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## FAIR Data publication for phenomics data

Cyril Pommier

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**HAL Id: hal-02787988**

**<https://hal.inrae.fr/hal-02787988>**

Submitted on 5 Jun 2020

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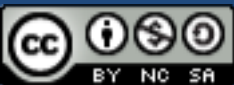
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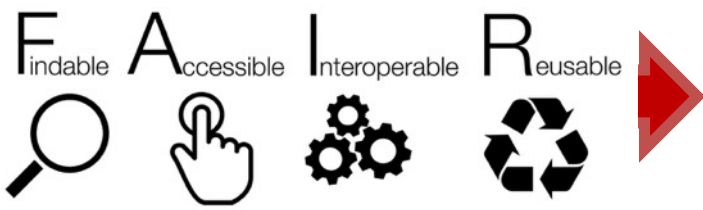
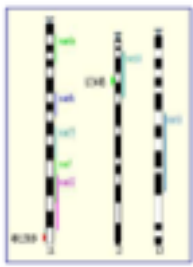
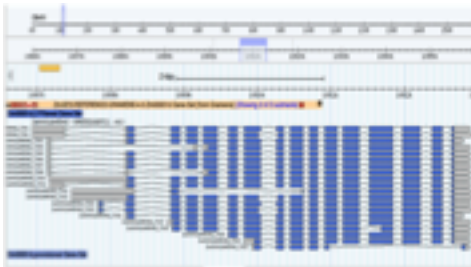
# Standards for Distributed Plant data integration



## Challenges and Solutions



# Genomic X Environment X Phenomic



- Climate change adaptation
- Variety improvement
- Cultural Practices adaptations
- ...



# FAIR Data Principles

Ids  
Metadata  
Index

Open Protocols  
Persistent Metadata

Semantics  
Linked Data  
Vocabularies

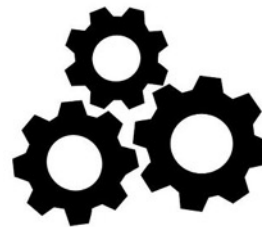
License  
Well described  
Provenance  
Standards

F  
Findable

A  
Accessible

I  
Interoperable

R  
Reusable



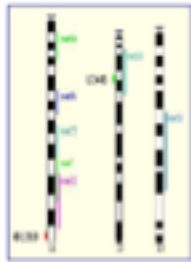
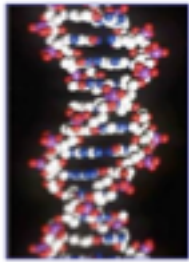
- Avoid Data Silos
- Interoperable Data and Tools Integration
  - ◆ Linked data
- Repositories Complementarity
  - ◆ Volume and Variety Burden Sharing

# FAIR for Genomic

- High Throughput
- Genome assemblies
- Genetic variations
- Established repositories
  - ◆ ENA/EVA
  - ◆ NCBI
  - ◆ Consortium/Species repositories
- Established standards
- Simple life cycle
  - ◆ Production → one data publication



