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**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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Nicolas Munier-Jolain

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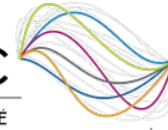
**INRAE**



agreenium

**UBFC**

UNIVERSITÉ  
BOURGOGNE FRANCHE-COMTÉ



**ÉCOPHYTO**  
DEPHY

Réseau de Démonstration,  
Expérimentation et Production  
de références sur les systèmes  
économiques en pléyocultures.

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

29th November 2022

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# Content

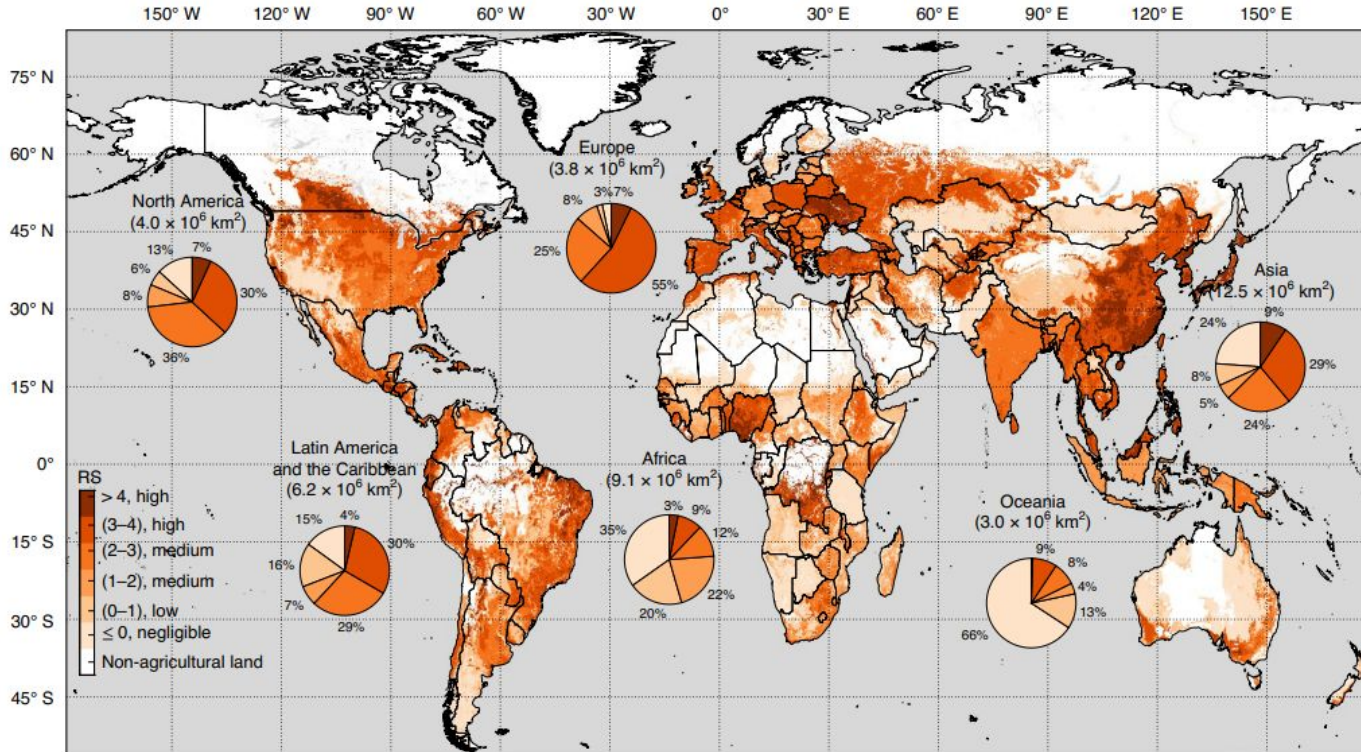
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- Context
- Research objectives
- Methodology
- Roadmap of the project
- Perspectives for further work

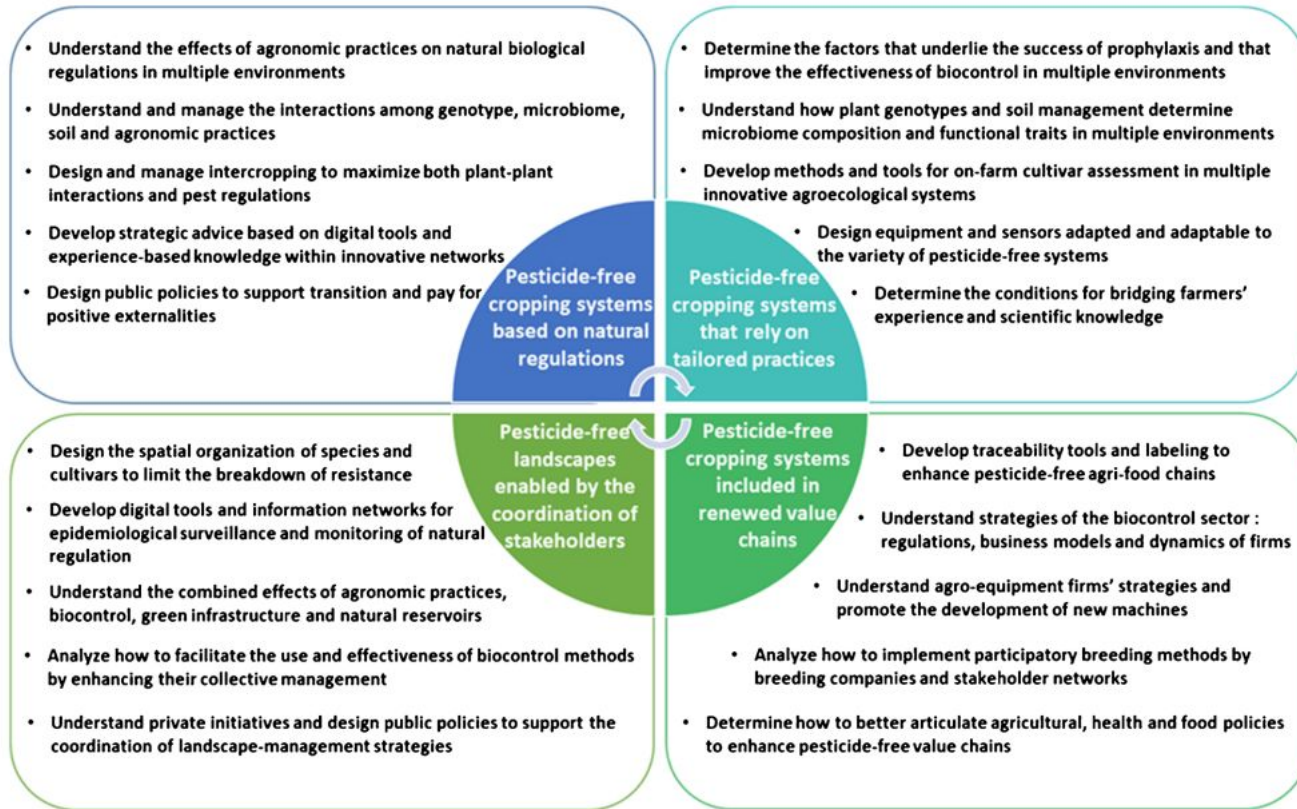
# Content

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- **Context**
- Research objectives
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- 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.



