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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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FRANÇAISE

*Liberté
Égalité
Fraternité*

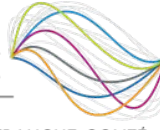
INRAE



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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 system

29th November 2022

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Content

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

Content

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

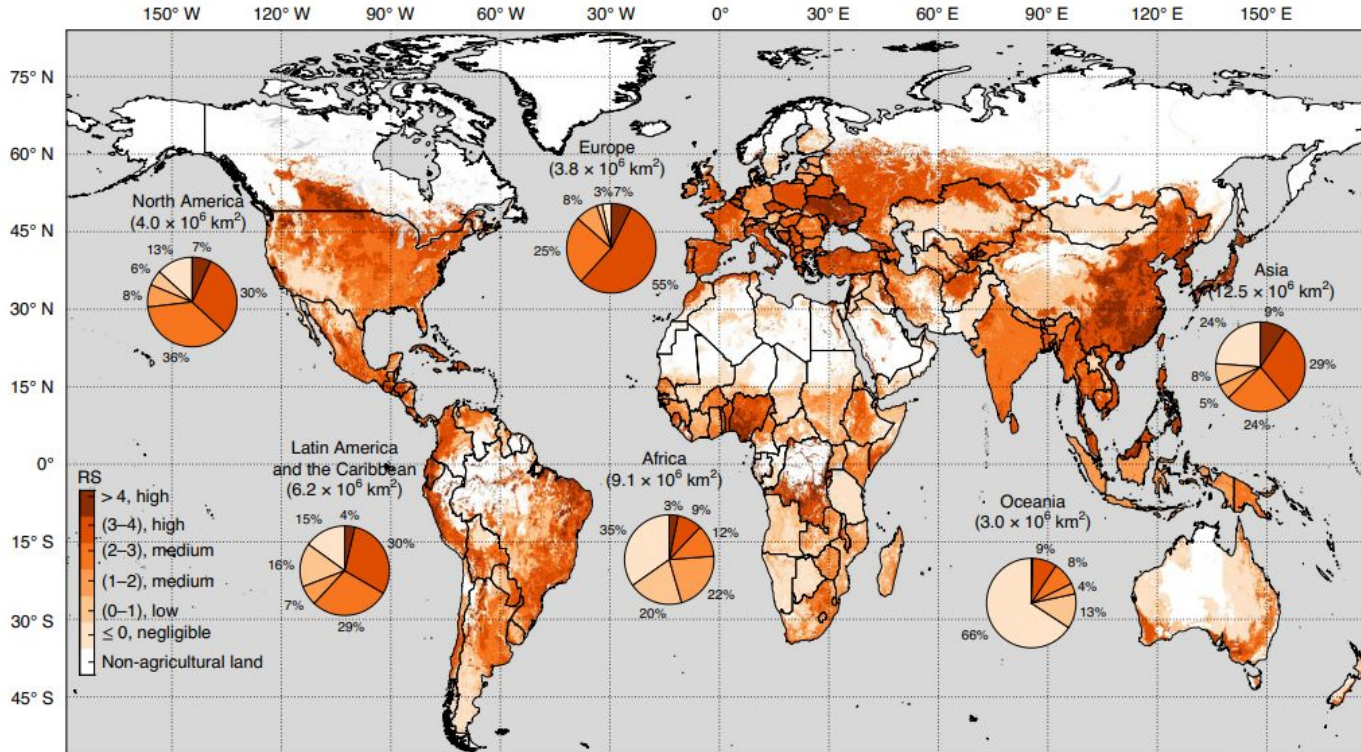
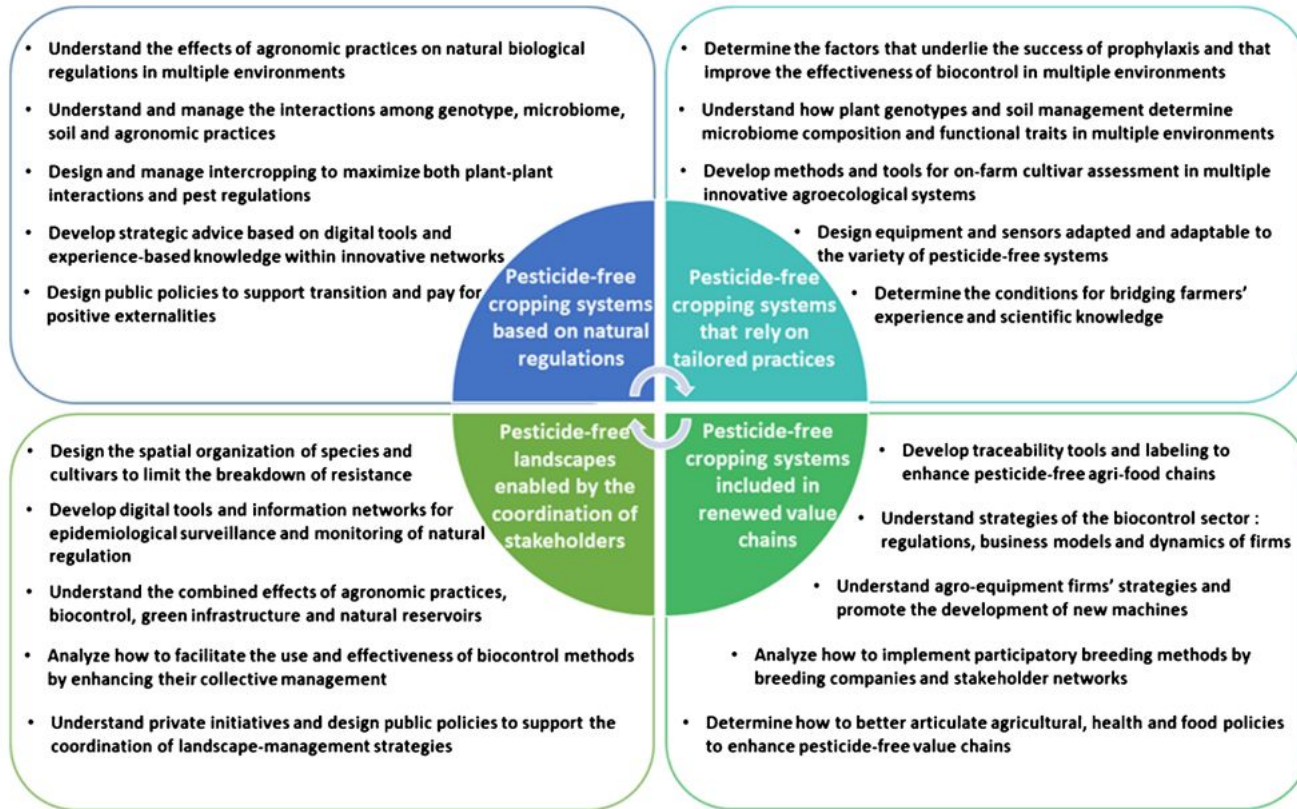


