



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



The Crop Ontology

www.cropontology.org

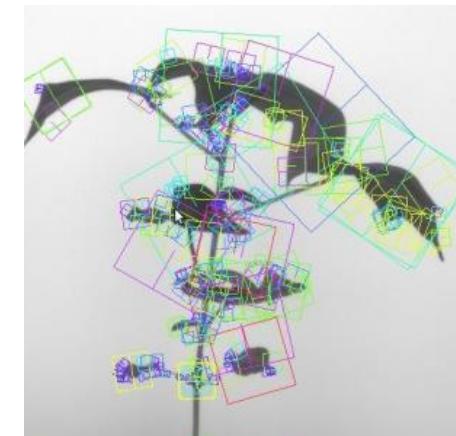
Harmonizing access to breeders' data

Elizabeth Arnaud, Leo Valette, Marie Angelique Laporte, Julian Pietragalla, Rosemary Shrestha, Medha Devare, Laurel Cooper, Pankaj Jaiswal, Glenn Hyman, Graham McLaren
And all crop curators and breeders



A common structured language for multidisciplinary agricultural research

- Molecular geneticists, breeders, physiologists and crop modelers must share each others ‘language’
- Enabling farmers to access information and exchange their preferences
- Calls for
 - a Common Terminology for annotating data
 - A mediation language that supports data interpretation



Harmonization of trait descriptions

- Germplasm Phenotyping/Evaluation data must be:
 - **Informative**: how to convert a free text, scoring, image/spectrum... into usable parameter?
 - **Exchangeable** across partners, between projects and between species.
 - **Properly annotated with metadata and trait concepts**, thus **enabling meta-analyses and linkage to the genotypes**.

Harmonization of Agronomic trials variables

- **Agronomic trial data are often collected in inconsistent ways—** and not consistently described and/or formatted.
- **Use of standardized metadata** drawn from an established '**agronomy ontology**' to describe the data is necessary
- An Agronomy Ontology will support the **integration** of pre-breeding, breeding and agronomy data
- Combining results of **field management practices x crop traits** leads to fully understand the dynamics of varying factors within any cropping system



©Cimmyt

Barriers

- **No naming convention for variables and methods** of measurement which are **heterogeneous**
- **Confusion between traits and variables**
- **No semantic coherence**
 - Same trait given different names or abbreviations by scientists
 - One trait named the same way for various species but refers to different plant structures
- **Definitions and measurements are different** between farmers, breeders, agronomists, modelers

The Integrated Breeding Platform

www.integratedbreeding.net

"THE BREEDING MANAGEMENT SYSTEM (BMS) MAKES LIFE EASIER FOR BREEDERS: THERE'S AN APPLICATION TO HELP THEM AT EVERY STEP AND THEY'RE ALL IN ONE PLACE."

- GRAHAM MCLAREN, DEPLOYMENT MANAGER

Photo credit: background: CIMMYT (modified)

GET STARTED WITH THE BMS

FOR PUBLIC INSTITUTIONS



"This integrated breeding system helps in making plant breeding an easier and shorter process. It has been instrumental in making us

FOR YOUR BUSINESS



"BMS is an accessible solution that brings simplification as well as transparency into breeding processes. It will help

FOR UNIVERSITIES



"The BMS tools will be very useful for lecturers as a complement to their curriculum. It will let us have impact on our students by

The Breeding fieldbook

Crop Ontology Sections

- General germplasm information
- **Phenotype and traits**
- Plant anatomy and development
- Location and **environment**
- **Trial management & experimental design**
- Structural and functional genomics



- Banana
- Barley
- Cassava
- Chickpea
- Common bean
- Cowpea
- Groundnut
- Lentil
- Maize
- Oat (*Global Triticeae*)
- Pearl millet
- Pigeon Pea
- Potato
- Soybean (*USDA & IITA*)
- Sweet Potato
- Rice
- Sorghum
- *Vitis* (*INRA*)
- Wheat
- Yam