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

**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.



# Current States

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## **Global production pressure**

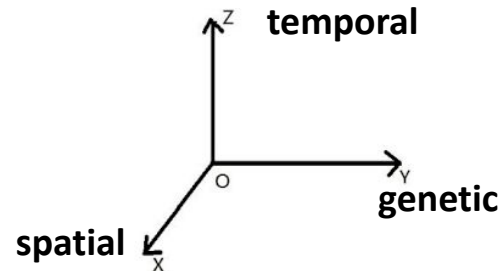
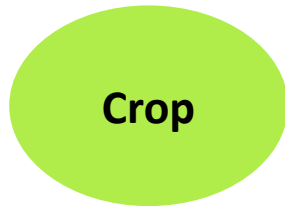
- Increasing population
- Climate change pressure
- Increasing vulnerability of conventional farming systems (FAO, 2020)

## **On the pesticide use**

- Health pressure, environmental leaching, biodiversity 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





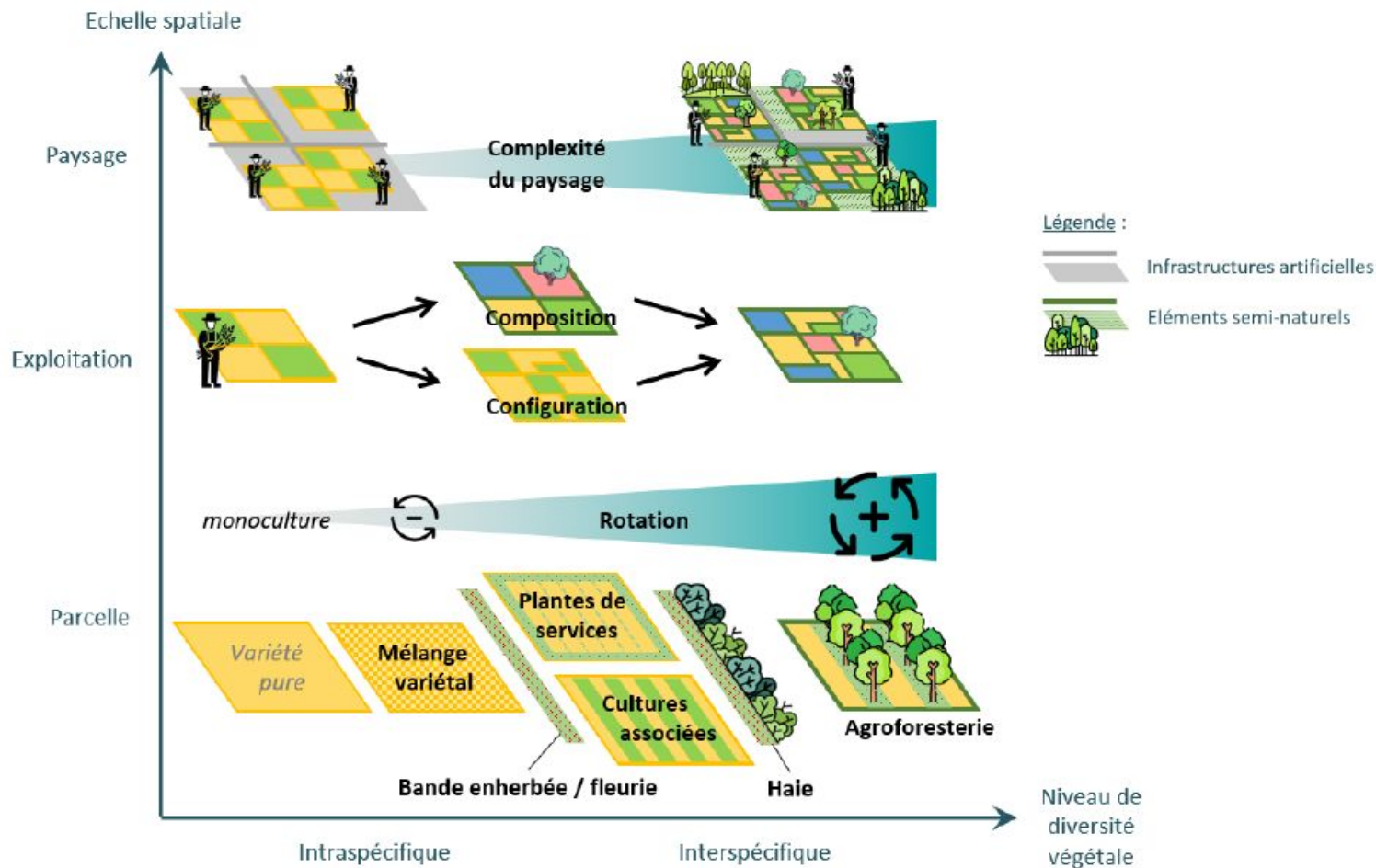


Figure 1. Représentation schématique des modalités de diversification végétale considérées dans l'ESCO

# Why crop diversification?



**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

# General strategy of system change

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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

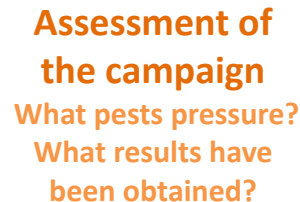
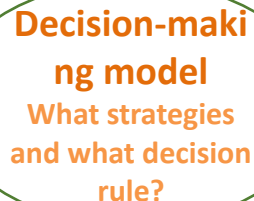


# ● AgroSYST

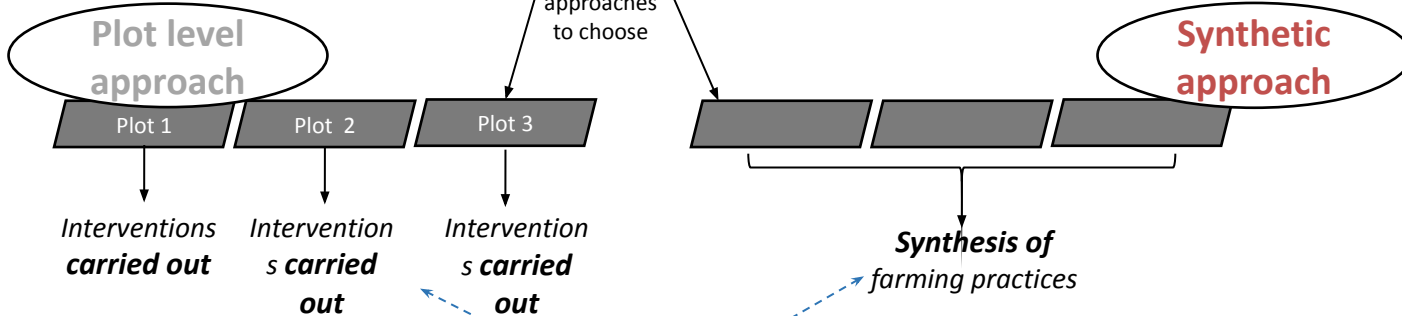
## 1. In which context?