Fig. 1 | Global map of pesticide RS. The map has a spatial resolution of 5 arcmin, which is approximately 10 km × 10 km at the Equator. The pie charts represent the fraction of agricultural land classed under different RS in each region, and the values in parentheses above the pie charts denote the total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



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

Global production pressure

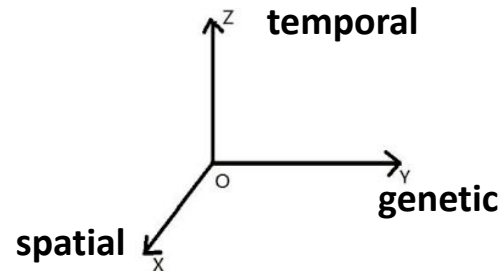
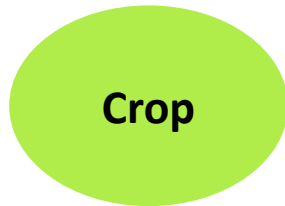
- Increasing population
- Climate change pressure
- Increasing vulnerability of conventional farming systems (FAO, 2020)

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



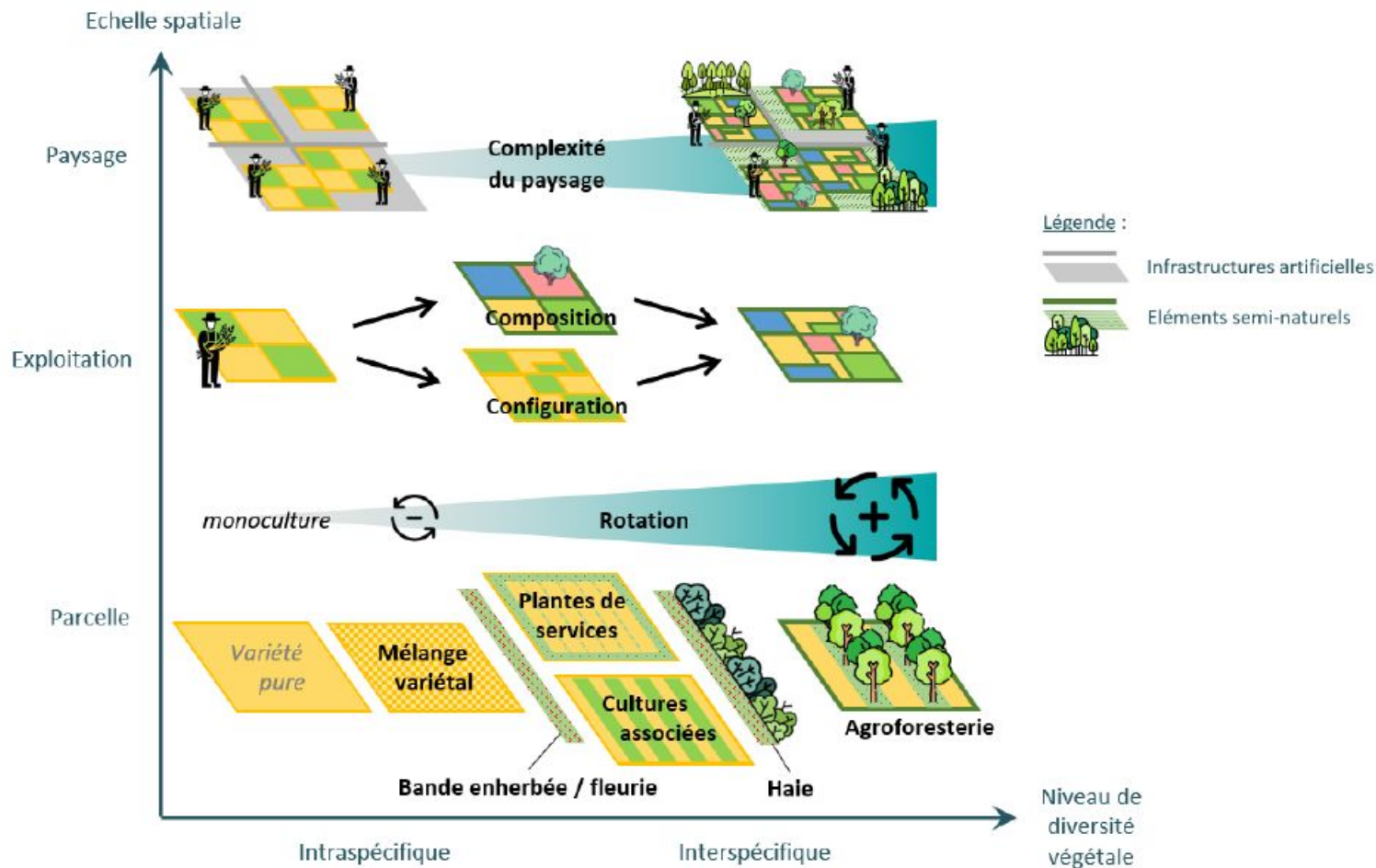


Figure 1. Représentation schématique des modalités de diversification végétale considérées dans l'ESCO

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

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



Can crop diversification reduce pesticide use?

Not so sure yet

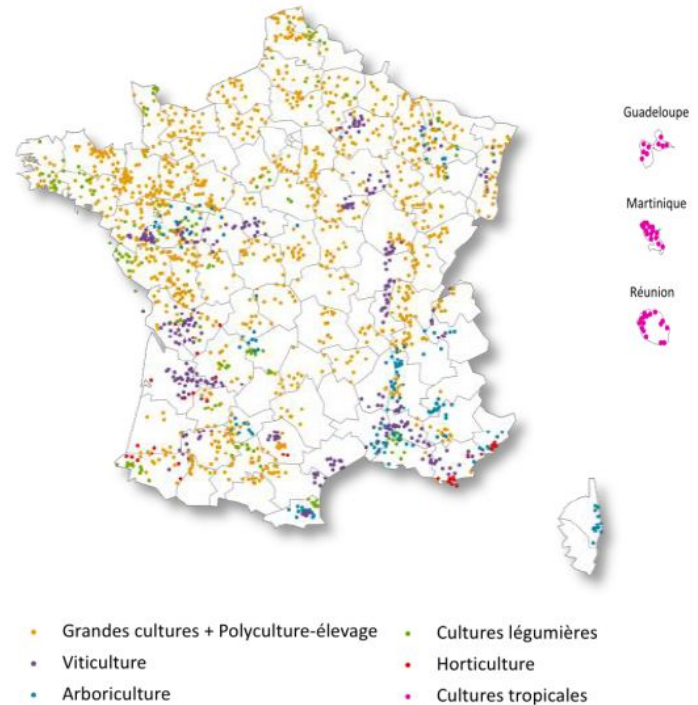
In some cases yes (Bonnet et al., 2021)