Crop Ontology

www.croponontology.org

Crop Ontology Curation Tool

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Common Bean Ontology

Ontology curators

• Guerrero Alberto Fabio, CIAT

Scientists

- Steve Beebe, bean program leader, CIAT
- Rowland Chirwa, CIAT
- Cesar Cajiao, Universidad de Pereira
- Jose A. Polania, CIAT
- I. Rao, CIAT
- H.F Buelna, CIAT
- C. Jara, CIAT
- J.M Bueno, CIAT

CO_335

[Add New Terms](#)

[API](#)

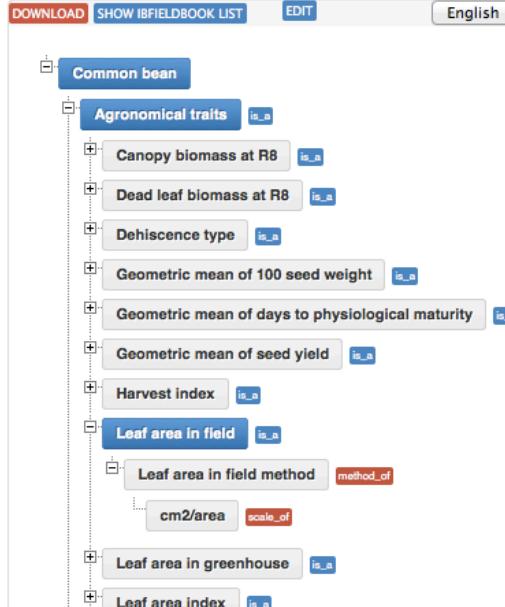
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[Agritrips](#)

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ElizabethArnaud



Leaf area in field

Permalink ▾ General 0 Comments

Identifier [CO_335:0000647](#)

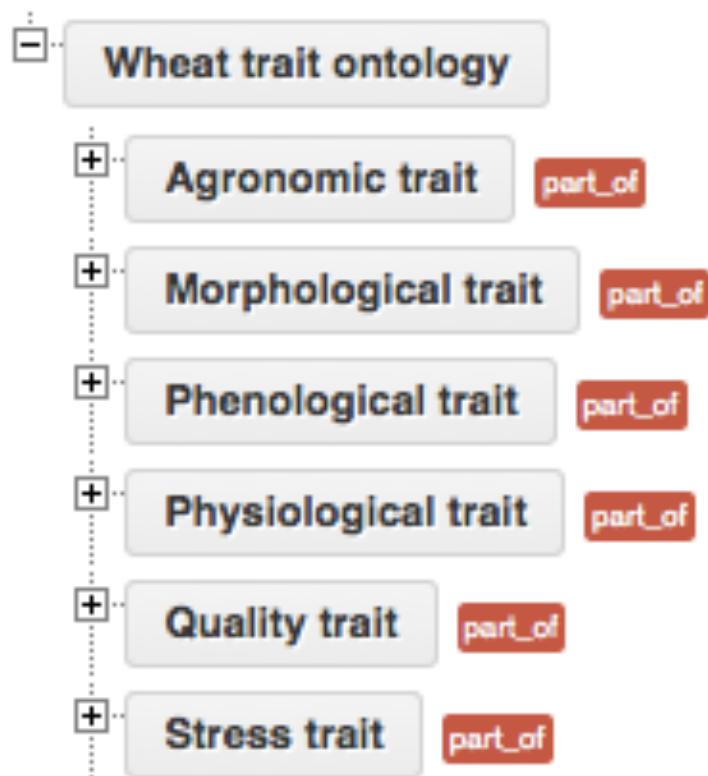
Abbreviated name LAF

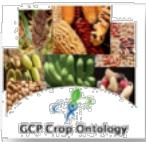
Description of Leaf area from 50 cm row length
Trait

Trait Class Agronomical traits

How is this trait Physiology studies
routinely used?

