Platform for Big Data in Agriculture

CGIAR

Semantics for Crops & Tools for Data Annotation

Elizabeth Arnaud, Bioversity International

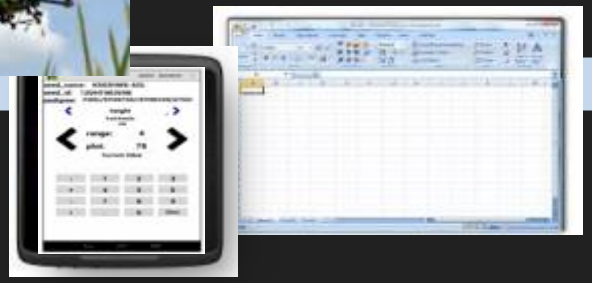
DECODING The Data Ecosystem

Big Data in Agriculture Course - Rabat - 10 - 14 December, 2018

Data Harmonization along the data management workflow and across IT tools

Semantics for harmonization & interoperability

Data Collect

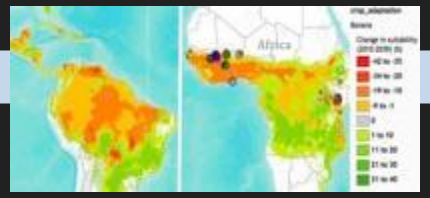


- BMS Fieldbook
- Banana Fieldtask
- KSU Fieldbook
- AGROFIMS fieldbook
- KDSmart
- ODK surveys
- …

Data storage

- BMS
- RTB NextGen Databases
- AGROFIMS
- Breeding4Rice
- KDExplore
- Dataverse, CKAN
- MARLO/MEL

Data Analysis



- IBP
- HIDAP
- FarmDesign
- Crop models
- ….

Data Access

- GARDIAN

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GARDIAN

FAIR Data in Agriculture

Interoperable - The most difficult to achieve and requires ontologies/controlled vocabularies

identification of key objects (Ontologies)

Use of proper concept identifiers

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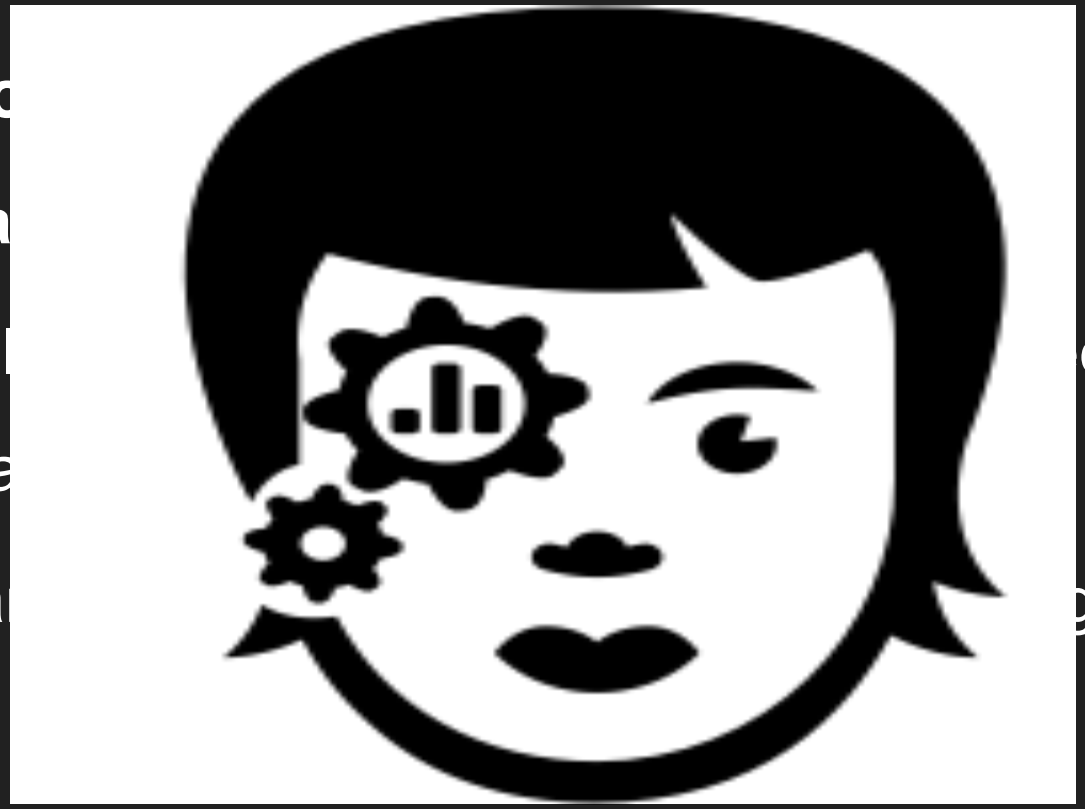
What is a vocabulary?

- **Controlled vocabularies:**
  - provide a **shared vocabulary** for a domain (all the terms)
  - provide **textual definitions** that describe the intended meaning of the classes in vocabularies
  - provide standard **identifiers for concepts** describing a given domain
- **Facilitate data publication and data access**

What is a vocabulary?

- **Controlled voc**
  - provide a **voca**
  - provide **textual** d meaning of the classes in voca
  - provide standa g a given domain
- **Facilitate data**



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What is an ontology?

- **Ontologies**:
  - provide standard **identifiers for classes and relations** that represent the phenomena within a domain
  - provide a **vocabulary** for a domain
  - provide **textual definitions** that describe the intended meaning of the classes and relations in ontologies
  - provide **machine-readable axioms** and definitions that enable computational access to some aspects of the meaning of classes and relations
- **Facilitate data integration, data access and analysis**

What is an ontology?

- **Ontologies**:
  - provide standard **ide** esent the phenomena within a domain
  - provide a **vocabular**
  - provide **textual defi** f the classes and relations in ontologie
  - provide **machine-rea** mputational access to some aspects of the
- **Facilitate data integ**

Annotations are links between ontology terms and data objects

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Harmonizing Phenotypic data

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Crop Ontology
Breaking semantic barriers to data interpretation

- Breeding Management Systems
- Meta Analysis across evaluation sites
- Confusion between **traits and variables**
- **No naming convention for variables and methods** of measurement which are heterogeneous
- Trait & Variable definitions and measurements are not similar between farmers, breeders, agronomists, modelers

=> One trait = 4 traits…

From D. Pot, CIRAD

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Crop Ontology
for agricultural data

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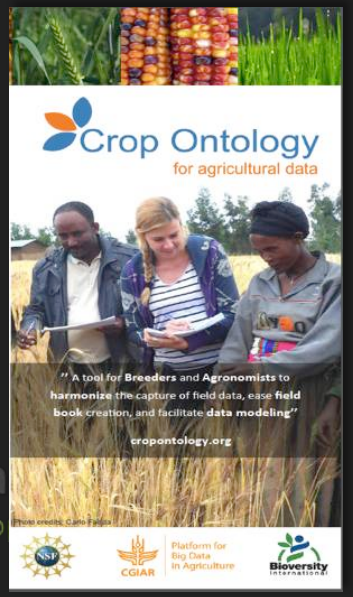
Provides measured traits, parameters and **their standard variables** for **the Breeding fieldbook and for data annotation in the crop databases**



Integrated Breedin
Today's tools for tomorrow's cro

CIMMYT
IITA
Rice Science for a Better World
INTERNATIONAL RICE RESEARCH INSTITUTE
CENTRO INTERNACIONAL DE LA PAPA
CIP
Bioversity International
ICARDA
CIAT
ICRISAT
Science with a human face

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Planteome

Crop Ontology
for agricultural data

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Phenotype data in breeding

Germplasm ID	PH	PH2	GCOL	GY
24530	80	1	2	35
85432	120	3	4	48
78452	95	2	4	43
56093	100	2	1	50

The height of the plant

The color of the grain

The grain yield

Annotation must explain:

1/ What is the observation about ?

=

TRAIT

Entity + Attribute

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for agricultural data

Phenotype data in breeding

Germplasm ID	PH	PH2	GCOL	GY
24530	80	1	2	35
85432	120	3	4	48
78452	95	2	4	43
56093	100	2	1	50

With a measuring tape

Estimated visually

Calculated
Panicle weight x panicle density

Annotation must explain:

2/ How is the trait observed ?

=

METHOD

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for agricultural data

Phenotype data in breeding

Germplasm ID	PH	PH2	GCOL	GY
24530	80	1	2	35
85432	120	3	3	48
78452	95	2	3	43
56093	100	2	1	50

cm

1 = short (<90cm)
2 = medium (>90cm and <110cm)
3 = tall (>110cm)

1 = white
2 = cream
3 = yellow

g/m²

Annotation must explain:

3/ How is the trait observation expressed?

=

SCALE

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Standard Variable in Crop Ontology

- Method and scales are important to capture for supporting data comparison & interpretation

A **Variable** is combination of

Property (Trait) + Method + Scales/units

- It annotates the **actual value of the measurement**
- Has a unique name -> Proposed naming convention: **P_M_S**

Trait = Entity+ Quality

(Root) (Length)

Average root length expressed in cm

Average root length scored on a 3 level scale :

1=short (<50cm)

2= medium (50-100cm)

3=long (>100cm)

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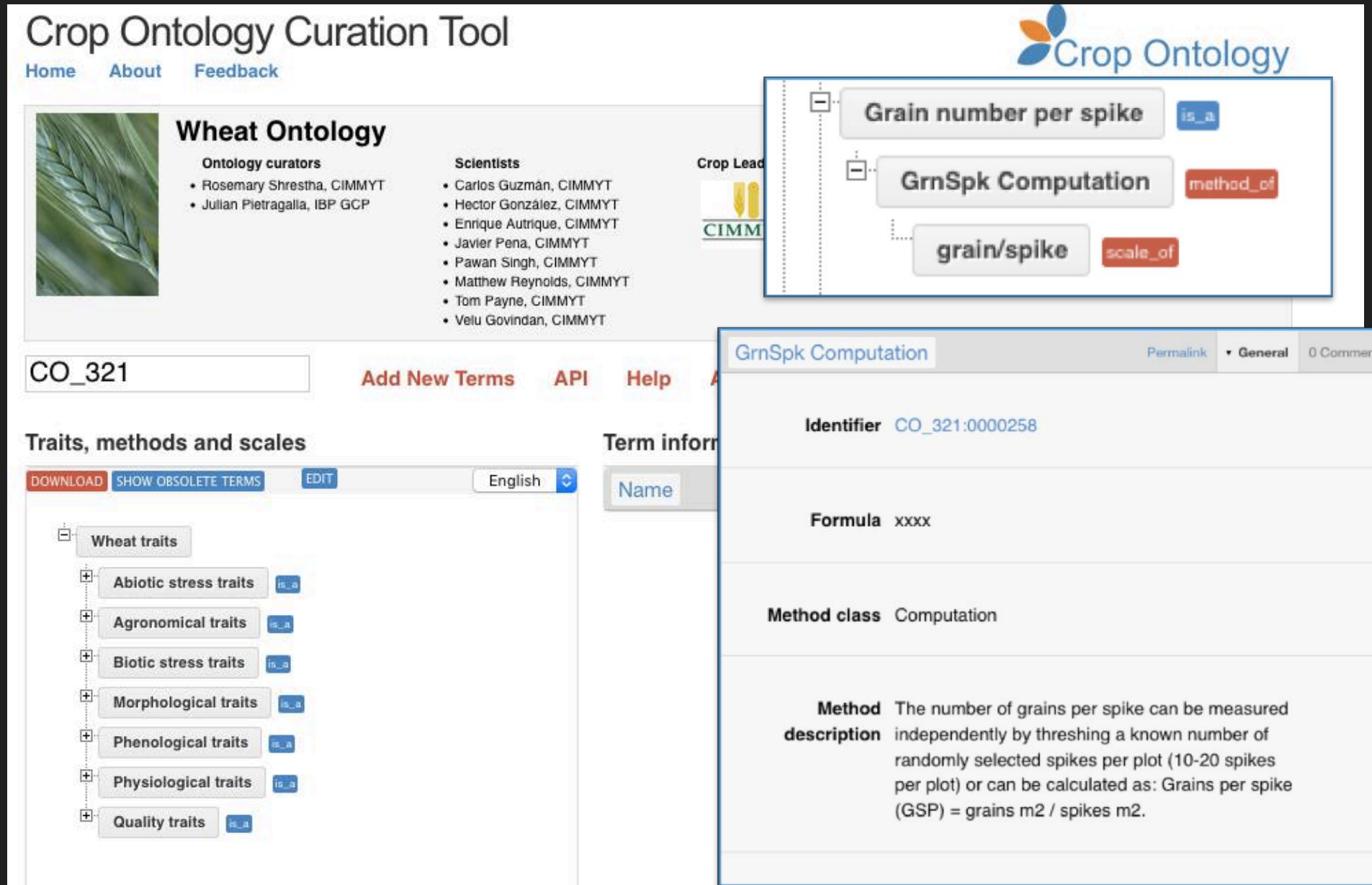
Crop Ontology Online

- 27 species
- Download in csv, obo, RDF
- API
- Helpdesk
- Adding farmers preferences, sensory traits



