Valuing the DEPHY network datasets to analyze relationships between crop diversity and pesticide use, to help the design of sustainable cropping systems

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Content

- Context
- Research objectives
- Methodology
- Roadmap of the project
- Perspectives for further work

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- Methodology
- Roadmap-Arrangement of different components
- Perspectives for further work

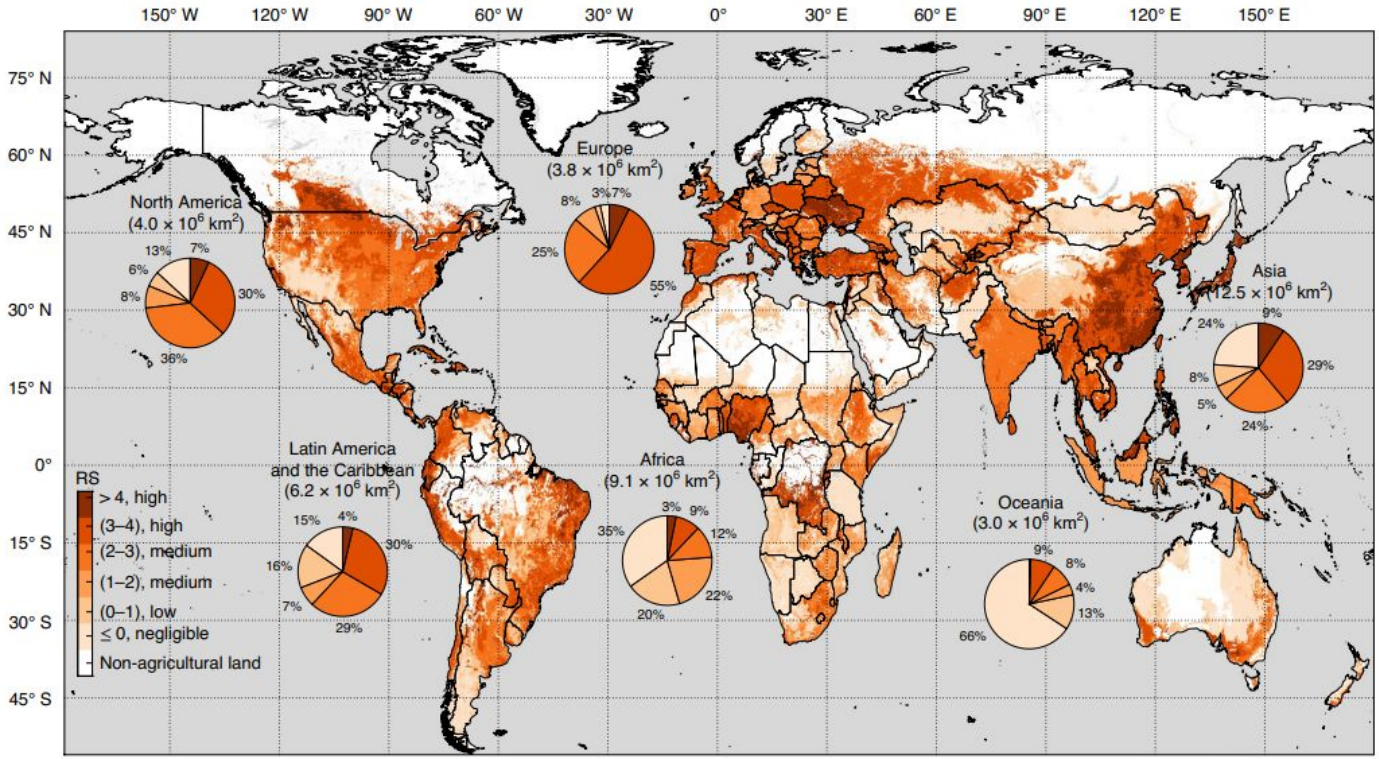


Fig. 1 | Global map of pesticide RS. The map has a spatial resolution of 5 arcmin, which is approximately 10 km × 10 km at the Equator. The pie charts represent the fraction of agricultural land classed under different RS in each region, and the values in parentheses above the pie charts denote the total agricultural land in that region.

Tang et al., 2021

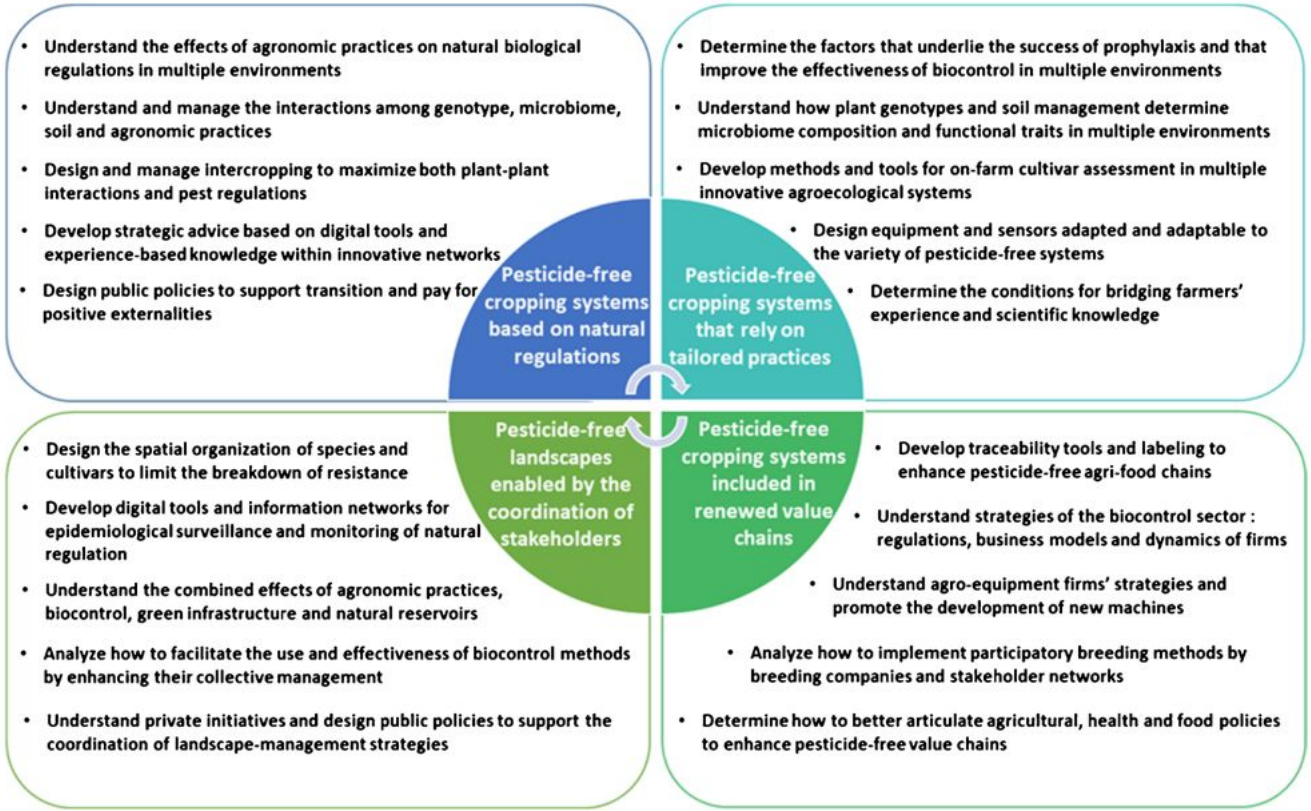


Fig. 7 Cross-cutting objectives and their related research topics. These objectives were designed collectively by the authors from the identification of complementary research topics that (1) belong to the five strategies to achieve the pesticide-free goal and that (2) are characterized by similar targets, scales, or the stakeholders involved.

