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## Ontology mapping for wheat trait information management



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Séminaire *semantic linked data*,  
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**Un exemple de valeur phénotypique :  
susceptibilité à la rouille des feuilles (susceptible to *leaf rust*)**



**Trait correspondant : resistance to *leaf rust***



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# Experimental data and text - complementary sources of information

Cultivar

Trait

Accession N°	rb: Susceptibility to leaf rust	pvp:
RE11058		3
CF11150		4
AO12016		4
RE11087		4
LYRIK		2
DI12010		6
CF11140		3
RE11035		2
CF11177		1
CF11115		2
DI12012		3
DI12011		2
EM11579		1
EM11582		4
<b>APACHE</b>		<b>1</b>
PREMIO		2
AO12018		4

Observed leaf rust score

Experimental phenotypic dataset

- These assays included inoculation with three different pathotypes on a segregating population originating from a cross between cv. *Apache* and cv. *Taldor*, a French cultivar susceptible to stripe rust
  - moderately tolerant to stripe rust
  - highly resistant to stripe rust
  - ...

Scientific articles



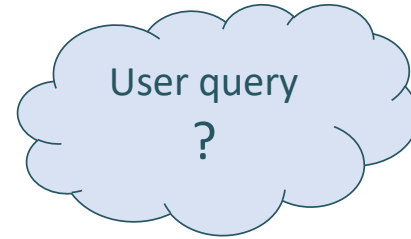
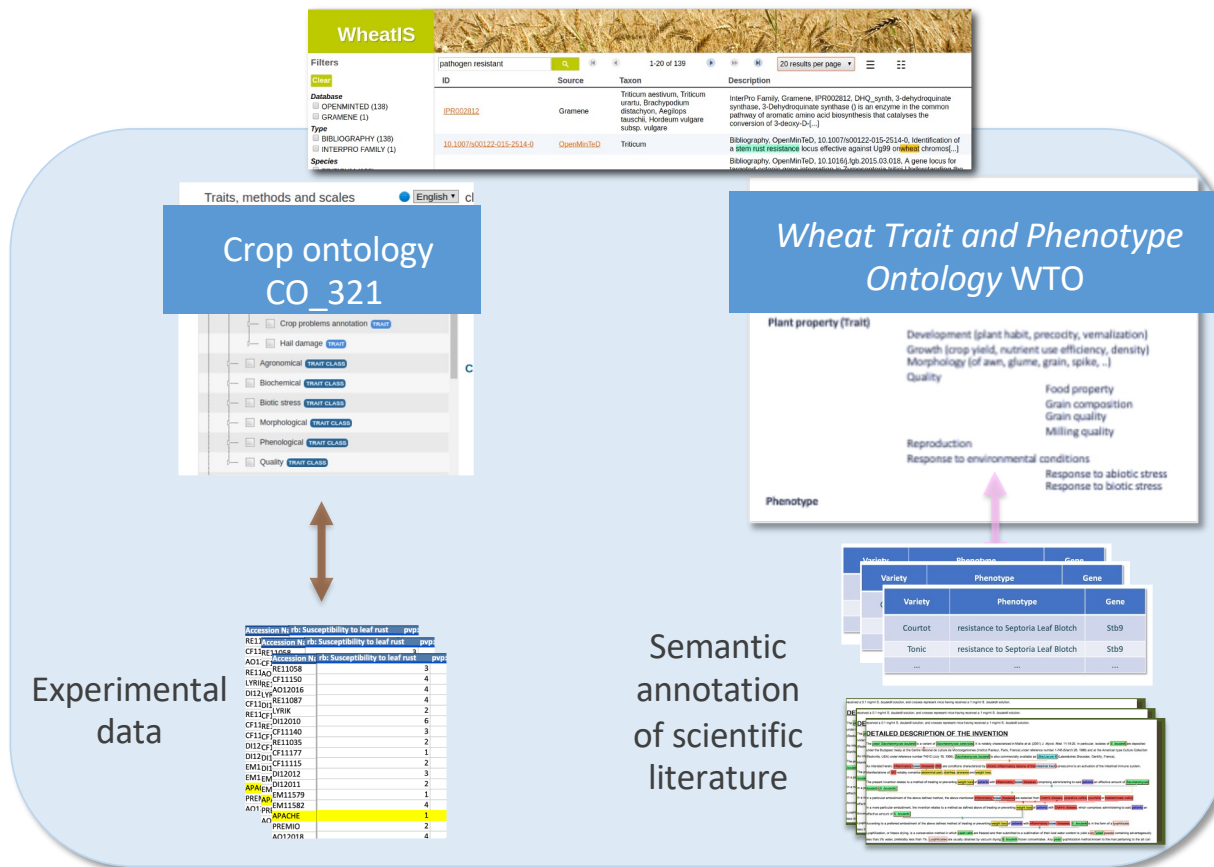
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# Semantic web technologies for a unified Knowledge Base