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Crop Ontology Curation Tool

Home About Feedback

Crop Ontology
for agricultural data

Lentil ontology

Ontology curators
- Karthika Rajendran, ICARDA

Scientists
- Shiv Kumar Agrawal, breeder, ICARDA

Crop Lead Center ICARDA

Partners

CGIAR research program CGIAR Research Program on Grain Legumes

CO_339

Add New Terms API Help Agtrials Annotation Tool Logout ElizabethArnaud

Traits, methods and scales

DOWNLOAD SHOW OBSOLETE TERMS EDIT English

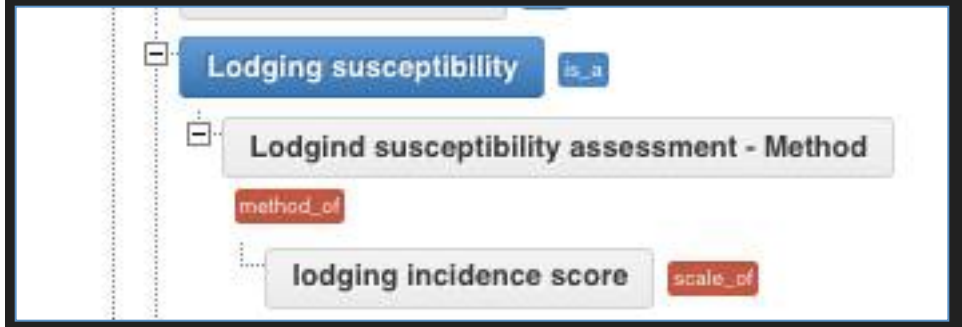
- Lentil traits
  - Abiotic Stress traits is_a
  - Agronomical traits is_a
    - Biological yield per area is_a
    - Biological yield per plant is_a
    - Harvest Index is_a
    - Height of the lowest pod is_a
    - Herbicide tolerance is_a
    - Lodging susceptibility is_a
      - Lodgind susceptibility assessment - Method
        - method_of
          - lodging incidence score scale_of
    - Number of peduncles per plant is_a
    - Number of pods per peduncle is_a

Term information

Name | Permalink | General | Comments

Variables

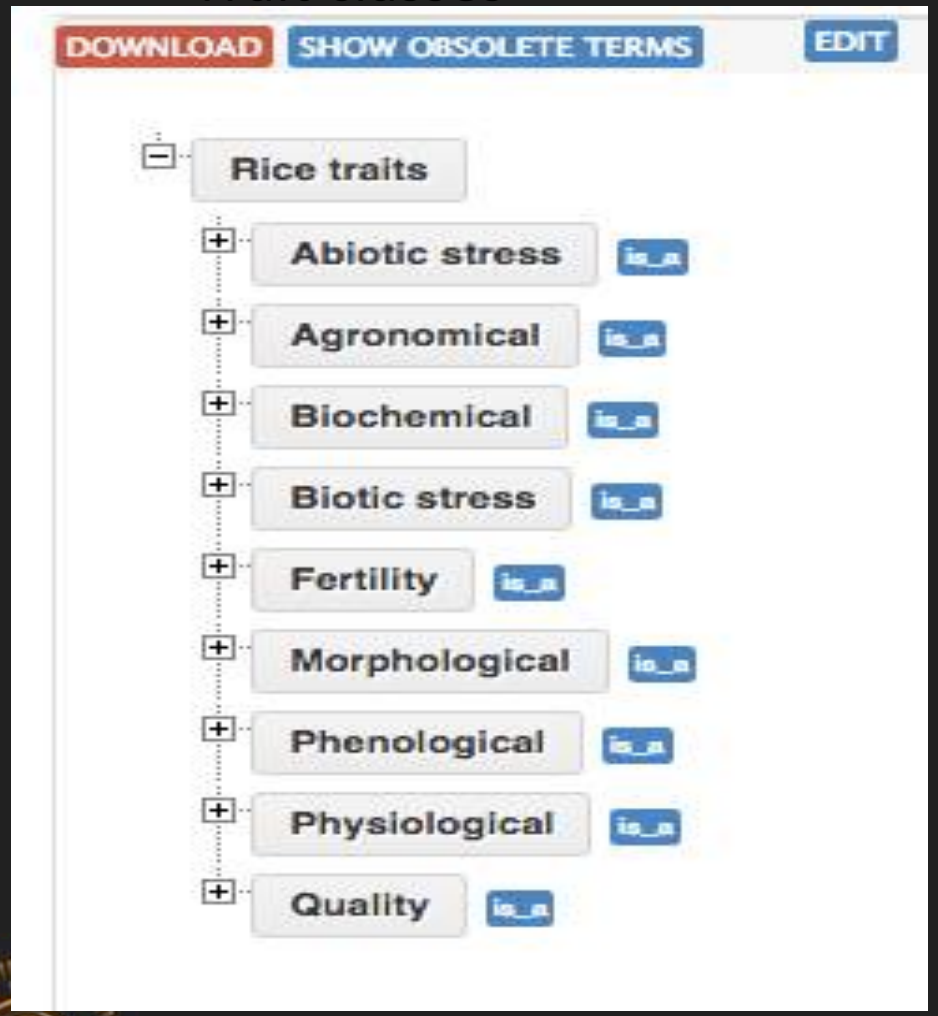
LodgSuscp_Est_1to7



lodging incidence score | Permalink | General | 0 Comments

Identifier	CO_339:0000092
Category 0	None
Category 3	Low
Category 5	Medium
Category 7	High
Scale class	Nominal
Scale name	lodging incidence score

Trait classes



All traits, Methods , scales have a definition

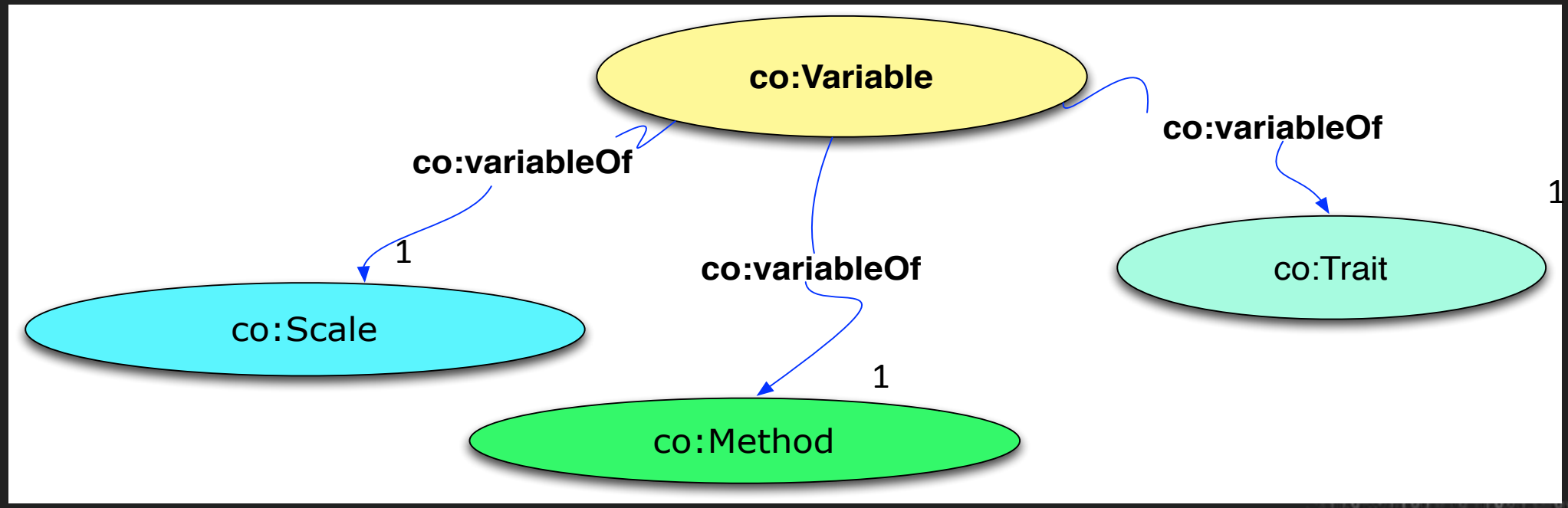
Classification of methods

		Method class	Examples
The trait is observed directly	By using a measuring device, a sensor	Measurement	- Plant height measuring with a ruler - Fruit weighing on a scale
	By counting entities	Counting	- Leaf counting
	By an assessment that only relies on the experience and subjectivity of the observer. The assessment is not supported by a measuring device.	Estimation	- Grain colour estimation - Damage on leaves visual estimation - Plant height visual estimation
The trait observation derives from an aggregation of observations (regardless of how they were observed i.e., measured, counted, estimated or computed)		Computation	- 1000 grain weight calculation (1000 * measured grain weight / grain count) - Harvest index calculation (Grain yield / Aboveground biomass) - Grain protein content calculation (Grain Nitrogen content * 6.25)

Classification of scales

Method name	Description
Code	This scale class is exceptionally used to express complex traits. Code is a nominal scale that combines the expressions of the different traits composing the complex trait. For example a disease related code might be expressed by a 2 digit expresing intensity and 2 character code expresing the severity. The first 2 digits are the proportion of plants affected by a fungus and the 2 characters refer to the severity, e.g. "75HD" means "75% of the plants are infected and plants are highly damaged". It is recommended to create variables for every component of the code.
Duration	The date class is for time elapsed between two events expressed in a time format, e.g. "days", "hours", "months".
Nominal	Categorical scale that can take one of a limited number of categories. There is no intrinsic ordering to the categories.
Numerical	Numerical scales express the trait with real numbers. The numerical scale defines the unit e.g. centimeter, ton per hectar, branches.
Ordinal	Ordinal scales are composed of ordered and fixed number of categories.
Text	A free text is used to express the trait. Also known as character variable.
Date	The date class is for events expressed in a time format, e.g. "yyyymmdd hh:mm:ss – UTC" or "dd/mm/yy".

Example of an ontology



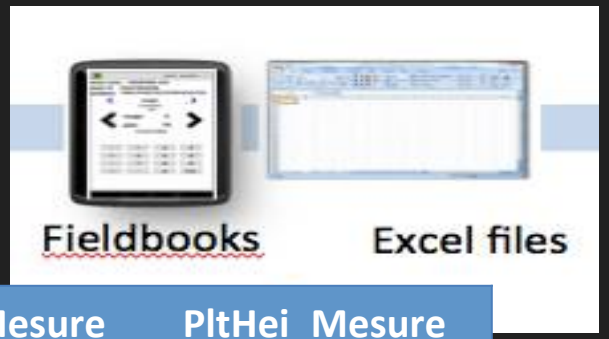
Improving the re-usability of the data file

The content of the Excel file is not always re-usable because of lack of clear variable name

Germplasm ID	PH	PH2	GCOL	GY
24530	80	1	2	35
85432	120	3	3	48
78452	95	2	3	43
56093	100	2	1	50

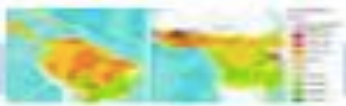
Fieldbook design system

Crop Ontology
for agricultural data



Germplasm ID	PltHei_Mesure_cm	PltHei_Mesure_category
24530	80	1
85432	120	3
78452	95	2
56093	100	2

Statistical analysis



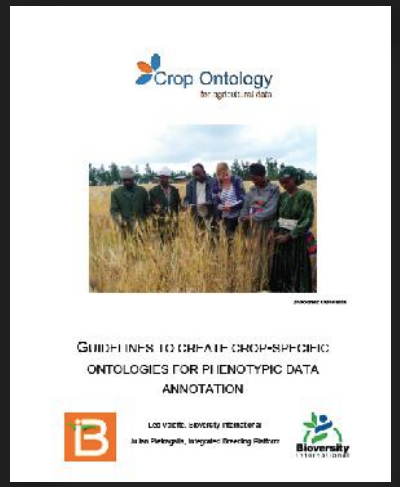
Crop Models

BREEDING MANAGEMENT SYSTEM

Data file using standard variables

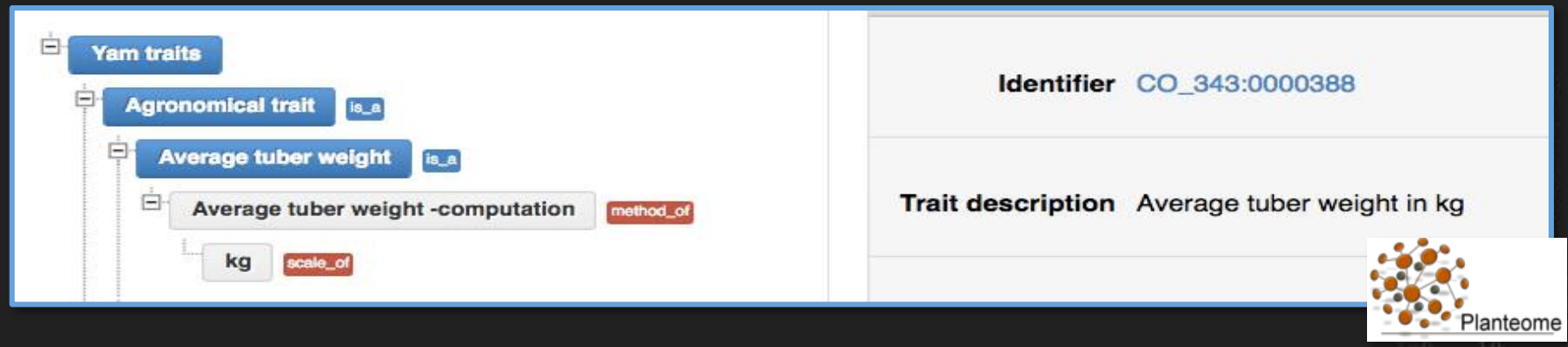
Crop Ontology for Trait Data

www.cropontology.org



Crop Ontology
for agricultural data

27 Plants (*latest Sugar Kelp - algae*)



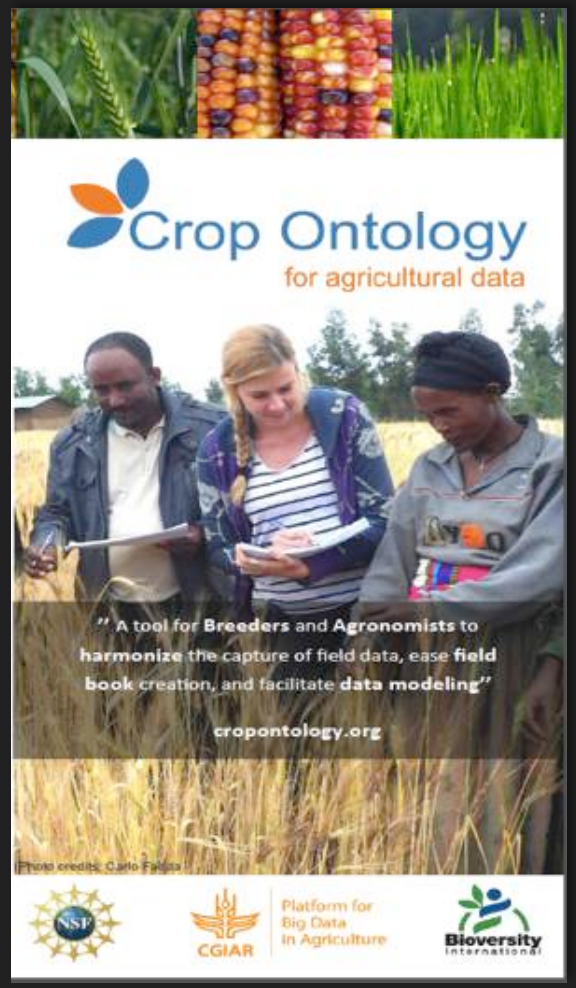
Good Practice for Trait Data Annotation

Community selects traits and standard variables → Create Fieldbook with Ontology → Data collect with standard variables → Formatted files in repositories or databases → Submission of new traits & variables / Use of the formatted data files