# FAIR for Phenomic $P = G \times E \times C$



**Plant Genotype**

**Interactions**



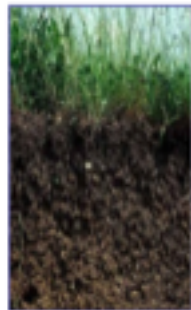
**Environment**



Climate



Cultural Practice



Soil



Stress

**Phenotype**



Phenology, Structure, Biochemical content

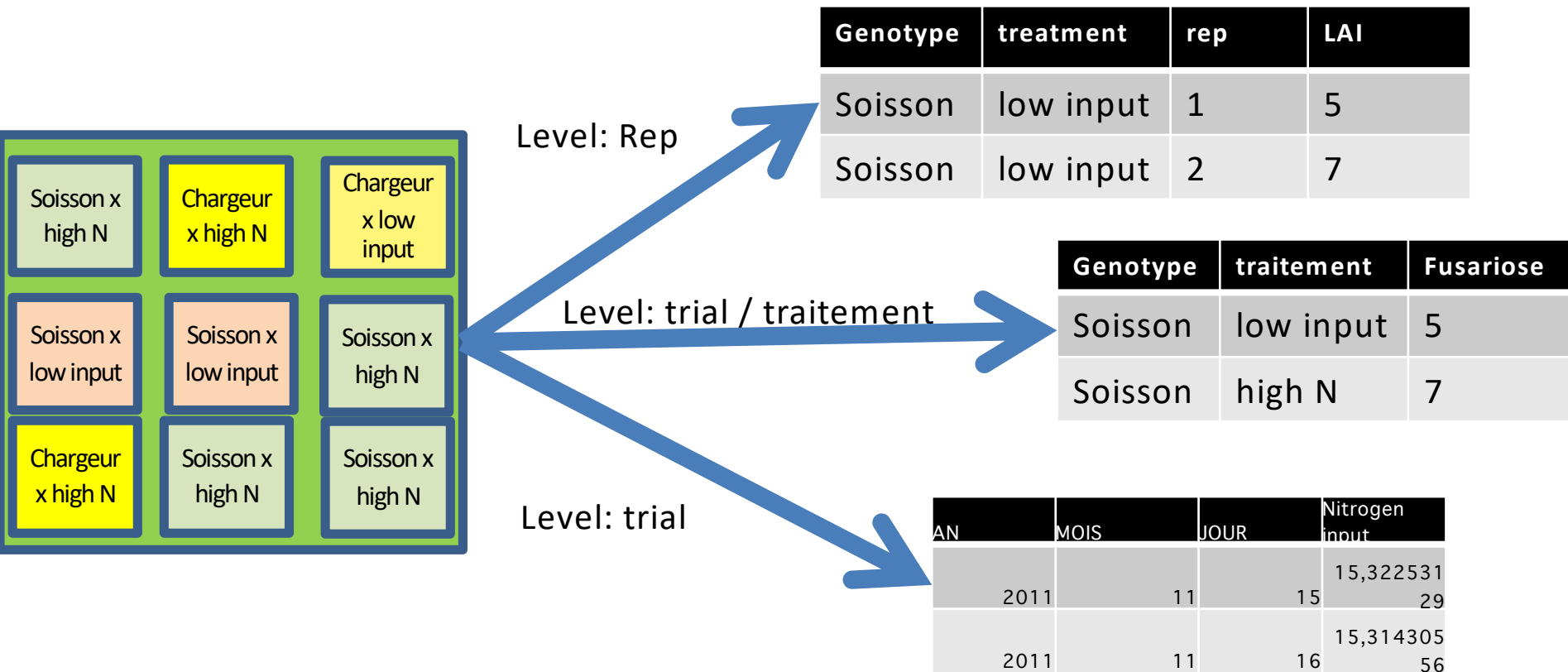
- Trait/Variable : a definition of an observable characteristic
  - ◆ Yield
- Phenotype : A trait/Variable with a value
  - ◆ Yield = 15 Kg by hect

# FAIR for Phenomic

- P = Genotype x Environment x Cultural practice
- Environment is critical, included in Phenotype lifecycle
- Raw data
  - ◆ Big : Terabyte by experiment
  - ◆ Patrimonial: long term storage
- No central Phenomic data archive
- Distributed Model
  - ◆ Wheat IS, Elixir, Transplant
  - ◆ Standards : Breeding API, MIAPPE, Crop Ontology
  - ◆ Several repositories: GnpIS, eDale, Emphasis (PHIS), PIPA/VIB, ...
- Complex life cycle

# Phenotyping Data life cycle

## Raw data

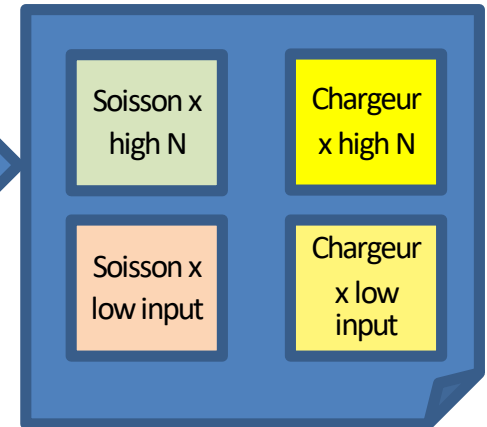
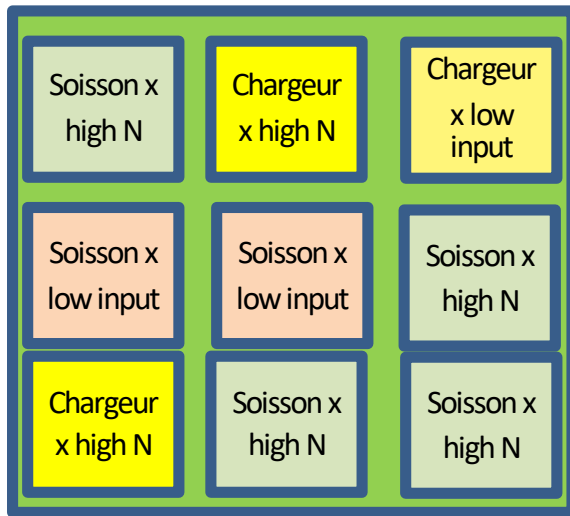