Phenotypic data and literature information on bread wheat cultivars



Retrieves interoperable information in a user friendly way

- Components**
- (1) Experimental data indexing and lifting
  - (2) Literature semantic annotation and lifting
  - (3) Mapping of ontology classes and lifting
  - (4) Knowledge model design

### (3) Trait and phenotype information, two complementary ontologies

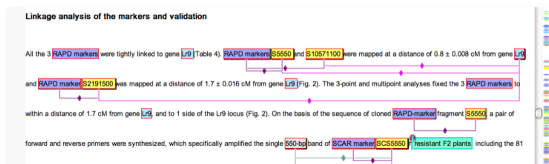
#### WTO

- Wheat Trait&Phenotype Ontology
- 753 traits and phenotypes
- Deep structure: 9 levels

#### CO\_321

- Crop Ontology for wheat
- Observation variables
  - trait +method+scale
- 460 trait classes
- Flat structure: 3 levels

<http://agroportal.lirmm.fr/ontologies/WHEATPHENOTYPE>



Crop Ontology for agricultural data  
Template and Guidelines :  
[www.croponontology.org](http://www.croponontology.org)



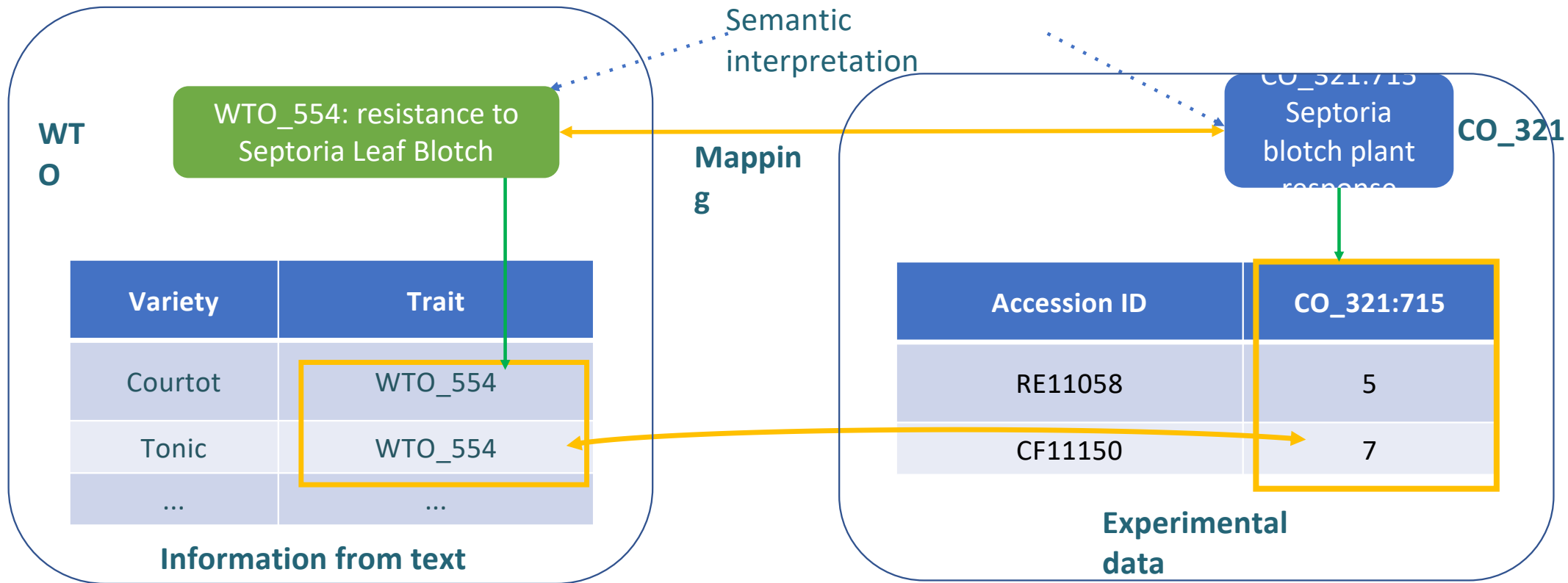
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# Searching for variety traits in textual and experimental databases

