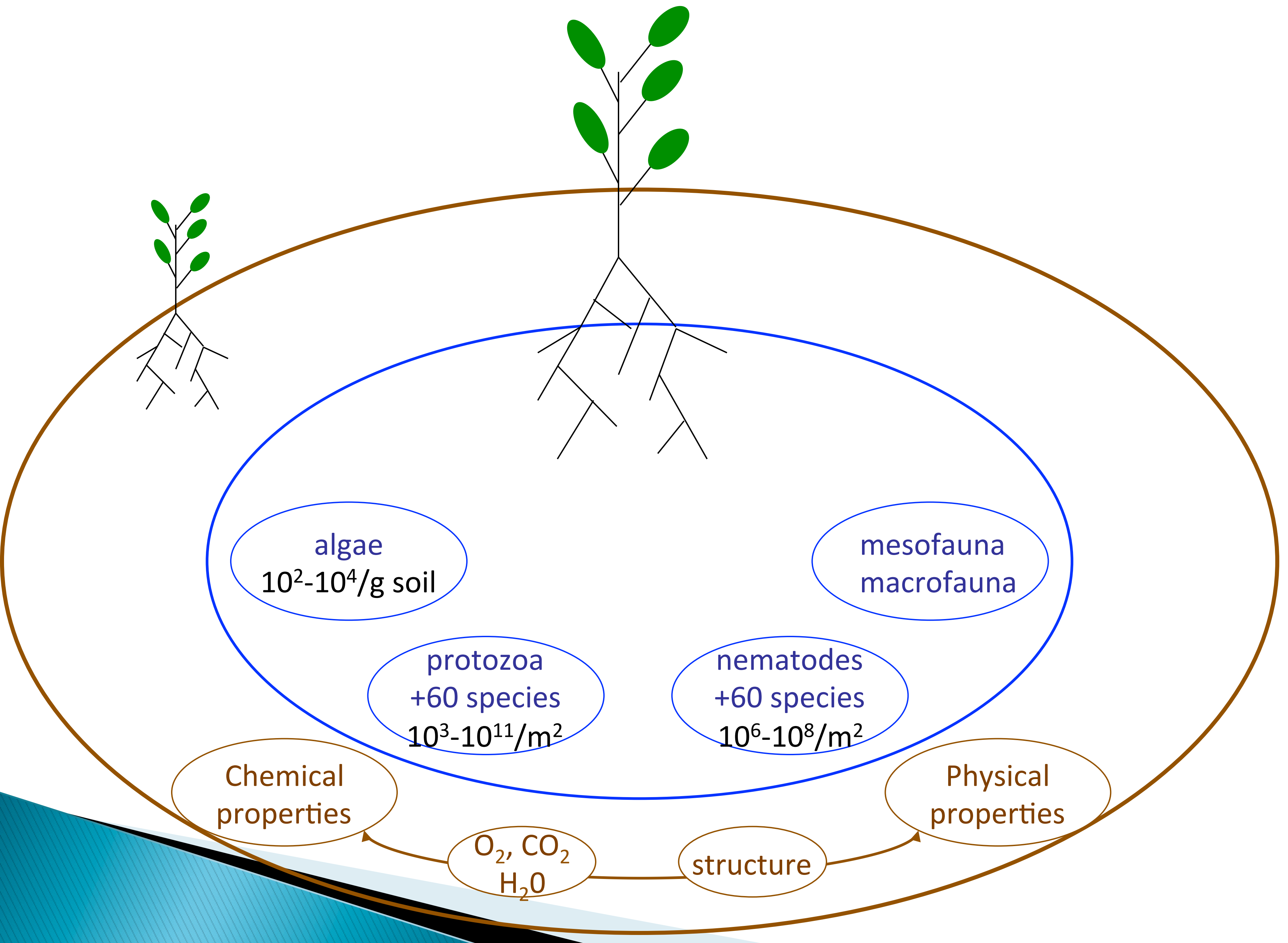
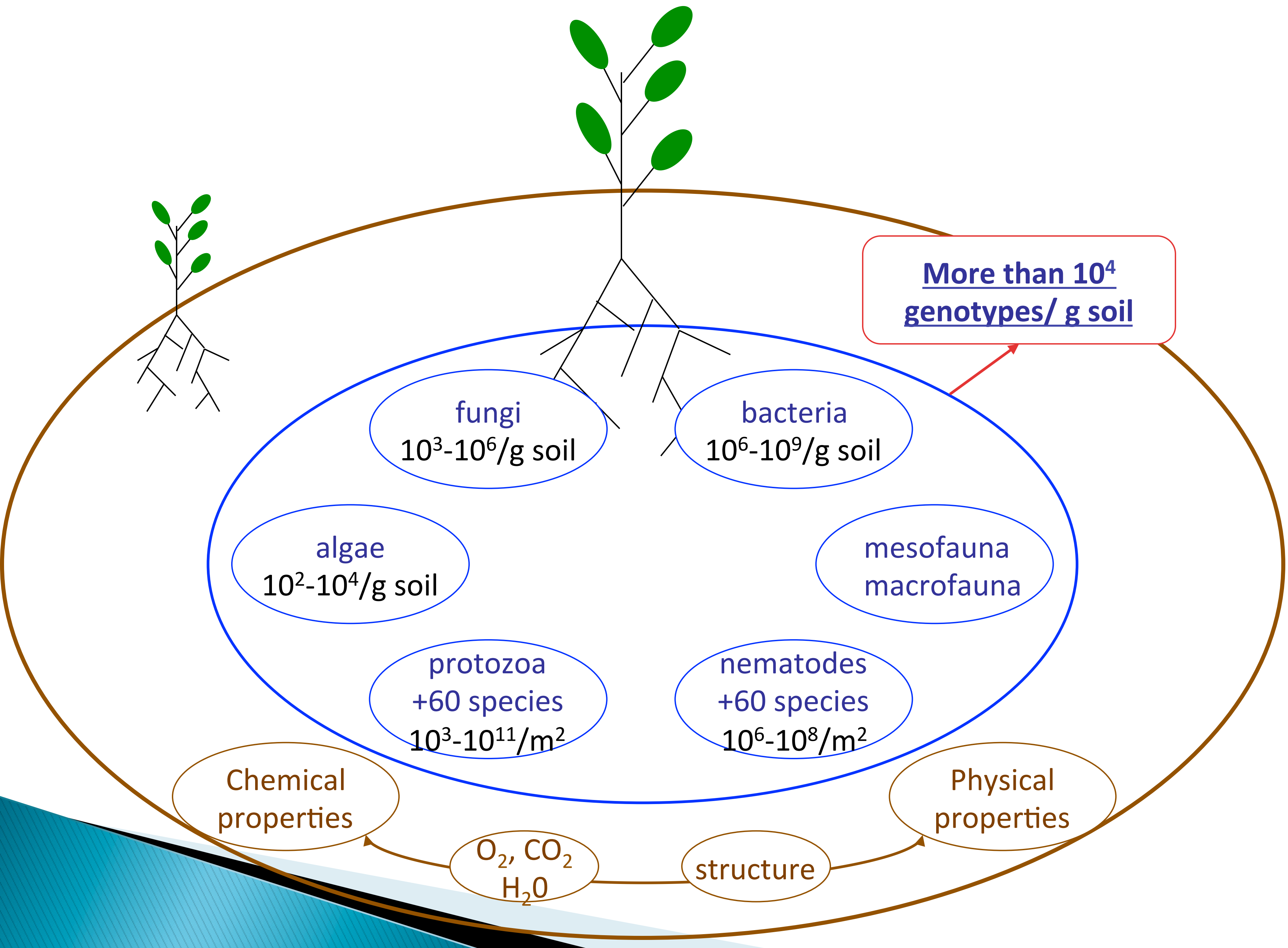
EFPP European Foundation for Plant Pathology

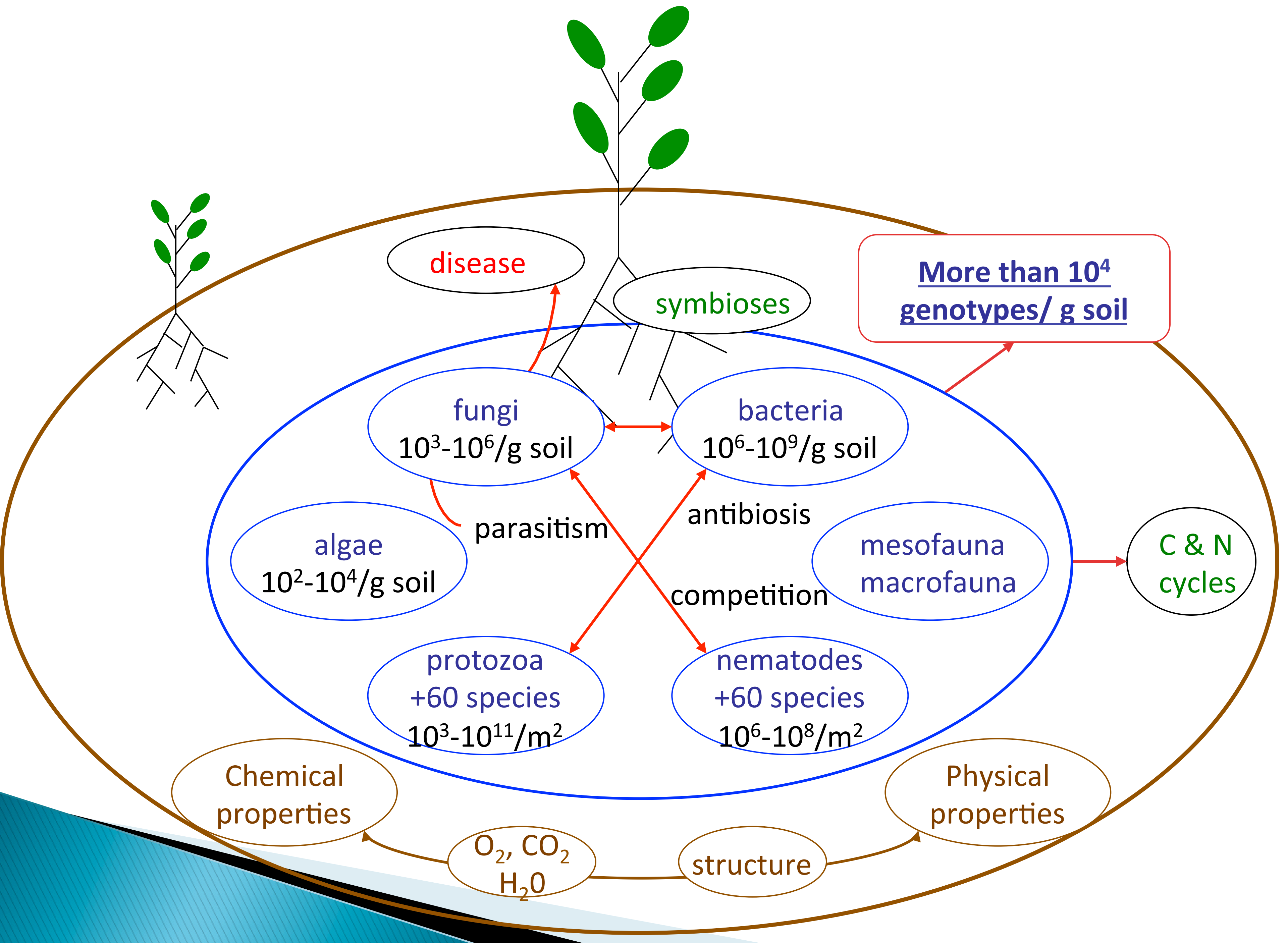

Soil:
a complex environment,
A reservoir of biodiversity
The seat of multitrophic interactions responsible for its functioning
and crop production
Chemical properties
Physical properties
O_2, CO_2
H_20
structure



algae
10²-10⁴/g soil
mesofauna
macrofauna
protozoa
+60 species
10³-10¹¹/m²
nematodes
+60 species
10⁶-10⁸/m²
Chemical properties
Physical properties
O₂, CO₂
H₂0
structure



More than 10^4 genotypes/ g soil
fungi
10^3-10^6/g soil
bacteria
10^6-10^9/g soil
algae
10^2-10^4/g soil
mesofauna
macrofauna
protozoa
+60 species
10^3-10^{11}/m^2
nematodes
+60 species
10^6-10^8/m^2
Chemical properties
Physical properties
O_2, CO_2
H_20
structure


disease
symbioses
More than 10^4 genotypes/ g soil
fungi
10^3-10^6/g soil
bacteria
10^6-10^9/g soil
parasitism
antibiosis
algae
10^2-10^4/g soil
mesofauna
macrofauna
C & N cycles
competition
protozoa
+60 species
10^3-10^{11}/m^2
nematodes
+60 species
10^6-10^8/m^2
Chemical properties
Physical properties
O_2, CO_2
H_20
structure

Why are management strategies
of short duration efficiency?