## 2. What farming strategies?



## 3. Which practices on which crop?



## 4. Which performances? (indicators calculated)

# ❖ Farm description

The screenshot shows the 'Farm description' page in the ÉCOPHYTO DEPHY application. The top navigation bar includes 'Tests TEAM AGS', user 'Mélinda TURPIN', and various utility icons. The main menu has tabs for 'CONTEXTEUEL ET ORGANISATIONNEL', 'SYSTÈME DE CULTURE / DÉCISIONNEL', 'BILAN DE CAMPAGNE', 'ACTES RÉALISÉS', 'ACTES SYNTHÉTISÉS', and 'PERFORMANCES'. A dropdown menu is open under 'CONTEXTEUEL ET ORGANISATIONNEL', showing 'Exploitation ou Domaine expérimental', 'Dispositif', and 'Réseau'. The breadcrumb trail is 'Domaines > CBO'. A summary table shows: Domaine: CBO\_test, Campagne: 2022 (2021 - 2022), Type de domaine: Exploitation agricole, Responsables: Voir la liste, Pièces jointes: 0. A horizontal menu below the breadcrumb has tabs: 'Contexte', 'Caractéristiques', 'Ateliers d'élevage', 'Sols', 'Parc matériel / Combinaisons d'outils', 'Cultures / Variétés / Cépages', 'Parcellaire / Parcelles', and 'Prix'. The 'Contexte' tab is selected. The main content area is titled 'Localisation géographique du domaine'. It contains a form with the following fields: 'Nom du domaine' (CBO\_test), 'Type de domaine' (Exploitation agricole), 'Nom de l'interlocuteur principal' (Team Agrosyst), and 'Commune' (21000, Dijon). Three blue buttons are present: 'Déclarer les coordonnées GPS', 'Déclarer le zonage du domaine', and 'Déclarer des stations météorologiques'. Below this is the 'Enjeux' section, which includes a map area labeled 'Environnemental' and a list of environmental indicators with percentage input fields: 'Part de la SAU en Zone vulnérable', 'Part de la SAU en Zone d'excédent structurel', 'Part de la SAU en Zone d'actions complémentaires', 'Part de la SAU en Zone Natura 2000', 'Part de la SAU en Zone d'érosion (arrêté préfectoral)', and 'Part de la SAU en Périmètre de protection de paysage'. Three callout boxes are overlaid on the page: a yellow box on the left titled 'Context & Characteristics' with the text 'Farm's details: Name, Location, Farm's orientation (sector), Labour force, ...'; an orange box on the right titled 'Livestock workshop: Animals, Size, Feeding, ...'; and another orange box below it titled 'Soils: Overall soils description'. The bottom of the page features a navigation bar with icons for 'CAMPAGNE(S)', 'RÉSEAU(X)', 'EXPLOITATION(S) OU DOMAINE(S) EXPÉRIMENTAL(UX)', 'DISPOSITIF(S)', and 'SYSTÈME(S) DE CULTURE', along with the 'Agrosyst' logo and a help icon.



RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function Addins

Environment History Connections Tutorial

R - Global Environment

Data

- crop\_synt 46397 obs. of 6 variables
- domaine\_code 1958 obs. of 1 variable
- interv\_both\_sdc 21928 obs. of 1 variable
- interv\_real 912521 obs. of 51 variables
- interv\_real\_sdc 8080 obs. of 1 variable
- interv\_real\_sdc... 6918 obs. of 1 variable
- interv\_real\_sdc... 6918 obs. of 1 variable
- interv\_synt 961928 obs. of 51 variables
- interv\_synt\_sdc 15010 obs. of 1 variable
- num\_dephy\_synt 9942 obs. of 7 variables
- rotation\_real 9370 obs. of 19 variables
- rotation\_synt 71774 obs. of 30 variables
- rotation\_synt\_n... 46397 obs. of 30 variables

systeme_syntetise_campaigns	culture_especes_edt	culture_nom	culture_precedent_rang_id	culture_rang
ticedSysteme...	2019	Colza Oléagineux Hiver	Colza d'Hiver	1
ticedSysteme...	2019	Blé tendre Hiver Meunier	Blé tendre d'Hiver	2
ticedSysteme...	2019	Orge 2 rangs Hiver	Orge d'Hiver	3
ticedSysteme...	2019	Sorgho Grain(fes)	Sorgho	4
ticedSysteme...	2019	Soja	Soja	4
ticedSysteme...	2019	Soja	Soja	4
ticedSysteme...	2019	Pois Protéagineux Hiver	Pois d'Hiver	5
ticedSysteme...	2019	Blé tendre Hiver Meunier	Blé tendre d'Hiver	6
ticedSysteme...	2019	Féverole Hiver	Féverole d'Hiver	7
ticedSysteme...	2018	Trèfle blanc ; Ray-grass anglais	PRAIRIE TEMPORAIRE	1
ticedSysteme...	2018	Trèfle blanc ; Ray-grass anglais	PRAIRIE TEMPORAIRE	2
ticedSysteme...	2018	Trèfle blanc ; Ray-grass anglais	PRAIRIE TEMPORAIRE	3
ticedSysteme...	2018	Trèfle blanc ; Ray-grass anglais	PRAIRIE TEMPORAIRE	4
ticedSysteme...	2018	Blé tendre Hiver Meunier	BLE	5
ticedSysteme...	2018	Pois Fourrage / Fourrage Hiver ; Triticale	METTEL	6
ticedSysteme...	2018	Mais	MAIS	7
ticedSysteme...	2018	Sarrasin	SARRASIN	8
ticedSysteme...	2018	Soja	SOJA	8
ticedSysteme...	2018	Blé tendre Hiver Meunier	BLE	9
ticedSysteme...	2018	Blé tendre Hiver Meunier	BLE	9
ticedSysteme...	2018	Pois Fourrage / Fourrage Hiver ; Triticale	METTEL	10
ticedSysteme...	2019	Colza Oléagineux Hiver	colza d'hiver	1
ticedSysteme...	2019	Orge 6 rangs Hiver	orge hiver	1
ticedSysteme...	2019	Blé tendre Hiver Amidon	blé tendre	2
ticedSysteme...	2019	Orge 2 rangs Printemps	orge de printemps	2
ticedSysteme...	2019	Blé tendre Hiver Amidon	blé tendre	2
ticedSysteme...	2019	Mais Grain(fes)	Mais grain	3
ticedSysteme...	2019	Mais Grain(fes)	Mais grain	3
ticedSysteme...	2019	Blé tendre Hiver Amidon	blé tendre	4
ticedSysteme...	2019	Mais Grain(fes)	Mais grain	4
ticedSysteme...	2019	Orge 2 rangs Printemps	orge de printemps	4
ticedSysteme...	2019	Tournesol	tournesol	5
ticedSysteme...	2019	Lupin blanc Hiver	lupin	5
ticedSysteme...	2019	Tournesol	tournesol	5