Query: all data about **Resistance to STB** in all **Wheat varieties**



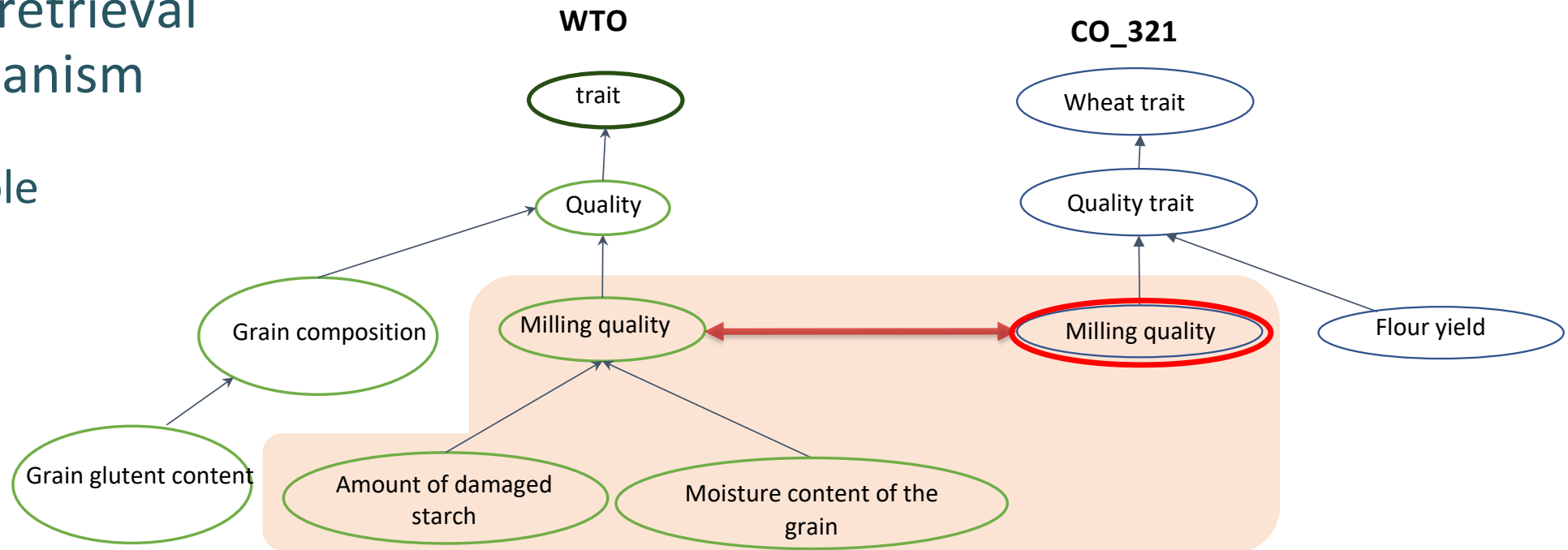
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# Data retrieval mechanism

## Example



**Query: All data about « milling quality » of wheat varieties?**

Data indexed by all subsumed classes:

WTO:Milling quality      CO:Milling quality

WTO:Moisture content of the grain

WTO:Amount of damaged starch

*more specific classes in WTO*



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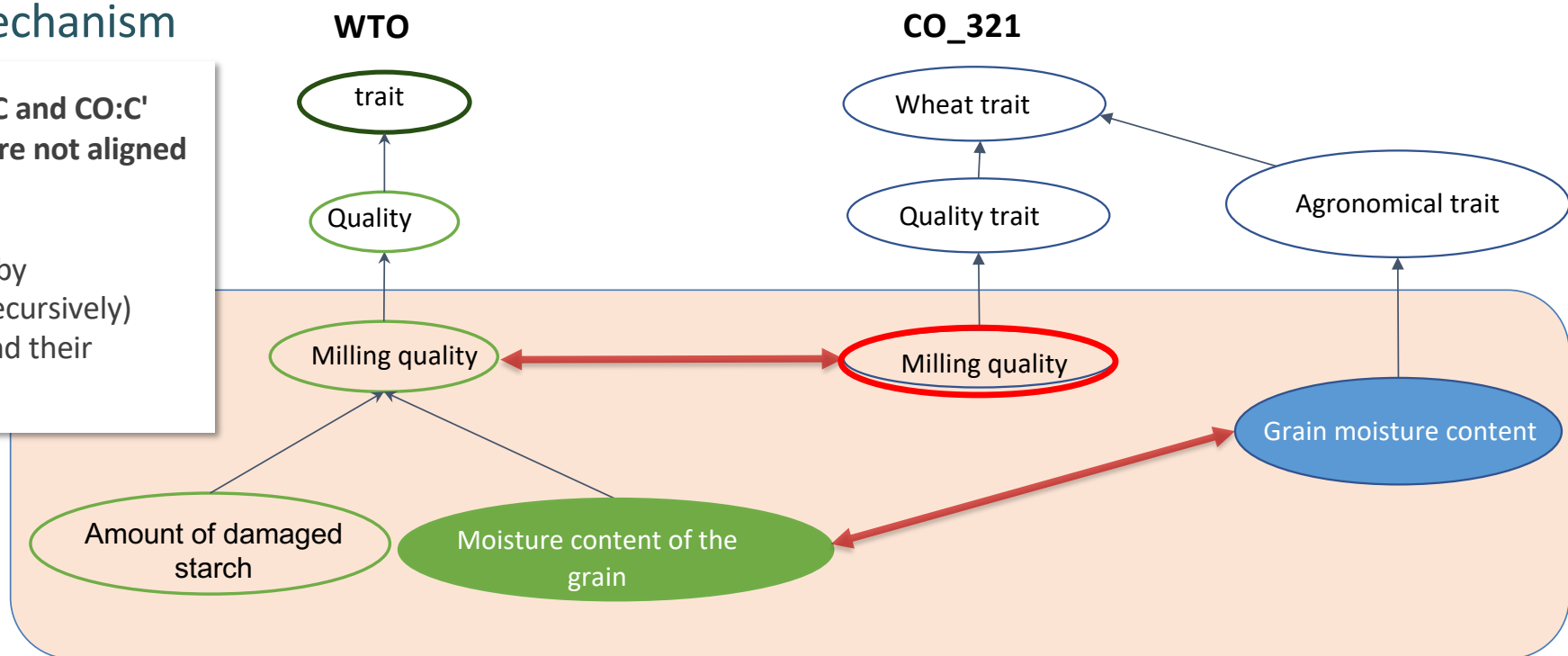
# Data retrieval mechanism