Binary interactions : crop ⟷ target population

Why are management strategies of short duration efficiency?

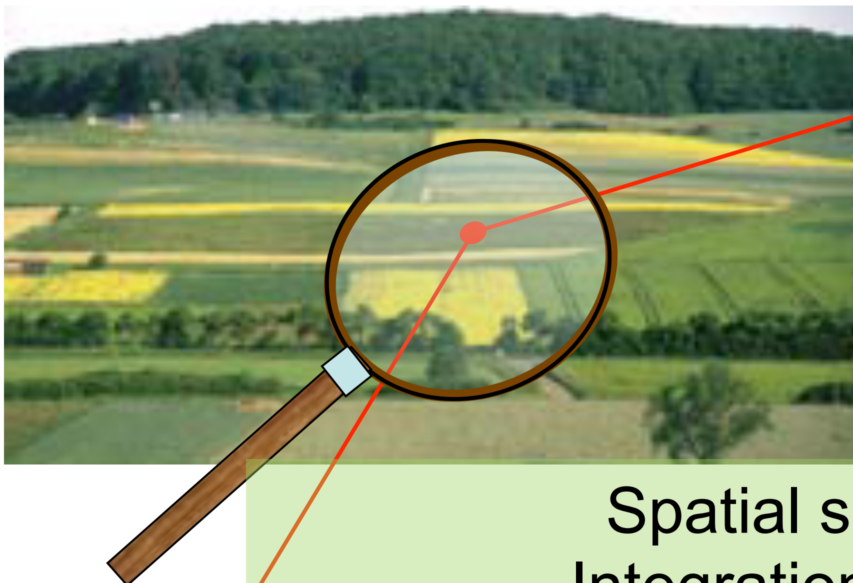
Binary interactions : crop ⟷ target population

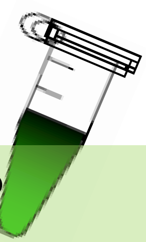
Methods :

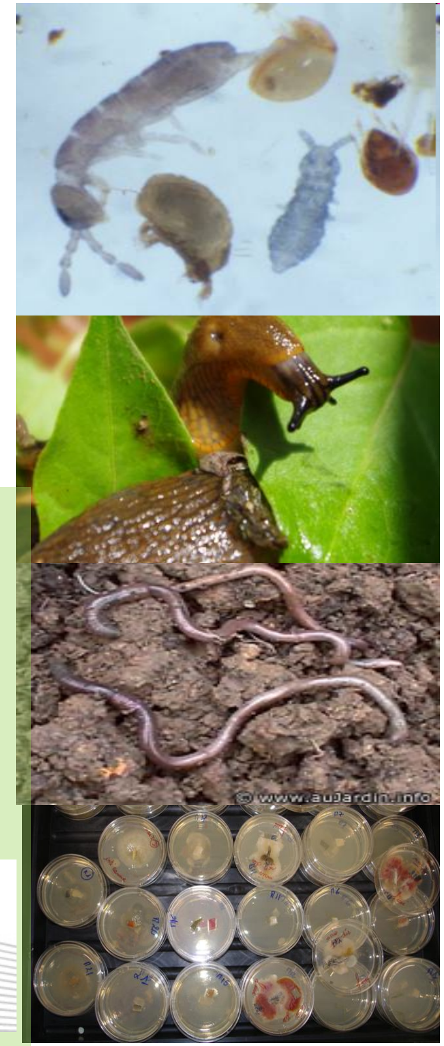
- pesticides
- resistant varieties
- GM plants
- healthy seeds
- physic therapy
- biocontrol agents

Risks

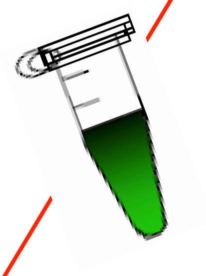
- To create partial or total ecological voids according to the action spectrum of chemical molecules.
- To create partial ecological voids (eradication of major pests)
- To circumvent the effect of the methods by bioaggressors or other pathotypes (adaptation).
- To stimulate other pest invasion and multiplication (no competition).



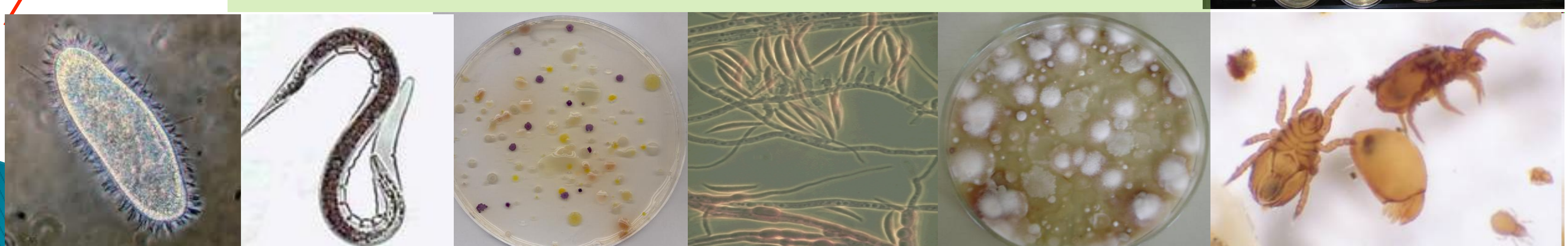




Spatial scale ?
Integration level?
Representativity?