Trait Classes agreed with Breeders





Direct upload & online visualization



Crop Ontology Curation Tool

Generation Challenge Programme
CULTIVATING PLANT DIVERSITY FOR THE RESOURCE POOR

Home About Users Feedback English ▾

number of panicles

Identifier CO_320:00000009

created_at Fri Jun 01 13:18:18 UTC 2012

synonym "panicle number" RELATED []

def "Average number of panicles per plant in a study."
[CO:rs]

Upload Excel

Longitud general de las raíces (corta, 2=intermedia, 3=larga)
Longitud promedio de los pedunculos (1=corto, 2=intermedio, 3=largo)
Color de la cascara de la raíz (1=claro, 2=medio oscuro, 3=oscuro)
Color de la pulpa de la raíz (1=blanca, 2=amarilla, 3=anaranjada)
Forma de la raíz (1=recta, 2=espiral, 3=angular)
Construcción:
Evaluación:
Evaluación:
Número de raíces comerciales
Porcentaje de trazos para raíces
Rendimiento de la planta (kg)
Índice de riego (Peso raíz/Peso total de la planta)
Rendimiento por hectárea (Ton)
Rendimiento por año (Ton)
Contenido de azúcar en el zumo (1=muy bajo, 9=muy alto)
Verdad seleccionada (1=S, 0=No)
Contenido de materia seca (%)
Número de establos germinantes
Vigor inicial (1=poco vigor, 5=muy vigoroso)
Presencia de flores en la planta (1=ninguna, 2=intermedia, 3=mucha)
Altura de la planta (cm)
Número de ramafilaciones
Altura de la primera ramafilación (cm)
Índice de ramificación respecto a la altura de la planta

The crop Ontology web site

A concept name server on the Cloud



Luca Matteis, Web developer,

Powered by Open Source

Crop Ontology is built on a range of modern open source technology including [Google App Engine](#), [jQuery](#), [HTML5](#) and [CSS3](#). The entire source code is available on [GitHub](#).

→ <https://github.com/lmatteis/Crop-Ontology>





Crop ontology on Google Cloud

Crop Ontology Curation Tool

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API

This is the official API for the Ontology Curation Tool. It allows you to programmatically retrieve and interact with Ontology data.

To let us gather feedback you can leave a comment using the form on the right.

API Data Types

Data can be requested in JSON.

API calls follow the [CRUD](#) semantics: create, retrieve, update and delete.

JSON DUMP

URL: <https://github.com/bioversity/Crop-Ontology/blob/master/public/dump.json>

Returns: JSON array of "raw" objects inside database

Search Terms

URL: <http://www.cropontology.org/search?q={query}>

Method: GET

Returns: Array of objects matching the search query - each object being a term

Example: <http://www.cropontology.org/search?q=stem rust>

Retrieve all Ontologies



Global Repository of Evaluation trials – Agtrials : **1,410 agronomic variables** are mapped to Crop Ontology traits for **29,633 trials** out of 34,329 trials description

EU-SOL - Solanaceae Breeding DB Wageningen.

International cassava DB – Boyce Thompson Institute/IITA

Phenomics Ontology Driven DB (PODD)