1. **Agronomy**
2. Genetics
3. Biological control
4. Machinery & digital
5. Economic & social

Jacquet et al., 2022

Current States

Global production pressure

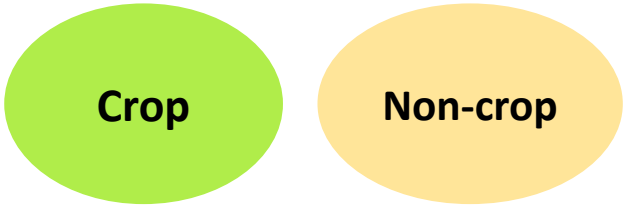
- Increasing population
- Climate change pressure
- Increasing vulnerability of conventional farming systems (FAO, 2020)

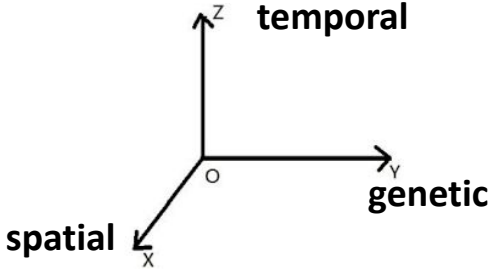
On the pesticide use

- Health pressure, environmental leaching, biodiveristy reduce (Rani, 2021)
- Increasing reliance on pesticide (Glyphosate)

What is agricultural diversification

- Diverse practice (reduced tillage, organic amendment)
- Diverse crop species (intercropping /crop rotation) **crop diversification**
- Non-crop species diversification (Flower strip, semi-natural habitat)
- Diversification of soil microorganism inoculation





Tamburini et al, 2020

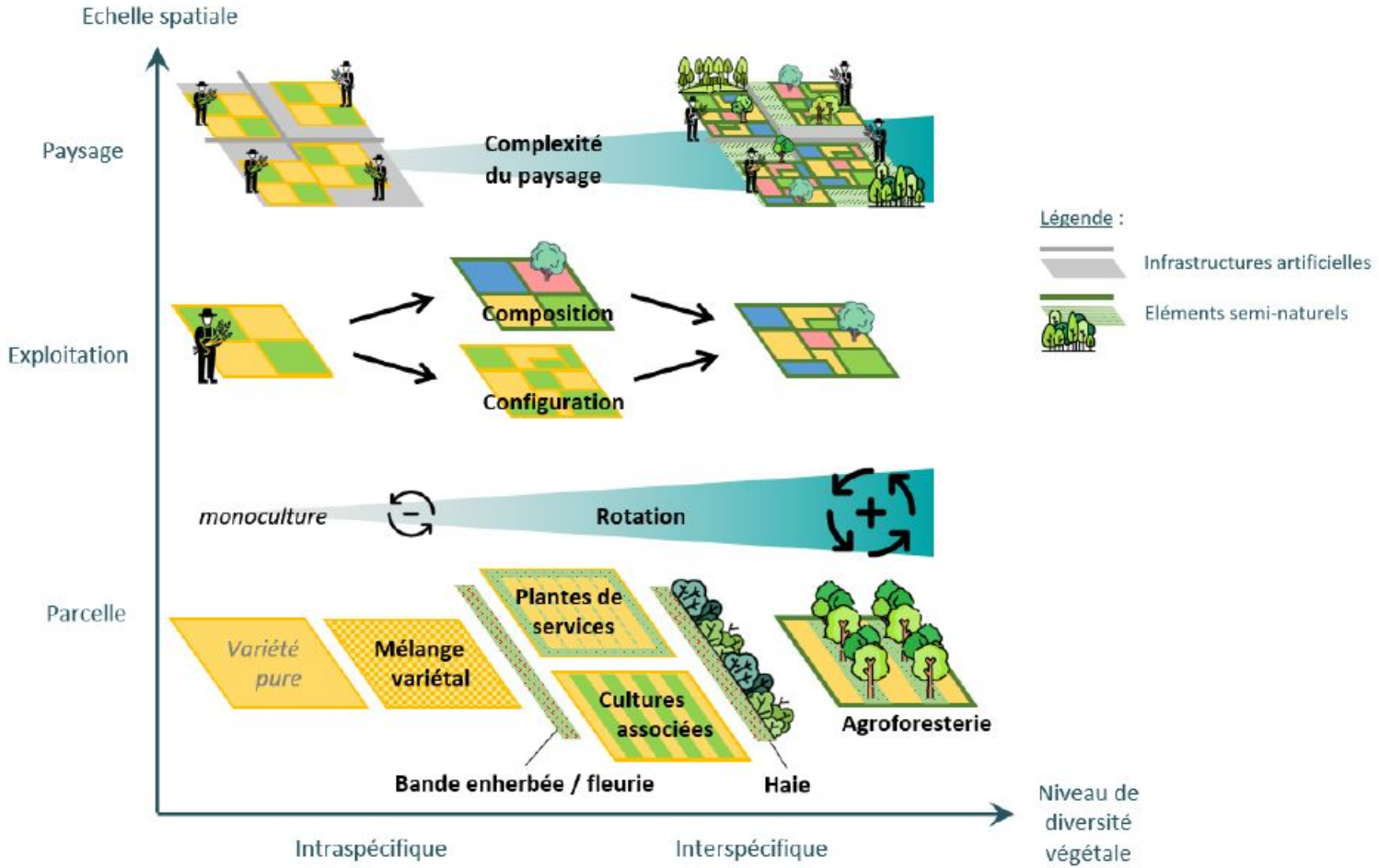


Figure 1. Représentation schématique des modalités de diversification végétale considérées dans l'ESCo

Why crop diversification?

Paradigm shift

Oversimplification of cropping systems

intensive pesticide use

- ➔ Environmental pollution,
- ➔ Biodiversity loss,
- ➔ Human health issues concerns
- ➔ Emergence selection of pest resistance

Cropping system diversity

Less reliable on external inputs

- ➔ Nutritional stability
- ➔ Production stability at national scale
- ➔ Provision of ecosystem services, e.g pest control

Beillouin et al., 2021

General strategy of system change

1. **Efficiency- precision agriculture**
1. **Substitution- less hazardous pesticide**
1. **Redesign- system thinking**

Can crop diversification reduce pesticide use?

Not so sure yet

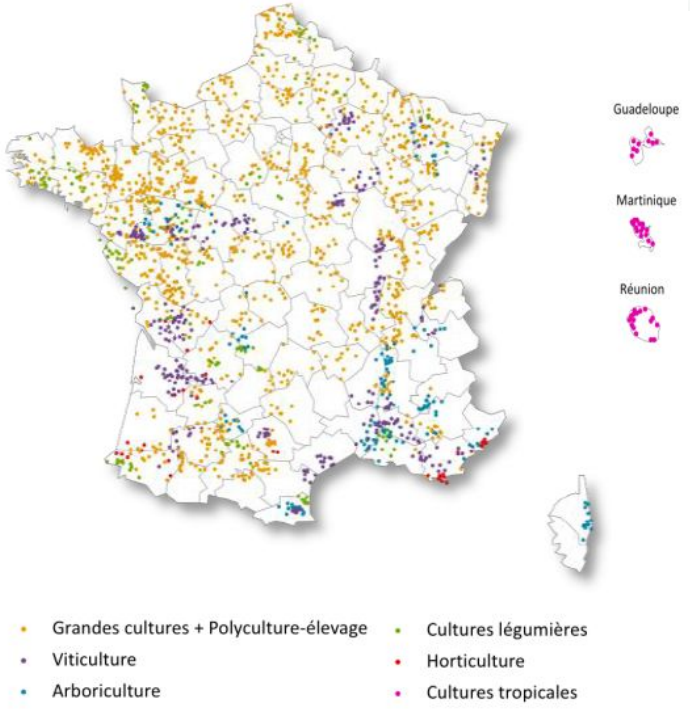
In some cases yes (Bonnet et al., 2021)

But some cases no, (Alletto et al., 2022)