# Phenotyping Data Computation

Raw data

Elaborated data



Genotype	treatment	rep	LAI
Soisson	fi	1	5
Soisson	fi	2	7

Genotype	treatment	LAI
Soisson	low input	6

# Phenotyping Data Computation

- NIRS

Individual	Genotype	Repetition	Date	4000	4002	4004	4006
662200657-1	662200657	1	Nov11	0.790383794657 181	0.790834341907 288	0.791261293580 598	0.791659233526 804
662200657-2	662200657	2	Nov11	0.817254078896 638	0.817865344054 208	0.818450087726 549	0.819007314250 037
662200659-1	662200659	1	Nov11	0.822434379133 726	0.822871701993 426	0.823268552780 517	0.823649256266 632

- After Calibration and Analysis

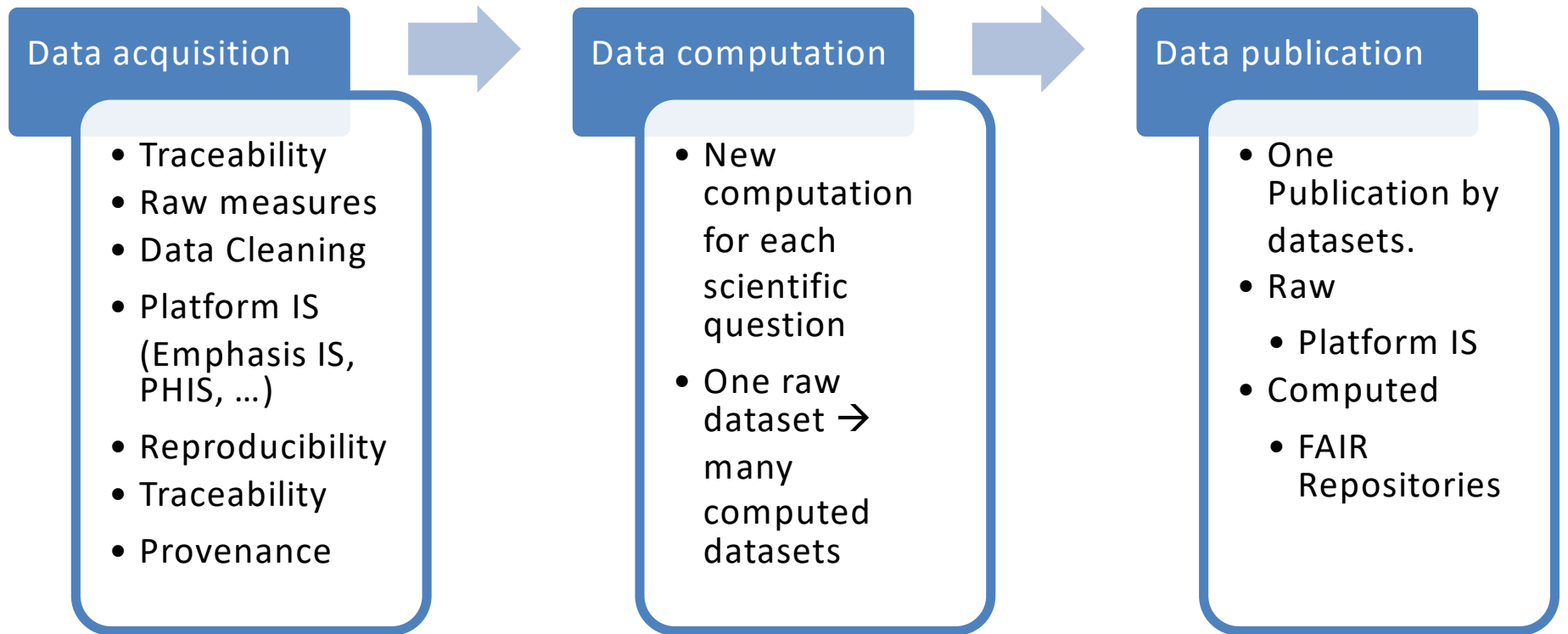
Individual	Genotype	Repetition	Gluc_sol	Gluc_solub	Gluc_hydrol	NIRS_id	Date
662200659-1	662200659	1	0.064074733	0.38557928	0.321504547	2274	Nov11

# Phenotyping Data Computation

- LIDAR
  - ◆ Very Big files
  - ◆ Plant Architecture
  - ◆ Raw extraction :
    - Leaf area, leaf angle
  - ◆ Elaboration → % interception
- Metabolomic
  - ◆ MSI Compliant Full description
  - ◆ Elaboration →
    - Leaf Protein concentration
    - Root Cellulose concentration

# Plant Phenotyping Life cycle

## Raw data long term conservation



IB 2018 Workshop  
main Topic

# Other type Lifecycle

- Heterogenous data types
  - ◆ Markers
  - ◆ Genetic resources accessions
  - ◆ Genetic experiment results
    - GWAS
    - Genomic Selection
    - Genetic Maps
  - ◆ Journal articles
  - ◆ Seeds of discovery data
- Minimal FAIR
  - ◆ Simple life cycle : publication
  - ◆ Findability : datadiscovery.