Differentiating traits and variables in 2015

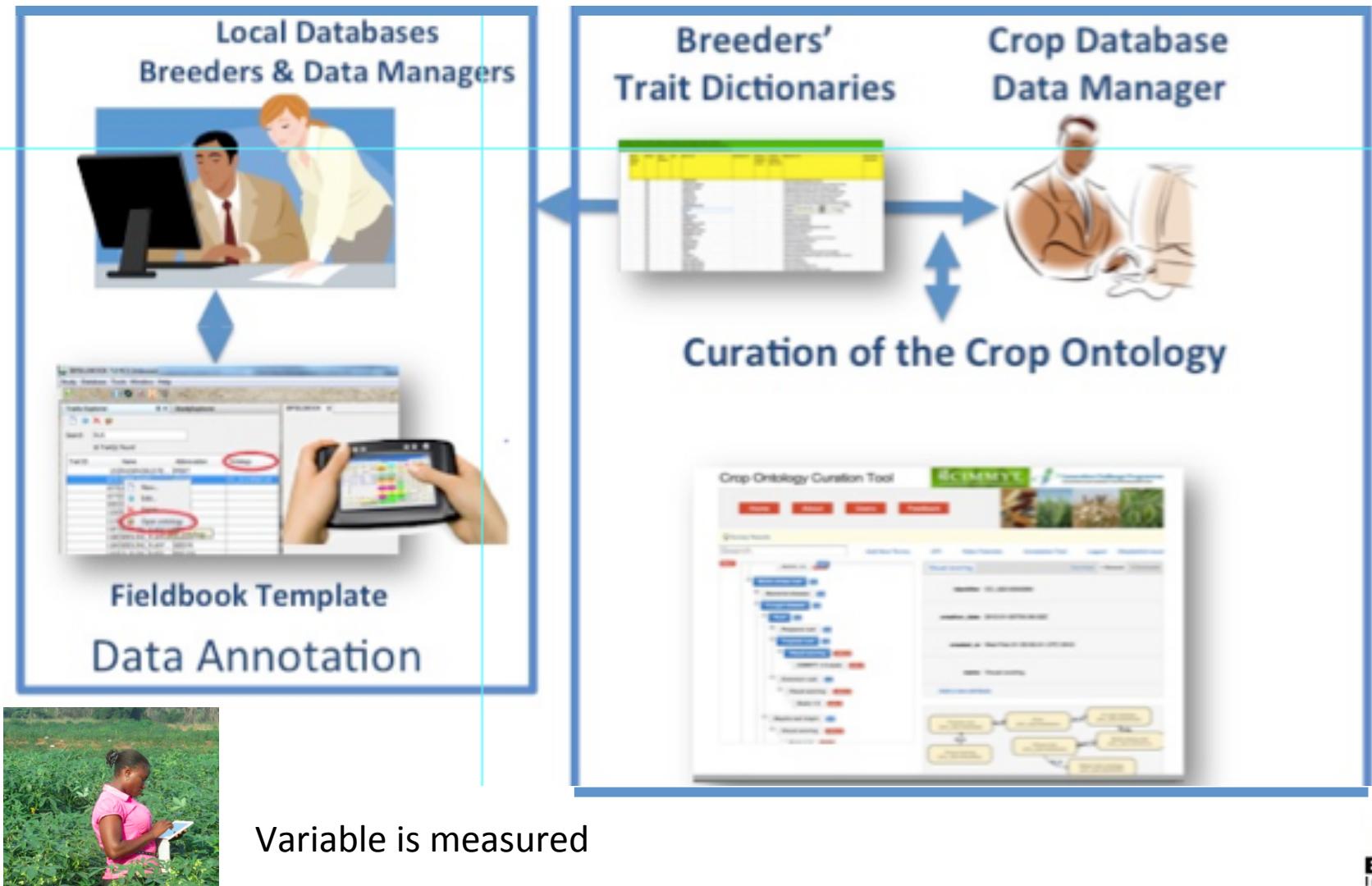


Julian Pietragalla
IBP, Agronomist



Léo Valette
Bioversity, Agronomist

Data and metadata workflow for breeders' data



CO Trait Dictionary: Trait

Trait = Entity + Quality
(Flower) (colour)

- A **Trait** can group several variables

Grain Weight

- Weight of 100 grains expressed in g
- Average weight of a grain, expressed in g
- Weight of 100 grains expressed on a categorical scale: 1=low (50-100g), 2=medium (100-150g), 3=high (150-200g)

Trait ID	CO_341:0000090
Trait	Flower color
Entity	Flower
Attribute	Colour
Trait synonyms	Flower pigmentation
Trait abbreviation	FCL
Trait abbreviation synonyms	FlwCol
Trait description	Color of the flower
Trait class	Morphological traits
Trait status	Recommended
Trait Xref	TO:0000537

Co Trait Dictionary: Measurement Method

- Breeders select their **methods of measurement for the variable**
- Important information to capture for data comparison and interpretation
- Current ontologies sometimes provide brief information on Methods but **as a text in the attribute information**
- Crop Ontology proposes a relationship call '**method_of**' and allocate a name and an **Method ID**