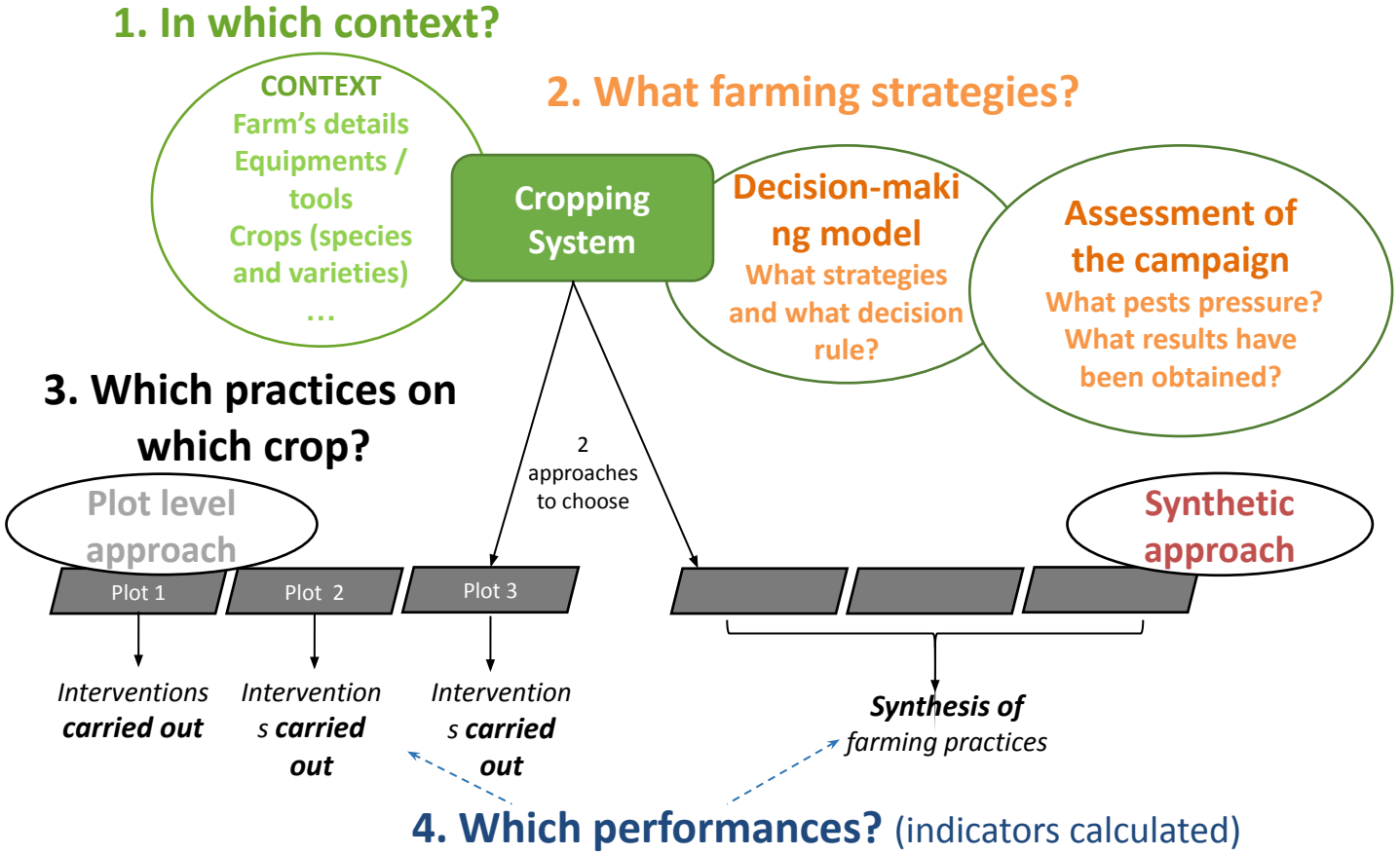
And they are both on experimental-site level.

Database DEPHY network

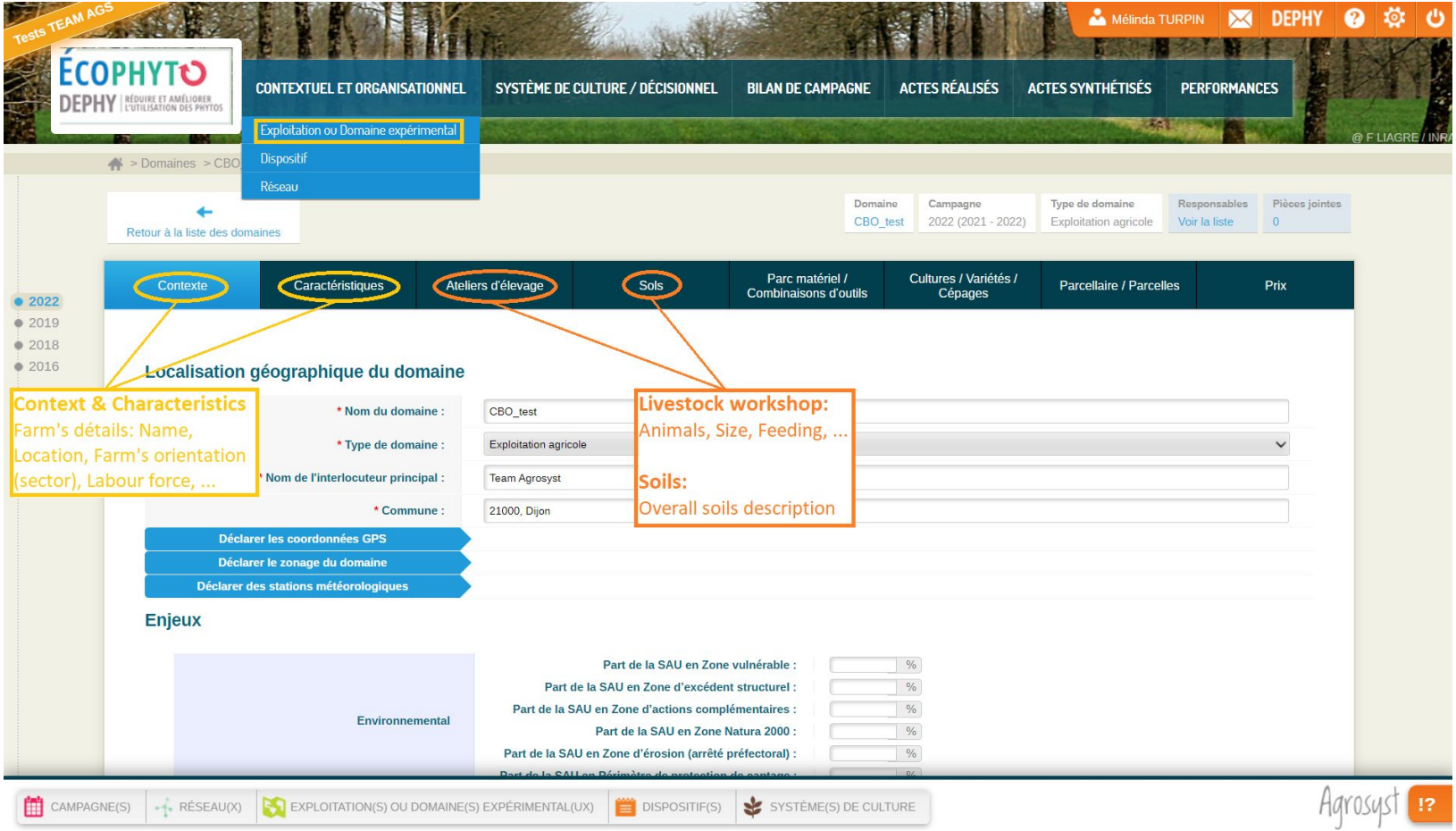
- A major action of the French Ecophyto National Action Plan.
- The DEPHY network coordinates 2000 voluntary farmers
- Farmers are engaged to demonstrate that reducing pesticide use is possible and cost-effective.
- Through a holistic approach of pest management