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



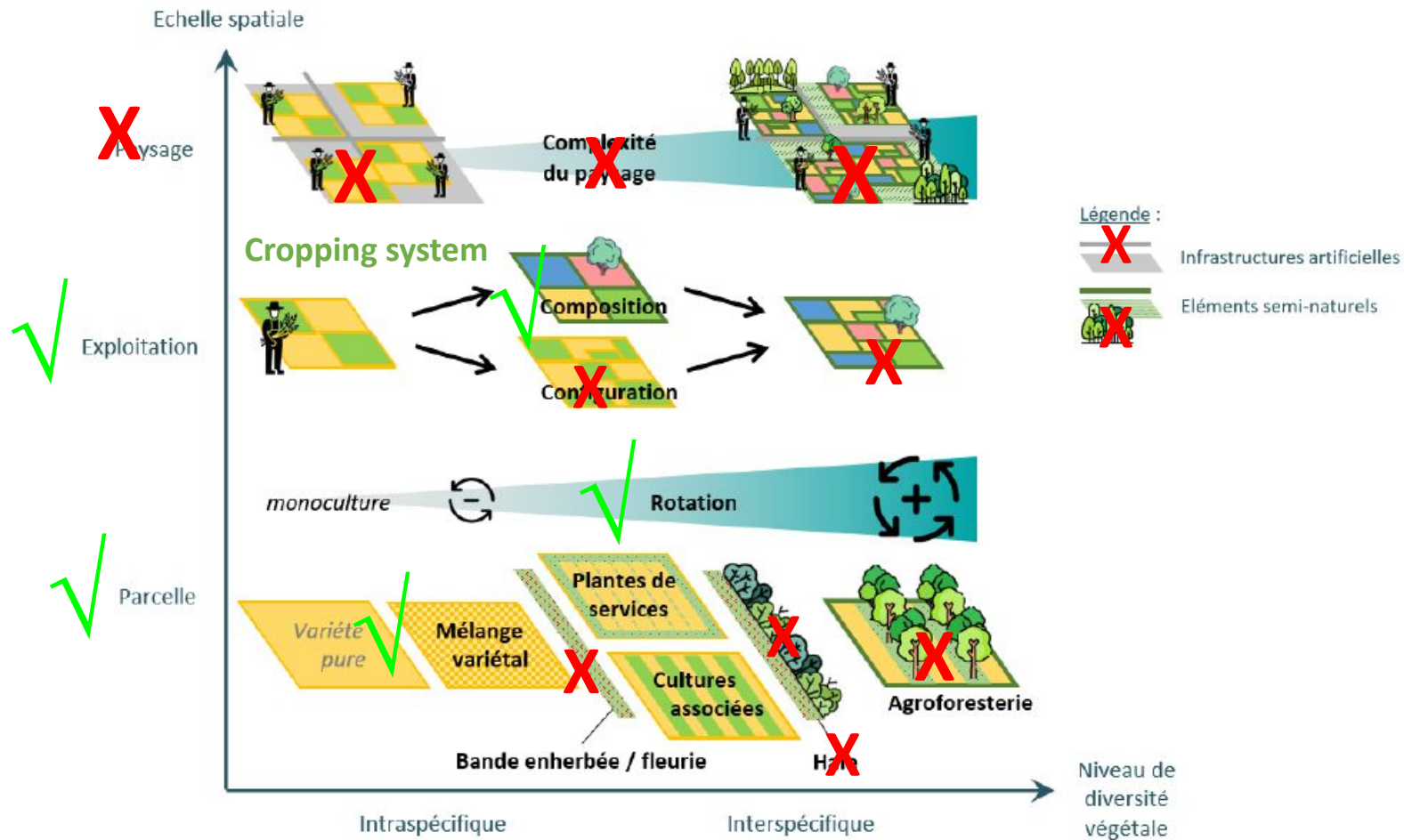


Figure 1. Représentation schématique des modalités de diversification végétale considérées dans l'ESCO

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- **Research objectives**
- Methodology
- Roadmap-Arrangement of different components
- Perspectives for further work
- 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,