Two aligned classes WTO:C and CO:C' may have ancestors that are not aligned

## Strategy

Union of the data indexed by

- all subsumed classes (recursively)
- all equivalent classes and their subsumed classes



### Query: All data about « Milling quality » of wheat varieties?

Data indexed by all subsumed classes= class subtrees:  
 WTO: Milling quality CO:Milling quality

*more specific classes in WTO*

WTO:Moisture content of the grain  
 WTO:Amount of damaged starch

CO:Grain Moisture content *equivalent class in CO*





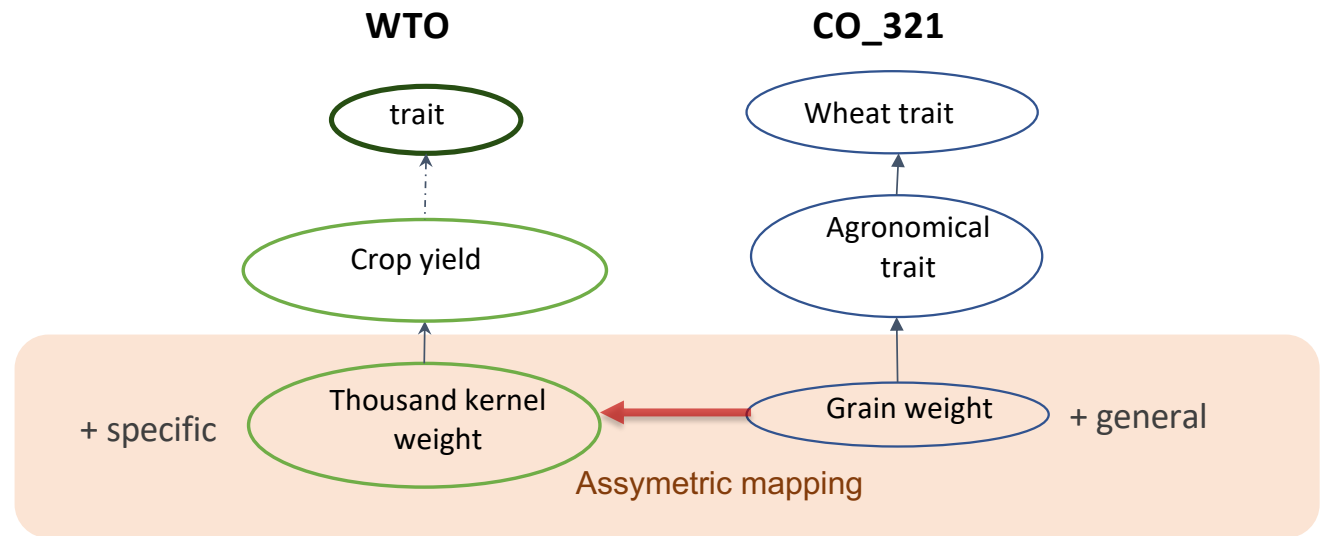
## Data retrieval mechanism

### Asymmetric mapping relation

CO: class is more general than any WTO classes (or the reverse)

#### Strategy

Asymmetry of the mapping  
Inference, but not equivalence



**Query: All data about « Grain weight» of wheat varieties?**

Retrieved data indexed by :

WTO: Thousand kernel weight    CO: Grain weight

**Query: All data about « Thousand kernel weight» of wheat varieties?**

Retrieved data indexed by :

CO: Thousand kernel weight

# Typology of mapping justifications

- 0** The classes are different
- 1** The classes are equivalent
  - 1.1** The classes have the same label or are slightly different, but have the same sense
  - 1.2** The classes share labels or synonyms
  - 1.3** The classes have different labels, but their definitions are similar, or the definition includes a label or synonym of the other class
  - 1.4** The classes are equivalent with respect to formal rules
  - 1.5** The mapping uses supplementary information (e.g., reference)
- 4,5,6** Complex mapping
- 7** The CO\_321 class is more general than the WTO class, and there is no relevant, more specific class
- 8** The WTO class is more general than the CO\_321 class, and there is no relevant, more specific class