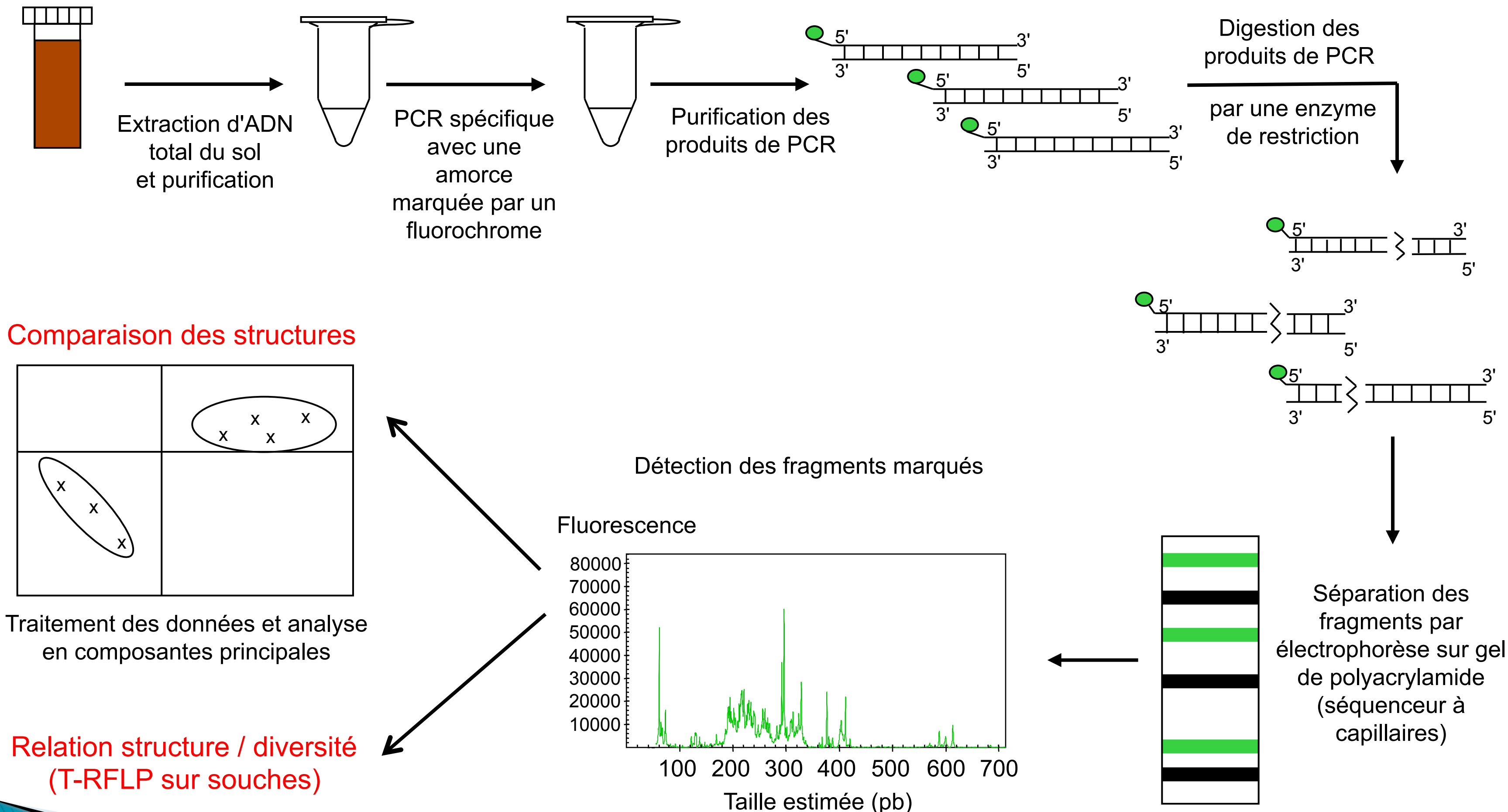


- Ecofinders
- Soil quality assesment

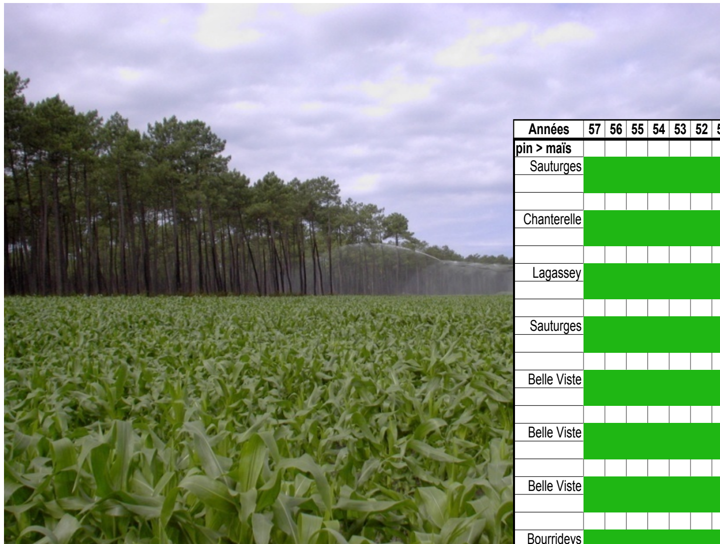


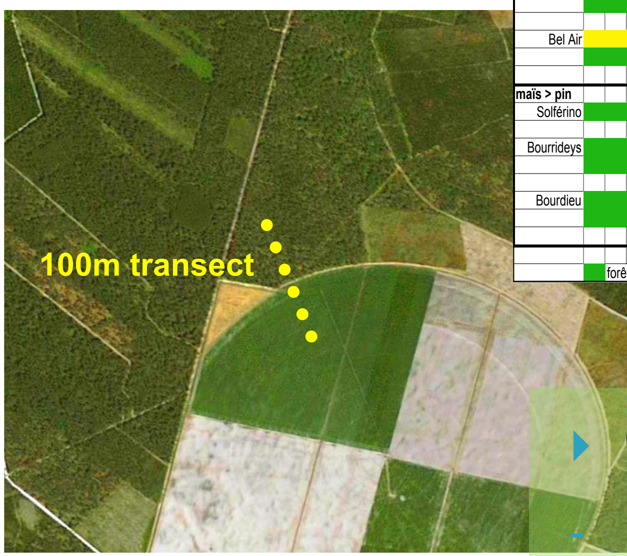
http://www.ecofinders.eu/

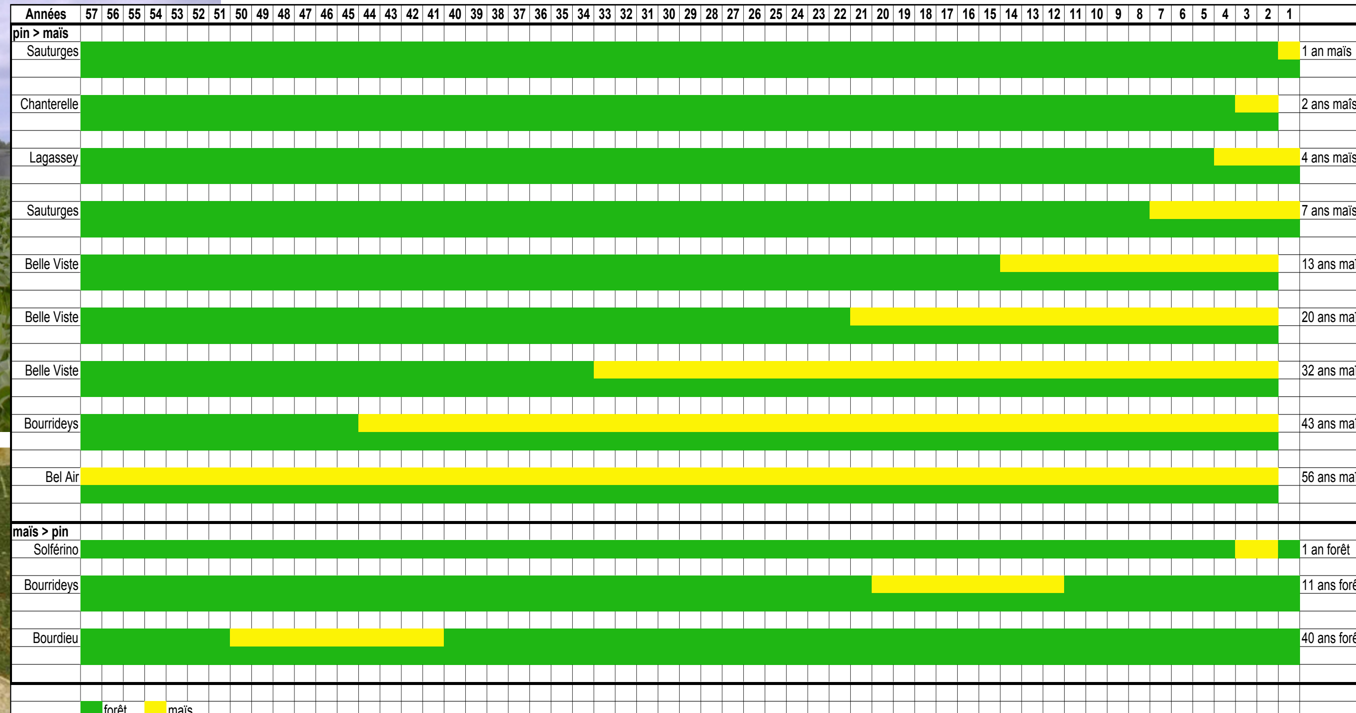
Terminal restriction fragment length polymorphism (T-RFLP) analysis



Land use,
increasing anthropogenic activities
and biotic reactions



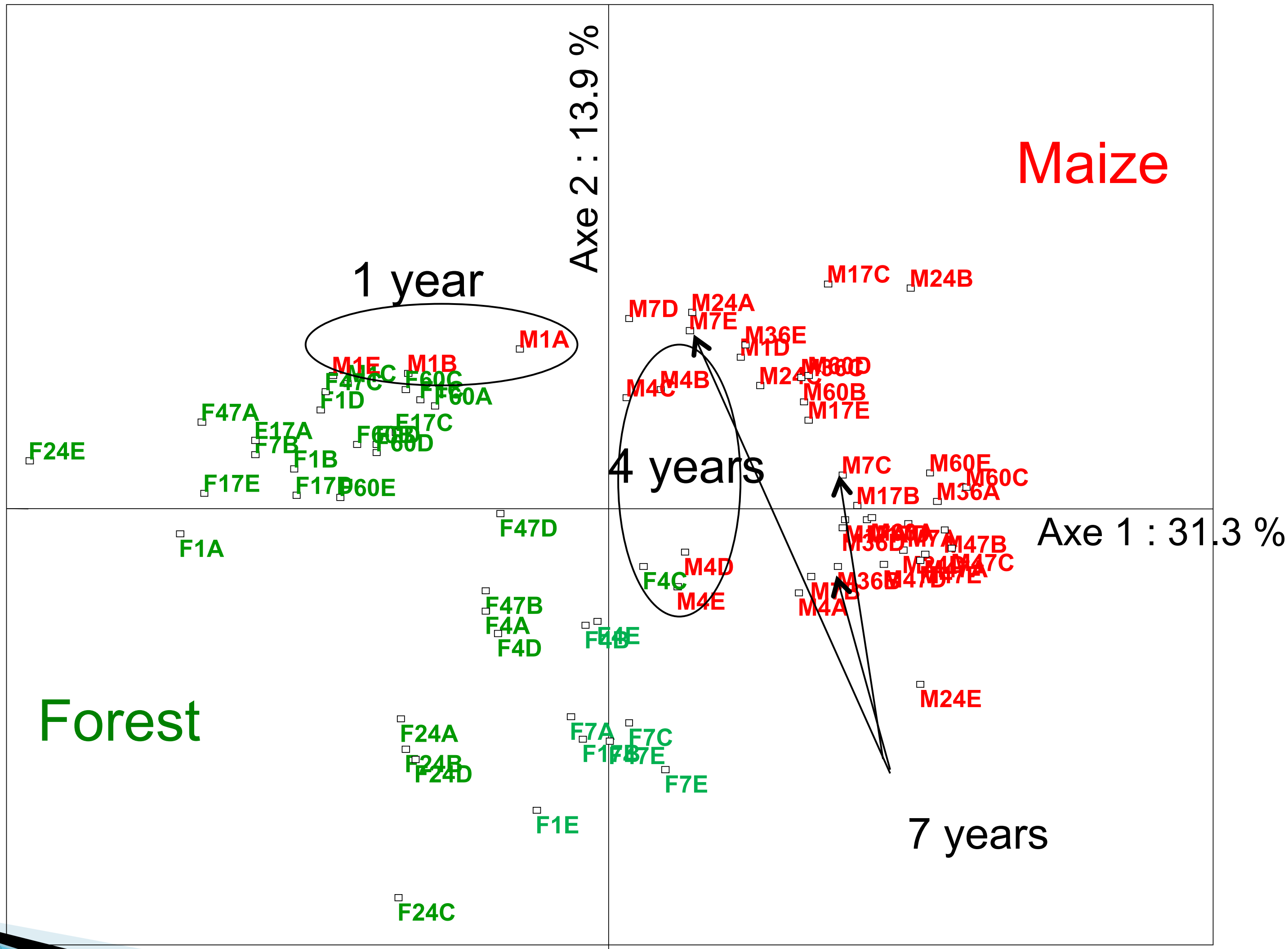




- **Chronosequence of land use**
  - forest = every 40 years
  - corn monocropped = 1, 2, 4, 7, … 56 years
  - carrot rotation (every 4 years) = 2 cycles

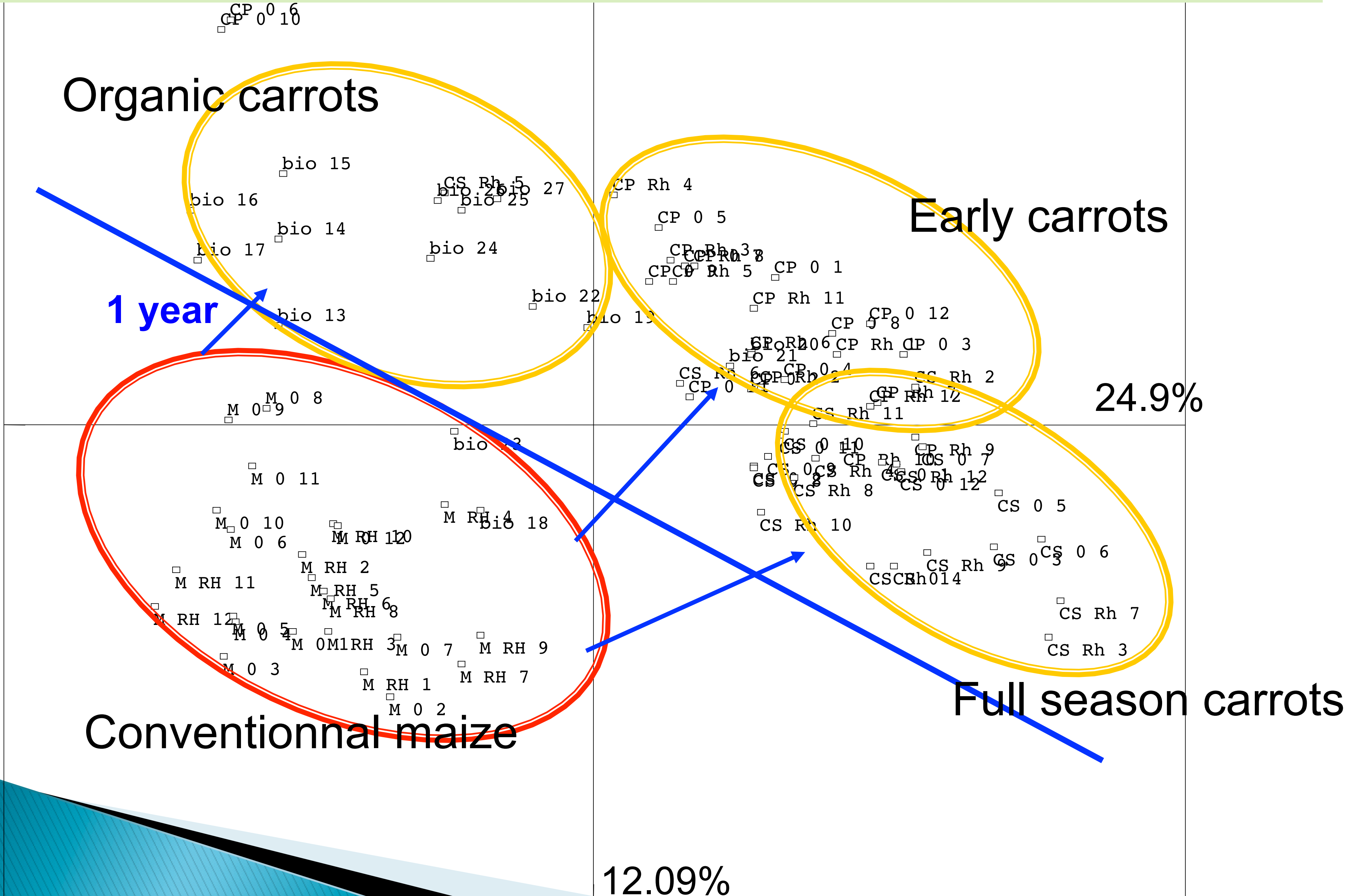
Structure of fungal communities, from forest to maize