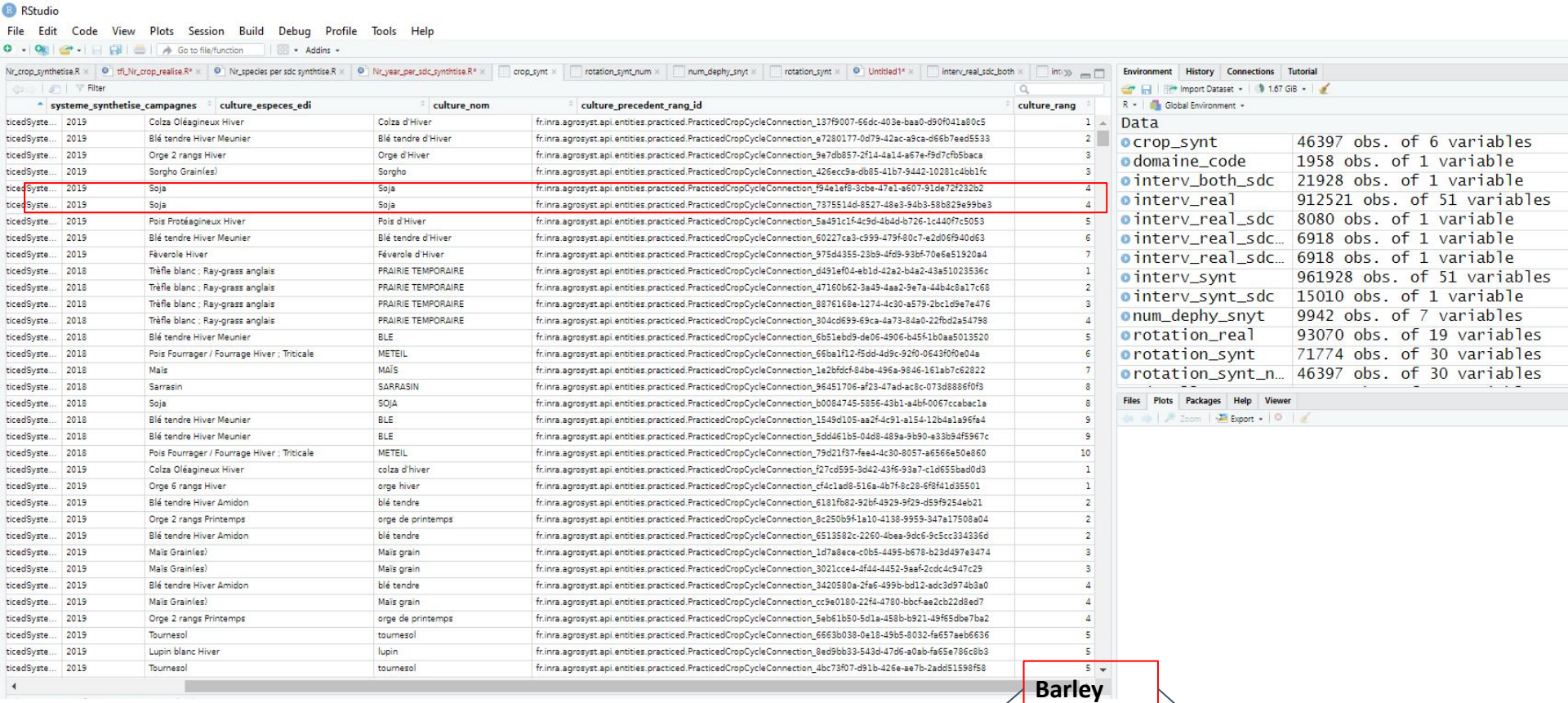


AgroSYST

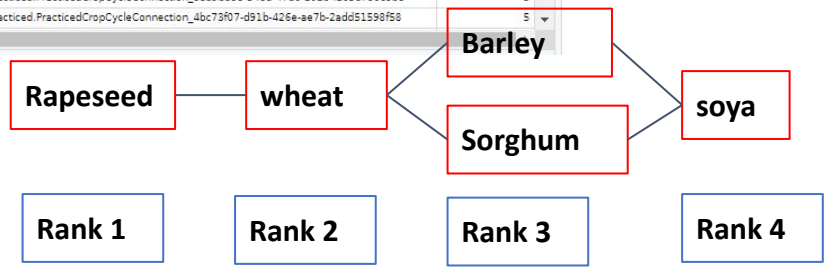

1. In which context?
CONTEXT
Farm's details
Equipments / tools
Crops (species and varieties)
…
2. What farming strategies?
Cropping System
Decision-making model
What strategies and what decision rule?
Assessment of the campaign
What pests pressure?
What results have been obtained?
3. Which practices on which crop?
2 approaches to choose
Plot level approach
Plot 1
Plot 2
Plot 3
Synthetic approach
Interventions carried out
Interventions carried out
Interventions carried out
Synthesis of farming practices
4. Which performances? (indicators calculated)

❖ Farm description





Two soya, same crop rank, but different crop rank id



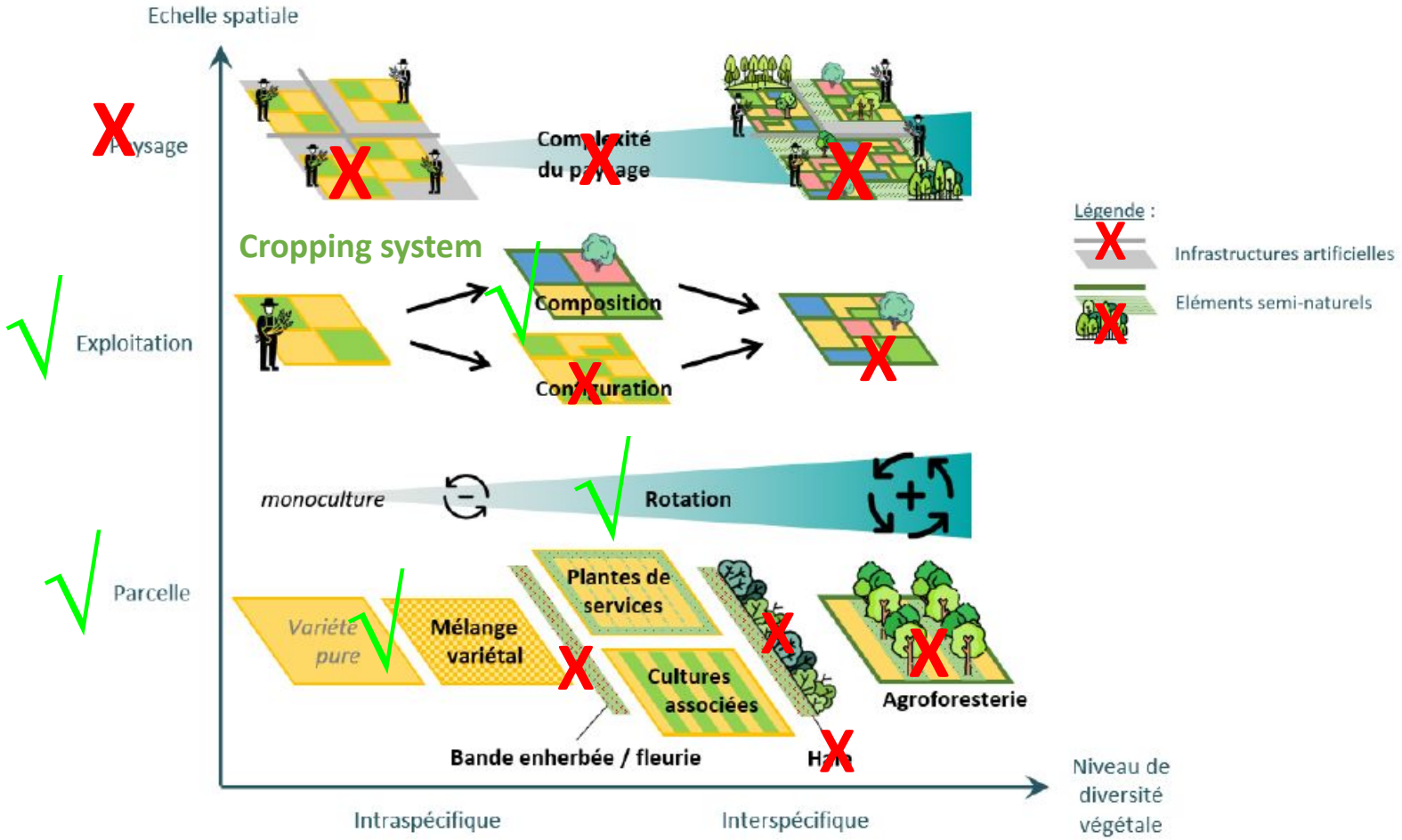


Figure 1. Représentation schématique des modalités de diversification végétale considérées dans l'ESCo

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- Time arrangement

Research Objective

1. Test if there is a relationship between crop diversity and TFI with existing indexes

2. Define production situation which facilitate crop diversity

Hypothesis

- Potential effects of crop diversification can reduce pesticide use
- Certain production situations could facilitate crop diversification strategy

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Methodology

Part I: Compute exiting index vs TFI

A. Crop diversity

1. **Ecological Index (Shannon Index/ Simpson Index)**
2. **Other Index (Crop species richness)(Bonnet et al, 2021)**

B. Functional group diversity

1. **Soil coverage (growing season)**
2. **Other functions**

C. Cropping system diversity

1. **Rotation diversity index (Keichinger et al, 2021),**
2. **Function crop diversity index (Nilsson et al., 2022)**
3. **Crop functional diversity on spatial and temporal scale (Zhao et al, 2022)**