Crop Ontology
for agricultural data

Germplasm ID	PltHei_Mesure_cm	PltHei_Mesure_category
24530	80	1
85432	120	3
78452	95	2
56093	100	2

Crop Traits



Provides names, definition and semantic relationships for measured traits and agronomic parameters with their standard variables for Agronomic and Breeding fieldbooks, surveys and for data annotation in the databases and repositories

Integrating Farmers preferences with respect to gender

Agronomy Ontology

- 'pest control process'
  - 'biological pest control process'
    - 'organisms augmentation process'
    - 'organisms conservation process'
    - 'organisms importation process'
  - 'chemical pest control process'
  - 'mechanical pest control process'
    - 'mechanical pest destruction process'
      - 'cold treatment'
      - 'diatomaceous earth spreading'
      - 'fire treatment'
      - 'flood treatment'
      - 'heat treatment'
      - 'soil solarization treatment'
      - 'steam treatment'
      - 'tillage process'
    - 'mechanical pest exclusion process'
      - 'mulching process'
      - 'using barrier process'
    - 'mechanical pest removal process'
      - 'hand picking process'
      - 'insect vacuuming process'
      - 'mowing process'
      - 'trapping process'
      - 'water pressure spraying process'

- 'regulation of grazing'
  - 'continuous grazing'
  - 'rotational grazing'
    - 'creep grazing'
    - 'first-last grazing'
    - 'intensive rotational grazing'
      - 'controlled grazing'
      - 'hohenheim grazing system'
      - 'holistic planned grazing'
      - 'mob grazing'
      - 'strip grazing'

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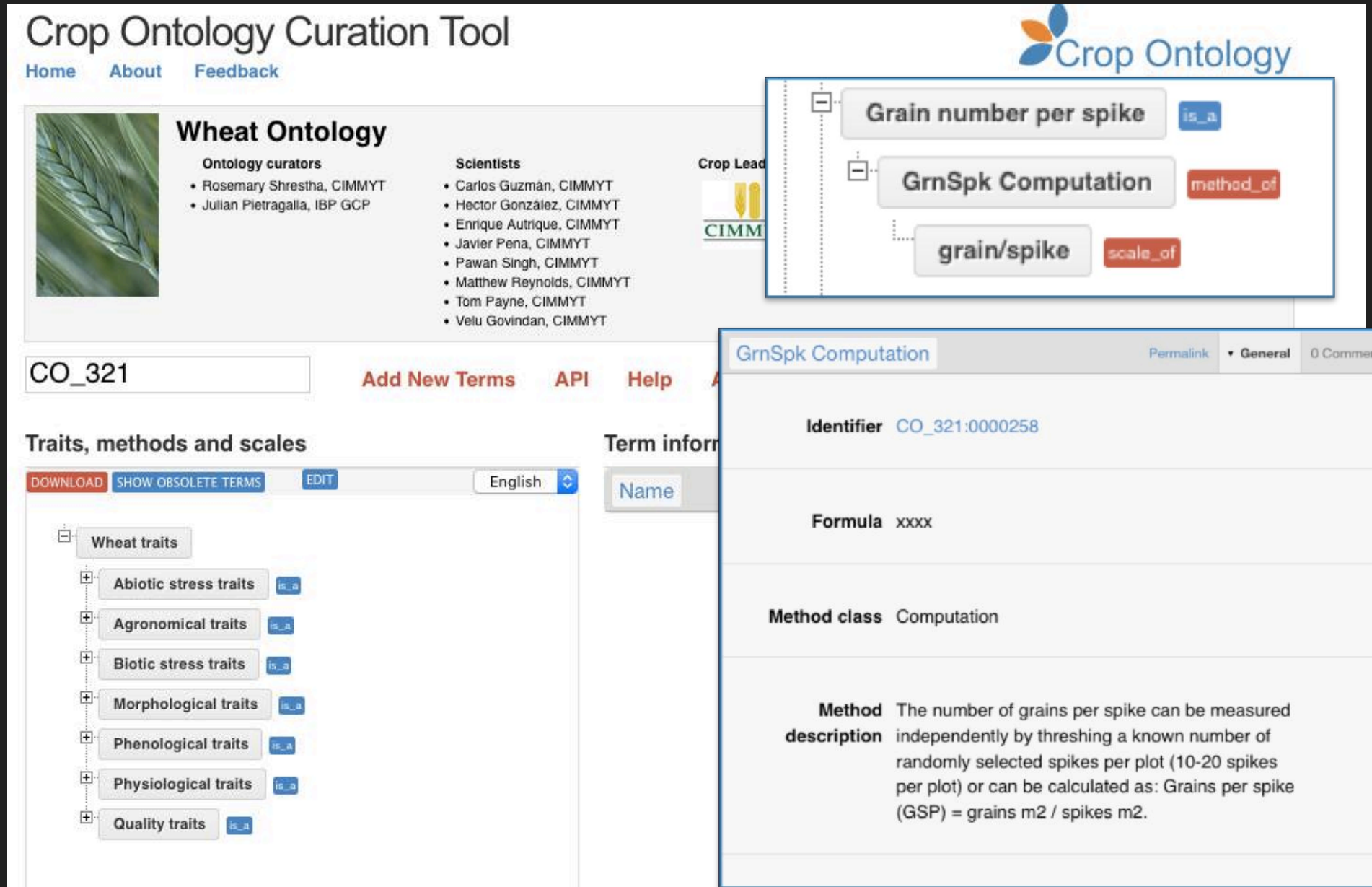
Crop Ontology Online

- 27 species
- Download in csv, obo, RDF
- API
- Helpdesk
- Adding farmers preferences, sensory traits



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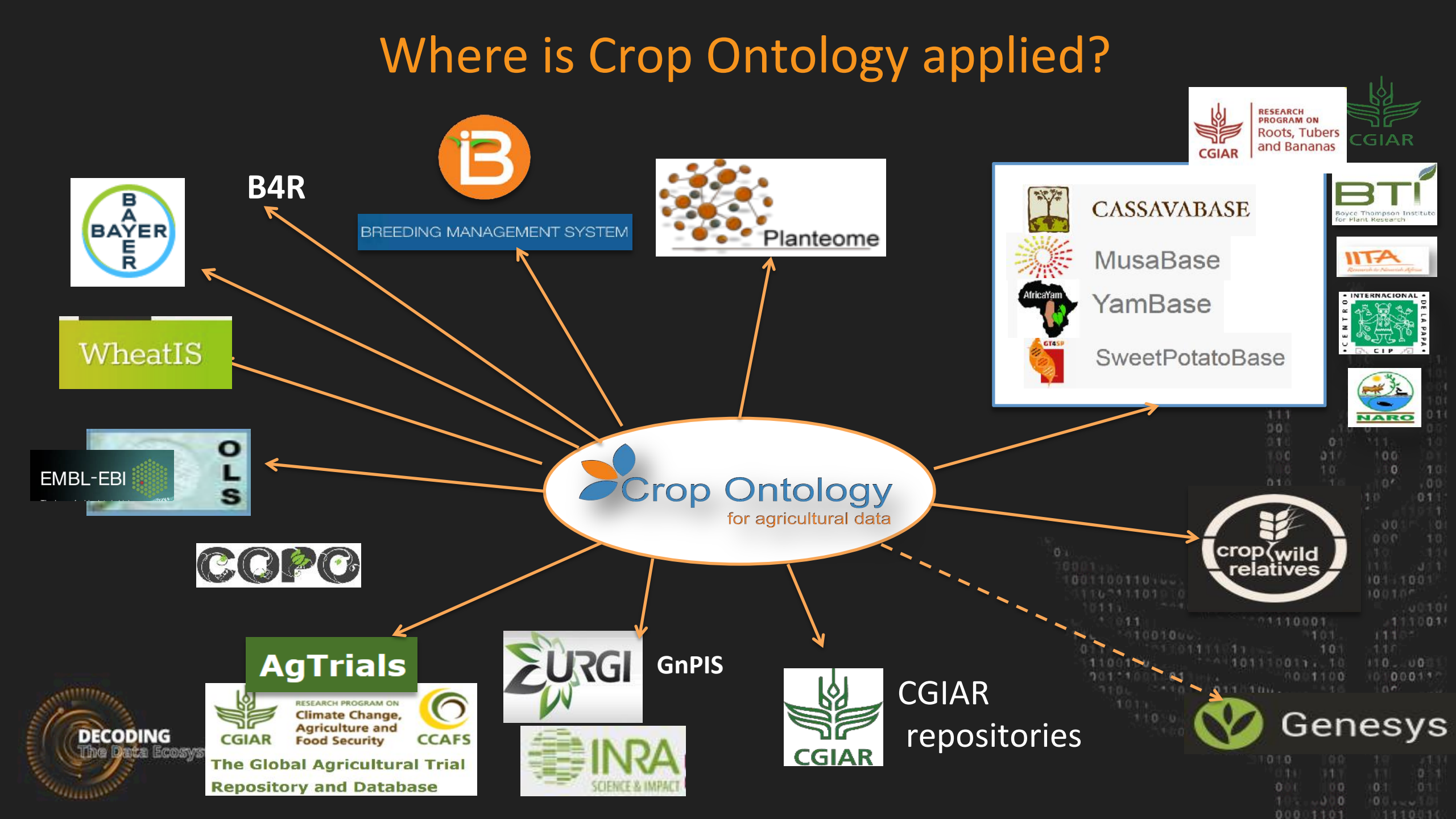
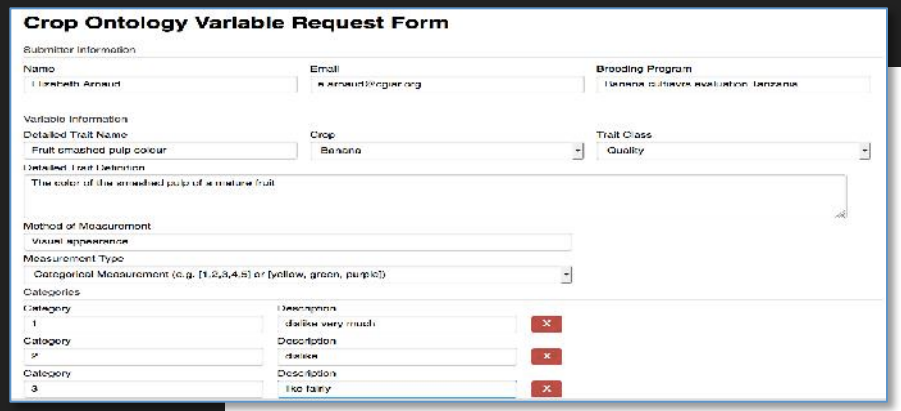
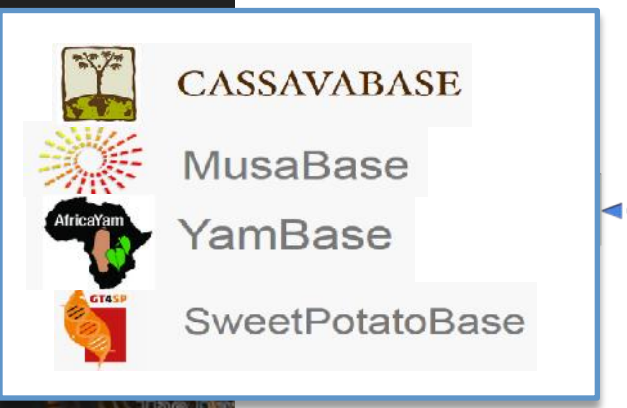
Where is Crop Ontology applied?