(same for the bacteria)



Edel-Hermann et al 2011

Structure of fungal communities, from maize to carrots



Edel-Hermann et al 2011

Carrot significantly reduces both richness and diversity

	Landes	**Forêt**	**Maïs**	**Carotte**
Phytoparasites		*Criconema*	*Criconema*	
stricts	*Helicotylenchus*	*Helicotylenchus*	*Helicotylenchus*	
	Helicotylenchus			
	Hemicriconemoides		*Hemicriconemoides*	
	Hemicriconemoides			
	Hemicycliophora	*Hemicycliophora*		*Hemicycliophora*
	Heterodera	*Heterodera*	*Heterodera*	
		Paratylenchus	*Paratylenchus*	
		Pratylenchus	*Pratylenchus*	*Pratylenchus*
	Rotylenchus	*Rotylenchus*	*Rotylenchus*	
	Trichodorus	*Trichodorus*	*Trichodorus*	*Trichodorus*
	Tylenchorhynchus		*Tylenchorhynchus*	
	Tylenchorhynchus		*Tylenchorhynchus*	
Généralistes		*Aphelenchoides*		*Aphelenchoides*
	Aphelenchoides			
		Ditylenchus		
		Filenchus	*Filenchus*	*Filenchus*
	Tylenchidae	*Psilenchus*	*Psilenchus*	*Rotylenchus*
		Tylencholaimus	*Tylencholaimus*	*Tylencholaimus*
		Tylenchus	*Tylenchus*	*Tylenchus*
	Dorylaimida	*Dorylaimida*	*Dorylaimida*	*Dorylaimida*

Mateille 2011

Agricultural practices :

Biofumigation,

Tillage,

Preceeding crops,

Organic amendments,

…,

- Bio-disinfection by introduction of a Brassicaceae (fodder radish)

Intermediate crop in maize-carrot rotation

T0 — April: -Raddish Sowing

June: Crushing and burying radish

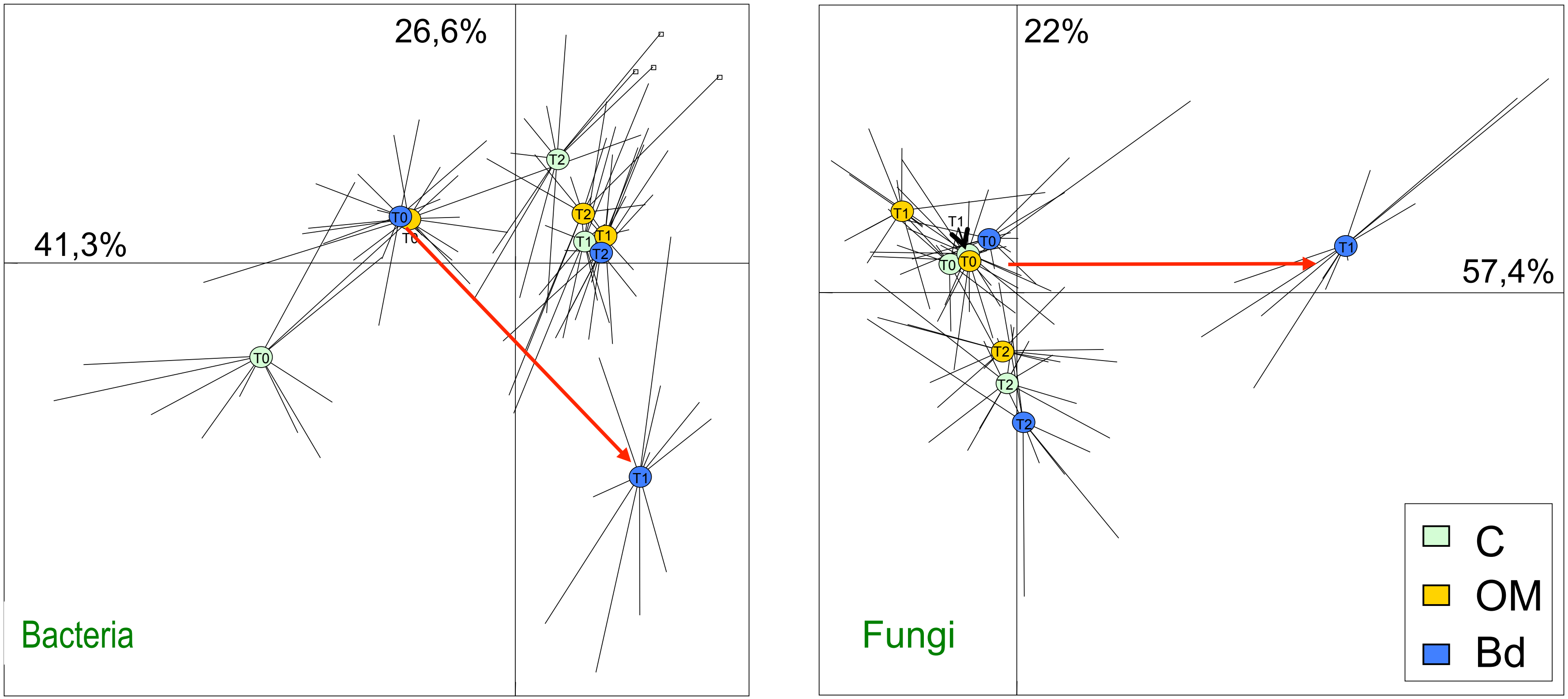
4 weeks

T1 — July: Carrot sowing

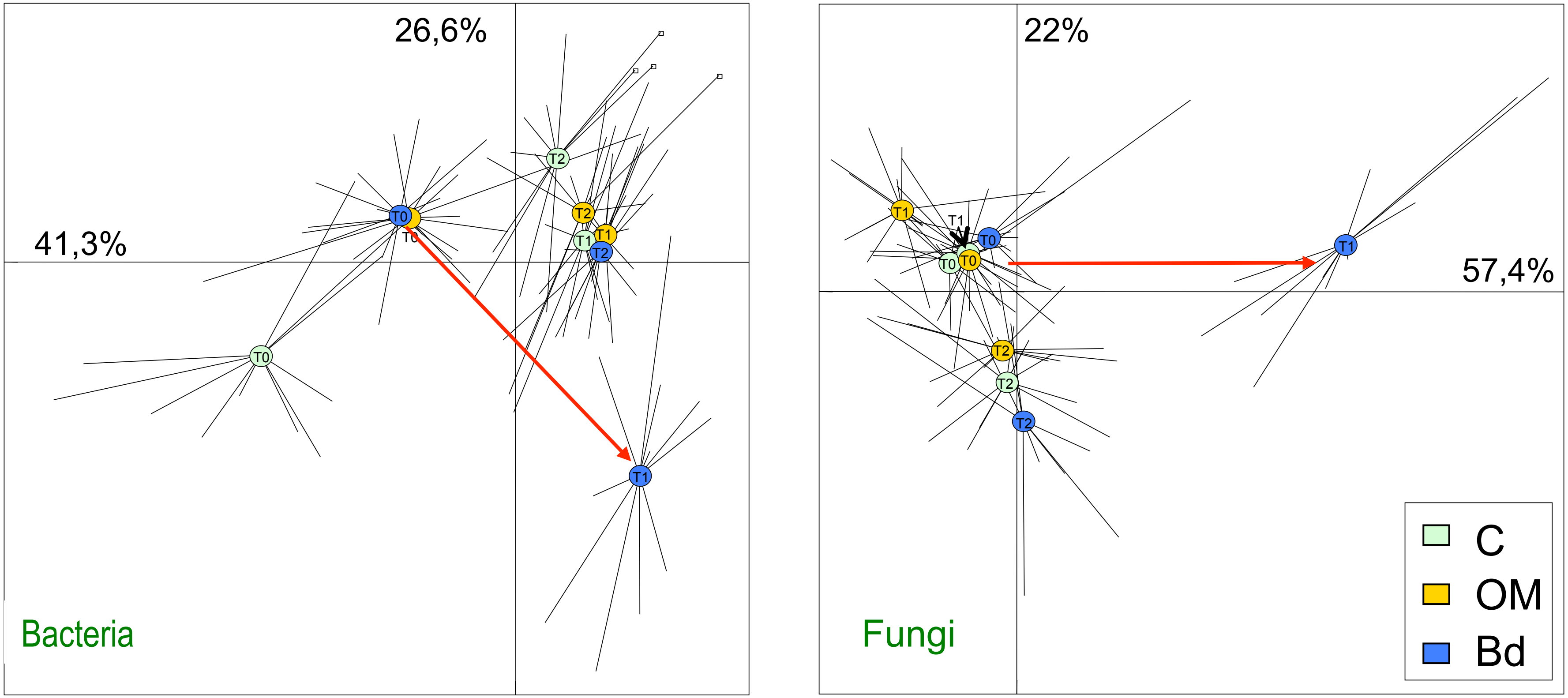
T2 — October: Harvest



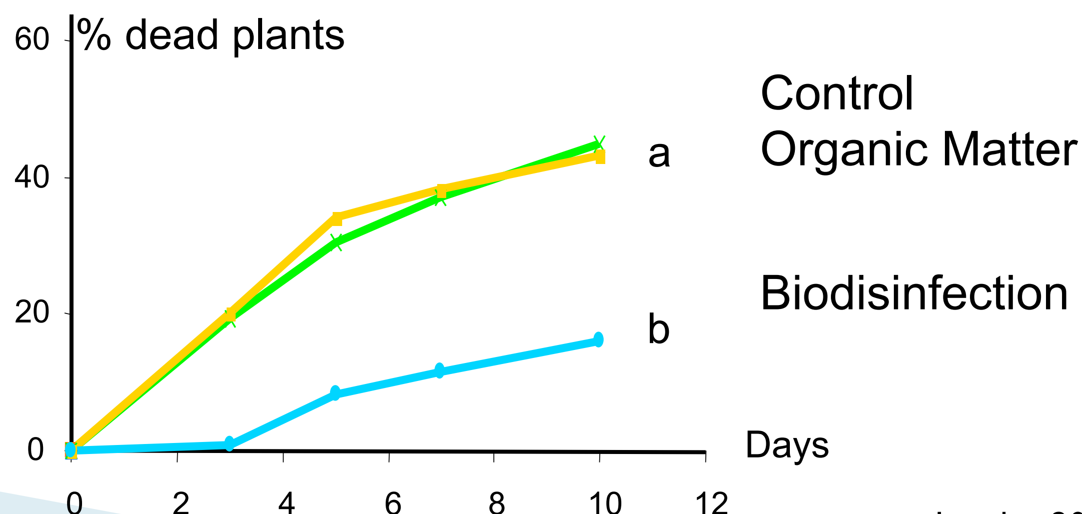




26,6%
41,3%
T0
T0
T2
T2
T1
T1
T2
T0
T1
Bacteria
22%
57,4%
T1
T1
T0
T0
T0
T1
T2
T2
T2
Fungi
C
OM
Bd