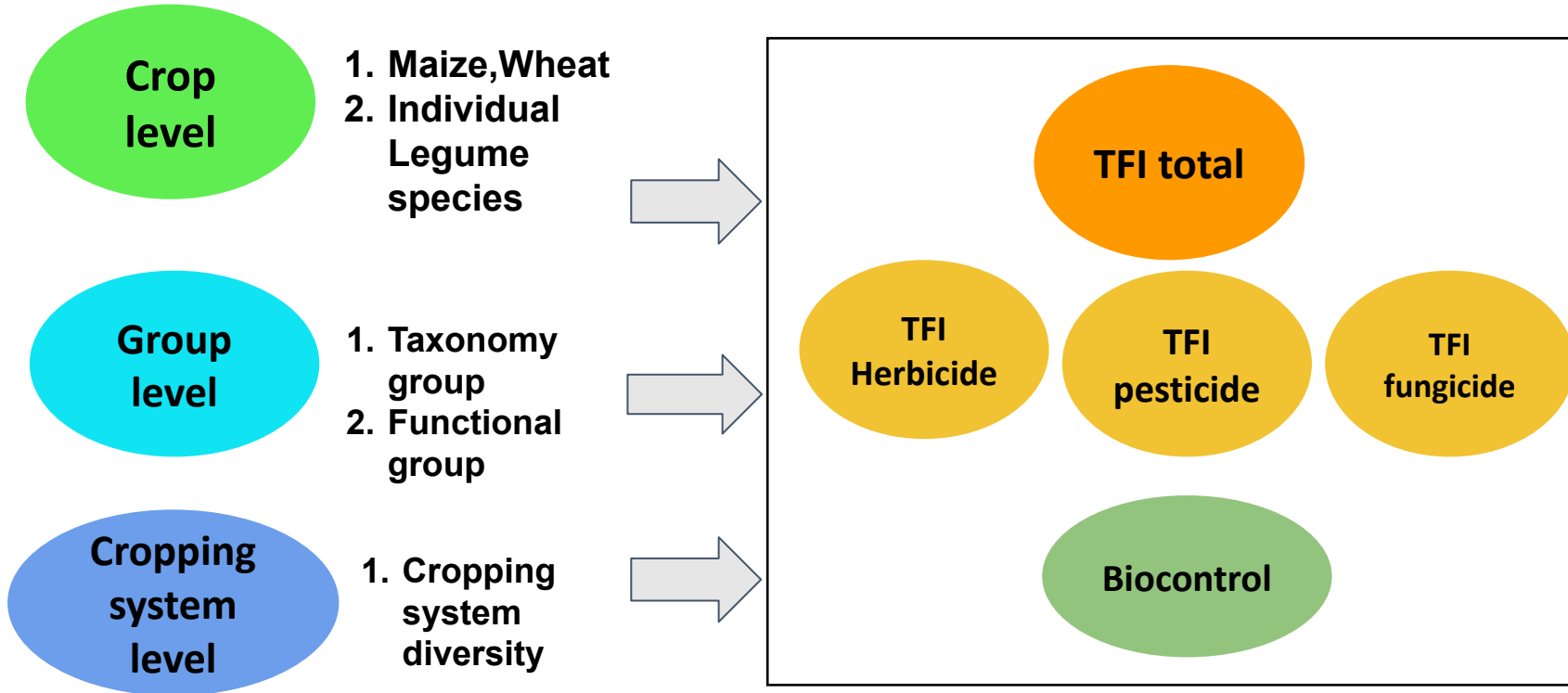
herbicide,

pesticide,

fungicide

biocontrol

# Diversity on



A transition from plant taxonomy to functional diversity

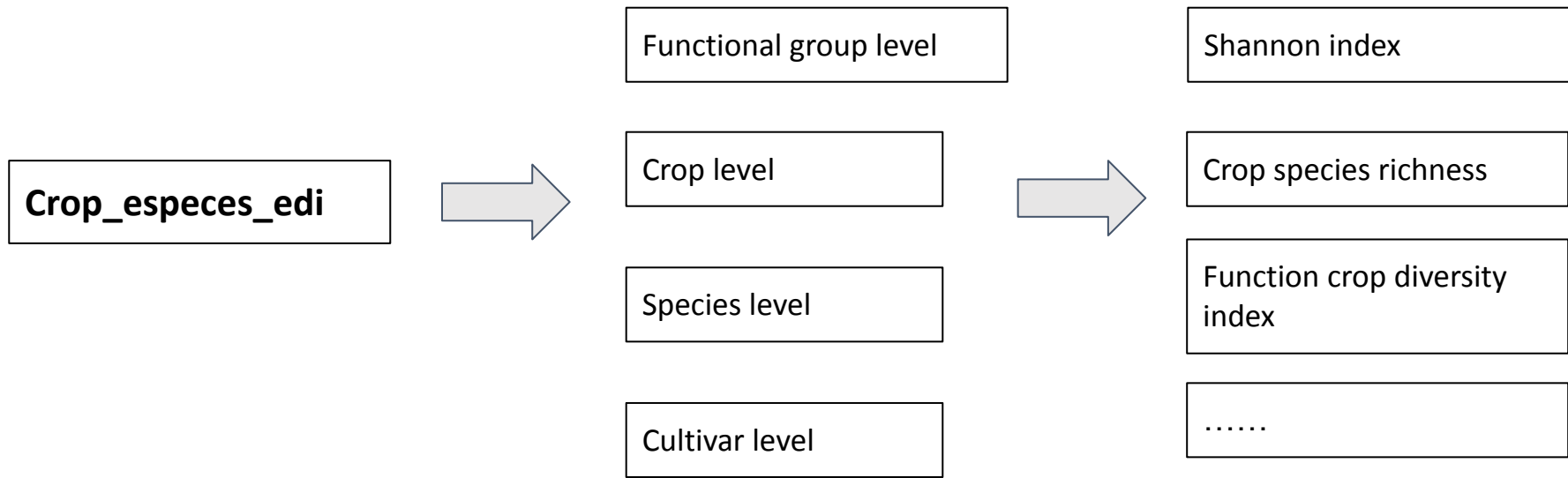
# Treatment Frequency Index (TFI) :

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

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

# Existing diversity Index selected

Index	Calculation	Strengths	weakness	Reference
Shannon	Shannon Index (H) = $-\sum_{i=1}^s p_i \ln p_i$	Able to calculate in AgroSYS data, representative of species diversity		
Simpson	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 = $-\sum_{g=1}^k p_g \ln(p_g)$			(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	<i>Diversité culturale</i> = $1/\sum (Surface\ groupe\ de\ culture\ n/Surface\ développée\ du\ SdC)^2$			



**Crop name registered in the database**

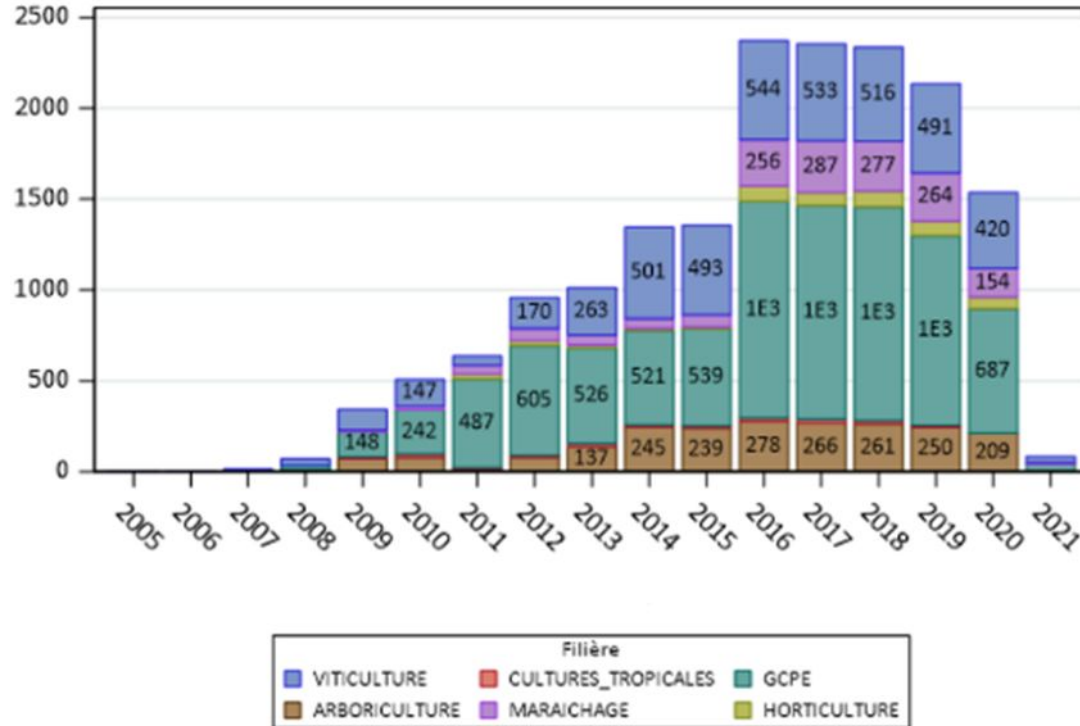
**Aggregate on different level**

**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**

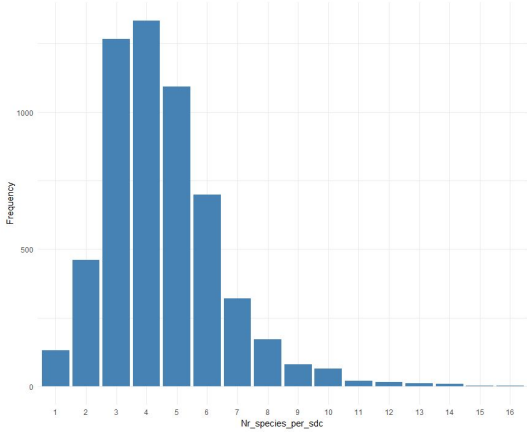
**As of August 28, 2021, DEPHY farms includes:**