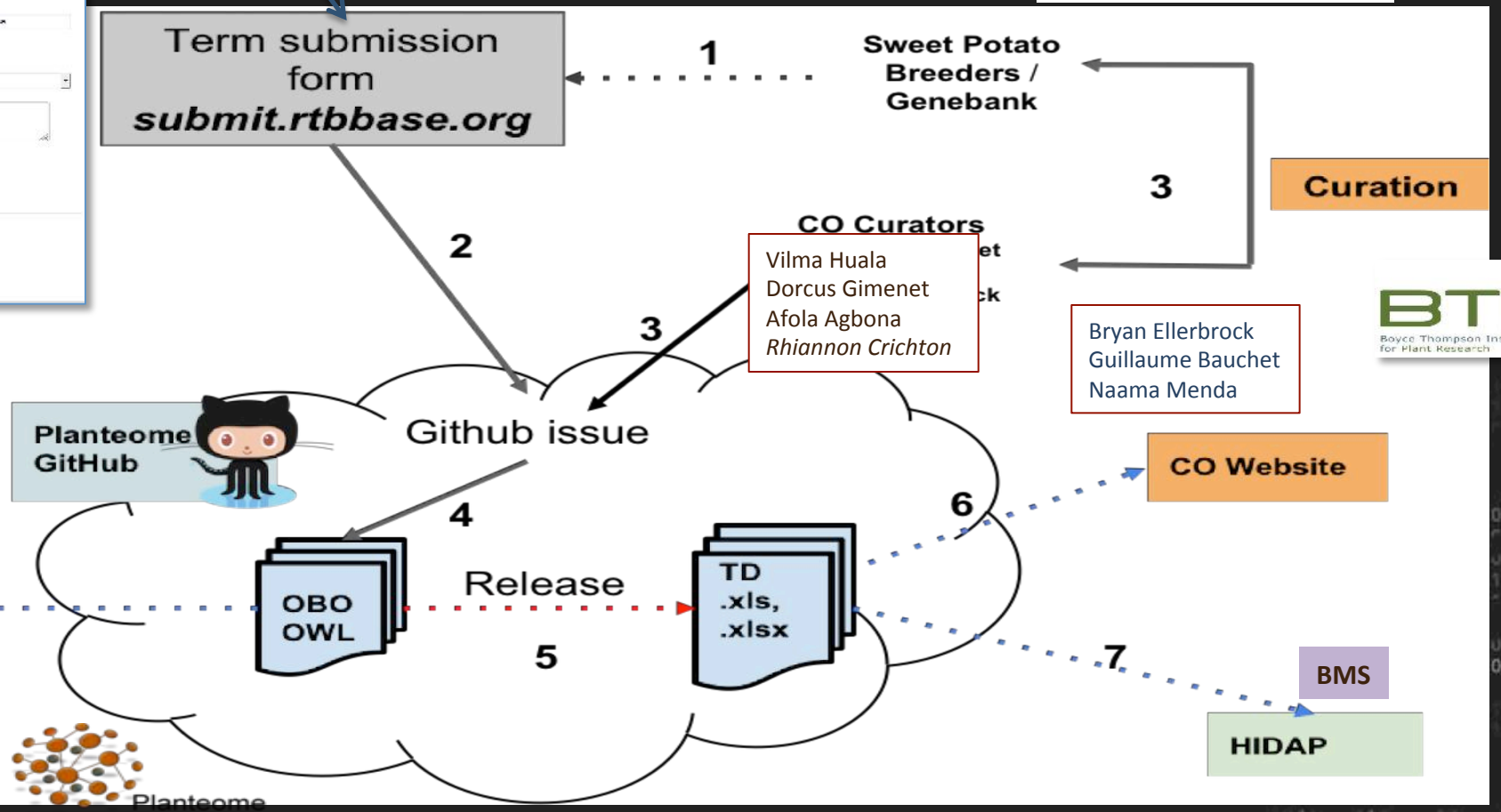


Crop Ontology Curation Workflow

From Next Gen Databases







Planteome

Getting Involved: How can you contribute and utilize these resources?

- Explore annotations and ontologies for your own research work
- Create a GitHub account to request terms, make comments, or share your own ontology
- Annotate your data, and work with us to submit to our repository

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Linking the application Crop Ontology to the reference Plant Ontology of Planteome

From Species-specific to species-agnostic

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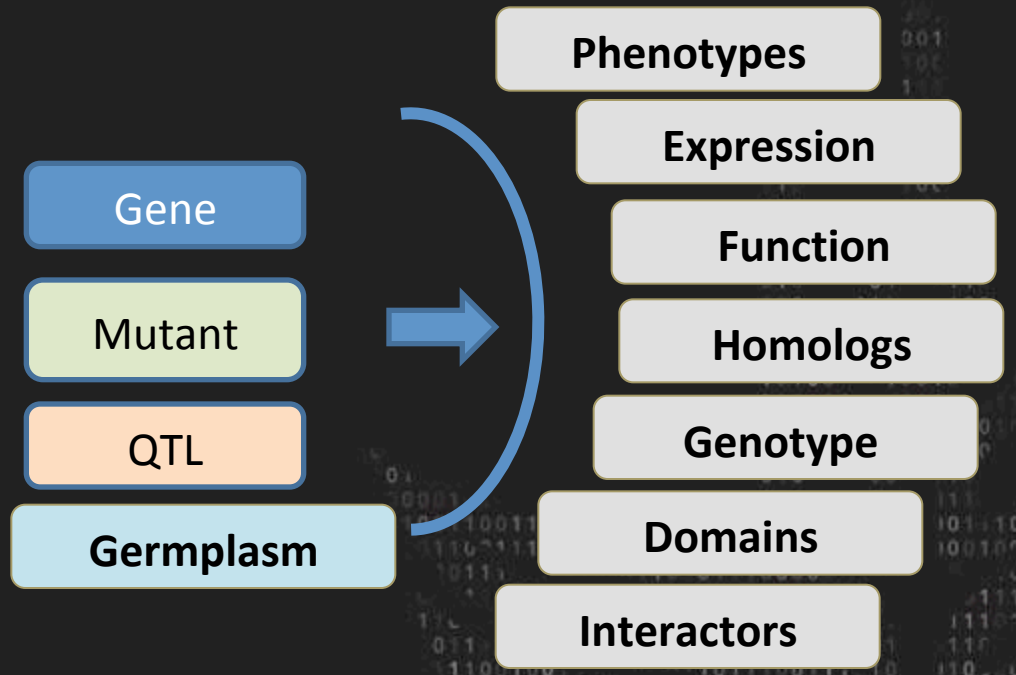
Ontologies can link to data from multiple species

Examples of fruit **color trait** (TO:0002617) across various species



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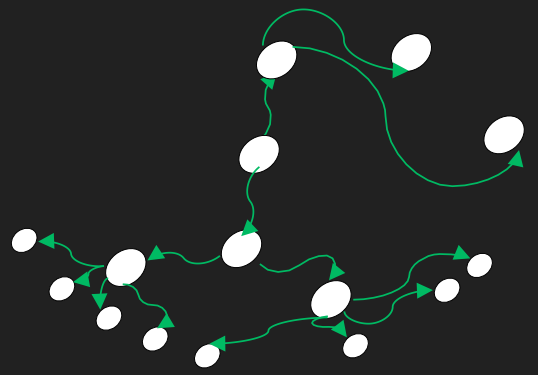
Species-Specific Ontologies and Data Annotations

Cassava- IITA

Image Source: Wikipedia

163 traits, for example:

- **stem number**
- **root neck length**
- **red spider mite severity**

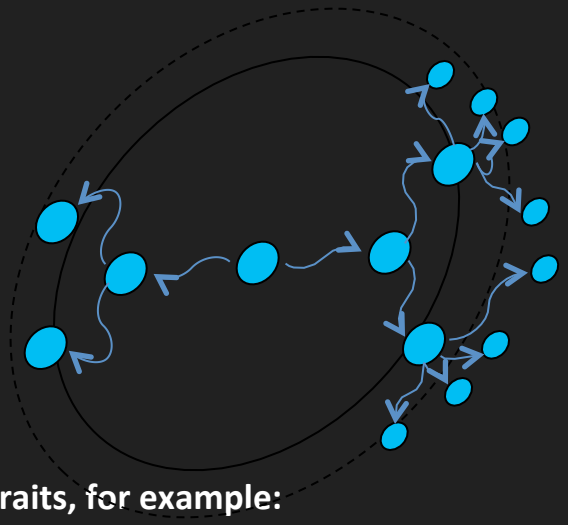


Three examples from CGIAR Centers integrated into Planteome:

How can we make interspecific comparisons across these ontologies?

Lentil- ICARDA

Image source: Karthika Rajendra



68 traits, for example:

- **pod weight**
- **cooking time**
- **root length**

Rice- IRRI

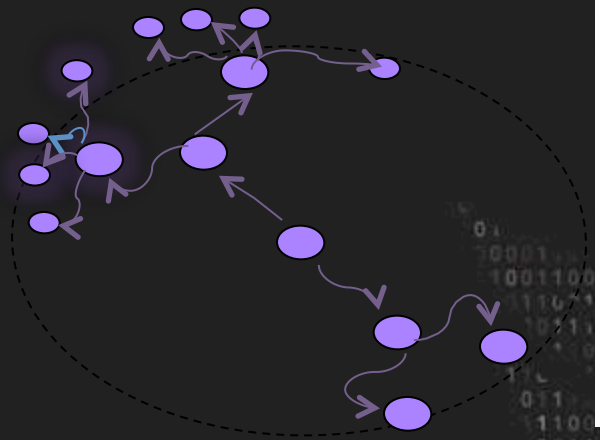


Image Source: Wikipedia

157 traits, for example:

- **caryopsis shape**
- **amylose content**
- **lodging incidence**

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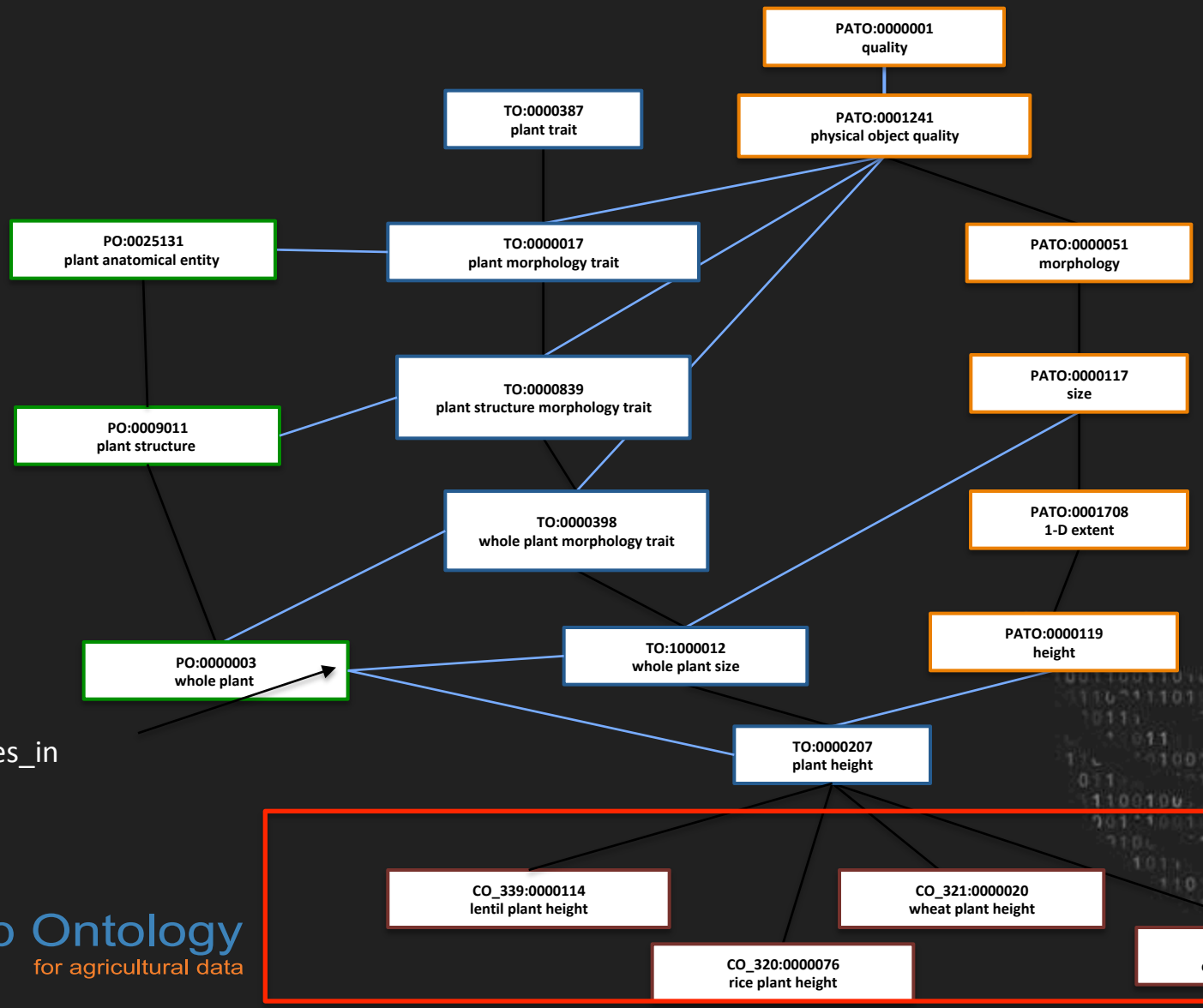
Integration of Species-Specific Ontologies in Planteome Reference Trait Ontology

Entities from Plant Ontology or Gene Ontology



Trait qualities from PATO

is_a

inheres_in

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Crop Ontology for agricultural data

Progress of CO to TO Mapping:

Ten CO crop vocabularies have been mapped to the TO:

	# traits	# manually curated
CO_320_rice	157	5
CO_321_wheat	266	9
CO_322_maize	200	31
CO_324_sorghum	130	27
CO_331_sweetpotato	195	27
CO_334_cassava	163	16
CO_336_soybean	83	2
CO_339_lentil	68	11
CO_341_pigeonpea	62	9
*CO_343_yam	159	40

*On the Planteome development browser (http://dev.planteome.org)
- will be available on live with the next AmiGO release

ACKNOWLEDGMENTS

Planteome Partners

Oregon State University

Pankaj Jaiswal (Lead PI), Laurel Cooper, Justin L. Elser, Austin Meier, Justin Preece

Sinisa Todorovic, Ryan S. Kitchen

Eugene Zhang, Botong Qu

Lawrence Berkeley National Lab
Christopher Mungall, Seth Carbon

NY Botanical Garden, USA
Dennis Stevenson

University at Buffalo, NY
Barry Smith

University of Birmingham, UK
Georgios Gkoutos,

Aberystwyth University, UK
John Doonan,

UC Santa Barbara
BS Manjunath (Bisque), Dimitry Fedorov, Kristian Kevilekval

Elizabeth Arnaud, Bioversity:
Marie-Angélique Laporte, Leo Valette

CGIAR:
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And many others!