Method ID	CO_341:0000091
Method	Flower color estimation
Method description	Visually estimated at 50% flowering
Formula	
Method class	Estimation
Method reference	

- Measurement
- Counting
- Estimation
- Computation

CO Trait Dictionary: Scale or unit

- Important for data alignment and comparison
- Crop Ontology propose a relation 'scale-of'
- Will use the Unit Ontology

Scale id	CO_341:0000092
Scale name	Visual Flower color scale
Scale class	Nominal
Scale Xref	
Category 1	1= Light yellow
Category 2	2= yellow
Category 3	3= orange yellow
Category 4	4= purple
Category 5	5= red

- Nominal
- Ordinal
- Numerical
- Time
- Duration
- Text
- Code

CO Trait Dictionary: Variable

A Variable is described by the assembly:

(Property (Trait) + Method + Scales/units)

- Unique name
- Annotate the **real value of the measurement** (for fieldbook, databases)
- Proposed standard variable naming : **P_M_S**

Variable name	FCL_VisEst_1to5
Variable synonyms	
Context of use	Breeding trials
Growth stage	50% Flowering
Variable status	Recommended
Variable Xref	BMS_20186



Breeding Management System

BMS_CASSAVA_TUTORIAL Ask Support

My Programs Ivallette ▾

MANAGE OR ADD VARIABLES

* indicates a mandatory field

VARIABLE DETAILS:

Variable Name: * FLOWER (Shared)

Description: Flowering-/Visual{Code (0,1,2,3)}

Role: * Categorical variate

Data Type: * Categorical variable

Valid Values:

0	ninguna
1	poca
2	intermedia
3	mucho

Add Value

PROPERTIES AND TRAIT CLASSES:

Filter for Trait Class: * Morphological (Shared) Manage

Description: Morphological

Property: * Flowering (Shared) Manage

Description: Presence of flowers in the plant (1=none, 1=few, 2=intermediate, 3=many)

Crop Ontology ID: CO_334:0000111

Trait Class Tree View:

- ALL
 - Crop research ontology
 - Crop trait ontology
 - Abiotic stress
 - Agronomic
 - Biochemical trait
 - Biotic stress
 - General
 - Grain quality
 - Morphological

METHODS AND SCALES:

Method: * Visual (Shared) Manage

Description: Visual

Scale: * Code (0,1,2,3) (Shared) Manage

Description: Code (0,1,2,3)

Back Update Delete

Developing an Agronomy Ontology & designing a fieldbook

- **CROP - PLANTING**
- **SEED TREATMENT**
- **IRRIGATION**
- **FERTILIZER**
- **PESTICIDE**
- **SOIL**
- **BIOTIC STRESS**
- **ABIOTIC STRESS**
- **HARVEST-YIELD**

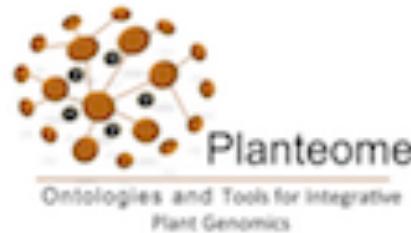


Necessitates combining variables for experimental design, environment, crop traits...

Aligning with the International Consortium for Agricultural System Applications (ICASA)

- Master list of **600 variables** describing crop management and recording plant responses.
- Standards for crop field research and for eco-physiological models.

Medha Devare
Data and Knowledge Manager
CGIAR Consortium Office



Contributing to the reference ontologies for plants:

Planteome pilot project started in 2015

Lead PI : Pankaj Jaiswal, Oregon State University

Co PIs: Elizabeth Arnaud, Crop Ontology Coordination Team at Bioversity International; John Doonan, Aberystwyth University; Denis Stevenson, New York Botanical Garden; Chris Mungall, Lawrence Berkeley National Laboratory.