Soil Inoculum Potential



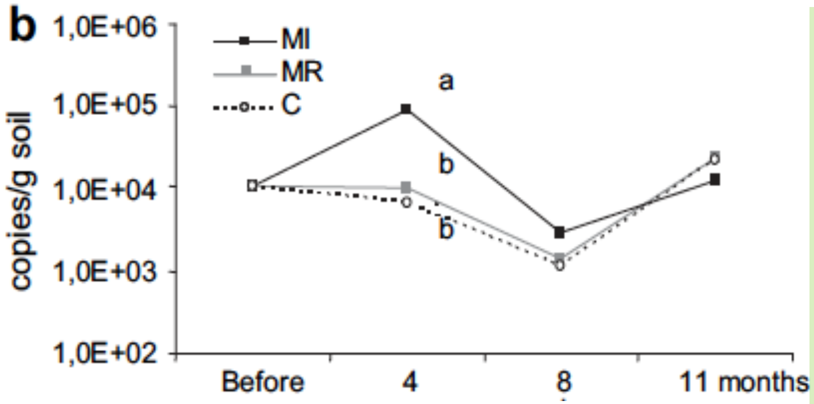
Janvier 2007

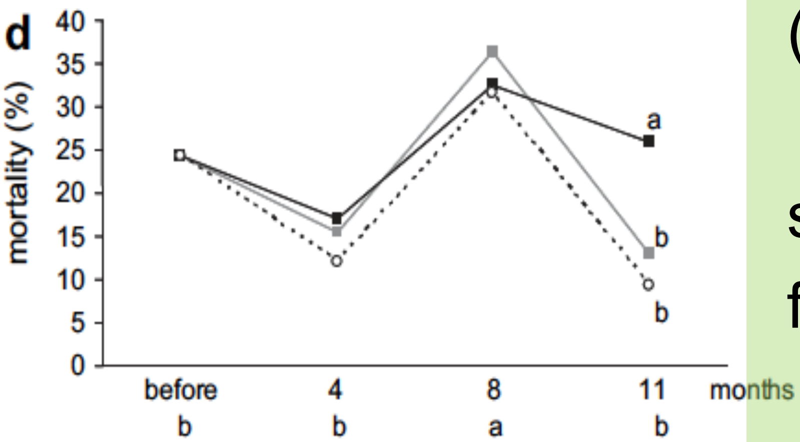


Conclusion:

Bio-disinfection by Brassicaceae:

- allows to control damping-off and root necrosis for the coming culture (fungi, nematodes)
- does not decrease or can sometime increase the risk of attacks for the following crops.
- Need for combining several strategies (bio-disinfection + BCA)





Friberg et al 2009

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Organic amendments

composts	V. dahliae	R. solani - cauliflowe	P.nicot- tomato	P. cinnamomi- lupin	Cylindrocl -adium spatiphylli	R. solani- pine	F. oxysporum flax
GR 6	14,52	-87,29	0,00	23,81	24,14	83,51	2,08
dec01	-21,37	57,80	52,17	-24,26	-27,90	0,87	64,17
GR5	31,73	0,00	--	-3,20	-11,54	15,35	58,23
dec02	-15,36	49,74	17,39	-3,47	-28,00	20,97	70,52
Ut 0303	1,28	68,03	28,99	-17,33	-18,53	-11,33	67,21
CO 7	34,76	32,10	14,49	48,53	-48,84	8,44	65,18
CO 16	31,47	35,29	58,82	-28,57	1,55	1,77	63,81
GR3a	38,05	11,90	--	61,30	-11,54	1,09	63,07
CO2	87,23	28,57	--	9,70	-23,08	-7,05	71,94
BOM 0303	-24,46	66,37	23,19	-20,80	63,54	29,92	65,81
GR3b	59,41	-4,24	2,94	71,43	23,81	4,48	47,89
1.02Ba	86,46	47,62		3,20	19,23	-0,88	45,66
CO 4	32,88	2,35	2,94	38,10	32,41	92,65	56,07
1.02S	74,03	50,00		3,20	34,62	-1,70	66,71
IS BS	-2,11	67,77	5,80	58,93	22,46	57,04	68,13
8.1S	86,25	38,10		3,20	53,85	-1,36	63,33
CO 17	52,96	8,47	91,18	57,14	47,38	4,92	32,85
CO 14	40,88	-10,12	67,65	47,62	100,00	27,24	65,86