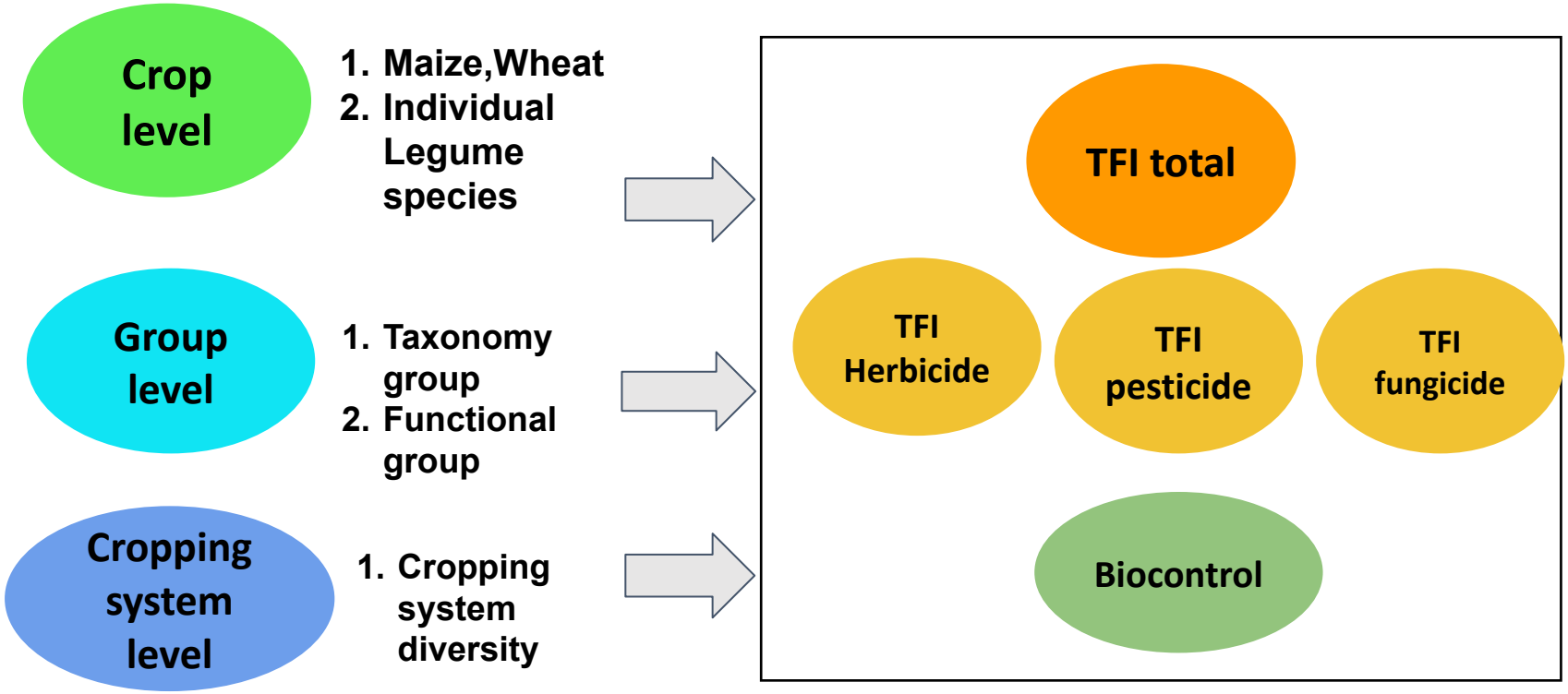
Methodology

Part II: Expert knowledge to compose crop diversity index vs TFI

Crop diversity =
Nr/Species +
Nr/family +
Nr/mixture +
Nr/Growing season +
Nr/temporary grassland +
(to be determined)

TFI:
Total,
herbicide,
pesticide,
fungicide
biocontrol

Diversity on



A transition from plant taxonomy to functional diversity

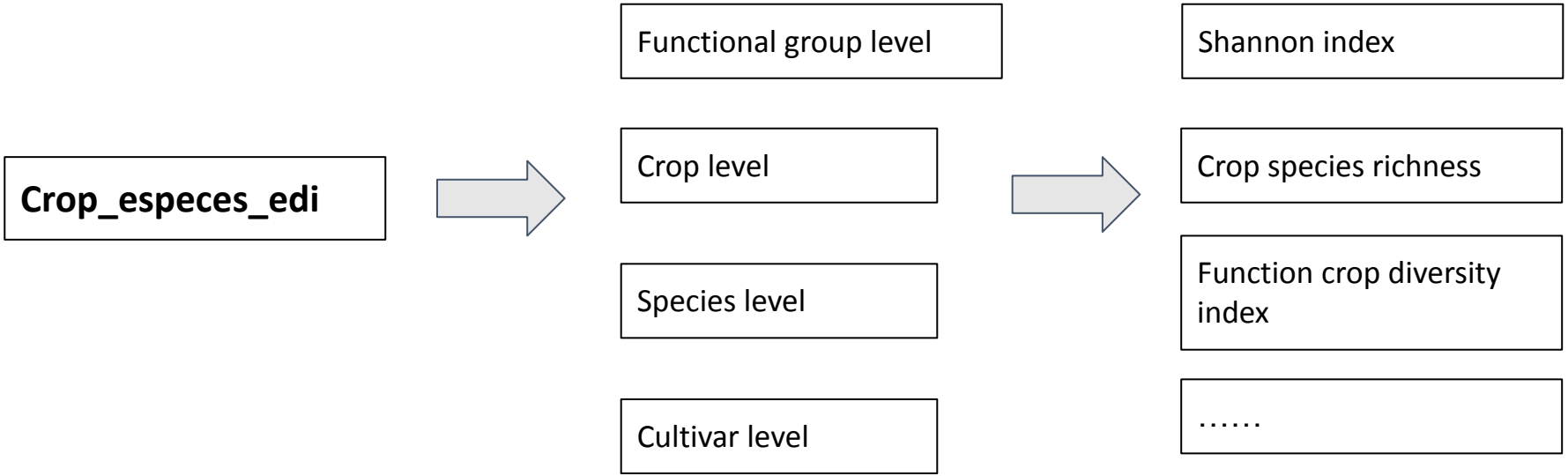
Treatment Frequency Index (TFI) :

- A metric to quantify pesticides use
- Automatically compute by AgroSYS, information system of DEPHY network dataset

$$\text{TFI} = \frac{Dose\ applied}{Dose\ registed} \times \frac{Treatd\ surface}{Surface\ total}$$

Existing diversity Index selected

Index	Calculation	Strengths	weakness	Reference
Shannon	$\text{Shannon Index (H)} = -\sum_{i=1}^{s} p_i \ln p_i$	Able to calculate in AgroSYS data, representative of species diversity		
Simpson	$\text{Simpson Index (D)} = \frac{1}{\sum_{i=1}^{s} p_i^2}$			
Crop Specific richness	0.3 × Number of species grown per_rotation + 0.7 × Number_of_species_grown_per_year		Definition of crop number and cropping system	(Last et al. 2014), (Bonnet et al., 2021)
Rotation diversity	To complex to put here…			(Keichinger et al., 2021)
function crop diversity index	HF = − ∑k g=1 pg*ln(pg)			(Nilsson et al., 2022)
Crop Specific and fonctional diveristy on spatial and temporal scale	Crop diveristy= N species* N group *N Year			Zhao et al, 2022 (Nature communication)
The crop diversity index used by AgroSys dataset, by Nicolas Chantier	*Diversité culturale*= 1/Σ (*Surface groupe de culture* n/*Surface développée du SdC*)2			



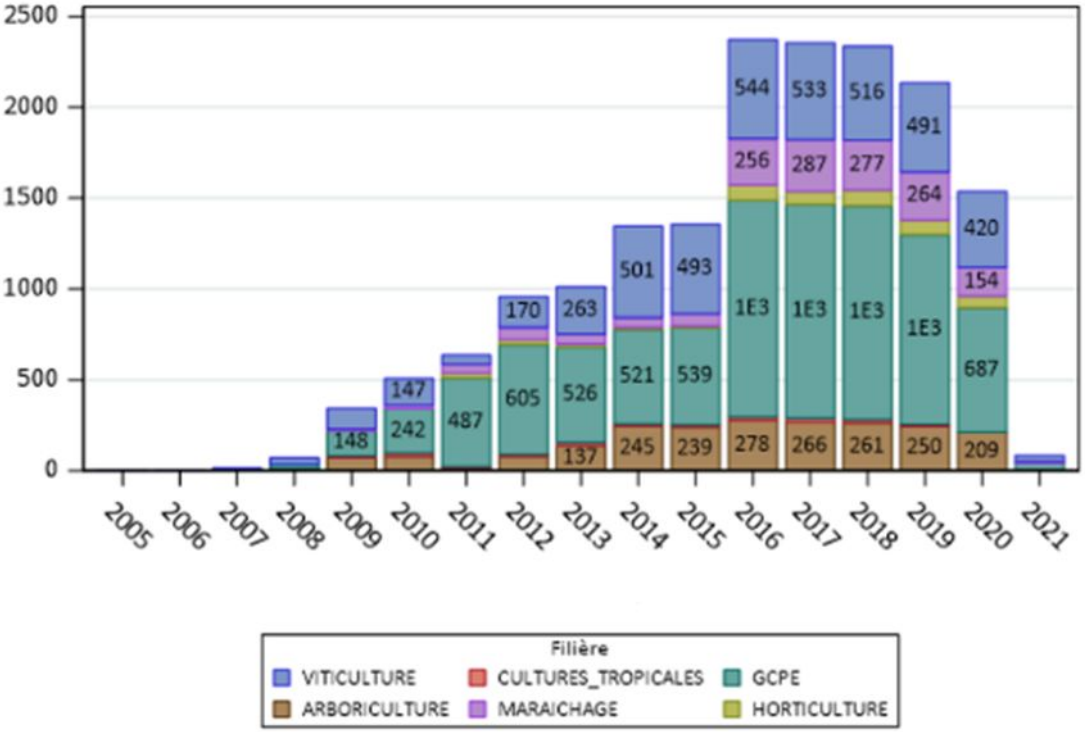
Crop name registered in the database

Aggregate on different level

Calculate indexes

- **Which aggregation level could be reflected in pesticide use?**
- **Which index have higher coverage of the diversity that we are intending to study?**