Collaborator Labs & Projects

Users and resource databases who have adopted the Planteome Ontologies and contributed data:

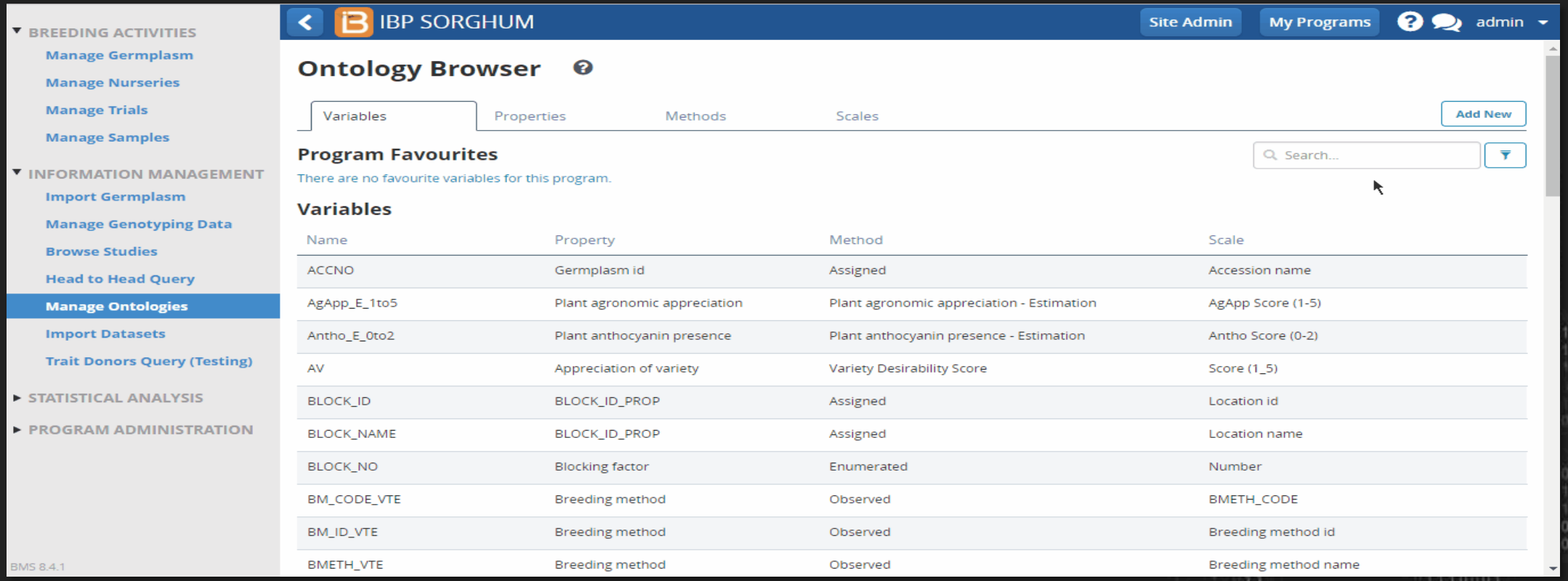
CyVerse, Gene Ontology Consortium, Protégé, OBO Foundry, Gramene, Ensembl Plants, USDA-GRIN, Rice Diversity Project, SolGenomics N, MaizeGDB, Rex Nelson, SoyBase, TAIR, Steve Cannon, LegumeIS DivSeek

And many others!

NSF #1340112

Ontology Manager of the Breeding Management System

- UX



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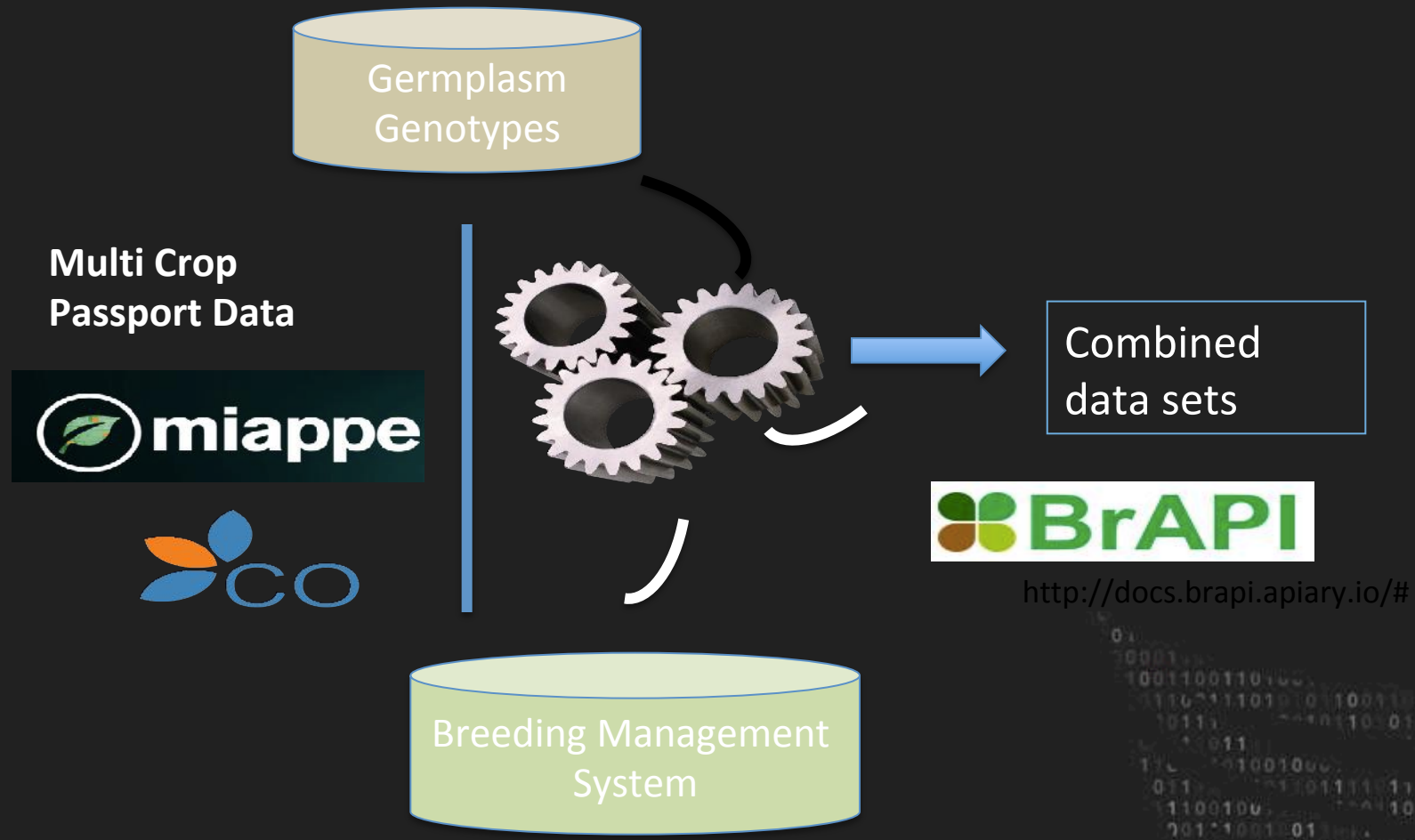
Integrated Breeding Platform
Today's tools for tomorrow's crops

CO variable format used by MIAPPE & Standard Breeding API (BrAPI)



MIAPPE = Minimum Information About a Plant Phenotyping Experiment

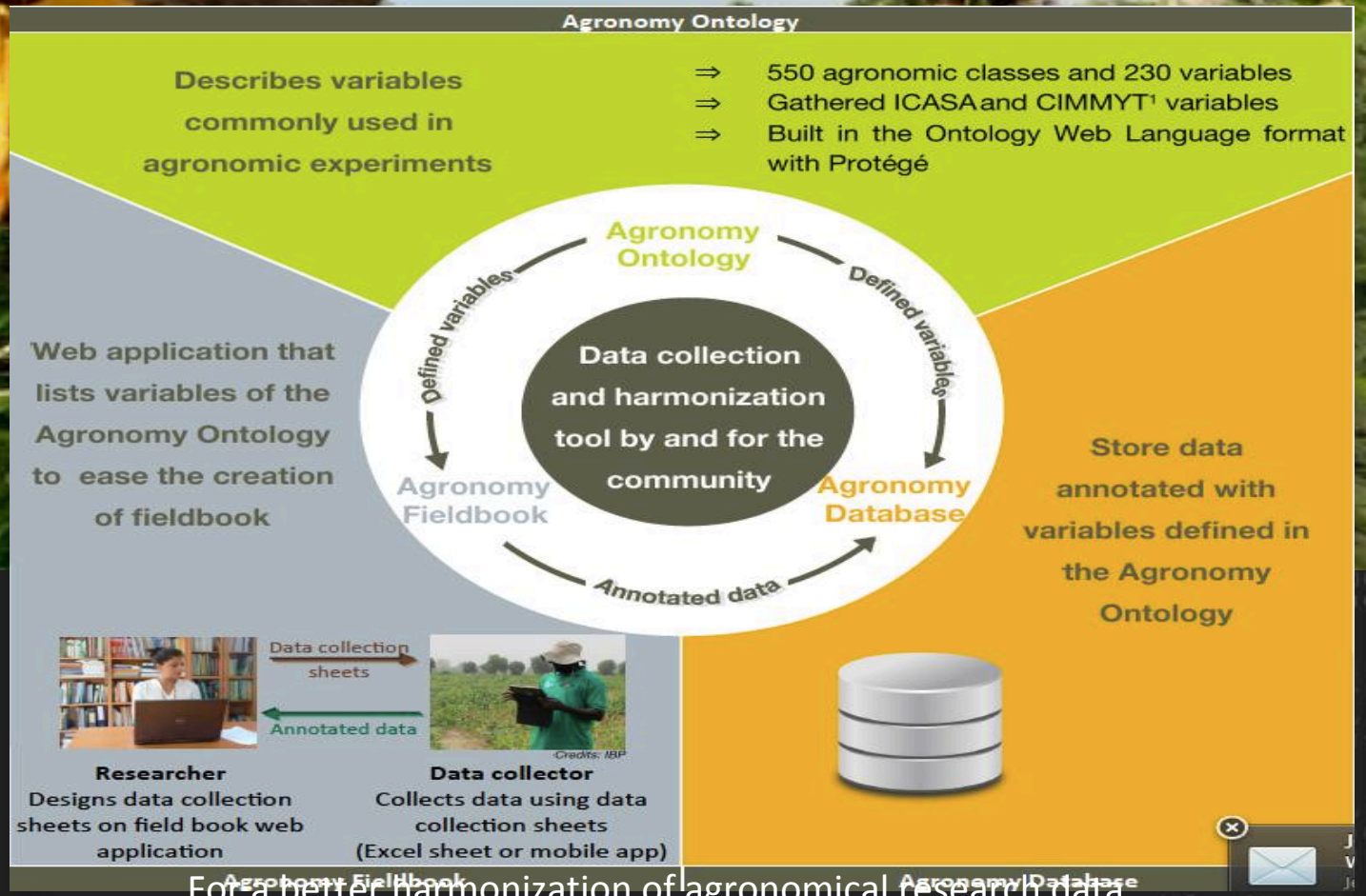
http://www.miappe.org/

Harmonizing Agronomic Data

Agronomy Ontology and Fieldbook

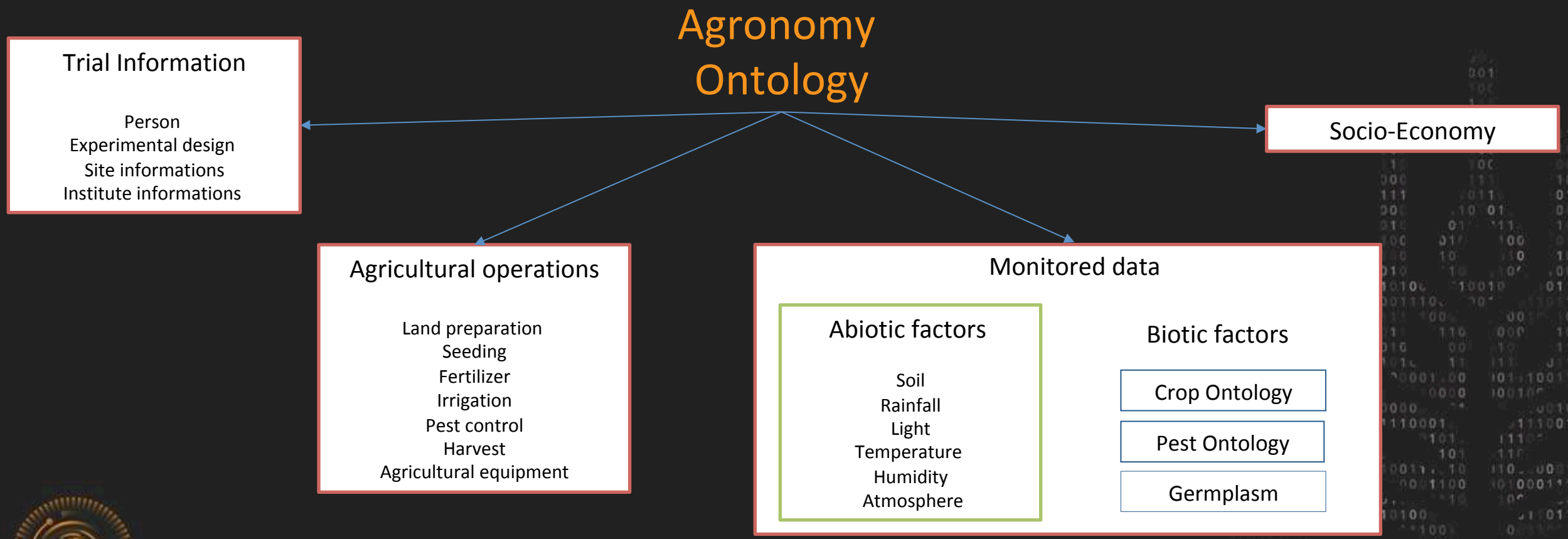
A collaborative project

A Community of Practice of agronomists and data managers is coalescing to contribute to the ontology content, test the agronomy fieldbook within ongoing projects, and provide feedback. Scientists from CIRAD, INRA, Crops for the Future, NARO, CIMMYT, have already showed their interest in participating.