## Examples of mapped classes

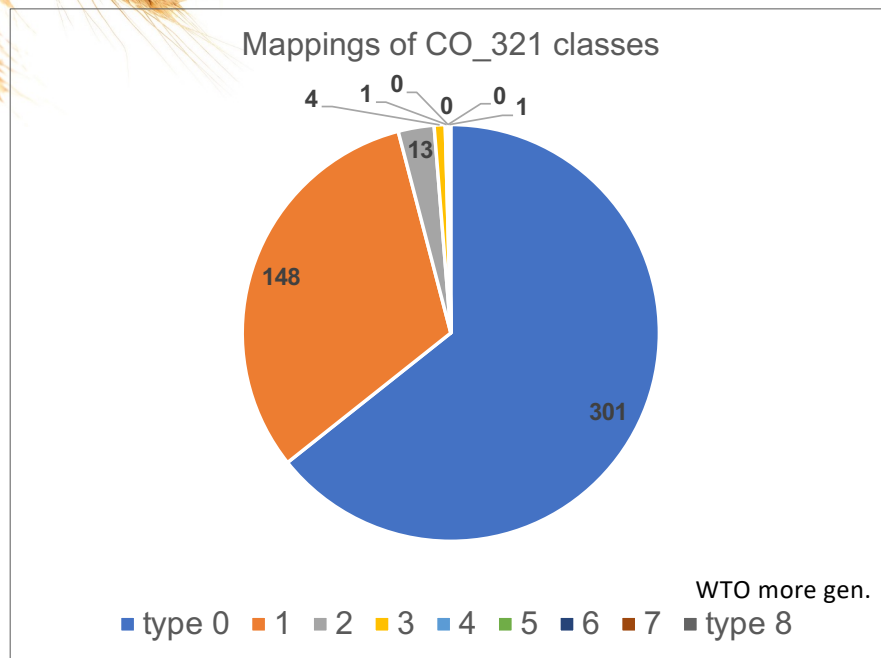
WTO:plant height	CO_321:plant height	exact	
WTO:plant habit	CO_321:plant growth habit	exact	
WTO:glutenin content	CO_321:glutenin Glu-D3 composition		+ gen.
WTO:above-ground dry matter quantity	CO_321:aboveground biomass		+ spec.

# Method for mapping the classes

- Tests with **automatic tools** find obvious string-matched pairs → Manual mapping.
- **We reused the mappings** of WTO and WIPO (ancestor of CO\_321) from a previous project
- We defined general **rules** for class label rewriting
- **Discussion and review** (recorded as Gitlab issues)
  - More than 60 questions that required expertise in wheat breeding
- We recorded **justification** and references to external sources
- **Consistency checking**

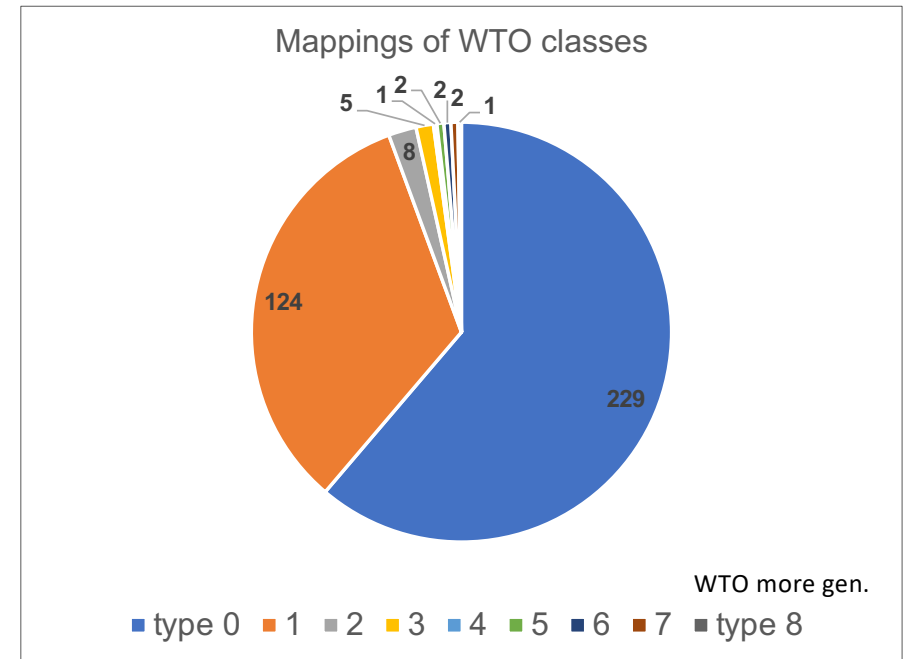


# Manual mapping of the classes of CO\_321 and WTO



## CO\_321 classes without mappings (type 0)

- topics absent from WTO (e.g. canopy traits)
- non trait classes (e.g. date, sample)



## WTO classes without mappings (type 0)

- topics absent from CO\_321 (e.g. root architecture)
- high-level classes (9 levels)

# Class mapping rules

Label mapping follows formal rules  
They formalize the rationale for the mappings  
with an objective of consistency.