**17062 SdC (Cropping system)**

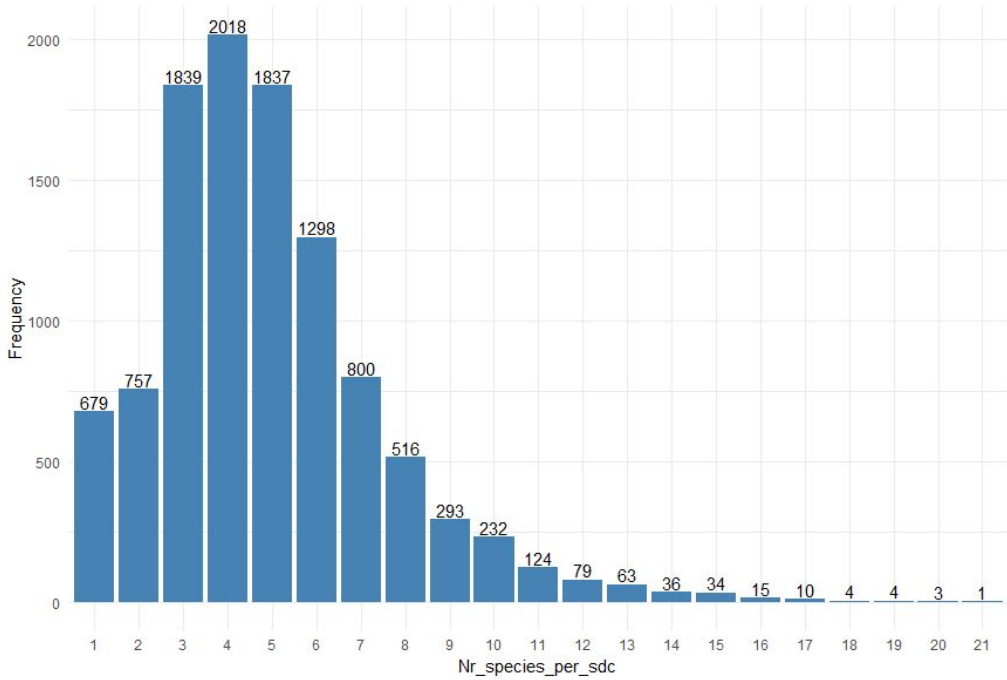
**75% in Synthesized  
25% in Realized**