Termorshuizen et al 2006

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Termorshuizen et al 2006

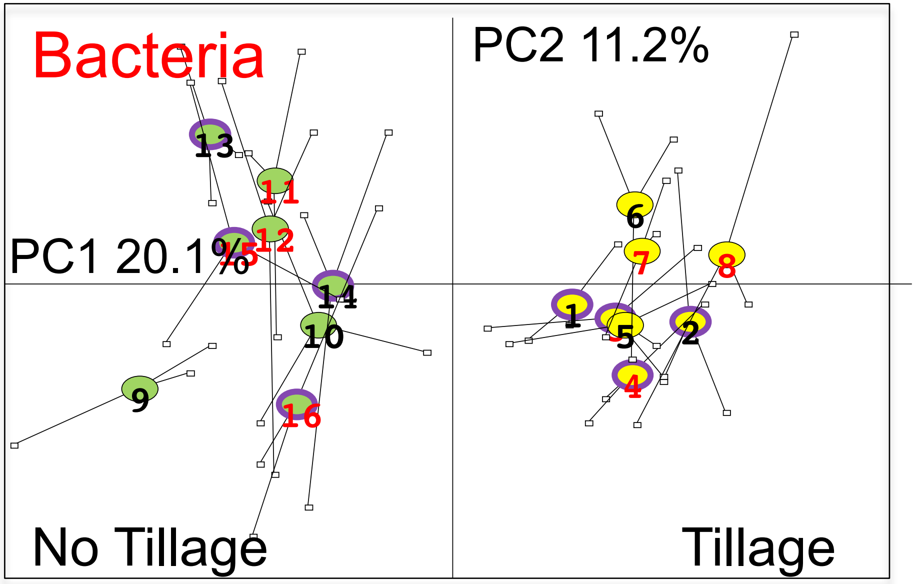
Tillage,

and crop residues,

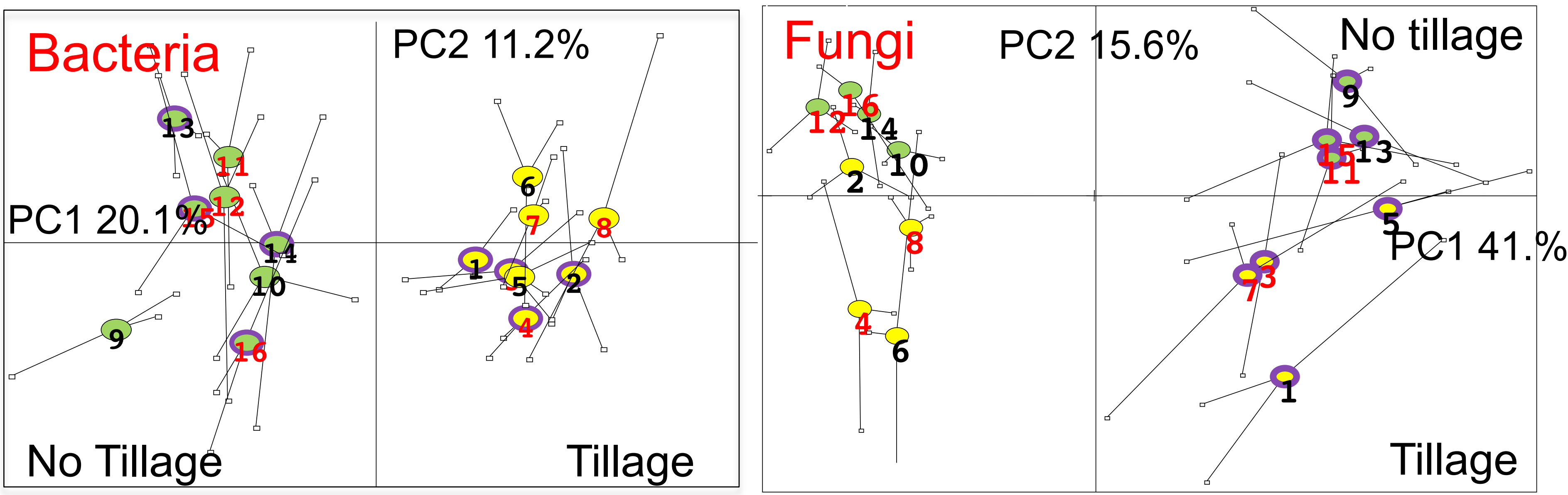
and preceding crop,

and rotation scheme,

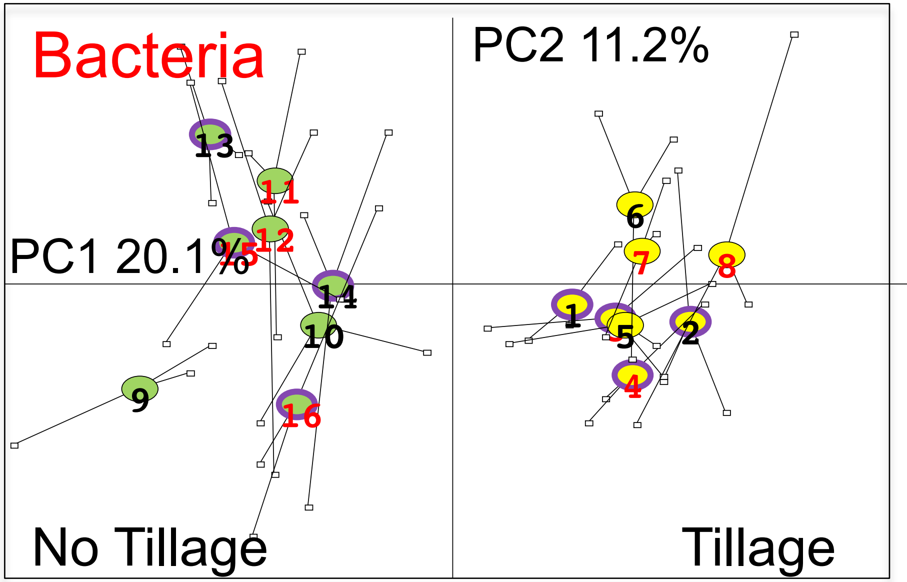
and,…

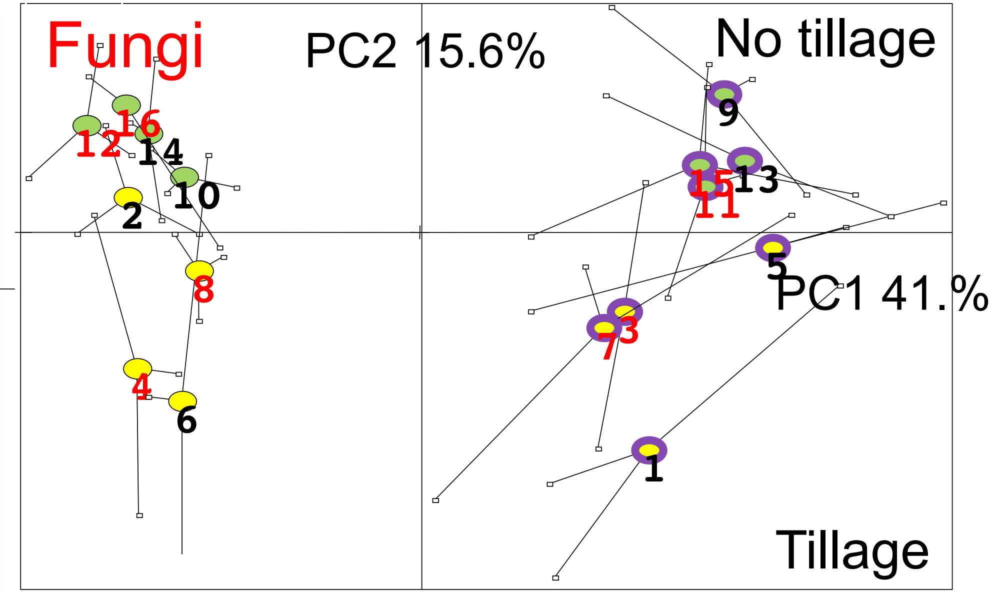


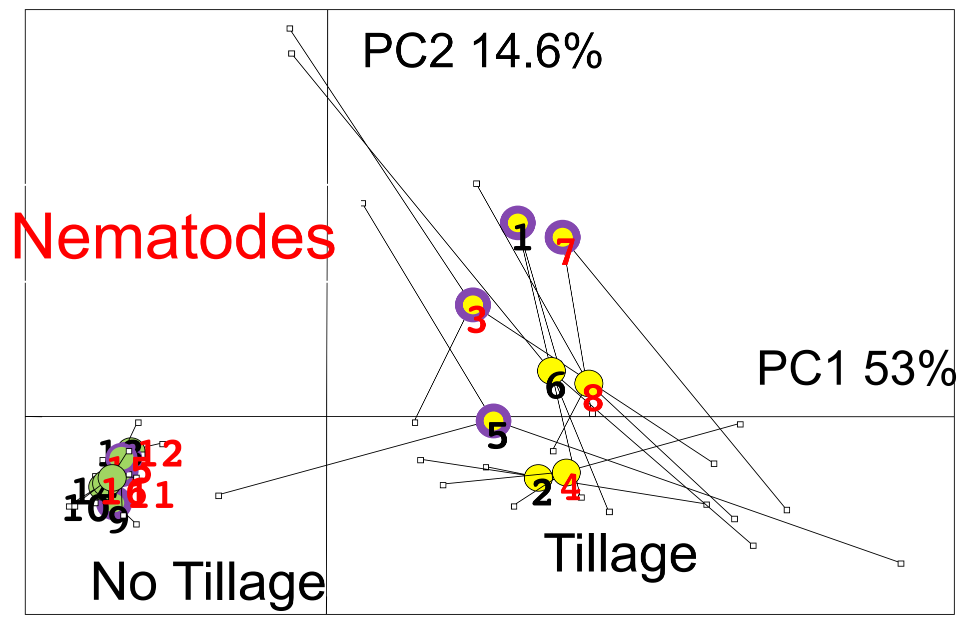
Bacteria
PC2 11.2%
PC1 20.1%
No Tillage
Tillage
13
11
12
15
14
10
9
16
6
7
8
1
5
2
4



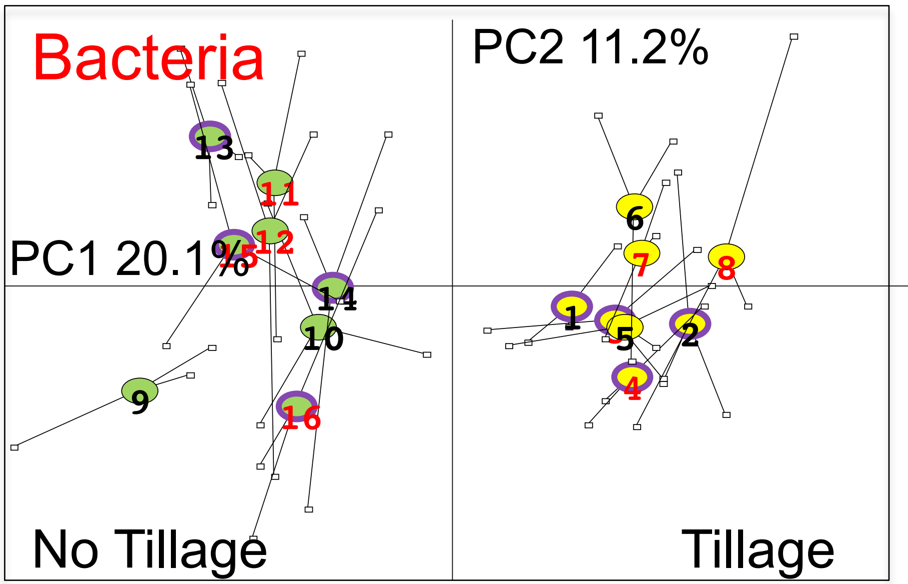
Bacteria
PC2 11.2%
PC1 20.1%
No Tillage
Tillage
13
11
12
15
14
10
9
16
6
7
8
1
5
2
4
Fungi
PC2 15.6%
No tillage
PC1 41.%
Tillage
16
12
14
10
2
8
4
6
9
15
13
11
5
7
3
1