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

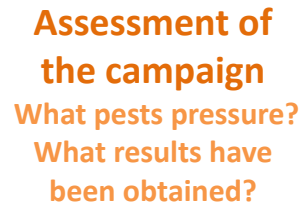
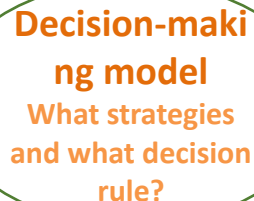


● AgroSYST

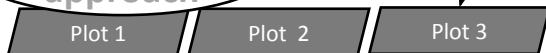
1. In which context?



2. What farming strategies?



3. Which practices on which crop?



Interventions carried out

Interventions carried out

Interventions carried out

2 approaches to choose



Synthesis of farming practices

4. Which performances? (indicators calculated)

❖ Farm description

Tests TEAM AGS

ÉCOPHYTO DEPHY RÉGULER ET AMÉLIORER L'UTILISATION DES PHYTOS

CONTEXTEUEL ET ORGANISATIONNEL | SYSTÈME DE CULTURE / DÉCISIONNEL | BILAN DE CAMPAGNE | ACTES RÉALISÉS | ACTES SYNTHÉTISÉS | PERFORMANCES

Exploitation ou Domaine expérimental
Dispositif
Réseau

Retour à la liste des domaines

Domaine: CBO_test | Campagne: 2022 (2021 - 2022) | Type de domaine: Exploitation agricole | Responsables: Voir la liste | Pièces jointes: 0

2022 | 2019 | 2018 | 2016

Contexte | **Caractéristiques** | **Ateliers d'élevage** | **Sols** | Parc matériel / Combinaisons d'outils | Cultures / Variétés / Cépages | Parcellaire / Parcelles | Prix

Localisation géographique du domaine

Context & Characteristics
Farm's details: Name, Location, Farm's orientation (sector), Labour force, ...

* Nom du domaine : CBO_test
* Type de domaine : Exploitation agricole
Nom de l'interlocuteur principal : Team Agrosyst
* Commune : 21000, Dijon

Livestock workshop:
Animals, Size, Feeding, ...

Soils:
Overall soils description

Déclarer les coordonnées GPS
Déclarer le zonage du domaine
Déclarer des stations météorologiques

Enjeux

Environnemental

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) : %
Part de la SAU en Périmètre de protection de paysage : %

CAMPAGNE(S) | RÉSEAU(X) | EXPLOITATION(S) OU DOMAINE(S) EXPÉRIMENTAL(UX) | DISPOSITIF(S) | SYSTÈME(S) DE CULTURE

Agrosyst

RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function Addins

Environment History Connections Tutorial

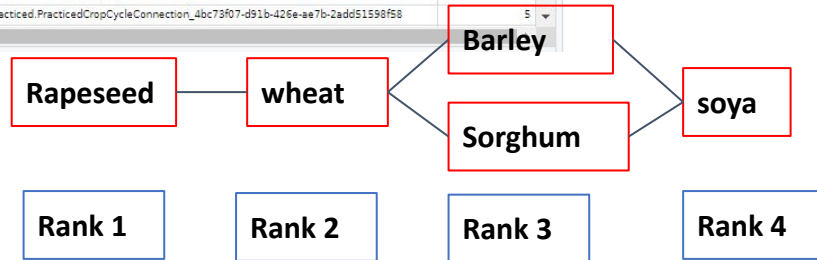
R - Global Environment

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 937070 obs. of 19 variables
- rotation_synt 71774 obs. of 30 variables
- rotation_synt_n... 46397 obs. of 30 variables

systeme_syntetise_campagnes	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	Tréfle blanc ; Ray-grass anglais	PRAIRIE TEMPORAIRE	1
ticedSysteme...	2018	Tréfle blanc ; Ray-grass anglais	PRAIRIE TEMPORAIRE	2
ticedSysteme...	2018	Tréfle blanc ; Ray-grass anglais	PRAIRIE TEMPORAIRE	3
ticedSysteme...	2018	Tréfle 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