Data description-total



DEPHY data volume also increases

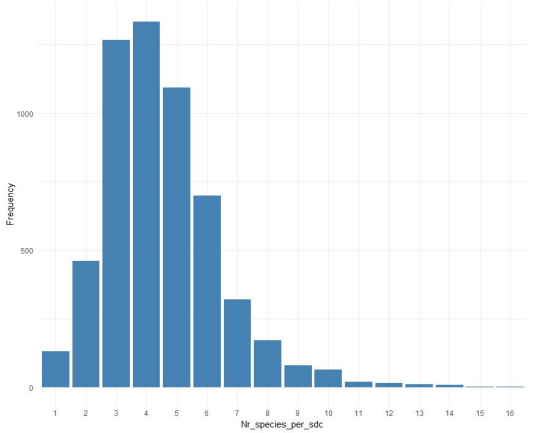
As of August 28, 2021, DEPHY farms includes:

17062 SdC (Cropping system)

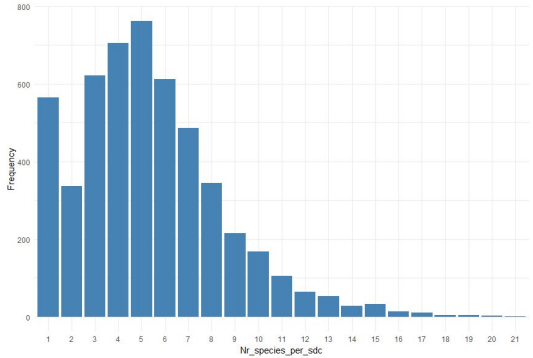
75% in Synthesized
25% in Realized

Data description - Number of species per cropping system

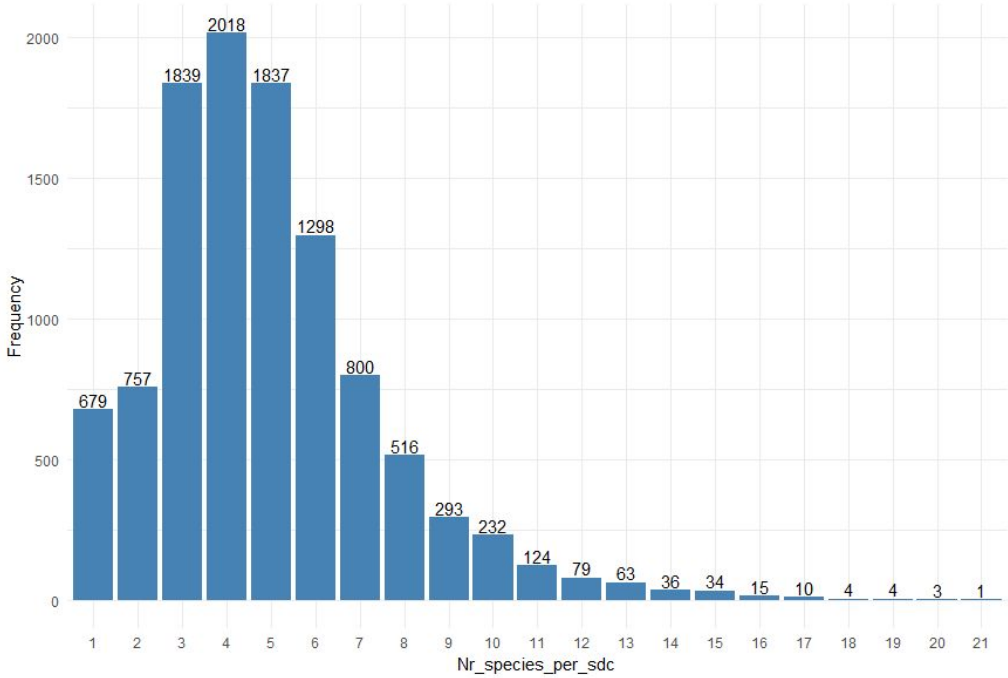
Synthetise