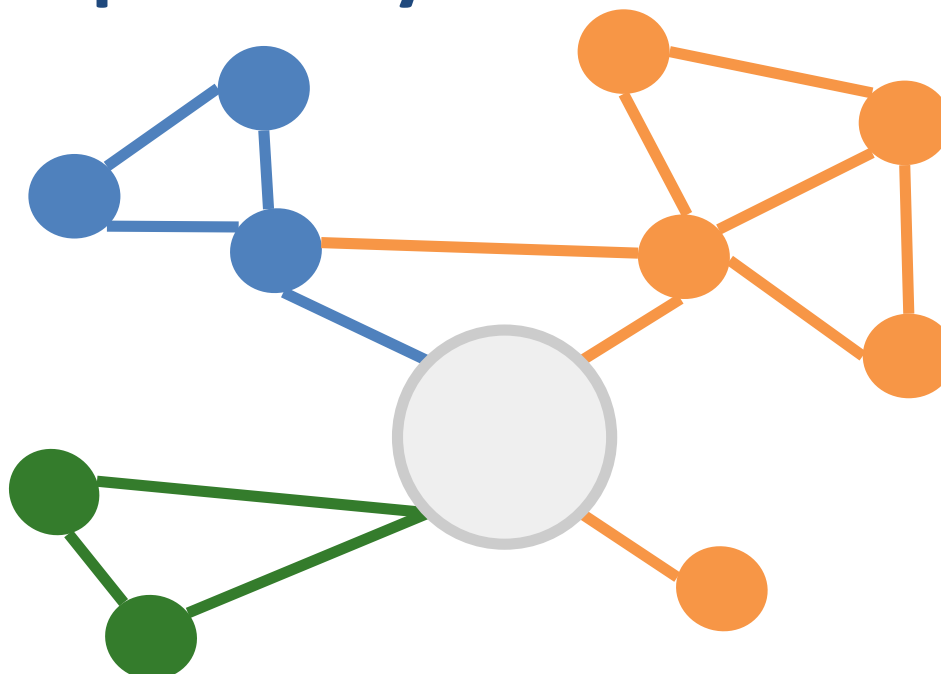
## FAIR: DATA STANDARDS



# Interoperability in International network

**National Networks**

**European Networks**



**Global Networks**

**International data standards**



Web services



Minimal information



Controlled vocabularies  
Trait dictionaries



MCPD



# Standard Sharing

How to cite this record FAIRsharing.org: GnplS; Genetic and Genomic Information System; DOI: 10.25504/FAIRsharing.dw22y3; Last edited: May 8, 2018, 9:00 a.m.; Last accessed: Jun 12 2018 9:23 p.m.

This record is maintained by [cpommier](#) [ORCID](#) and [ThomasLetellier](#)

Record added: March 2, 2016, 5:59 a.m.

Record updated: May 7, 2018, 11:29 a.m. by [ThomasLetellier](#).

## In Collections

[Wheat Data Interoperability Guidelines](#)

[ELIXIR node contributed resources](#)

## Support

[General](#)

## Related Standards

### Reporting Guidelines

[Minimum Information about Plant Phenotyping Experiment](#)

### Terminology Artifacts

[Crop Ontology](#)

[Plant Ontology](#)

### Models and Formats

[Investigation Study Assay Tabular](#)

[Generic Feature Format Version 3](#)

[Variant Call Format](#)



# WheatIS standards

- <http://wheatis.org/DataStandards.php>
- Phenotypes guidelines
- MIAPPE
- Croponontology
- Breeding API

## Wheat Data Interoperability Guidelines

Home Guidelines **▼** Ontologies & Vocabularies Use cases **▼** Getting involved About **▼**

Home / Phenotypes

### Phenotypes

Phenotypes are characteristics of an organism resulting from interactions between genes and the environment. Plant phenotyping can be used in several fields, such as breeding and crop improvement. Phenotypic data (traits and associated value) can be used in several fields of research in multi-location environments, germplasm bank and crop improvement. Furthermore, phenotypes are in interaction, like for instance in crop yield and grain quality.