## Examples of biotic stress trait class mapping rules

### Score

**resistance to** + 'name of disease' (**WTO**) ↔ 'name of disease' + **score** (**CO\_321**)

Example: WTO: **resistance to** Septoria Leaf Blotch (WTO:554) ↔ CO\_321:Septoria **score** on leaf (CO\_321:1010036)

### Severity

**resistance to** + 'name of disease' (**WTO**) ↔ 'name of disease' + **severity** (**CO\_321**)

Example: WTO: **resistance to** Powdery Mildew (WTO:551) ↔ CO\_321:Powdery mildew **severity** (CO\_321:0000939)

### Incidence + part of plant (name of disease)

**resistance to** + 'name of disease' (**WTO**) ↔ 'name of disease' + **part of plant** + **incidence** (**CO\_321**)

Example: WTO: **resistance to** Fusarium head blight (WTO:0483) ↔ CO\_321:Fusarium head blight **spikelet incidence** (CO\_321:0000711)



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# Mapping information

WTO_ID:class_ID	WTO class name(PrefLabel)	Verification (Or	Mappings	Sub ma	CO_321_ID:trait_ID	CO_321 trait name	Reason for alignment	Rules
	subject_label		predicate	predicat	object_id	object_label	comment	
<a href="#">WTO_0000063</a>	above-ground dry matter quantity	Maria et al.			CO_321:0000006	Aboveground biomass		
<a href="#">WTO_0000121</a>	admixture	Jacques et al.	0				no appropriate mapping found	
<a href="#">WTO_0000205</a>	aluminium resistance	Jacques et al.	1	1,4	CO_321:0000079	Aluminum tolerance		<a href="#">Rule 4</a>
<a href="#">WTO_0000450</a>	aluminium toxicity	Jacques et al.	1	1,4	CO_321:0000079	Aluminum tolerance		<a href="#">Rule 3</a>
<a href="#">WTO_0000123</a>	amount of damaged starch	Maria et al.	0				no appropriate mapping found	
<a href="#">WTO_0000064</a>	anther color	Maria et al.	0				no appropriate mapping found	
<a href="#">WTO_0000065</a>	anther extrusion	coming from alic	1	1,1	CO_321:0000982	Anther extrusion		
<a href="#">WTO_0000296</a>	aphid resistance	AO1H project	1	1,4	CO_321:0000085	Aphid damage		<a href="#">Rule 2</a>
<a href="#">WTO_0000281</a>	resistance to root lesion nematode		1	1,4	CO_321:0000086	Armyworm damage		<a href="#">Rule 2</a>
<a href="#">WTO_0000451</a>	arsenic toxicity	Jacques et al.	4		CO_321:0500024	Grain Arsenic content	related to plant toxicity without	
<a href="#">WTO_0000066</a>	awn	Maria et al.	0				no appropriate mapping found	
<a href="#">WTO_0000125</a>	awn color	Maria et al.	1	1,1	CO_321:0000960	Awn color		
<a href="#">WTO_0000126</a>	awn length	Maria et al.	1	1,1	CO_321:0000026	Awn length		
<a href="#">WTO_0000452</a>	bacterial leaf blight resistance	Clara et al.	1	1,4	CO_321:0000932	Bacterial leaf blight se	disease would be deduced from	<a href="#">Rule 1. 1.3</a>
<a href="#">WTO_0000067</a>	beginning of anthesis	Maria et al.	1	1,3	CO_321:0000121	Anthesis time	development and has a	
<a href="#">WTO_0000302</a>	billbug resistance	Clara et al.	7		CO_321:0000089	Insect damage		<a href="#">Rule 2</a>
<a href="#">WTO_0000453</a>	boron toxicity	Clara et al.	1	1,4	CO_321:0000678	Boron tolerance		<a href="#">Rule 3</a>



# Les besoins pour des alignements réalisés manuellement

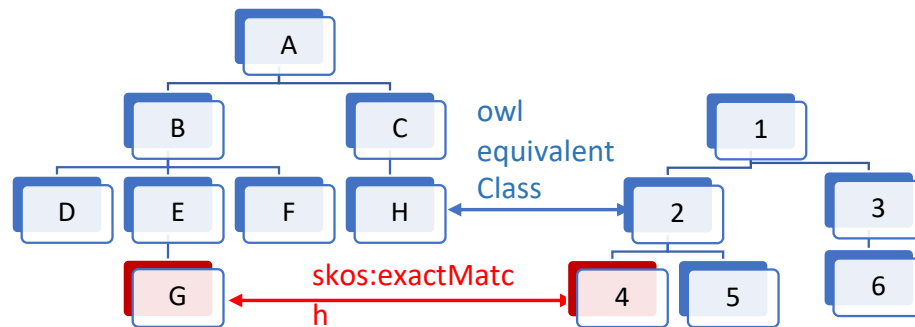
Ce qu'on souhaite représenter :