Realise

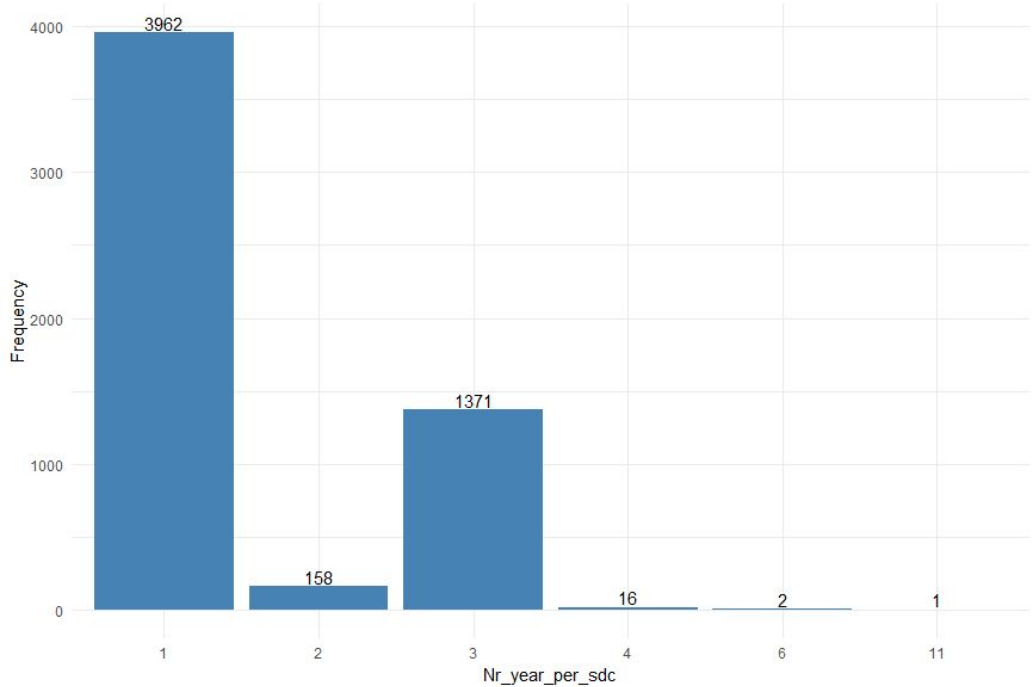


Both

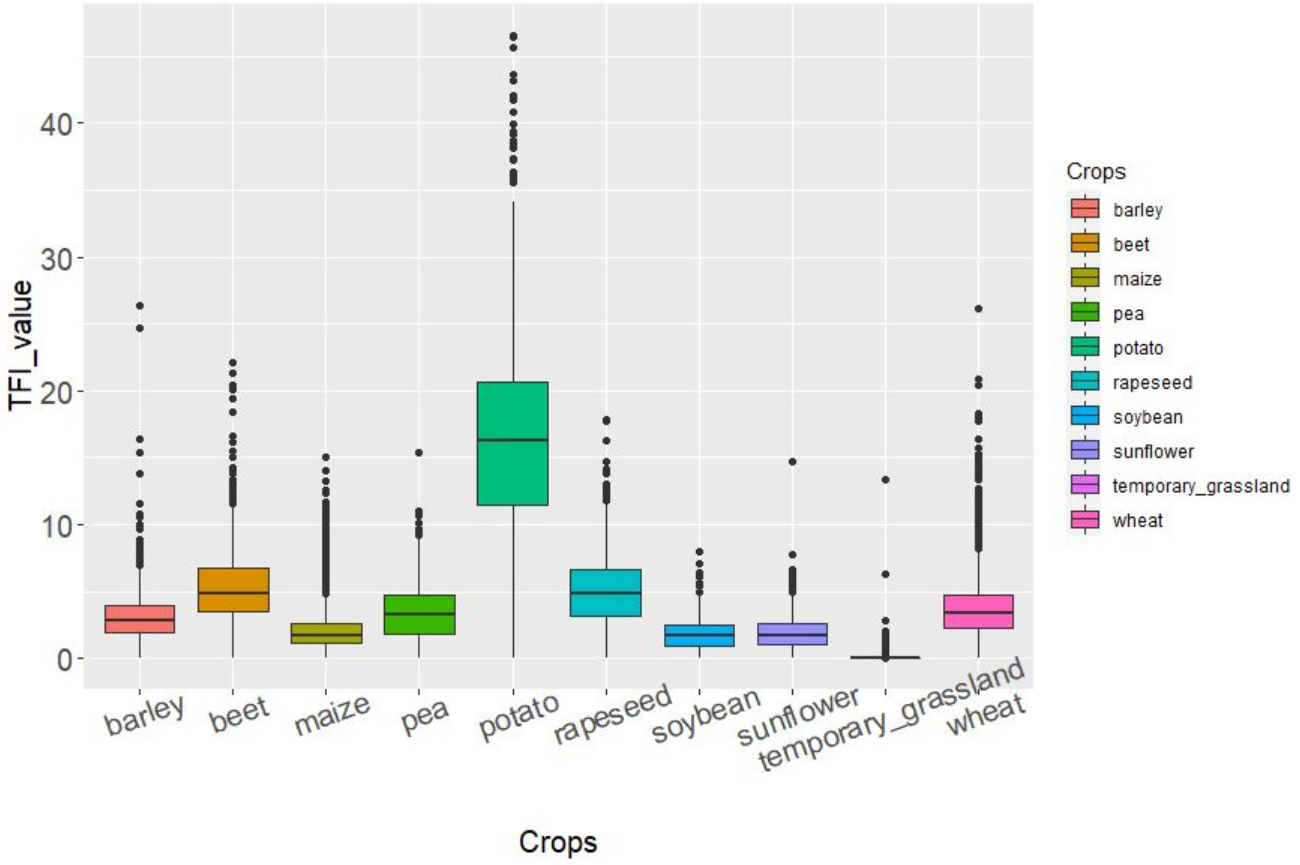


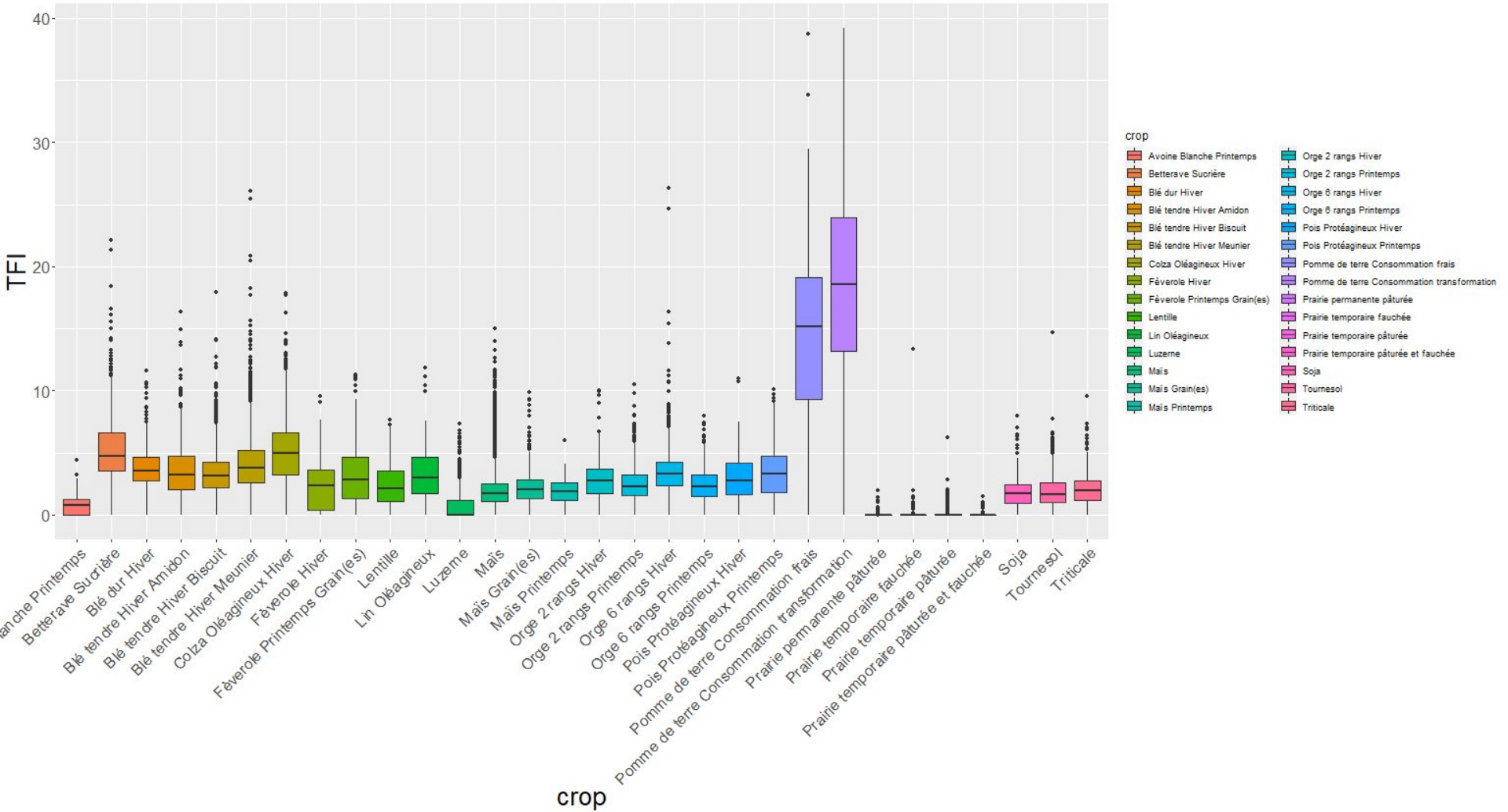
Data description synthesis (a combined year)

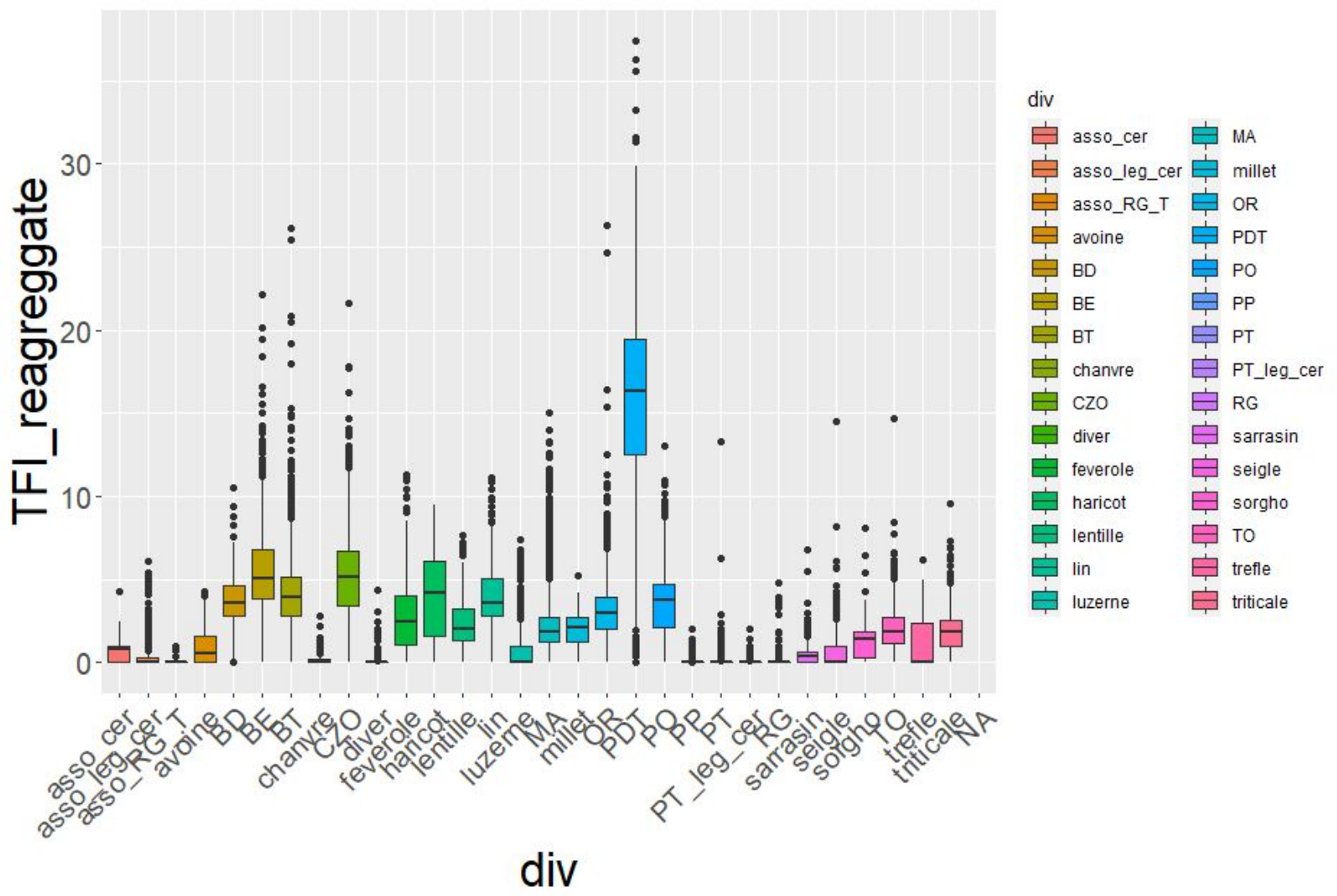
Number of year per sdc in synthtise: mostly one year and three years, also includes (2 years, 4 years, 6 years, 11 years)