Getting Involved



## 1. Data formats

We recommend following minimum format principles with data variables (trait along with method, units and scales or environmental conditions). This principle has been formalized in the **MIAPPE** under improvement.

The **Breeding API**, described below, is a MIAPPE compliant web service API specification.

There is also an emerging initiative to produce a semantic web version of MIAPPE through **to RDF transformation (new!)**.

See the **germplasm recommendations** for data format regarding germplasm information.

- Reuse for other crops: Rice, ...

## Wheat Data Interoperability Guidelines

[Home](#) [Guidelines](#) [Ontologies & Vocabularies](#) [Use cases](#) [Getting involved](#) [About](#)

[Home](#) / [Getting involved](#)

### Getting involved

## See who endorses the guidelines

To stay relevant and useful for the wheat data community, it is important that the recommendations contained here are maintained. This will be especially true as new technologies are developed requiring standards to be agreed. The maintenance of the guidelines will depend on an ongoing process of monitoring practices across the wheat community, and maintaining communication with those who are producing and using wheat data. There are many ways you can help.

**Become an adopter:** Please let us know why and how these guidelines are helpful to you and your institution. See the [Current list of adopters](#)

**Give your feedback:** You can contact us either by email or by leaving a comment on a specific page. This is an easy way to propose improvements or corrections, update the state of the art and share best practices and useful tools.

#### Getting Involved



Whe

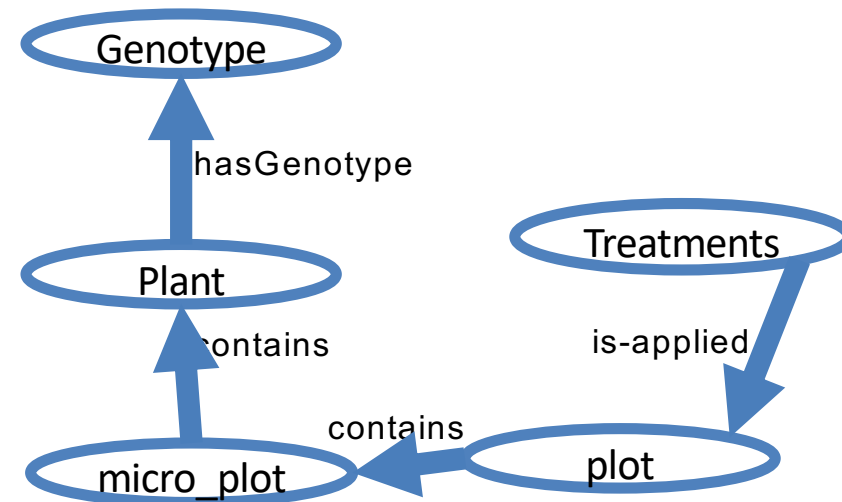
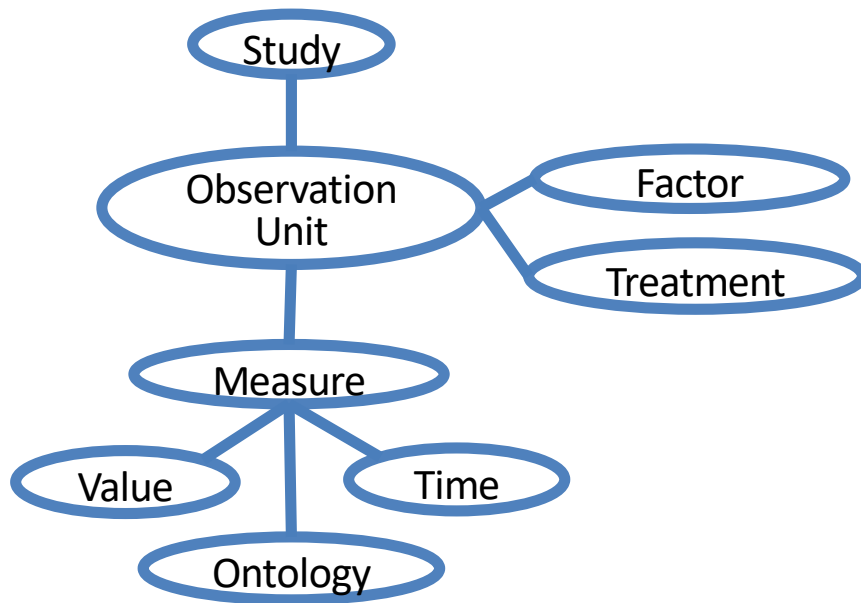
# INTEROPERABILITY: SEMANTIC



FAIR

# Semantic

- Define concepts: plant, micro\_plot, phenotype, experiment, event
- Define Relations: micro\_plot contains plant
- Common Vocabularies and ontologies
  - ◆ Agrovoc, Plant Ontology, Crop Ontology, Environment Ontology, ...