# Data description - Number of species per cropping system

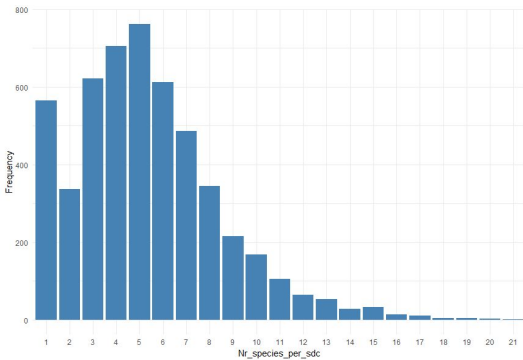
Synthetise



Both



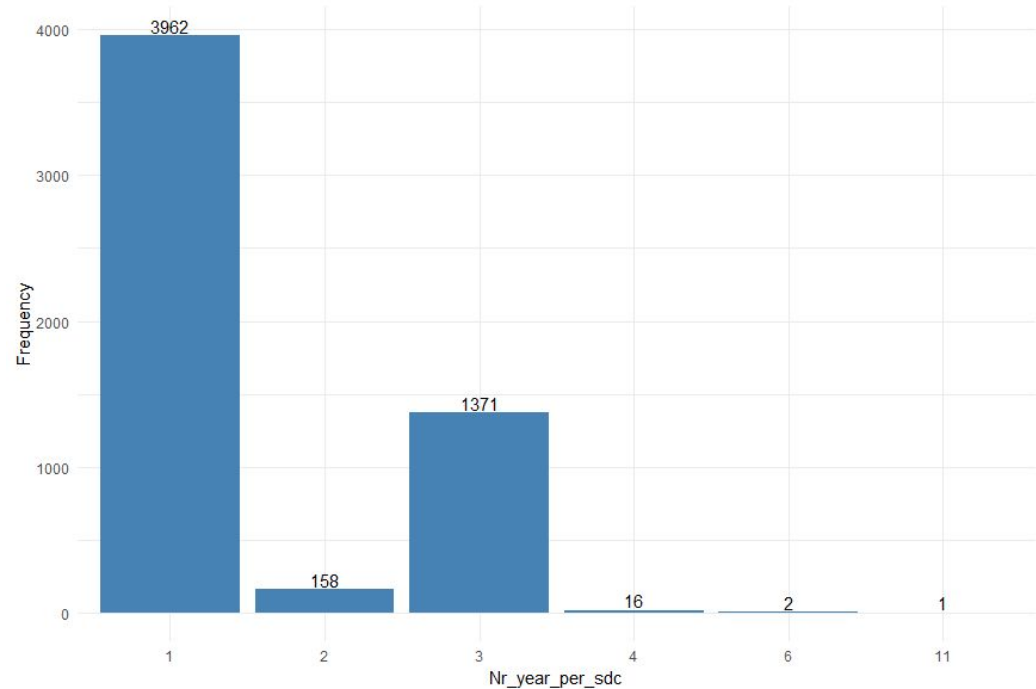
Realise



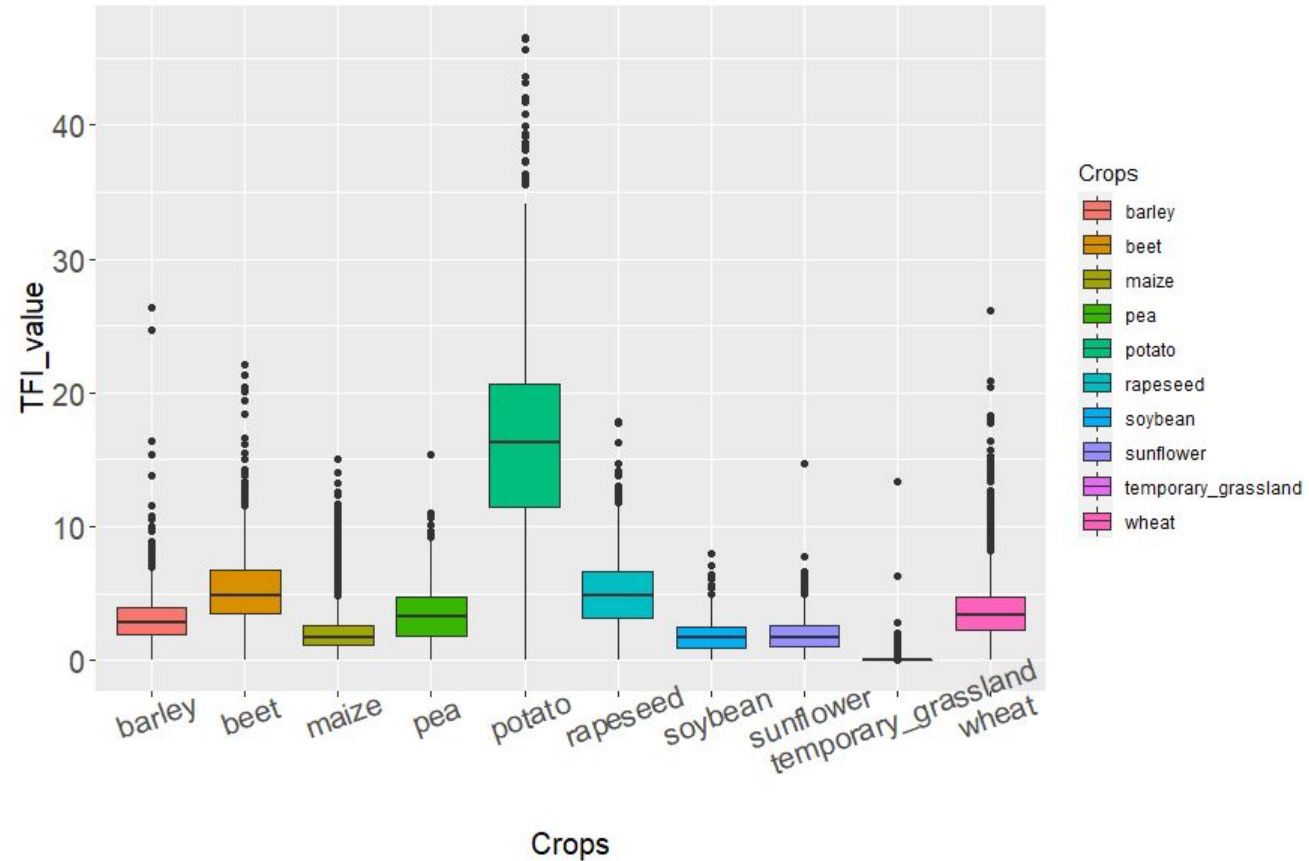


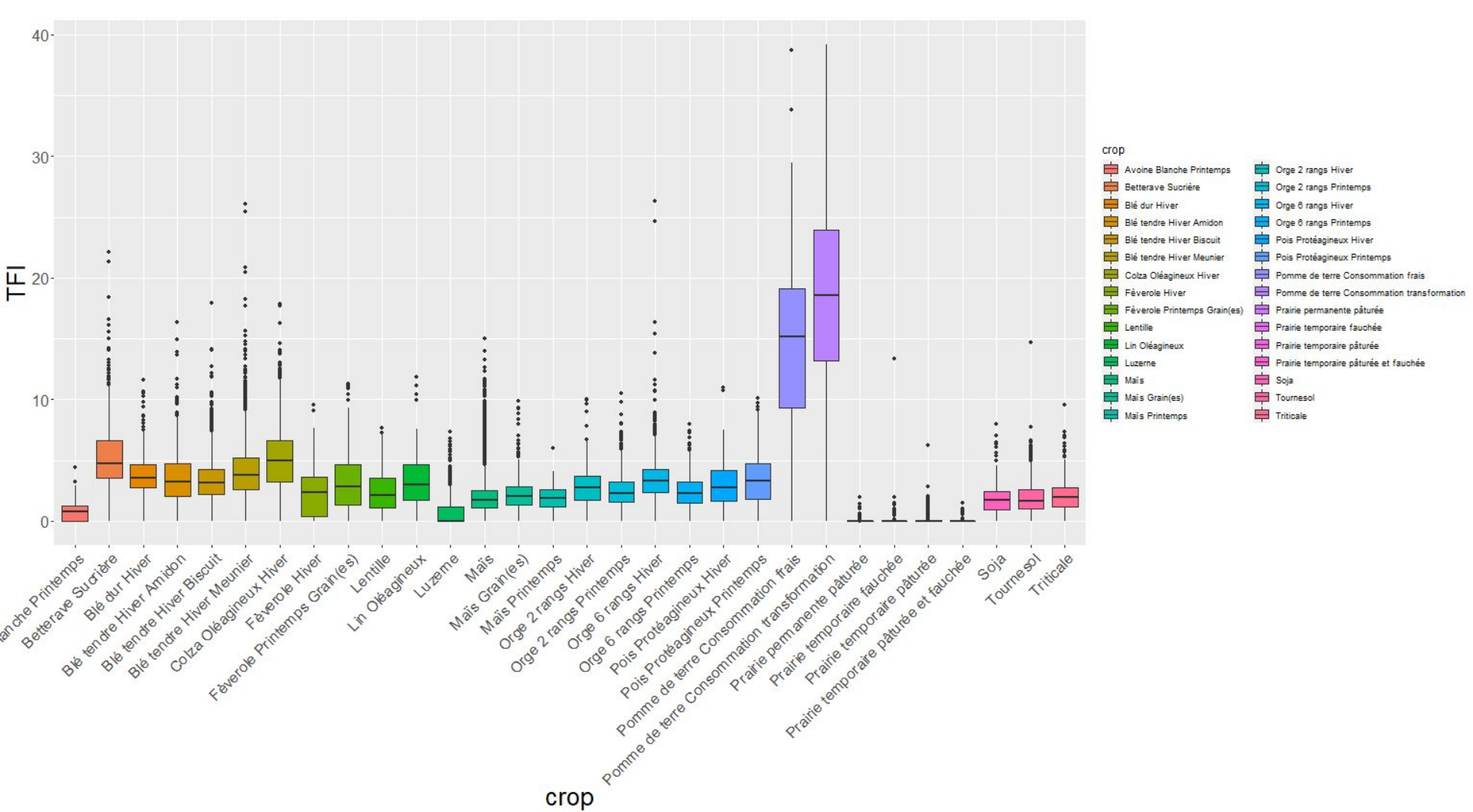
# Data description synthesis (a combined year)