TFI with crops

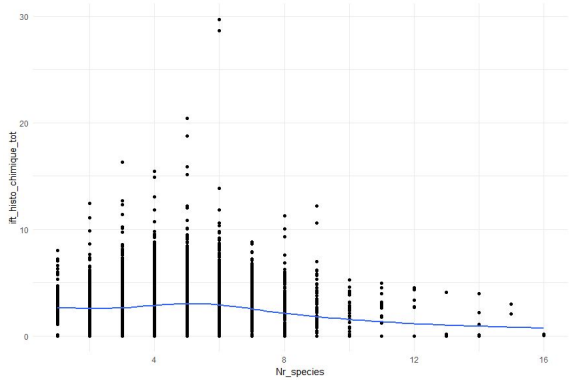



TFI
40
30
20
10
0
crop
Avoine Blanche Printemps
Betterave Sucrière
Blé dur Hiver
Blé tendre Hiver Amidon
Blé tendre Hiver Biscuit
Blé tendre Hiver Meunier
Colza Oléagineux Hiver
Fèverole Hiver
Fèverole Printemps Grain(es)
Lentille
Lin Oléagineux
Luzerne
Maïs
Maïs Grain(es)
Maïs Printemps
Orge 2 rangs Hiver
Orge 2 rangs Printemps
Orge 6 rangs Hiver
Orge 6 rangs Printemps
Pois Protéagineux Hiver
Pois Protéagineux Printemps
Pomme de terre Consommation frais
Pomme de terre Consommation transformation
Prairie permanente pâturée
Prairie temporaire fauchée
Prairie temporaire pâturée
Prairie temporaire pâturée et fauchée
Soja
Tournesol
Triticale
crop
Avoine Blanche Printemps
Betterave Sucrière
Blé dur Hiver
Blé tendre Hiver Amidon
Blé tendre Hiver Biscuit
Blé tendre Hiver Meunier
Colza Oléagineux Hiver
Fèverole Hiver
Fèverole Printemps Grain(es)
Lentille
Lin Oléagineux
Luzerne
Maïs
Maïs Grain(es)
Maïs Printemps
Orge 2 rangs Hiver
Orge 2 rangs Printemps
Orge 6 rangs Hiver
Orge 6 rangs Printemps
Pois Protéagineux Hiver
Pois Protéagineux Printemps
Pomme de terre Consommation frais
Pomme de terre Consommation transformation
Prairie permanente pâturée
Prairie temporaire fauchée
Prairie temporaire pâturée
Prairie temporaire pâturée et fauchée
Soja
Tournesol
Triticale

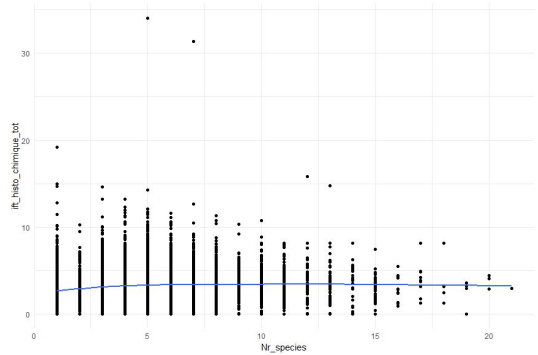

TFI_reagreggate
30
20
10
0
asso_cer
asso_leg_cer
asso_RG_T
avoine
BD
BE
BT
chanvre
CZO
diver
feverole
haricot
lentille
lin
luzerne
MA
millet
OR
PDT
PO
PP
PT
PT_leg_cer
RG
sarrasin
seigle
sorgho
TO
trefle
triticale
NA
div
div
asso_cer
asso_leg_cer
asso_RG_T
avoine
BD
BE
BT
chanvre
CZO
diver
feverole
haricot
lentille
lin
luzerne
MA
millet
OR
PDT
PO
PP
PT
PT_leg_cer
RG
sarrasin
seigle
sorgho
TO
trefle
triticale

Preliminary result-
Treatment frequency index vs Number of species in each cropping system

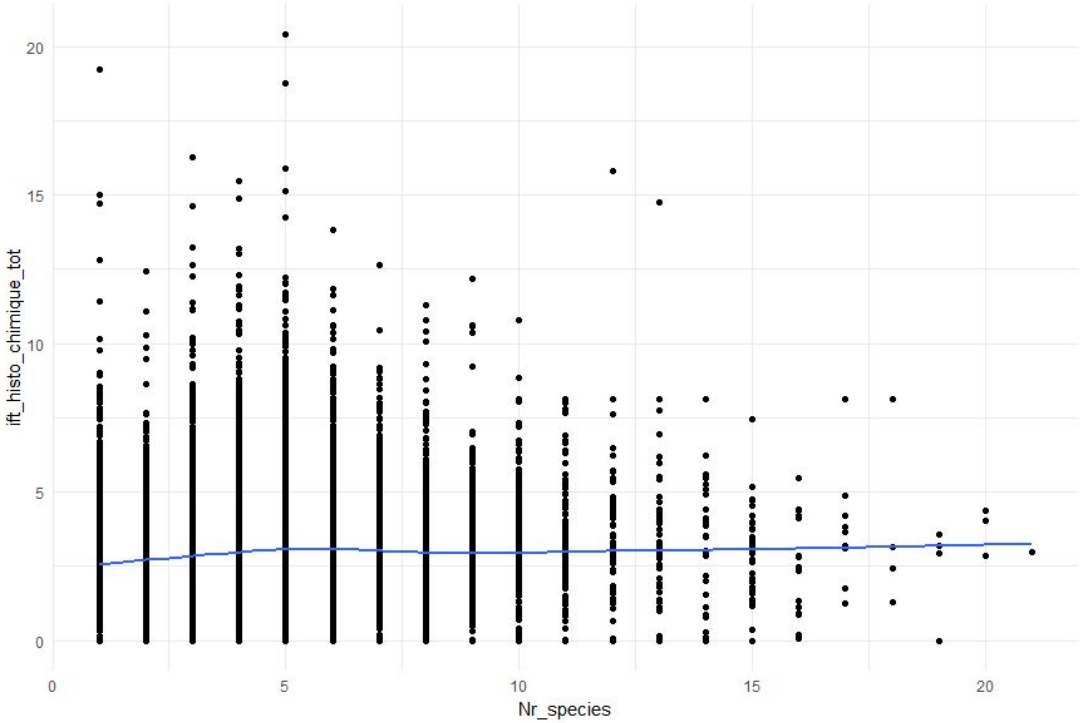
Synthesis



Realise



TFI vs crop number（synthetise + realise）



Methodology

➢ Define production situation

- Soil : soil type, soil depth, organic matter content
- Precipitation: annual precipitation
- Temperature : annual average temperature, average temperature during summer
- Radiation: length of daytime during summer, length of daytime during winter
- Distant to natural infrastructure: river, natural habitat
- Market: if 50km has same crop, we assume the market is available.

To be determined

Perspective

- Continue to work on the database to divide the crop on different level

- Calculate crop diversity indexes based on different divisional method

- Thanks for your time