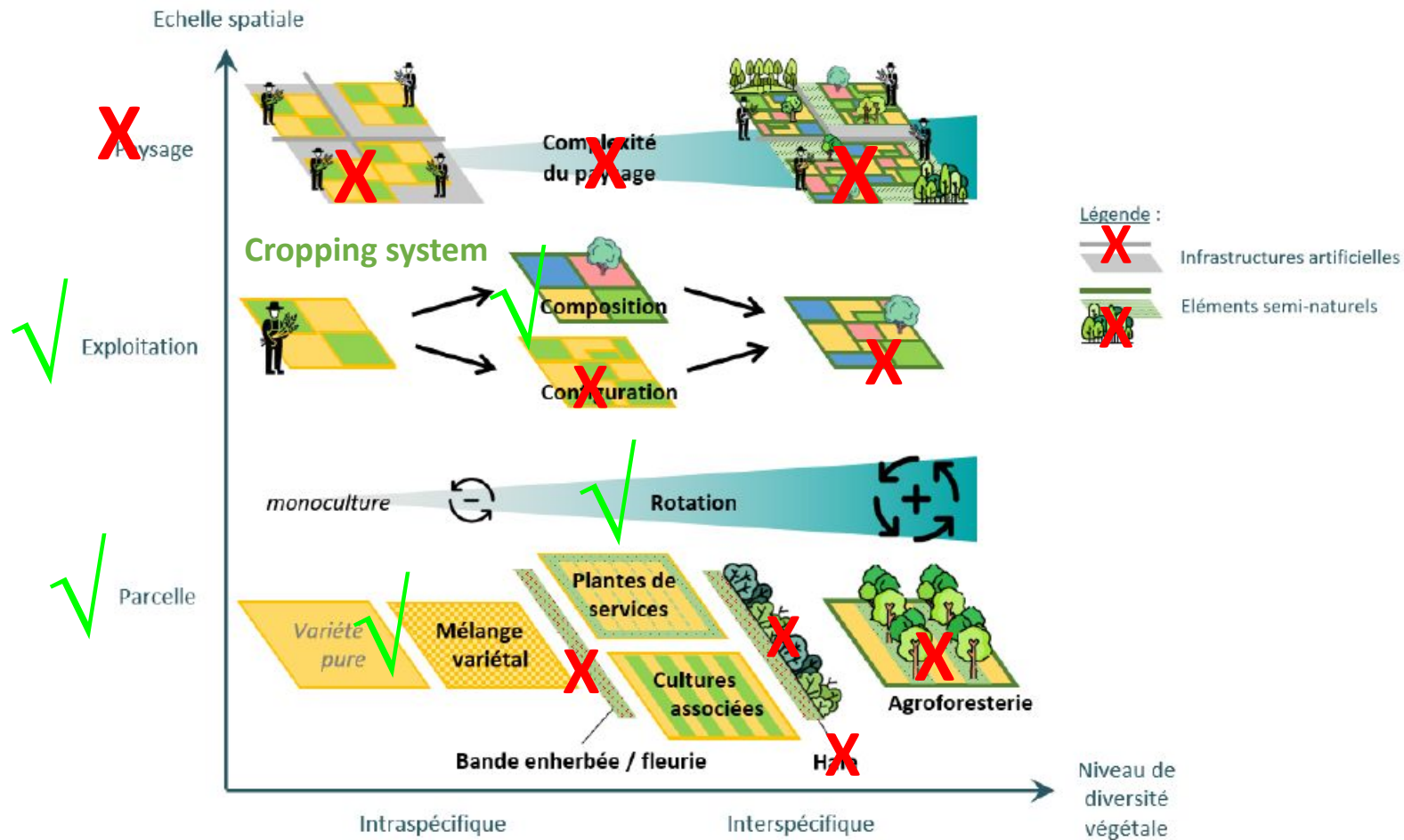


Figure 1. Représentation schématique des modalités de diversification végétale considérées dans l'ESCO

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- 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,

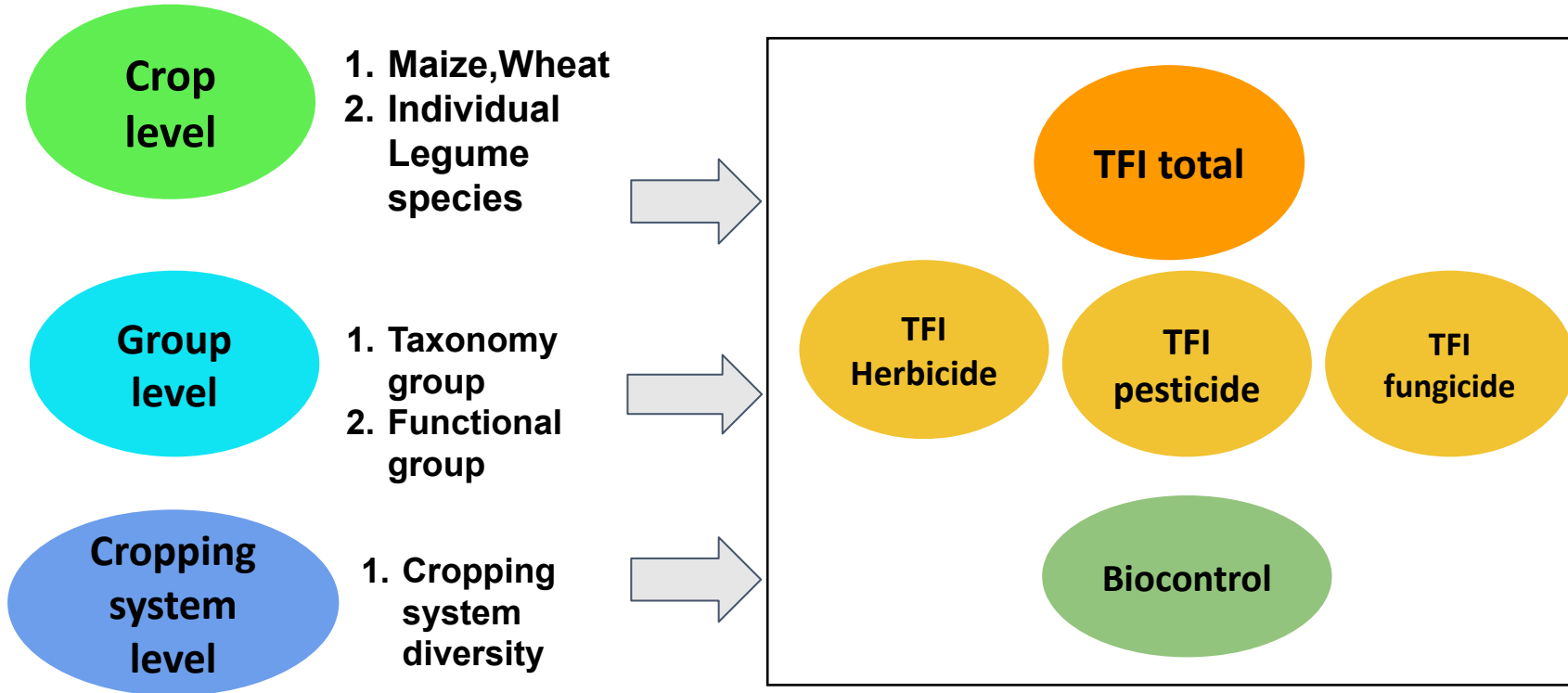
herbicide,

pesticide,

fungicide

biocontrol

Diversity on



A transition from plant taxonomy to functional diversity

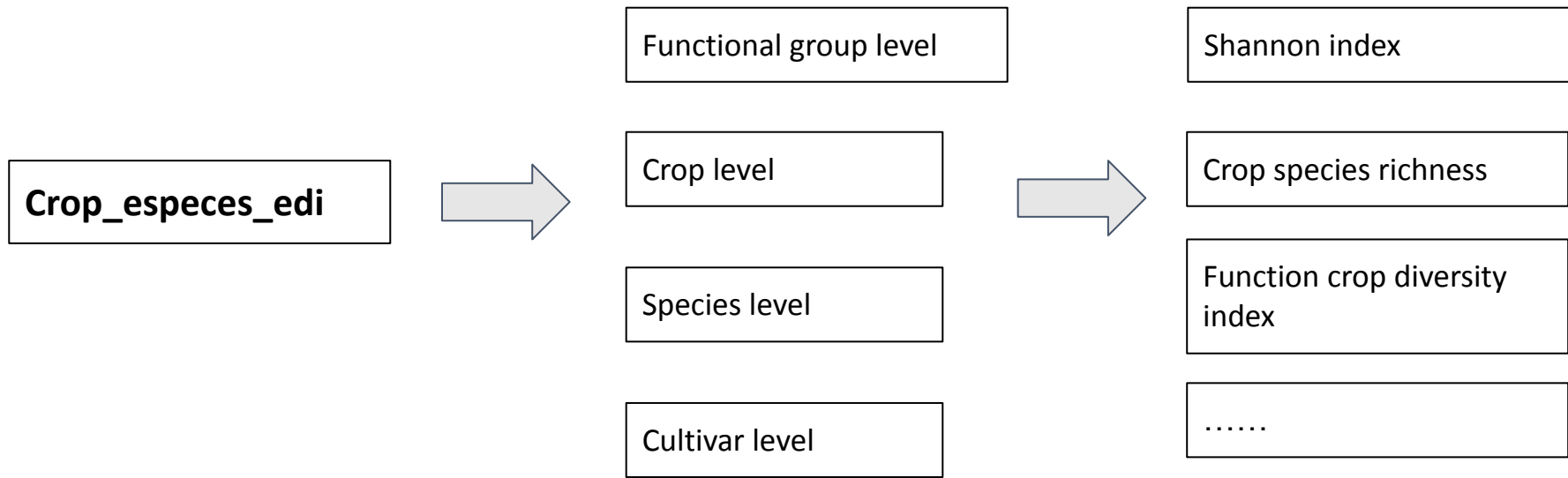
Treatment Frequency Index (TFI) :