For a better harmonization of agronomical research data

Development of the Agronomy Ontology (AgrO)



AgrO Content

agricultural implements, inputs, agricultural practices
Entity and a Quality (e.g.: field (entity) area (quality))

- 'crop residue management process'
  - 'crop residue burning process'
  - 'crop residue spreading process'
  - no-till
  - 'tillage process'

- 'land levelling process'
  - 'laser land levelling process'
  - 'traditional land levelling process'

- 'tillage process'
  - 'conservation tillage process'
    - mulch-till
    - ridge-till
    - strip-till
  - 'conventional tillage process'
  - 'puddling process'
  - 'reduced tillage process'

- 'plant transplanting process'
- 'planting process'
  - 'seeding process'

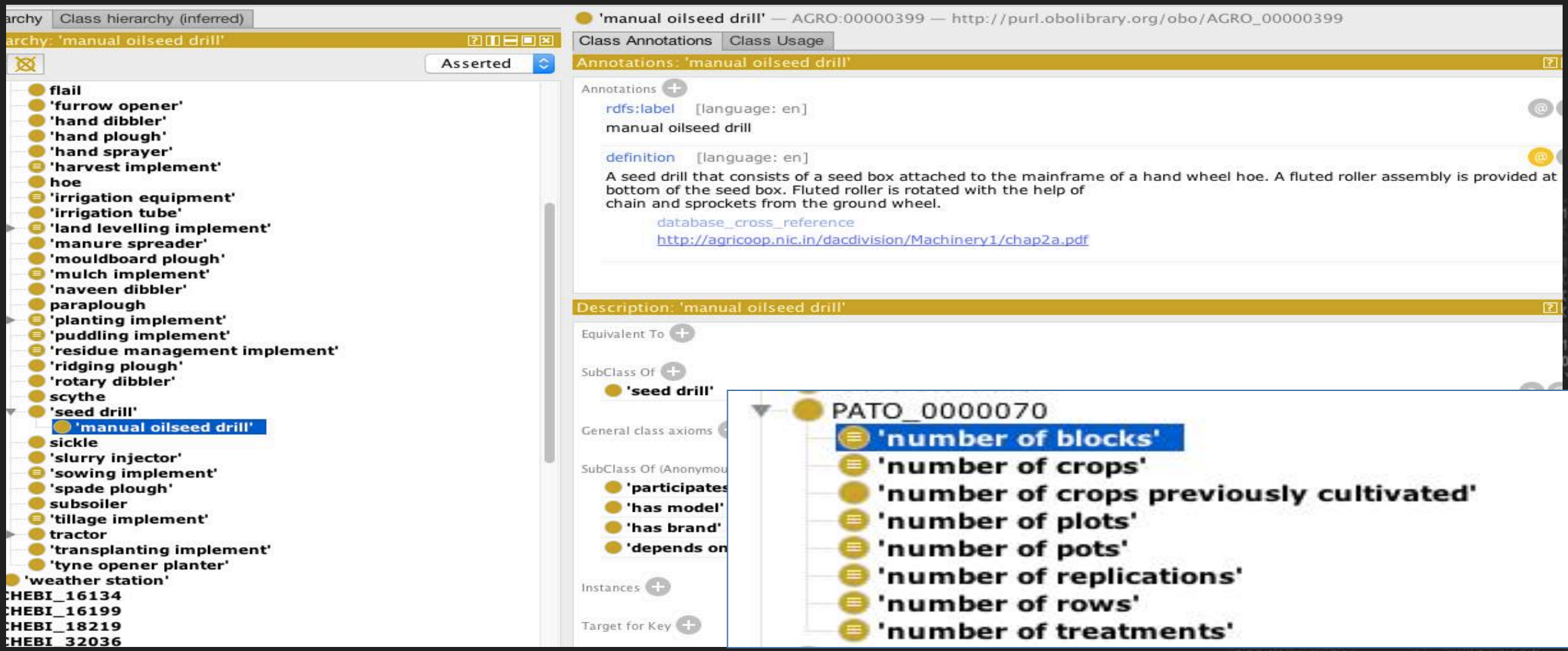
- 'pest control process'
  - 'biological pest control process'
    - 'organisms augmentation process'
    - 'organisms conservation process'
    - 'organisms importation process'
  - 'chemical pest control process'
  - 'mechanical pest control process'
    - 'mechanical pest destruction process'
      - 'cold treatment'
      - 'diatomaceous earth spreading'
      - 'fire treatment'
      - 'flood treatment'
      - 'heat treatment'
      - 'soil solarization treatment'
      - 'steam treatment'
      - 'tillage process'
    - 'mechanical pest exclusion process'
      - 'mulching process'
      - 'using barrier process'
    - 'mechanical pest removal process'
      - 'hand picking process'
      - 'insect vacuuming process'
      - 'mowing process'
      - 'trapping process'
      - 'water pressure spraying process'

- 'irrigation process'
  - 'localized irrigation process'
    - 'drip irrigation process'
    - 'pitcher irrigation process'
    - 'subsurface drip irrigation process'
    - 'subsurface textile irrigation process'
  - 'sprinkler irrigation process'
    - 'center-pivot irrigation process'
  - 'sub-irrigation process'
    - 'subsurface drip irrigation process'
    - 'subsurface textile irrigation process'
  - 'surface irrigation process'
    - 'bassin irrigation process'
    - 'border irrigation process'
    - 'furrow irrigation process'
    - 'uncontrolled flooding process'

- 'pruning process'
  - 'desuckering process'
  - 'detrashing process'
  - 'limbing process'
  - 'tree topping process'

- 'regulation of grazing'
  - 'continuous grazing'
  - 'rotational grazing'
    - 'creep grazing'
    - 'first-last grazing'
    - 'intensive rotational grazing'
      - 'controlled grazing'
      - 'hohenheim grazing system'
      - 'holistic planned grazing'
      - 'mob grazing'
      - 'strip grazing'

AgrO - a composite ontology in OWL

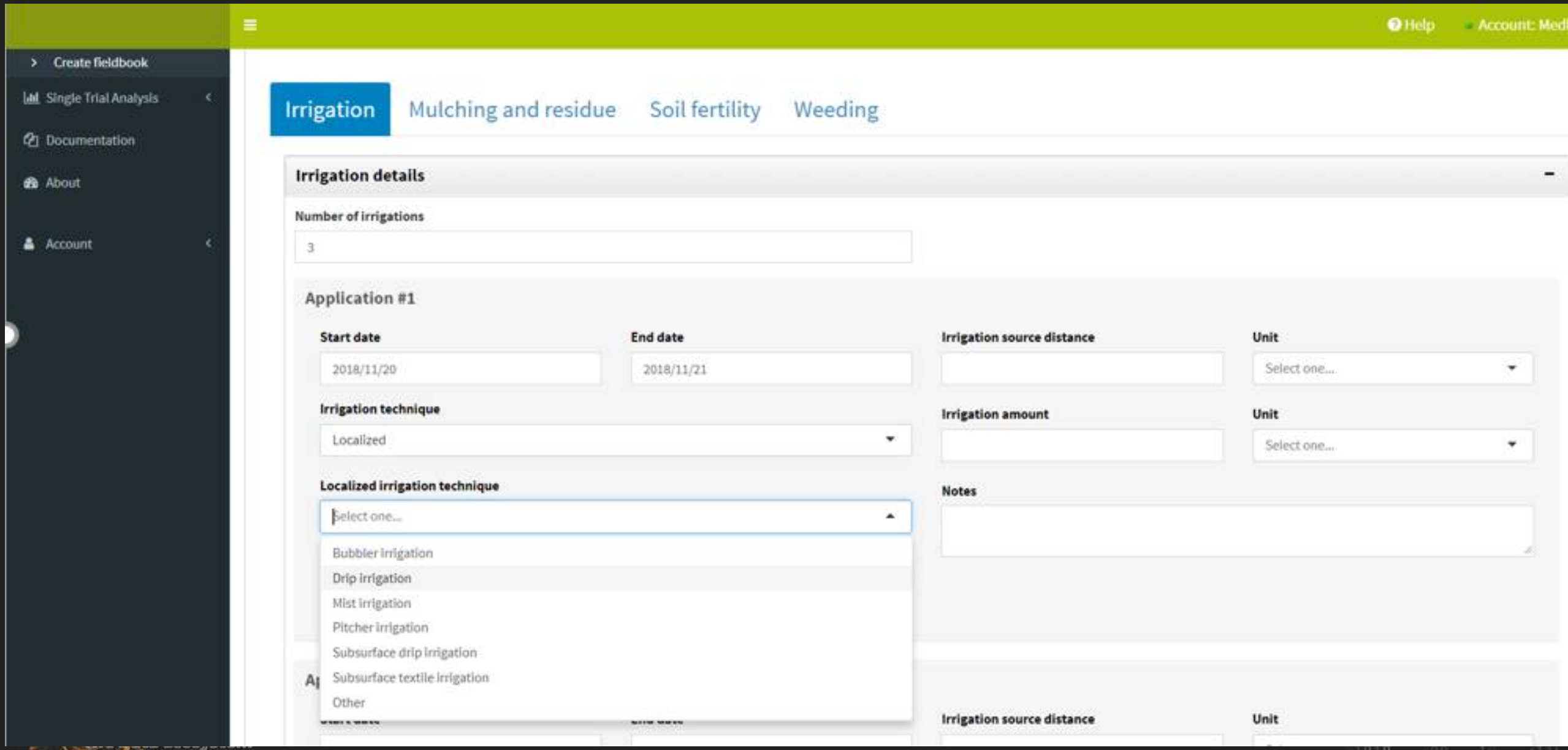


Quality classes are imported from PATO (Phenotypic Quality Ontology), whereas the unit classes are imported from the Unit Ontology

AgrO Github

https://github.com/AgriculturalSemantics/agro

AgroFIMS – user-tested; ready to field-test in Spring 2019


Help
Account: Med
Create fieldbook
Single Trial Analysis
Documentation
About
Account
Irrigation
Mulching and residue
Soil fertility
Weeding
Irrigation details
Number of irrigations
3
Application #1
Start date
2018/11/20
End date
2018/11/21
Irrigation source distance
Unit
Select one...
Irrigation technique
Localized
Irrigation amount
Unit
Select one...
Localized irrigation technique
Select one...
Notes
Bubbler irrigation
Drip irrigation
Mist irrigation
Pitcher irrigation
Subsurface drip irrigation
Subsurface textile irrigation
Other
Irrigation source distance
Unit

Crop measurement

Please, select measurement by click.