Elizabeth Arnaud et al.

## 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 or Environment**

Elizabeth Arnaud et al.

## Phenotype data in breeding

Annotation must explain:

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

2/ How is the trait observed ?

=

**METHOD**

With a measuring tape

Estimated visually

Calculated  
Panicle weight x panicle density

Elizabeth Arnaud et al.

## Phenotype data in breeding

Annotation must explain:

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

3/ How is the trait observation expressed?

=

**SCALE**

cm

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

1 = white  
2 = cream  
3 = yellow

g/m<sup>2</sup>



Elizabeth Arnaud et al.

## Phenotype data in breeding

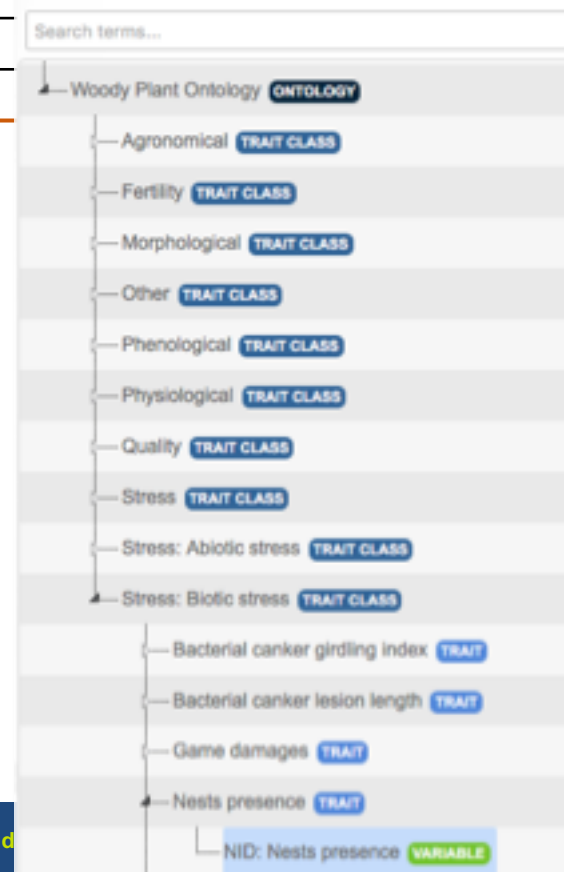
Germplasm ID	PH	PH2	GCOL	GY
24530	80	1	2	35
85432	120	3	3	48
78452	95	2	3	43
56093	100	2	1	50

**1 VARIABLE**  
=  
**1 TRAIT/ENV**  
**+ 1 METHOD**  
**+ 1 SCALE**

**Woody Plant Ontology** ONTOLOGY

Ontology name: Woody Plant Ontology  
 Authors: Célia Michotey  
 Version: v1  
 Licence: CC BY 4.0  
 Links: [CropOntology.TVD5 format](#)  
[Adonis format](#)

### Traits, methods and scales



### NID: Nests presence VARIABLE

Identifier	WOODY:0000067
Name	NID
Synonyms	Nests presence NID(Adonis)
Context of use	Trial evaluation
Status	Standard for INRA
Institution	INRA
Scientist	Célia Michotey
Date	13/03/2017
Crop	Woody Plant
<b>Nests presence TRAIT</b>	
Identifier	WOODY:1000056
Name	Nests presence
Description	Presence or absence of nests
Main abbreviation	NID
Status	Standard for INRA
Class	Stress: Biotic stress
<b>Visual scoring METHOD</b>	
Identifier	WOODY:2000003
Name	Visual scoring
Description	Visual assessment with a reference scoring scale
Class	Estimation
<b>Presence/ absence SCALE</b>	
Identifier	WOODY:3000003
Name	Presence/Absence
Data type	Nominal
Decimal places	0
Min	0



# INTEROPERABILITY: STANDARD



# Minimum Information About Plant Phenotyping Experiment

- Standard
  - ◆ Data exchange and traceability
  - ◆ Repositories
- Input and output for analysis pipelines developed for phenotyping and genetic
- Implementations
  - ◆ Repositories/Databases
  - ◆ Web Service 
  - ◆ RDF
    - ◆ <http://purl.org/pppeo>