- **Des informations sur les ontologies sources (Version, Identifiant...)**
- Autour des alignement :
  - **Spécifier des classes ou des instances (via les URI)**
  - **Une direction entre les deux objets alignés**
  - **La cardinalité (1:1, 1:n)**
  - **La nature de l'alignement (exact; broad ; narrow)**
  - **Des propriétés d'alignement issues de formalismes divers (owl; SKOS)**
  - **La méthode utilisée (outil, algorithme...)**
  - *Restriction d'application du mapping*
  - **Raison du mapping**

**En gras, les besoins couverts par SSSOM**

# WTO-CO\_321 mapping

Will be shortly published on AgroPortal



**author ID, author label, reviewer ID reviewer Label, mapping\_Date**  
automatically inferred from the metadata

## Skos mappings

Equivalent

code 1 → skos:exactMatch

More general/more specific

code 7 → skos:broadMatch

code 8 → skos:narrowMatch

## OWL mappings

Equivalent

code 1 → owl:equivalentClass

More general/specific

code 7, 8 → rdfs:subClassOf

## Evolution of SSOM wrt our needs

Formalization of the mapping rules (currently free text)

Specification of the use scope



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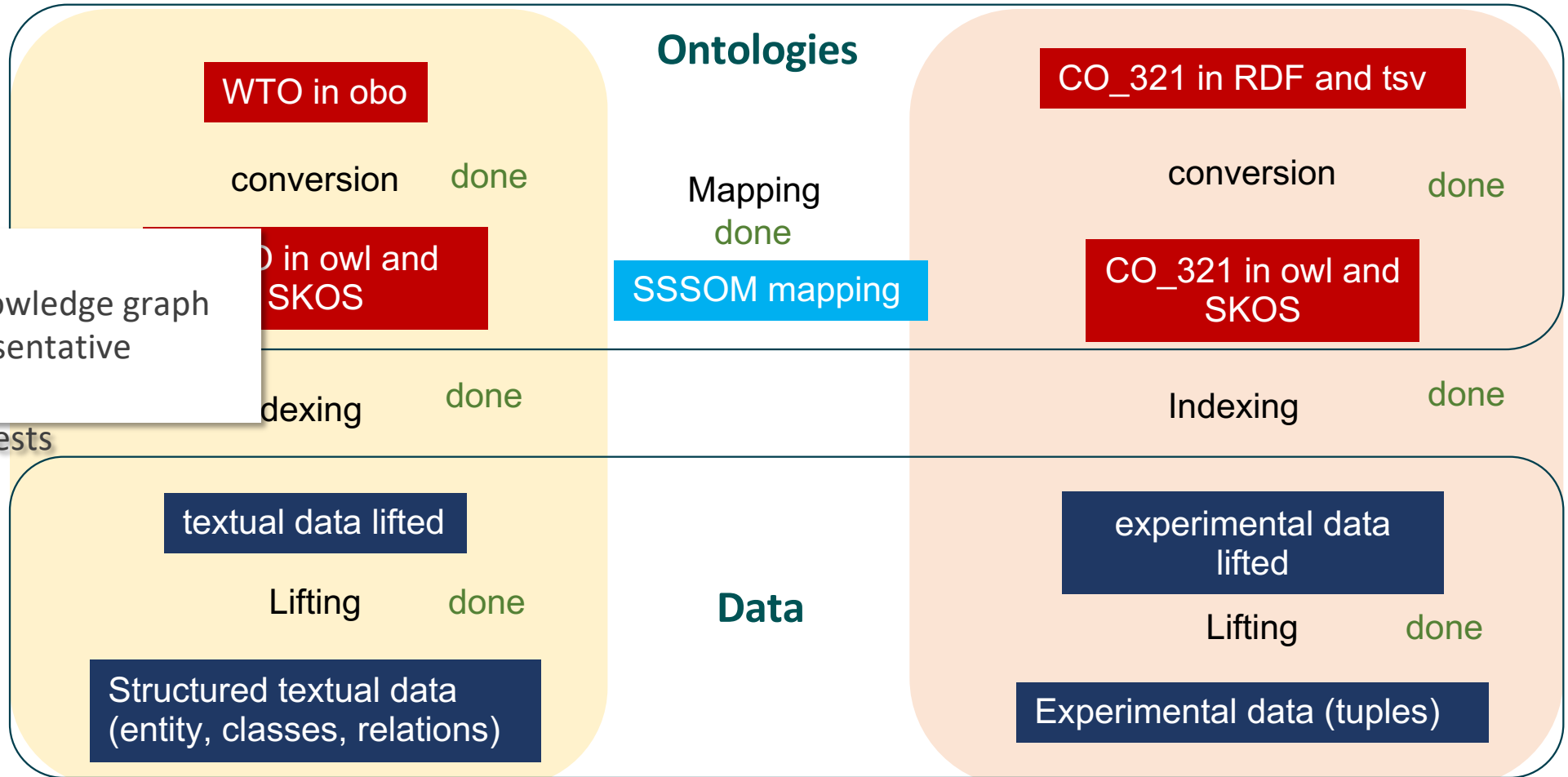
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8		<a href="http://purl.obolibrary.org/obo/WTO_0000304">tp://purl.obolibrary.org/obo/WTO_0000304</a>	cold resistance	skos:closeMatch	<a href="http://ontology.org/rdf/CO_321:1010144">ontology.org/rdf/CO_321:1010144</a>	Frost susceptibility	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0003-4805-8">https://orcid.org/0000-0003-4805-8</a>	Sophie Aubin Claire Nédellec Thomas Letellier		Jacques Legouis
9		<a href="http://purl.obolibrary.org/obo/WTO_0000304">tp://purl.obolibrary.org/obo/WTO_0000304</a>	cold resistance	skos:closeMatch	<a href="http://ontology.org/rdf/CO_321:0000080">ontology.org/rdf/CO_321:0000080</a>	Cold tolerance	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr
0		<a href="http://purl.obolibrary.org/obo/WTO_0000305">tp://purl.obolibrary.org/obo/WTO_0000305</a>	cold tolerance	skos:exactMatch	<a href="http://ontology.org/rdf/CO_321:0000080">ontology.org/rdf/CO_321:0000080</a>	Cold tolerance	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr
1		<a href="http://purl.obolibrary.org/obo/WTO_0000070">tp://purl.obolibrary.org/obo/WTO_0000070</a>	coleoptile length	skos:exactMatch	<a href="http://ontology.org/rdf/CO_321:0000029">ontology.org/rdf/CO_321:0000029</a>	Coleoptile length	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr
2		<a href="http://purl.obolibrary.org/obo/WTO_0000071">tp://purl.obolibrary.org/obo/WTO_0000071</a>	crop yield	skos:closeMatch	<a href="http://ontology.org/rdf/CO_321:0000013">ontology.org/rdf/CO_321:0000013</a>	Grain yield	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr
3		<a href="http://purl.obolibrary.org/obo/WTO_0000215">tp://purl.obolibrary.org/obo/WTO_0000215</a>	crumb firmness	skos:broadMatch	<a href="http://ontology.org/rdf/CO_321:0000065">ontology.org/rdf/CO_321:0000065</a>	Bread crumb structure	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr
4		<a href="http://purl.obolibrary.org/obo/WTO_0000072">tp://purl.obolibrary.org/obo/WTO_0000072</a>	culm length	skos:exactMatch	<a href="http://ontology.org/rdf/CO_321:0000060">ontology.org/rdf/CO_321:0000060</a>	Stem length	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr
5		<a href="http://purl.obolibrary.org/obo/WTO_0000011">tp://purl.obolibrary.org/obo/WTO_0000011</a>	development	skos:closeMatch	<a href="http://ontology.org/rdf/CO_321:0000016">ontology.org/rdf/CO_321:0000016</a>	Growth stage	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr
6		<a href="http://purl.obolibrary.org/obo/WTO_0000308">tp://purl.obolibrary.org/obo/WTO_0000308</a>	dough extensibility	skos:narrowMatch	<a href="http://ontology.org/rdf/CO_321:0000212">ontology.org/rdf/CO_321:0000212</a>	Dough alveograph value L	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr
7		<a href="http://purl.obolibrary.org/obo/WTO_0000309">tp://purl.obolibrary.org/obo/WTO_0000309</a>	dough resistance to shearing	skos:relatedMatch	<a href="http://ontology.org/rdf/CO_321:0000213">ontology.org/rdf/CO_321:0000213</a>	Dough alveograph value P	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr
8		<a href="http://purl.obolibrary.org/obo/WTO_0000310">tp://purl.obolibrary.org/obo/WTO_0000310</a>	dough strength	skos:closeMatch	<a href="http://ontology.org/rdf/CO_321:0000145">ontology.org/rdf/CO_321:0000145</a>	Dough alveograph P/L	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr
9		<a href="http://purl.obolibrary.org/obo/WTO_0000311">tp://purl.obolibrary.org/obo/WTO_0000311</a>	drought tolerance	skos:exactMatch	<a href="http://ontology.org/rdf/CO_321:0000131">ontology.org/rdf/CO_321:0000131</a>	Drought tolerance	semapv:ManualMappingCuration	<a href="https://orcid.org/0000-0002-1110-8">https://orcid.org/0000-0002-1110-8</a>	Mariya Evtimova Claire Nédellec	<a href="https://orcid.org/0000">https://orcid.org/0000</a>	Michael Alaux Cyr



# Final knowledge graph (on going)





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