Select all

Show 25 entries

Search:

	Crop	Group	Subgroup	Crop measurement	Scale
1	Cassava	General	Timing	Date	yyyy/mm/dd
2	Cassava	Biomass	Harvest	Area harvested	m2
3	Cassava	Biomass	Storage roots	Fresh weight	g
4	Cassava	Biomass	Storage roots	Subsample fresh weight	g
5	Cassava	Biomass	Storage roots	Subsample dry weight	g
6	Cassava	Biomass	Storage roots	Moisture content	%
7	Cassava	Biomass	Storage roots	Dry weight	g
8	Cassava	Biomass	Storage roots	Dry matter yield	kg/ha
9	Cassava	Biomass	Leaves	Fresh weight	g
10	Cassava	Biomass	Leaves	Subsample fresh weight	g
11	Cassava	Biomass	Leaves	Subsample dry weight	g
12	Cassava	Biomass	Leaves	Moisture content	%
13	Cassava	Biomass	Leaves	Dry weight	g
14	Cassava	Biomass	Leaves	Dry matter yield	kg/ha
15	Cassava	Biomass	Stems	Fresh weight	g

ICRISAT Dataverse: Data set annotation with ontologies

Annotation on Dataverse

to 10 of 254 Results

Sort

Phenotypic evaluation data of Pigeonpea (C.acutifolious) medium duration advanced lines trial for year 2016-17

Nov 14, 2018 - Phenotypic

Sameer Kumar, CV; Anupama Hingane, 2017, "Phenotypic evaluation data of Pigeonpea (C.acutifolious) medium duration advanced lines trial for year 2016-17", doi:10.21421/D2/XAUZBD, ICRISAT Dataverse, V3, UNF:6:Elf26uVvetmS2bWWuQeAWQ==

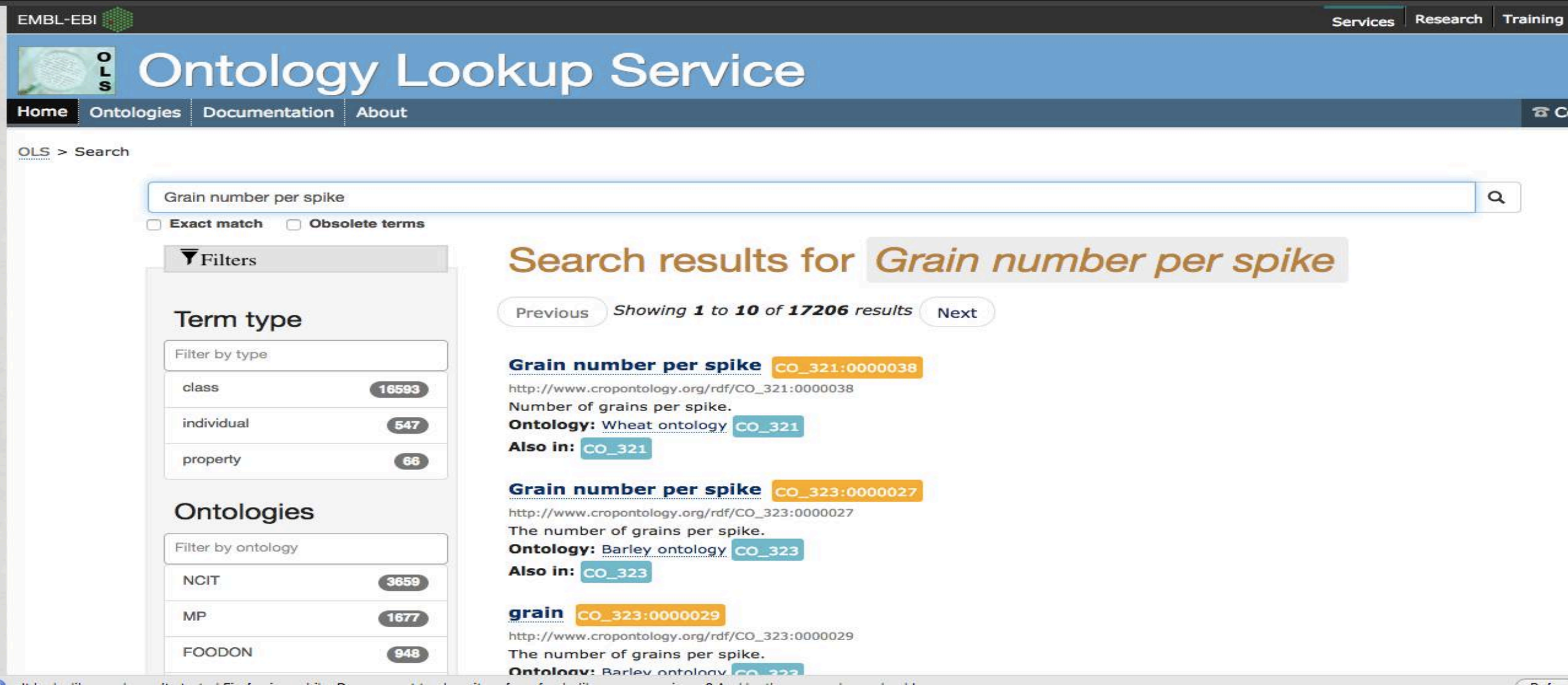
Keyword

Chickpea (CROP ONTOLOGY) http://www.cropontology.org/terms/CO_338:ROOT/
Plant height (CROP ONTOLOGY) http://www.cropontology.org/terms/CO_338:0000270/
Days to maturity (CROP ONTOLOGY) http://www.cropontology.org/terms/CO_338:0000281/
Days to 50% flowering (CROP ONTOLOGY) http://www.cropontology.org/terms/CO_338:0000279/
Replication number (CROP ONTOLOGY) http://www.cropontology.org/terms/CO_715:0000246/
Entry number (CROP ONTOLOGY) http://www.cropontology.org/terms/CO_715:0000031/
Seed yield per plot (CROP ONTOLOGY) http://www.cropontology.org/terms/CO_338:0000271/

A	B	C	D	E	F	G	H	I	J	K
Plot No	Replication Number	Entry No	Entry name	Days to 50 percent flowering	Days to maturity	Plant height	Plant count at harvest	Seed yield per plot	Seed yield	Hundred seed weight
401	1	1	ICCV 14301	47	96	39,4	90	457,33	953	35,1
402	1	8	ICCV 14308	47	97	38,4	70	570,13	1188	40
403	1	20	Local Check	48	98	46,6	75	696,00	1450	39
404	1	16	ICCV 14316	47	98	41	75	738,76	1539	45,5
405	1	19	KAK 2	46	96	45,8	102	618,00	1287	38
406	1	14	ICCV 14314	46	95	44,8	91	959,00	1998	39,5

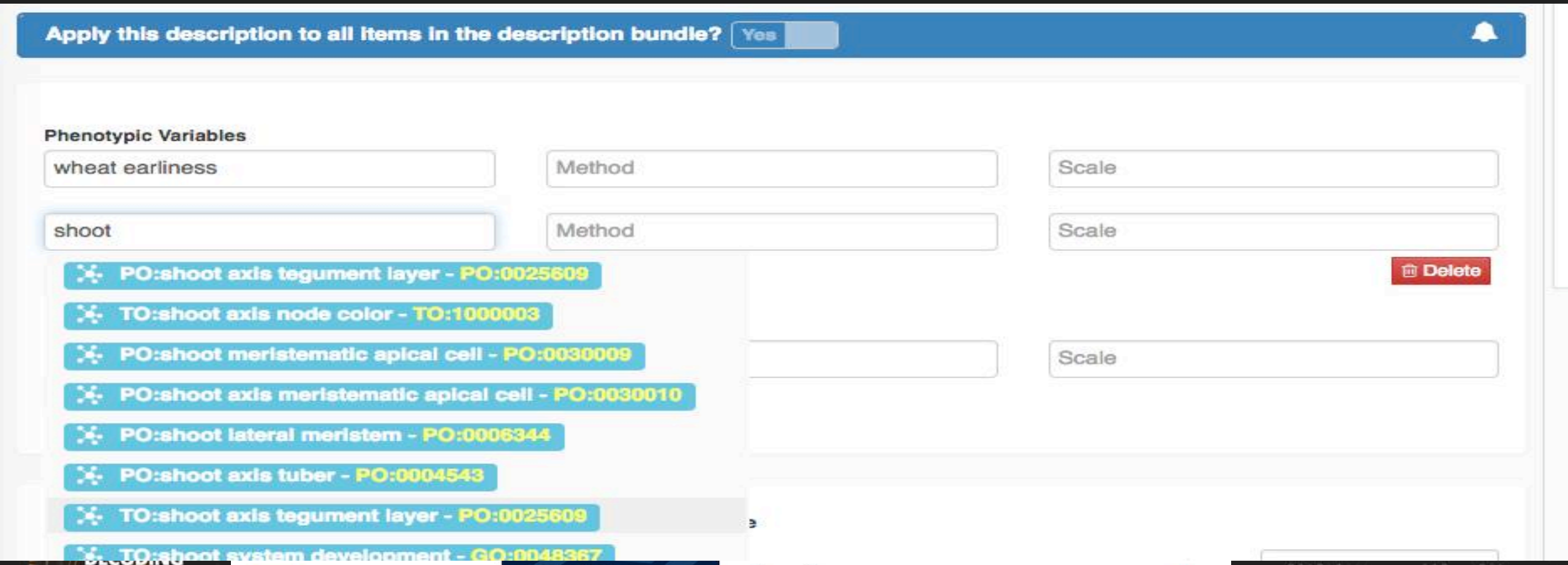
DECODING
The Data Ecosystem

Ontology Look Up Service
European Bioinformatics Institute



Data Annotation tool for public repositories using the OLS

https://copo-project.org/



Earlham Institute

Oxford e-Research Centre

University of York

EMBL-EBI

Multi-disciplinary data for agriculture research questions

- In Nigeria, Rainfed lowlands = 70% of total rice area.
- Yield losses resulting from flooding may range from 10% to total crop loss.

Question:

Identify rice varieties that are high-yielding and flood-tolerant that can grow in Nigeria in rain-fed lowlands subject to recurrent devastating flooding?

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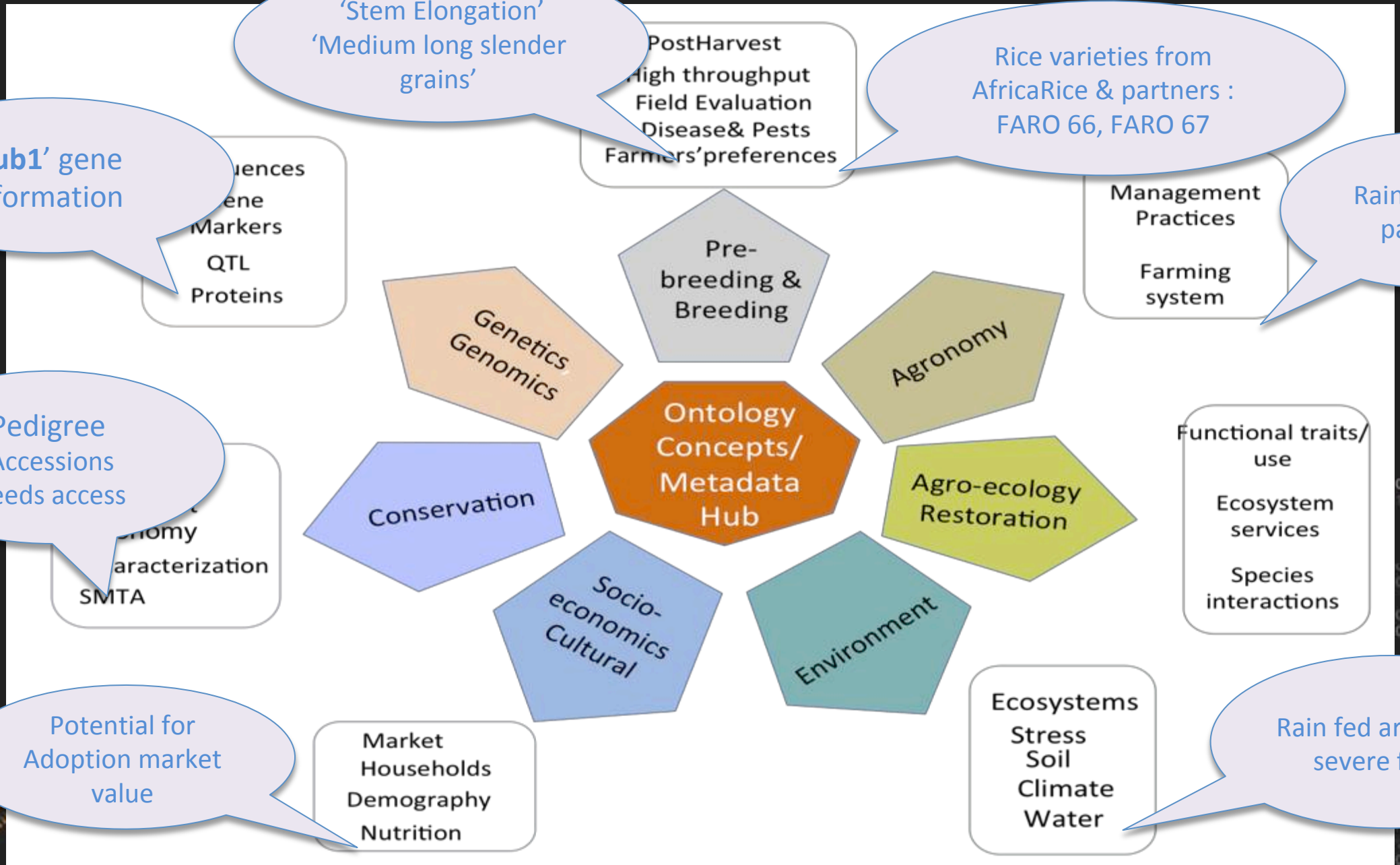
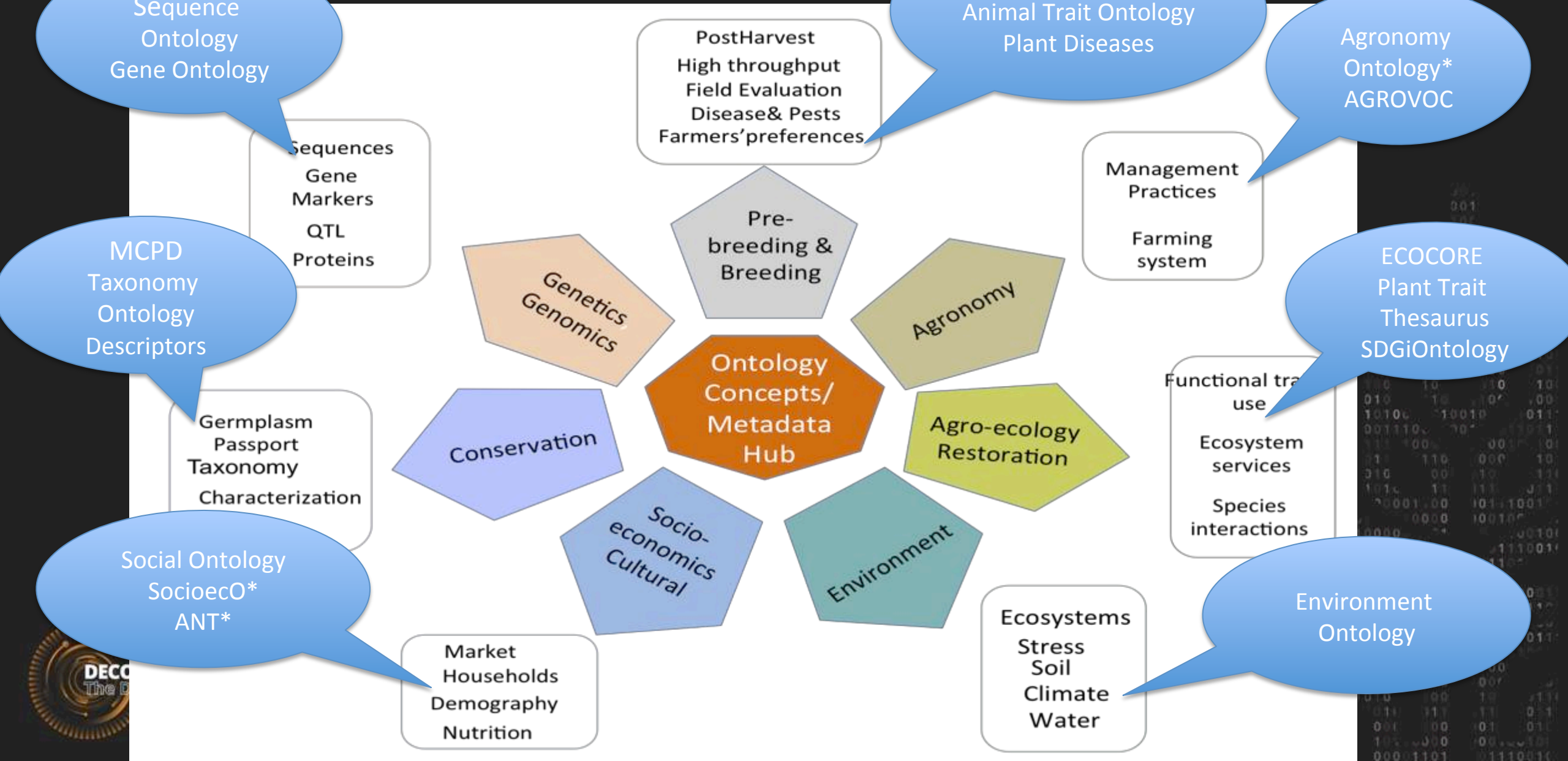
Multi-disciplinary Agricultural Data