- 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) = $-\sum_{i=1}^k p_i \ln p_i$	Able to calculate in AgroSYS data, representative of species diversity		
Simpson	Simpson Index (D) = $\frac{1}{\sum_{i=1}^k p_i^2}$			
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

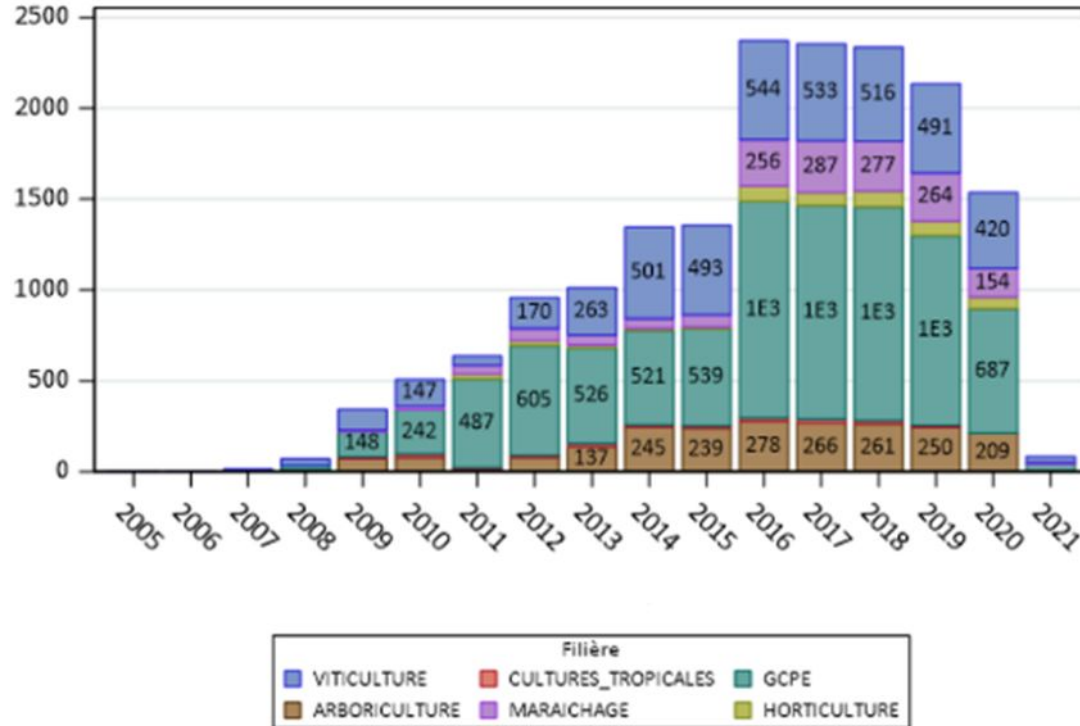
Aggregate on different level

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

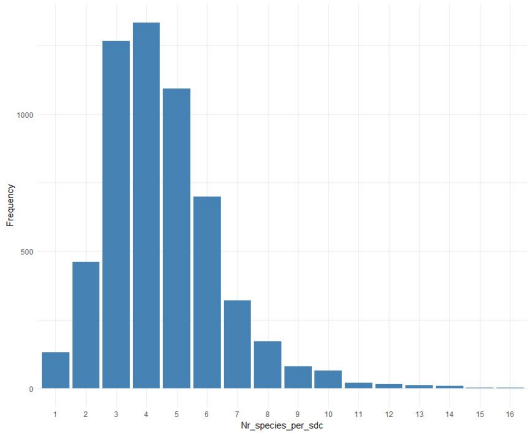
As of August 28, 2021, DEPHY farms includes:

17062 SdC (Cropping system)

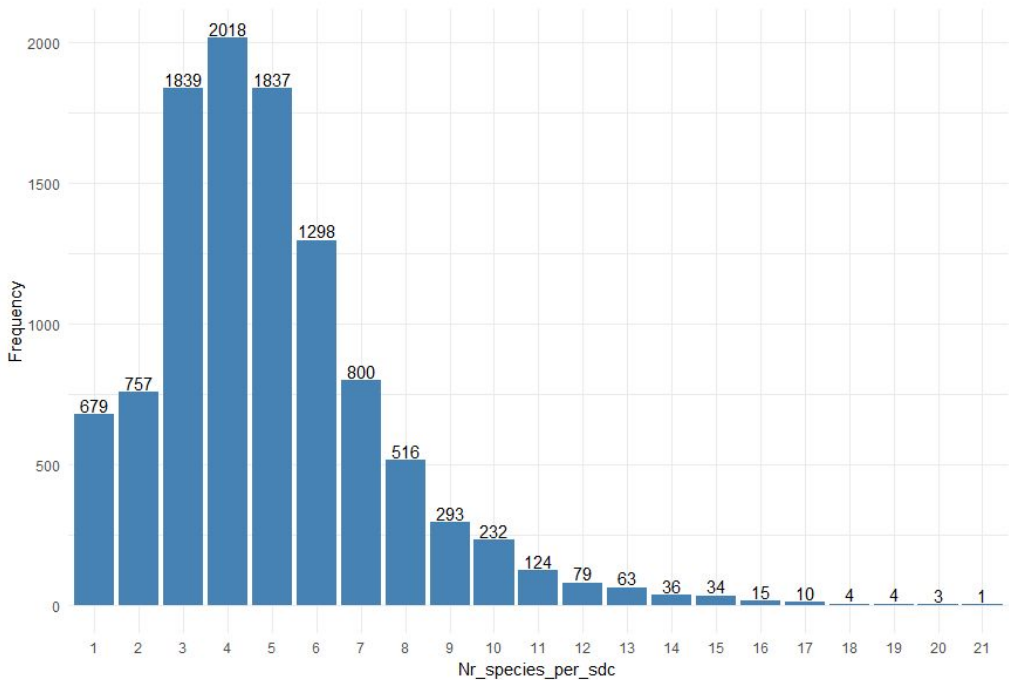
**75% in Synthesized
25% in Realized**

Data description - Number of species per cropping system

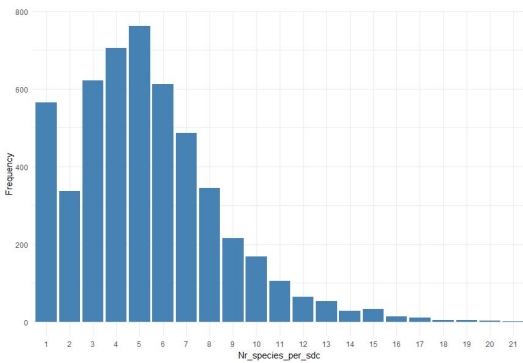