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

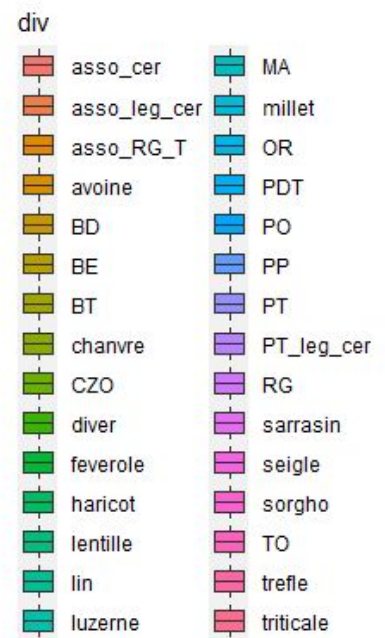
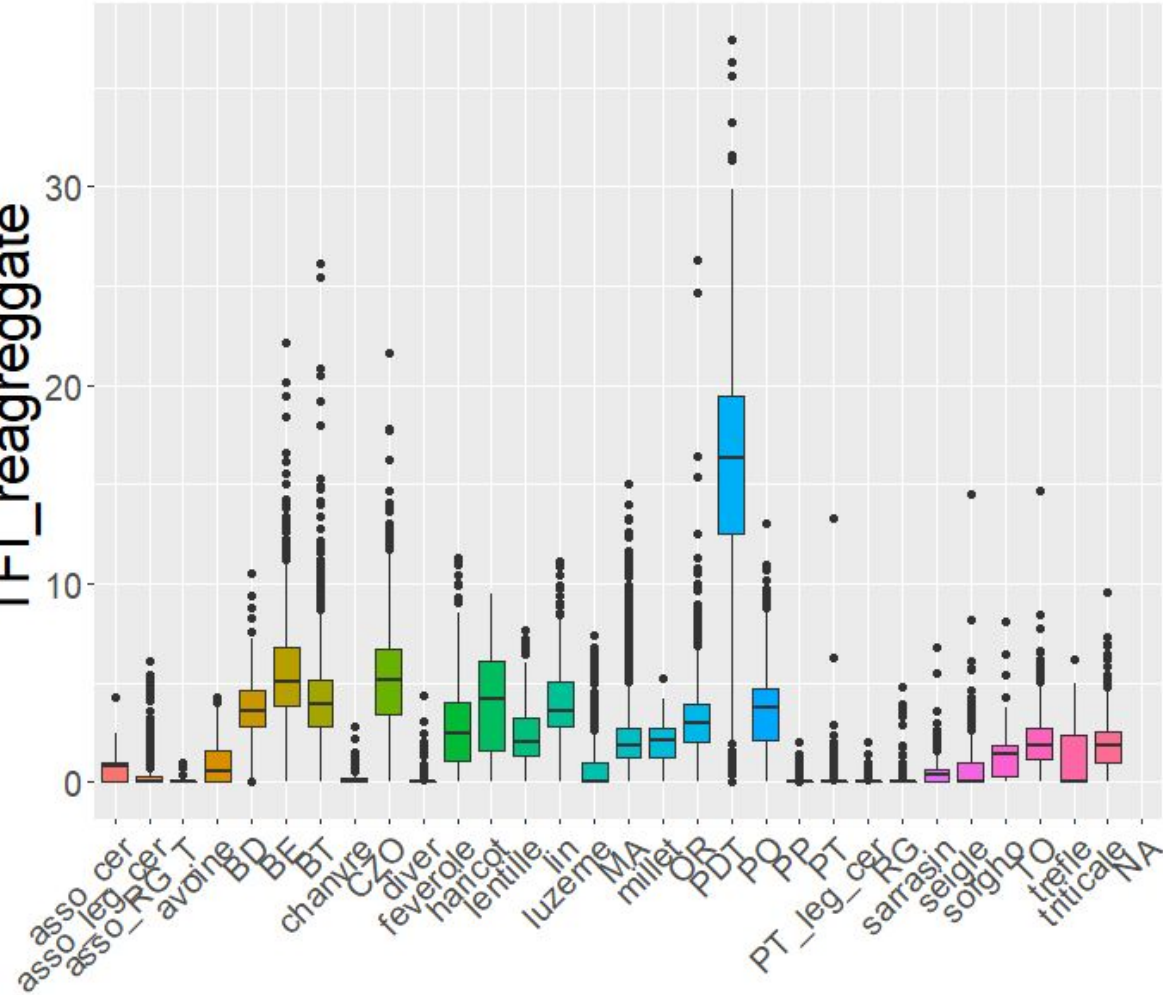


# TFI with crops





TFI\_reaggate

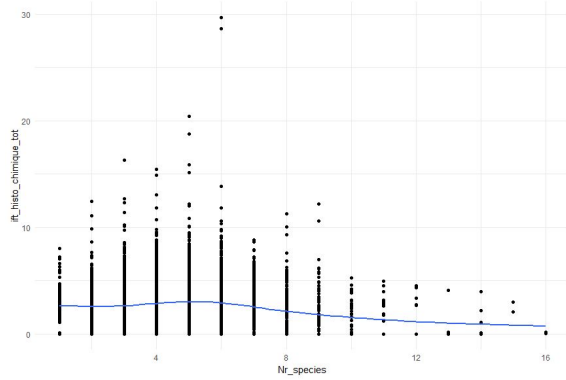


div

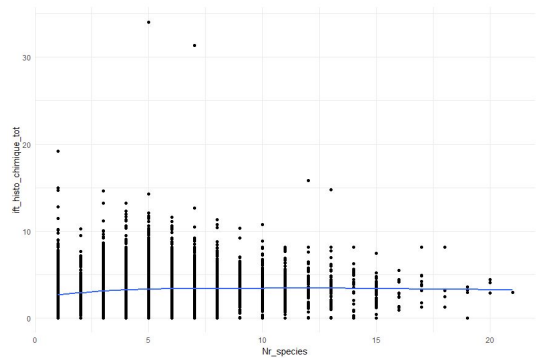
# Preliminary result-

## Treatment frequency index vs Number of species in each cropping system

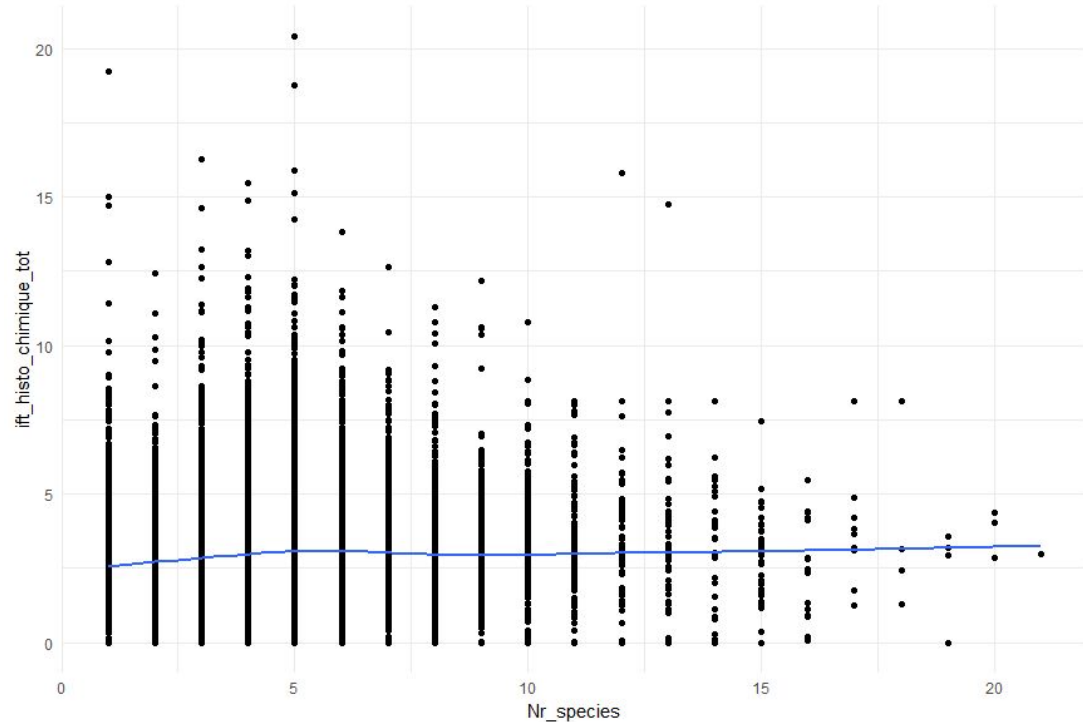
### Synthesis



### 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