Platform for Big Data in Agriculture

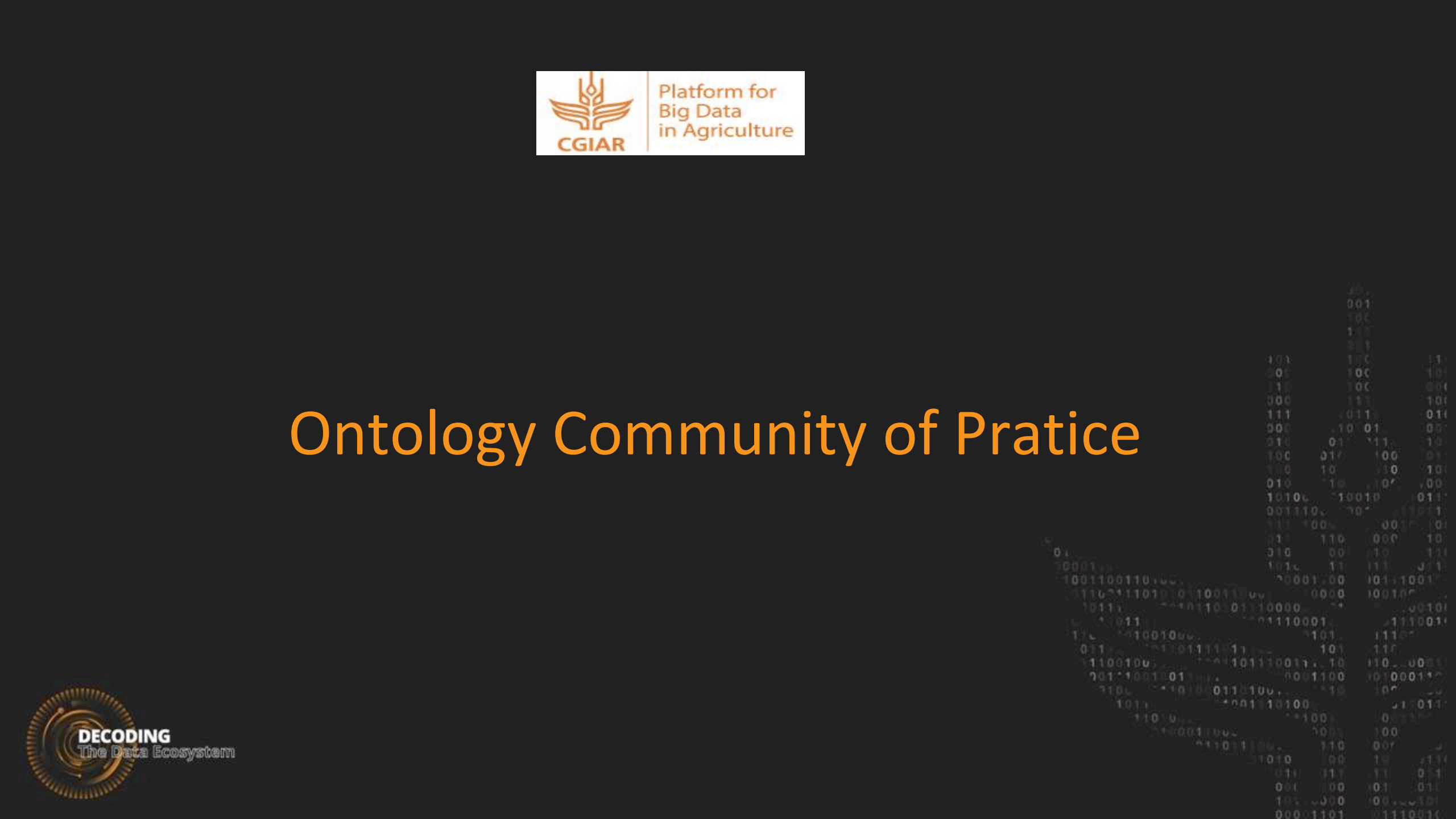
CGIAR

Multi-disciplinary Agricultural Data



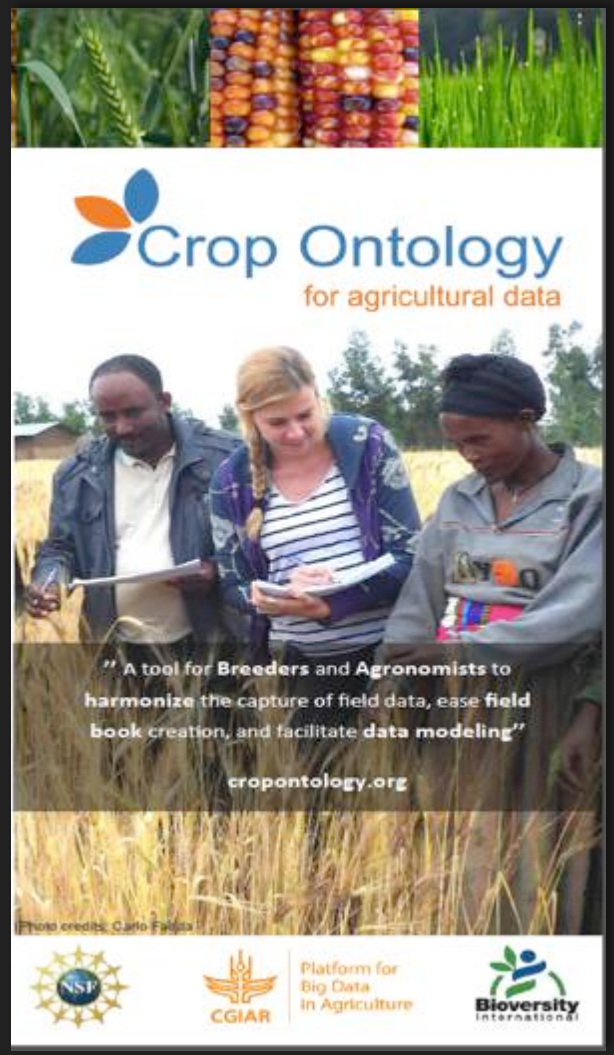
CGIAR Platform for Big Data in Agriculture

Ontology Community of Pratice



DECODING The Data Ecosystem

Crop Traits



Agronomy Ontology

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      - 'holistic planned grazing'
      - 'mob grazing'
      - 'strip grazing'

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Collaboration of the Ontology CoP and the Socio Economic Data CoP For household surveys

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Bioversity International

Discussion and Working Groups

Livestock Ontology

Plant Phenotype

Genetics and Genomics

Plant Stress

Fish Ontology

IWMI
International
Water Management
Institute

Water Management

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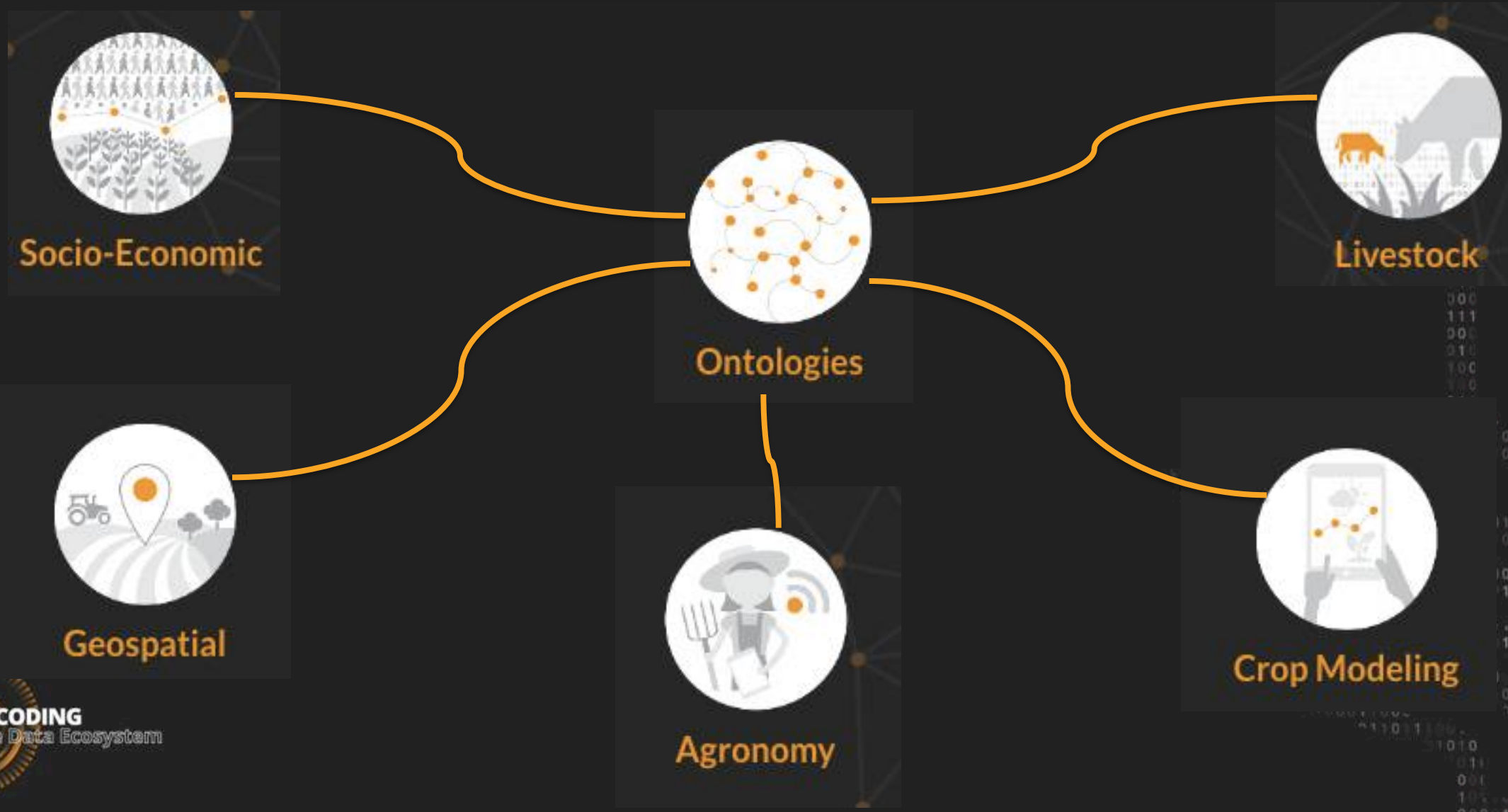
Bioversity
International

Platform for Big Data in Agriculture

CGIAR

Adopt, adapt and **validate best practices, guidelines** to support the **harmonization** and **interoperability** of data needed by the Big Data Platform and to support the other Communities of Practice.



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A Growing Community Of Practice

PhenoHarmonIS workshop

2012

2014

2016

2018

More news

Interested in joining our community of practice?

Sign up to our mailing list for community news and updates.

Sign up

VS

and for data interoperability and data discovery following the FAIR principles.

This space can be used as a discussion area, share and