Synthetise



Both

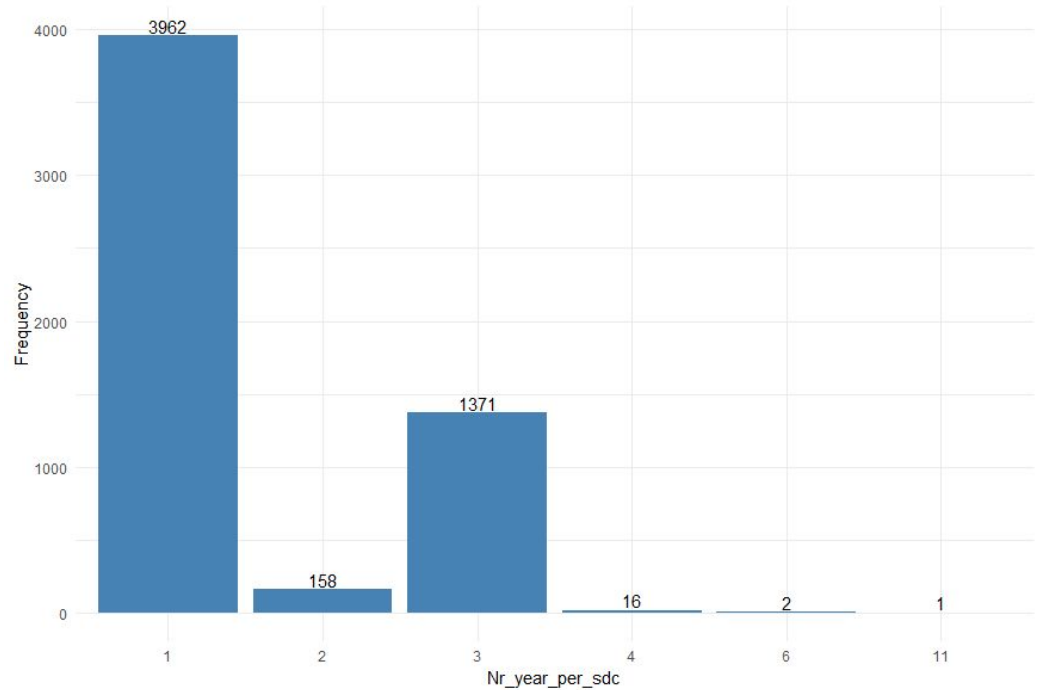


Realise

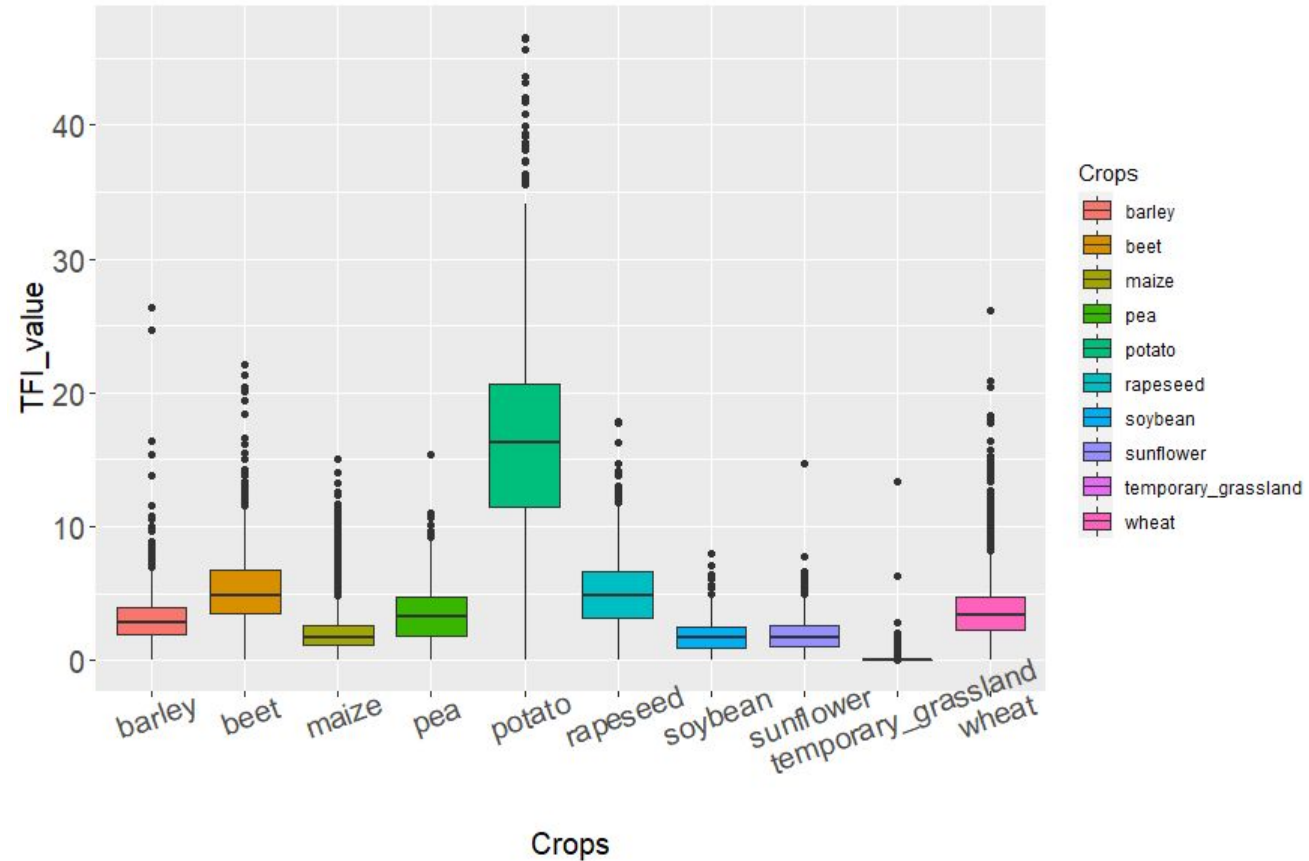


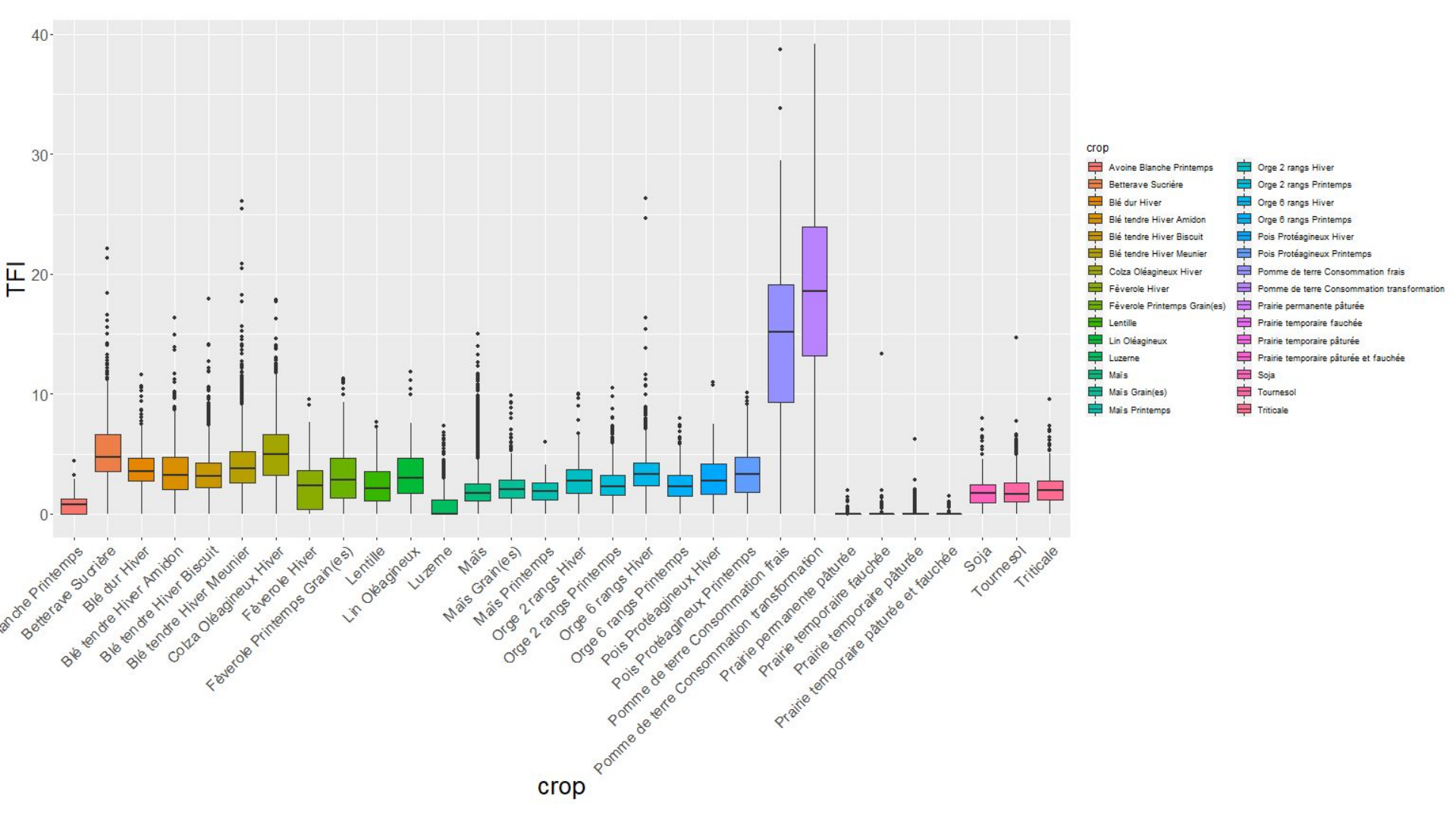
Data description synthesis (a combined year)