Engineering Crop Ontology for semantic web

4. provide the overarching semantic for querying, reasoning and data mining across various species

3. Simple Relationships
Narrow/Broader/synonym
(available in csv, SKOS, OBO, Excel)

2. Structured dictionary for Trait, Method, scales/units, standard variable names

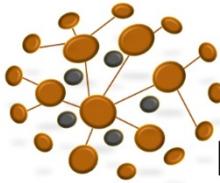
1. **No** semantic relationship
Species-specific lists

Reference upper-level Ontologies

Crop Ontology

Trait Dictionary

Lists of variables/traits



Planteome

Planteome Overview

Common Reference Ontologies for Plants (cROP) and
Tools for Integrative Plant Genomics

- Centralized platform for **reference ontologies for plants**
- Online informatics portal for **ontology-based, annotated data** for plant germplasm, gene expression, and non-model genomes
- **Data query, analysis, visualization and community-based annotation and curation tools**

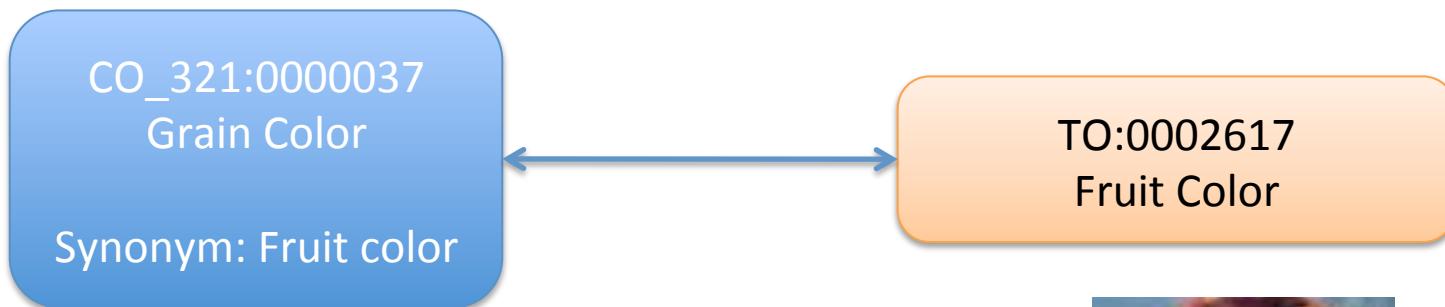
- Plant Ontology (PO)
- Plant Trait Ontology (TO)
- Plant Stress Ontology (PSO)
- Plant Experimental Conditions
Ontology (PECO/EO)
- Gene Ontology (plants)
- Phenotypic Qualities Ontology (PATO)
- Cell Type Ontology (CL)
- Chemicals (ChEBI)
- Protein Ontology (PRO)