## Measures for interoperability of phenotypic data: minimum information requirements and formatting

Hanna Ćwiek-Kupczyńska, Thomas Altmann, Daniel Arend, Elizabeth Arnaud, Dijun Chen, Guillaume Cornut, Fabio Fiorani, Wojciech Frohmberg, Astrid Junker, Christian Klukas, Matthias Lange, Cezary Mazurek, Anahita Nafissi, Pascal Neveu, Jan van Oeveren, Cyril Pommier, Hendrik Poorter, Philippe Rocca-Serra, Susanna-Assunta Sansone, Uwe Scholz, Marco van Schriek, Ümit Seren, Björn Usadel, Stephan Weise, Paul Kersey and Paweł Krajewski 

*Plant Methods* 2016 12:44 | DOI: 10.1186/s13007-016-0144-4 | © The Author(s) 2016

Received: 15 April 2016 | Accepted: 18 October 2016 | Published: 9 November 2016

## Towards recommendations for metadata and data handling in plant phenotyping

Paweł Krajewski<sup>1,\*</sup>, Dijun Chen<sup>2</sup>, Hanna Ćwiek<sup>1</sup>, Aalt D.J. van Dijk<sup>3</sup>, Fabio Fiorani<sup>4</sup>, Paul Kersey<sup>5</sup>, Christian Klukas<sup>2</sup>, Matthias Lange<sup>2</sup>, Augustyn Markiewicz<sup>6</sup>, Jan Peter Nap<sup>3</sup>, Jan van Oeveren<sup>7</sup>, Cyril Pommier<sup>8</sup>, Uwe Scholz<sup>2</sup>, Marco van Schriek<sup>7</sup>, Björn Usadel<sup>4,9</sup> and Stephan Weise<sup>2</sup>

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[Table of Contents](#)

### This Article

*J. Exp. Bot.* (2015) 66 (18): 5417-5427.  
doi: 10.1093/jxb/erv271  
First published online: June 4, 2015  
This article appears in: [Special](#)