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

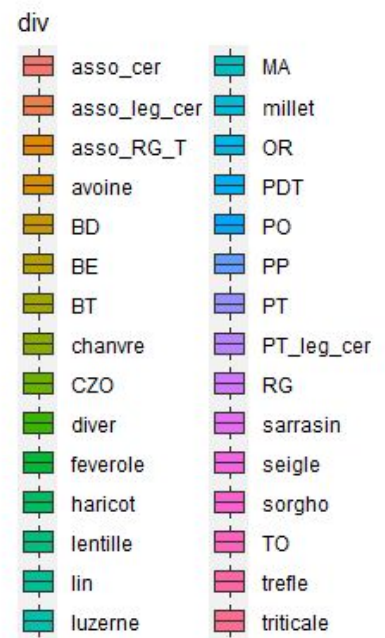
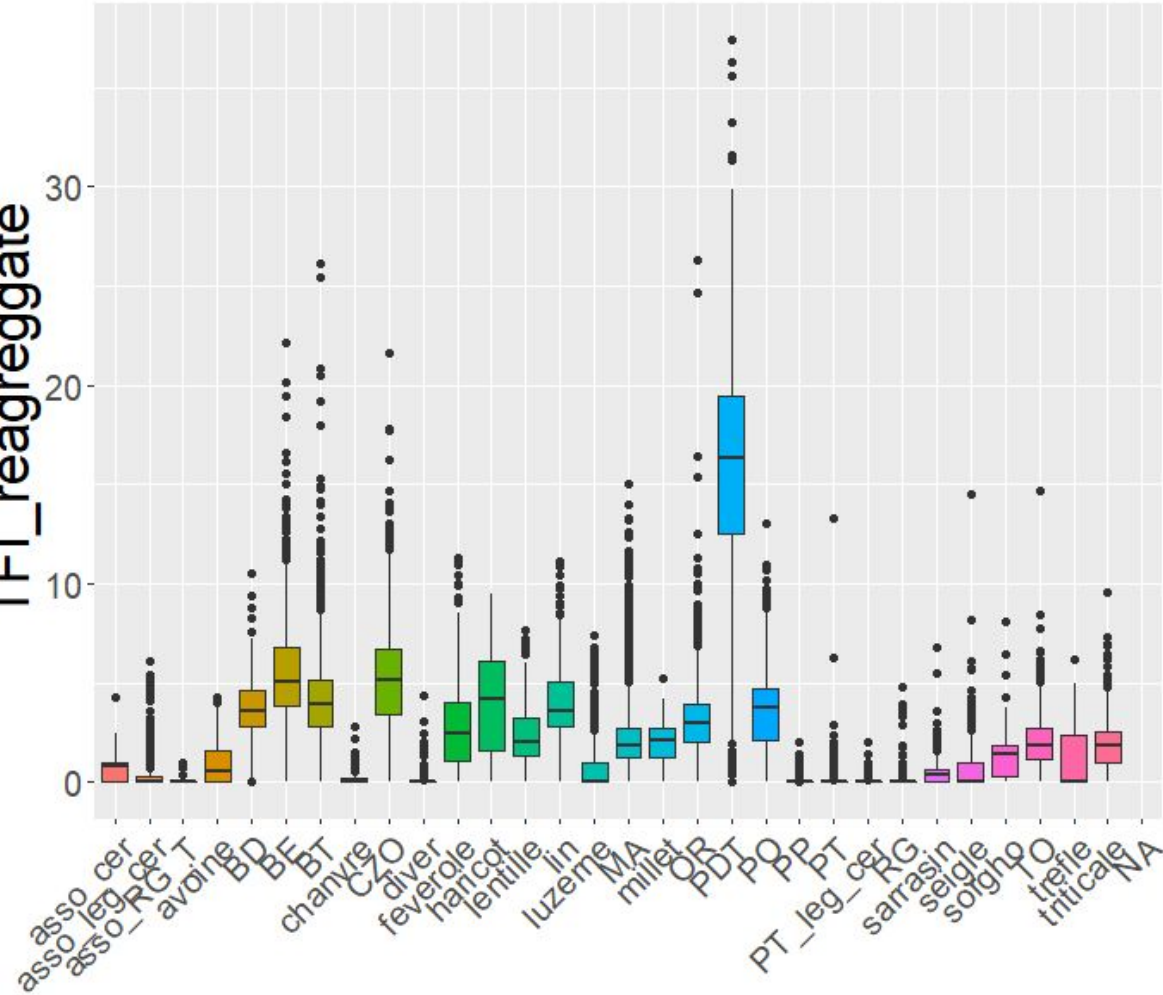


TFI with crops





TFI_reaggate

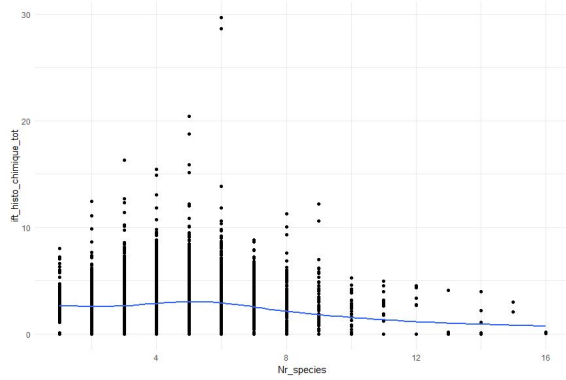


div

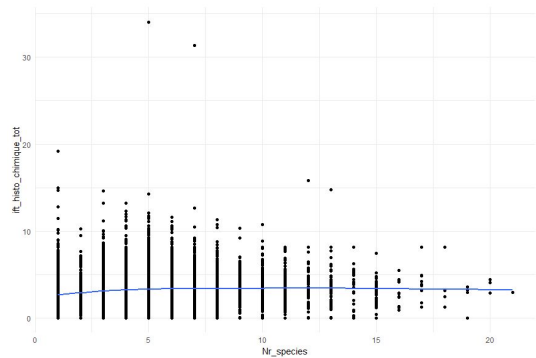
Preliminary result-

Treatment frequency index vs Number of species in each cropping system

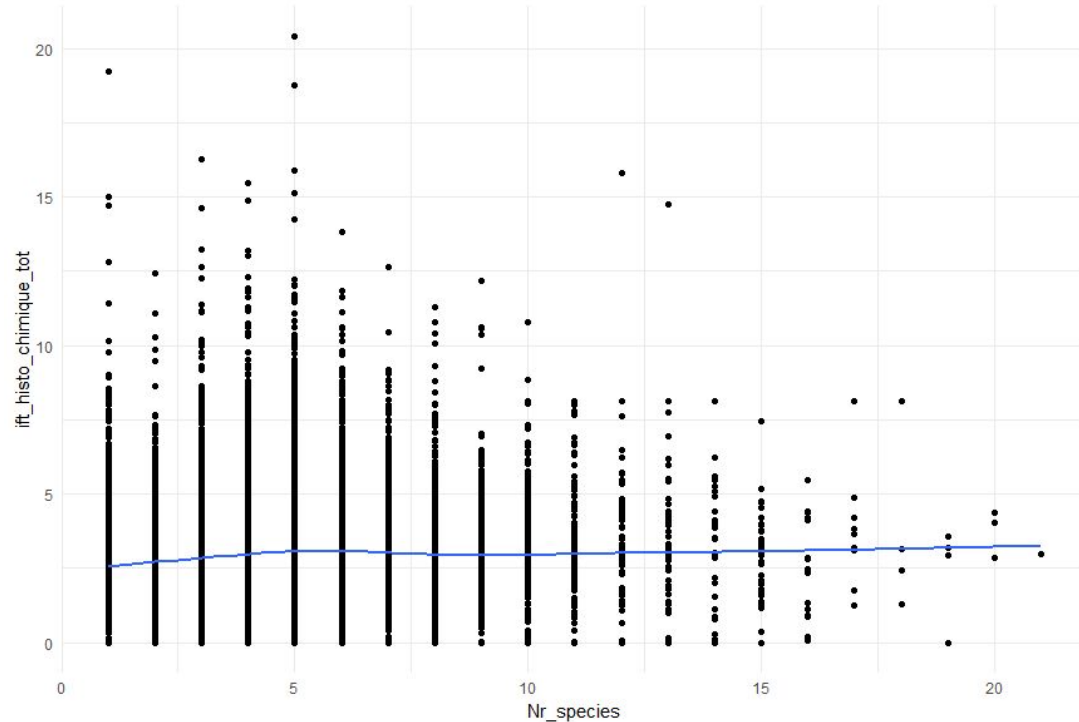
Synthesis



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