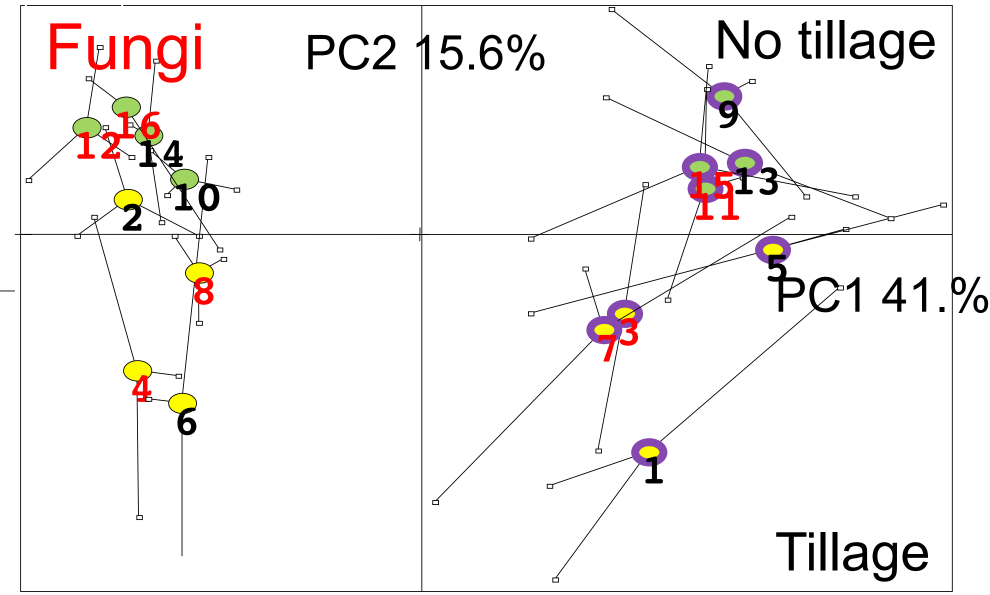






Abid et al 2012

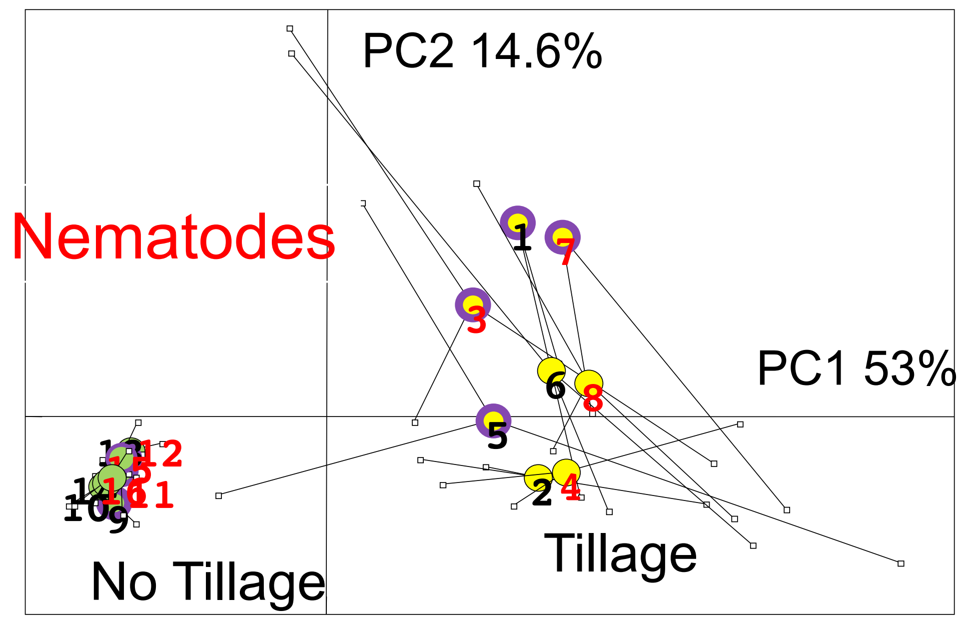




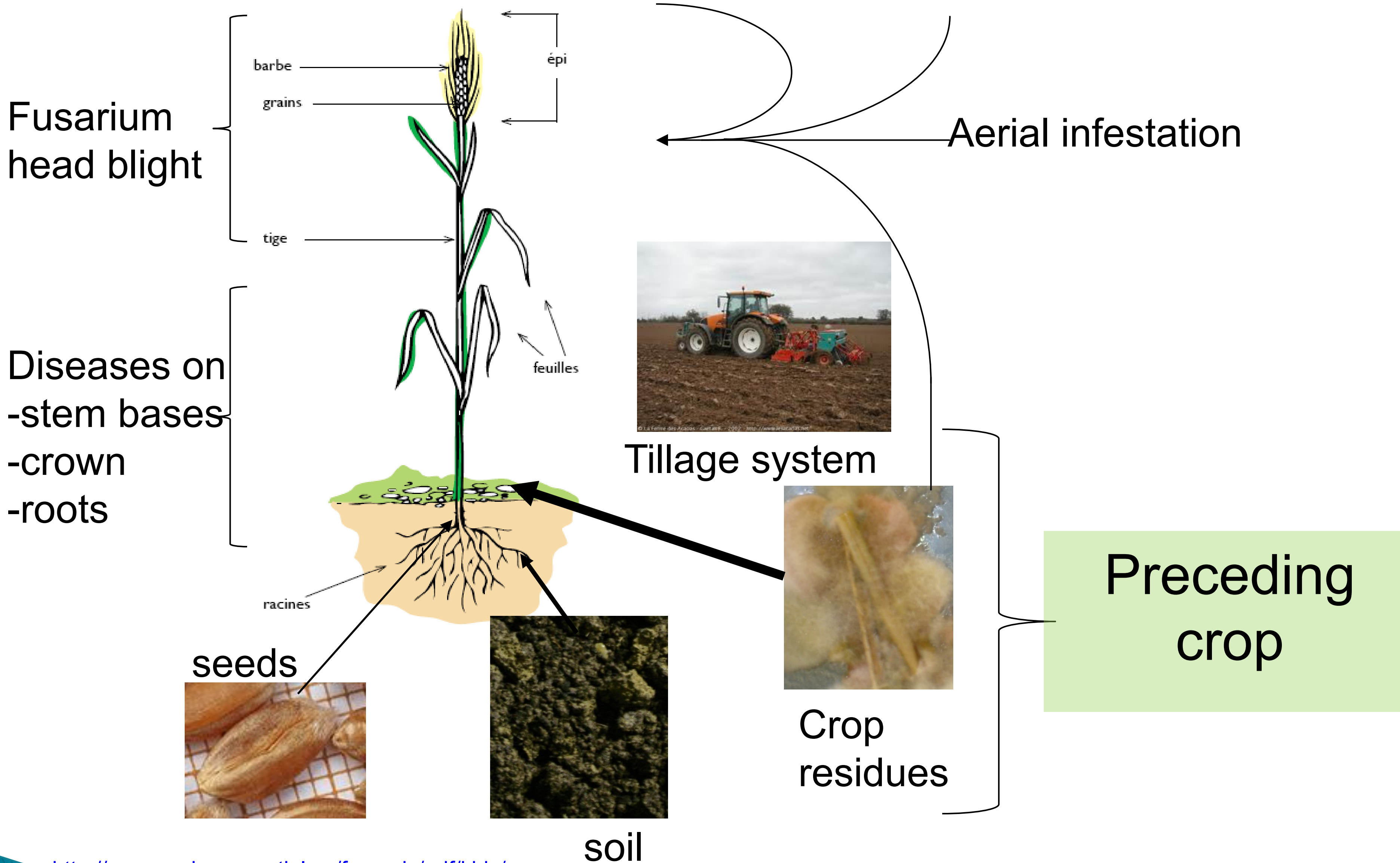
Shallow vs Mouldboard tillage

	No Til	+Til	
FHB/Spikelets	19.8%	13%	*
FHB/ears	9.4%	5.6%	*
Yield (Kg/ha)	7666	8473	**

Protozoa : DON > tillage

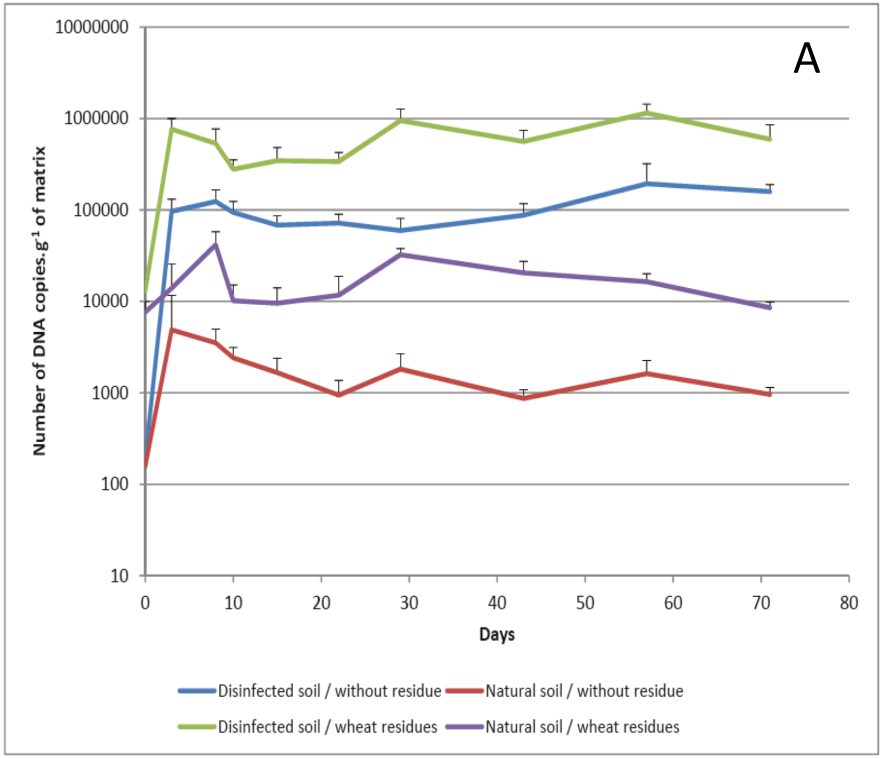


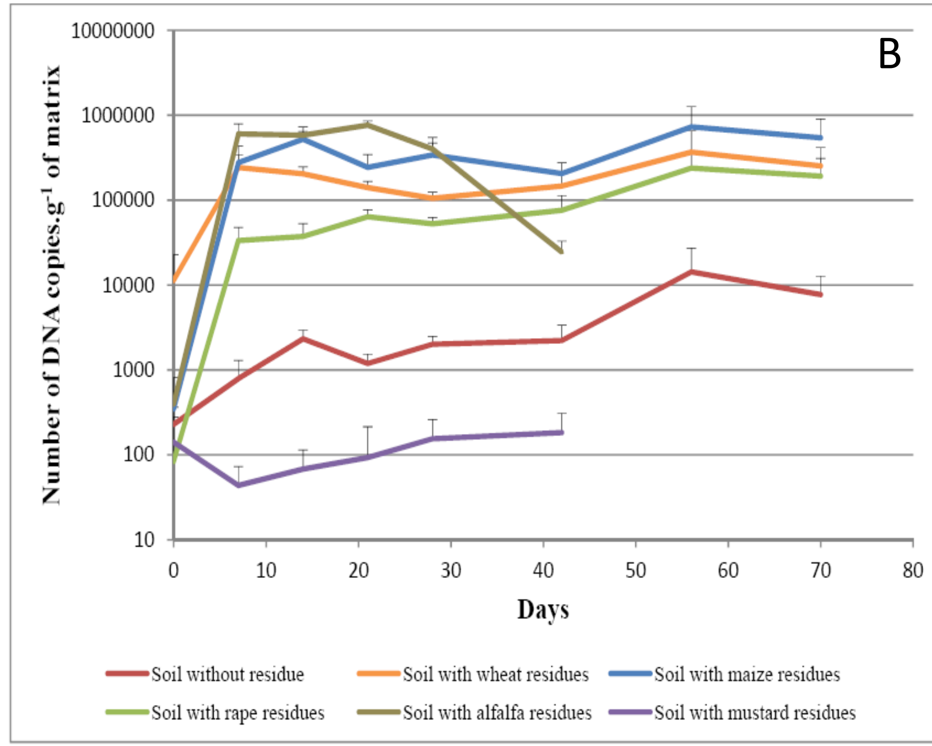
Abid et al 2012



http://www.grainsessential.ca/francais/pdf/kids/

Population dynamics of *F. graminearum* in crop residues





- ⇨ Presence of putative direct or/and indirect antagonistic (micro)organismes
- ⇨ Qualitative and quantitative role of crop residues: preceding crop, intermediate crop, …

Leplat et al 2012

Fusarium graminearum

- Causes Fusarium head blight and seedling blight
- Produces mycotoxins (such as DON Deoxynivalenol)

Fusarium graminearum

Causes Fusarium head blight and seedling blight

Produces mycotoxins (such as DON Deoxynivalenol)

F. graminearum overwinters in the soil, on crop residues and serve as primary inoculum

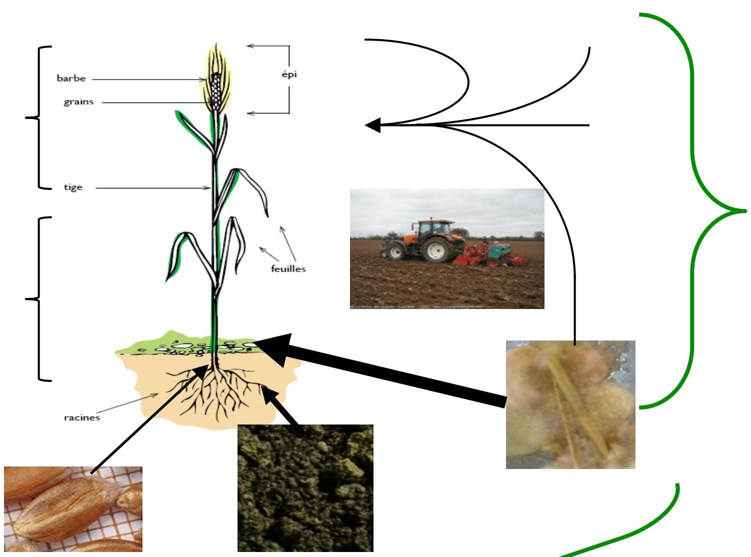
Produces disease to the next crop

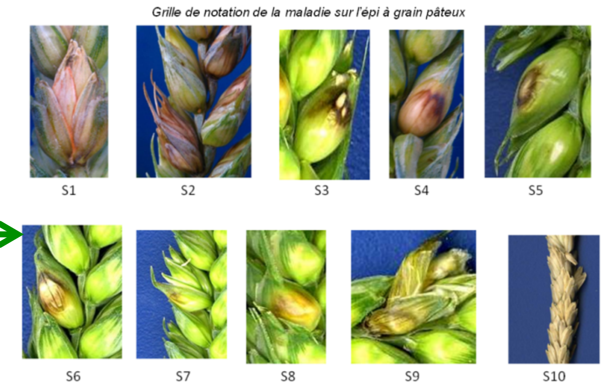
Crop residue + mycotoxins

Soil microflora and fauna (antagonists, decomposers)