Mapping Crop Ontology to the references ontologies with AML

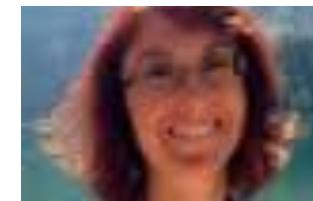


Direct mappings between CO trait ontologies and the Plant Trait Ontology

Automatic mappings are generated using the AML¹ tool, then are manually curated

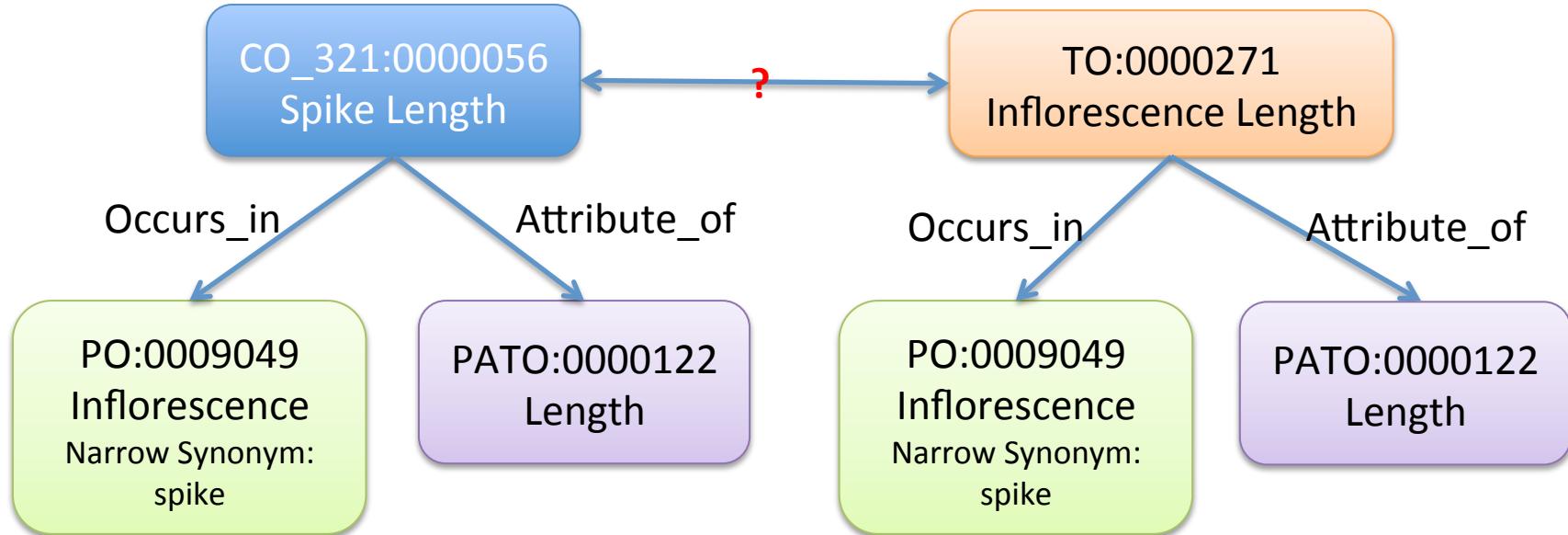


Mappings performed by Marie Angélique Laporte
AML tool : Catia Pesquita cpesquita@di.fc.ul.pt and Daniela
Oliveira doliveira@lasige.di.fc.ul.pt LaSIGE - Large-Scale
Informatics Systems Laboratory ¹ <https://github.com/AgreementMakerLight/AML-Project>

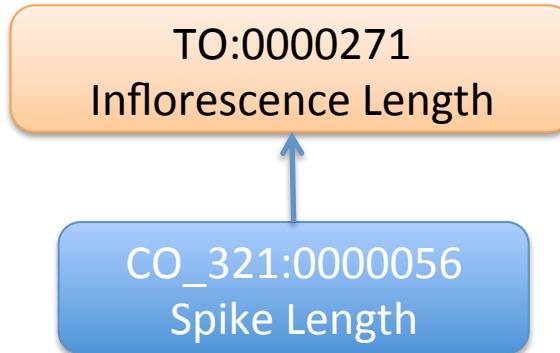


Mapping for inference

Compound mappings



Inference



Sustainability

- Developing the Agronomy Ontology + fieldbook will require additional funds
- Maintaining Crop Ontology to support IBP – BMS and expand to new crops
- A resource for CGIAR's OD-OA strategy
- Adding farmers' preferences obtained via Participatory Variety Selection (PVS)
- 3-year NSF funding for Planteome pilot project
- Aligning with Agrovoc, CABI, NAL thesauri
- Securing the infrastructure and site – test of bioportal instance
- Expanding the active community:
 - International Wheat Initiative
 - Collaborative, Open Plant Omics (COPO): a community-driven bioinformatics platform for plant science (BBSRC)
 - The ISA-Tools group at Oxford and test their Statistical Method Ontology :<http://www.stato-ontology.org>
 - Planteome is included in the Divseek initiative which aims at fostering collaboration for analyzing the high throughput genomics and phenomics data
- Informing and training scientists and data managers:
 - Annual workshop for scientists to discuss their data and the definitions of traits
 - Training in the use of Trait Dictionaries and data curation with Metadata

CGIAR Crop Lead Centers and partners

Since 2008



Community workshop in 2014, Montpellier : <http://tiny.cc/rw51ax>