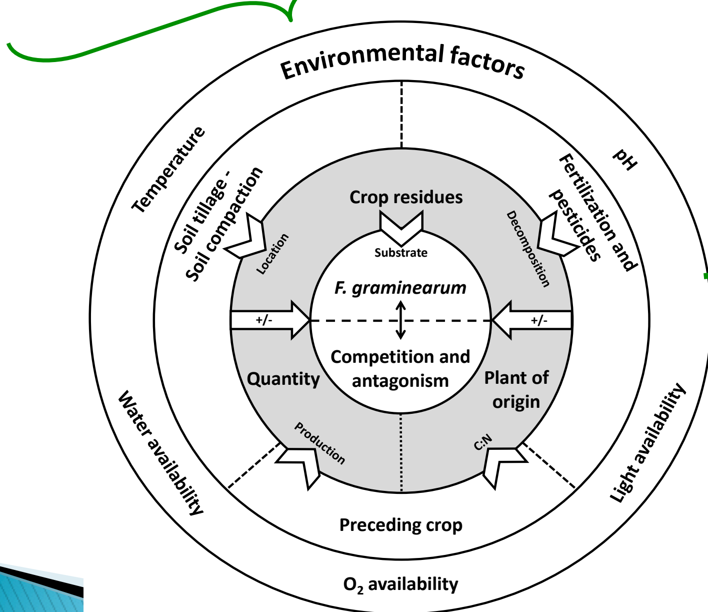
Survival

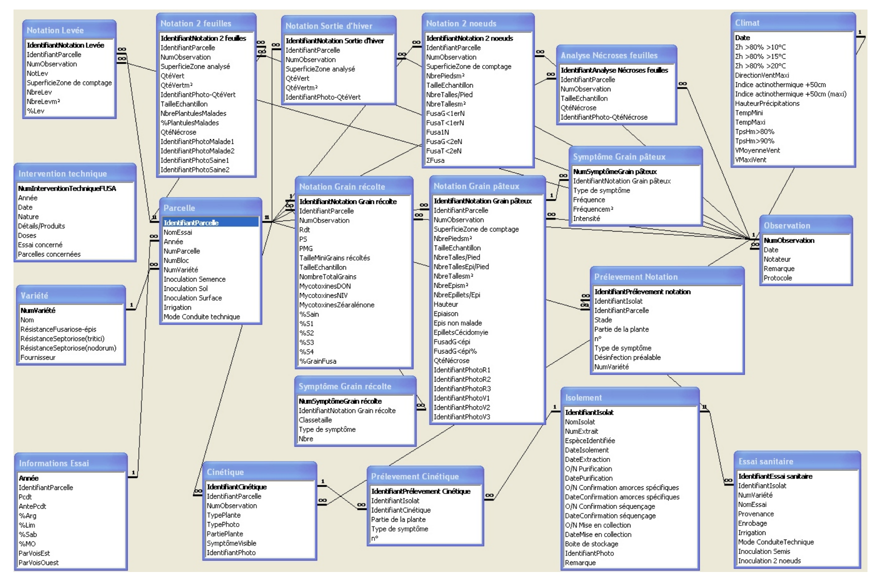
Do mycotoxins have an impact on soil microflora and fauna during the decomposition of crop residues in the soil ?





⇨ Risk assessment





⇨ Mathematical models

week 0	Week 8	Week 24

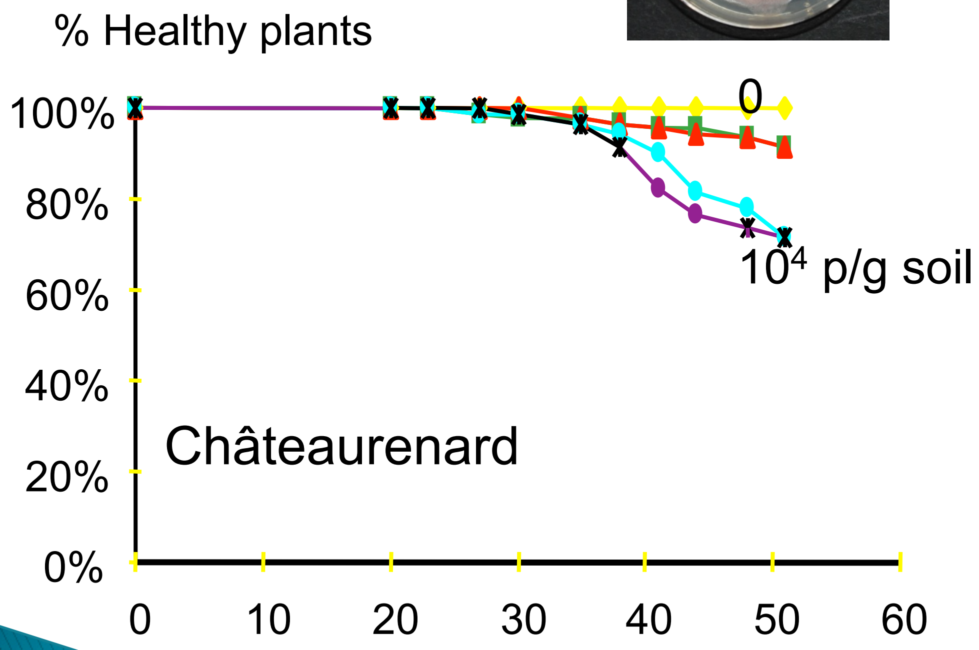
No earthworm

Plus earthworms

- Contribution of earthworms to the incorporation of wheat straw (and other plant residues) in the soil
- Decomposition ↗ mineralization and C sequestration

Suspressive soil of Chateaurenard

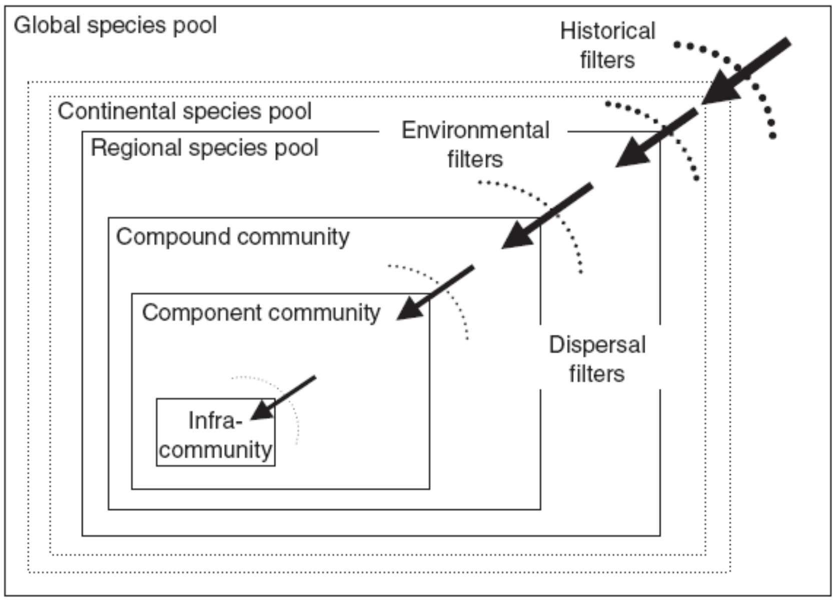
- empirical approach ➔ Fo47
- functional genomics ➔ functional groups



Comparative Metagenomics and Metatranscriptomics of various suppressive soils :

- Fusarium wilt
- R. solani diseases
- Take-all decline

1 - Understanding the process of assemblage of the species (or similar) => response traits



⇒ To analyze the response to anthropogenic activities

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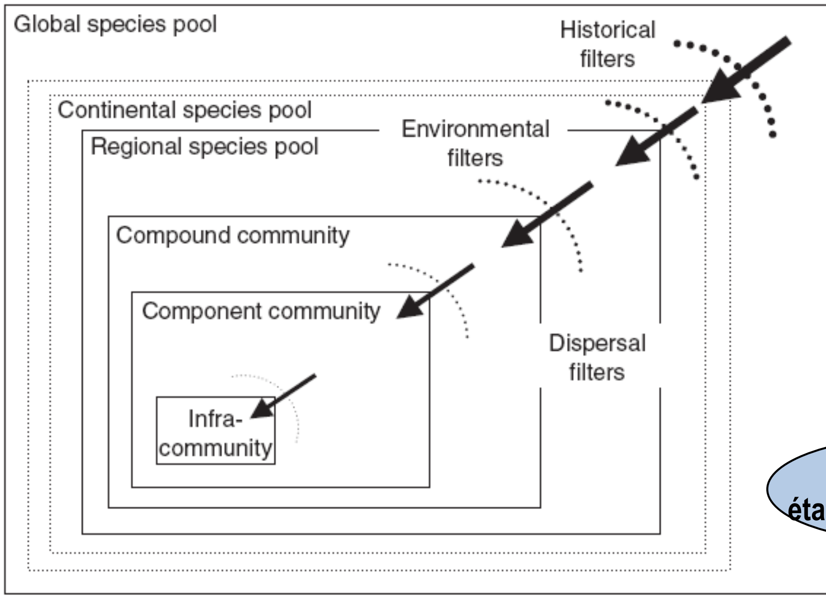
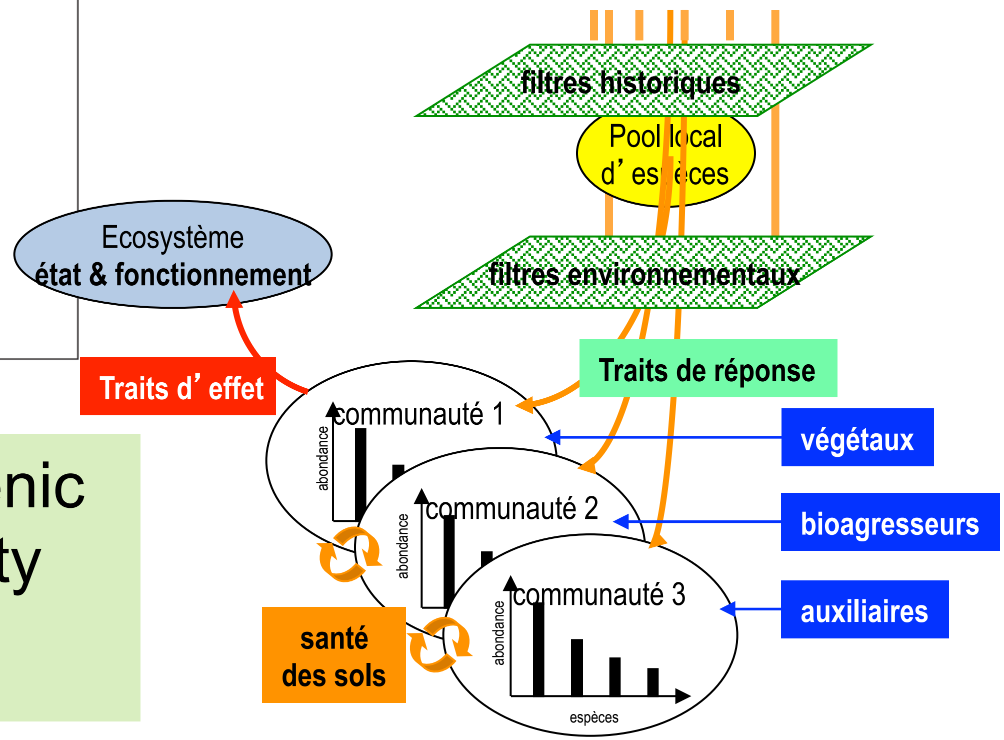


⇒ To analyze the response to anthropogenic activities



2 - Managing the pathogenic activity through biodiversity (**effect traits**)

=> Multitrophic interactions *(IOBC)*

Ecology of soil-borne plant pathogens