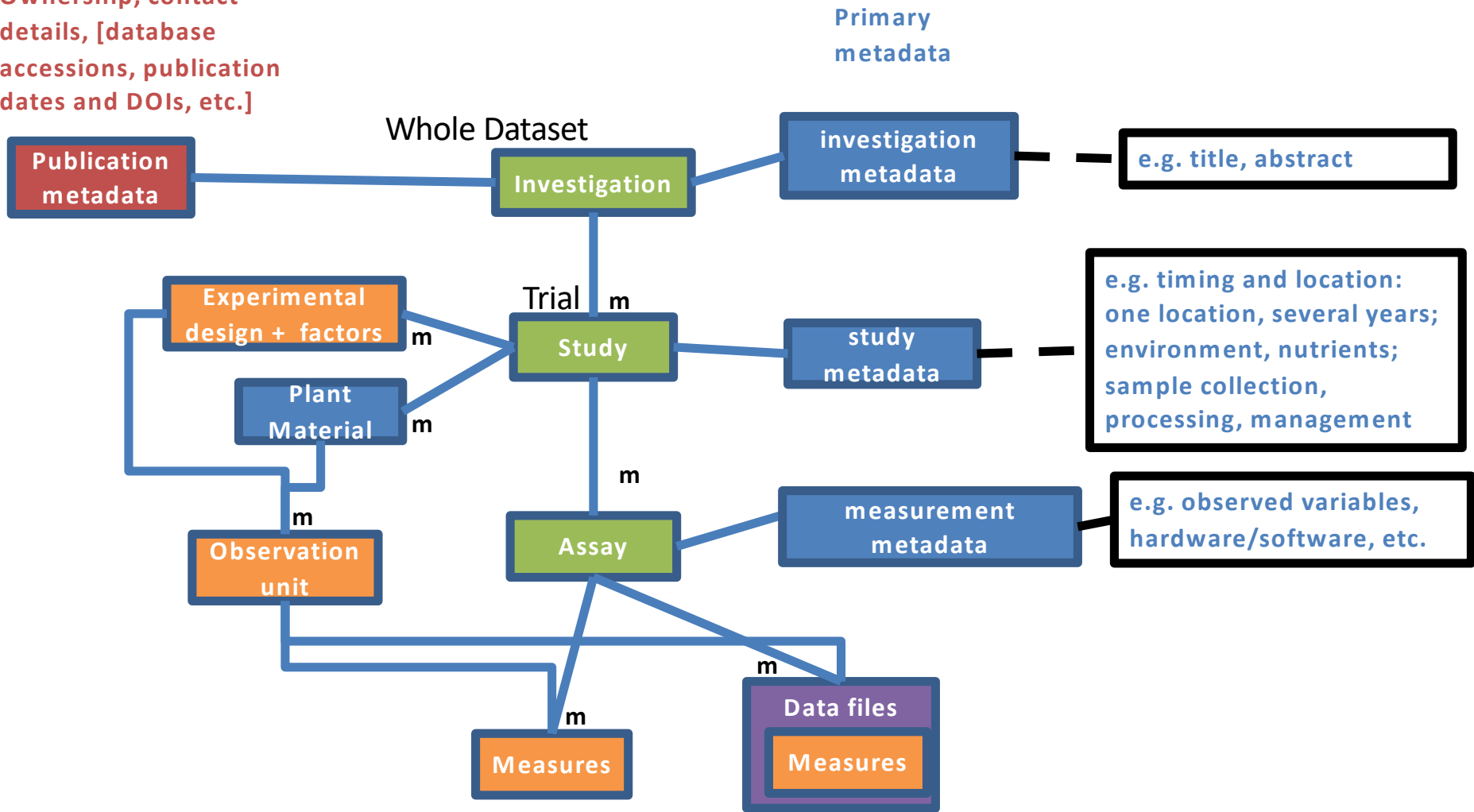
# MIAPPE Construction

- Contribution
  - ◆ European Infrastructures : Elixir (Bioinformatics), Emphasis/EPPN (Phenotyping)
  - ◆ National Institutes: France, Germany, Poland, UK, Portugal, Slovenia, Nederland, Belgium, Italy
- Steering committee
  - ◆ Elixir: European Bioinformatic infrastructure
  - ◆ Emphasis: European plant phenotyping infrastructure
  - ◆ Bioversity International - CGIAR
  - ◆ Elizabeth Arnaud, Paul Kersey, Pawel Krajewsky, Matthias Lange, Cyril Pommier, Bjorn Usadel
- Current Versions
  - ◆ Version 1 : Transplant + EPPN + Phenome
  - ◆ Version 1.1 : validation in progress
    - Documentation and model: Biologist friendly
    - Adaptations to new implementations



# MIAPPE v1.1 Overview

Ownership, contact details, [database accessions, publication dates and DOIs, etc.]



# MIAPPE v1.1 Overview

## Plant Material

- **Biosource : Plant Material identification**
- Multi Crop Passport Descriptor (MCPD) compliant
  - ◆ <https://www.biodiversityinternational.org/e-library/publications/detail/faobiodiversity-multi-crop-passport-descriptors-v21-mcpd-v21/>
  - ◆ FAO & Biodiversity International
  - ◆ Genebanks
- ID Fields are reused in MIAPPE
- Key : Identification
  - ◆ 0. Persistent unique identifier : PUID = URI/DOI
  - ◆ 1. Institute code
  - ◆ 2. Accession number
  - ◆ 5. Genus
  - ◆ 6. Species
  - ◆ 7. Subspecies : ‘subsp.’ (for subspecies); ‘convar.’ (for convariety); ‘var.’ (for variety); ‘f.’ (for form); ‘Group’ (for ‘cultivar group’)
  - ◆ 28. Remarks
- Suitable for non Genbank collections : breeder varietal list, laboratory collection, ...

# MIAPPE v1.1 Overview

## Variables

- Observation Variables
  - ◆ Phenotype & environment
  - ◆ Trait : What is measured
  - ◆ Method : How is it measured
  - ◆ Scale : How is it observed
  - ◆ Variable : trait + method + scale

**traits, methods and scales**

DOWNLOAD SHOW OBSOLETE TERMS English

- Wheat traits
  - Abiotic stress traits
  - Acid soil tolerance
  - AcidTol Estimation (method of)
  - Aluminum tolerance
  - Boron tolerance
  - Cold tolerance
  - Drought tolerance
  - Frost damage
  - Hail damage
  - Heat tolerance
  - Herbicide damage
  - Leaf rolling incidence

**TERM INFORMATION**

AcidTol Estimation

Identifier CO\_321:0000299

Method class Estimation

Method description Observe the growth of plants under low pH (acid) soil conditions

Method name AcidTol Estimation

Method reference Reynolds et al., 2011

**traits, methods and scales**

search terms...

Woody Plant Ontology ONTOLOGY

**Woody Plant Ontology ONTOLOGY**

Ontology name Woody Plant Ontology

Authors Célia Michotey

Version v1

Licence CC BY 4.0

Links [CropOntology\\_TYDS format](#)  
[Adonis format](#)

- Physiological TRAIT CLASS
- Quality TRAIT CLASS
- Stress TRAIT CLASS
  - Stress: Abiotic stress TRAIT CLASS
  - Stress: Biotic stress TRAIT CLASS
    - Bacterial canker girdling index TRAIT
    - Bacterial canker lesion length TRAIT

**NID: Nests presence VARIABLE**

Identifier	WOODY:0000067
Name	NID
Synonyms	Nests presence NID(Adonis)
Context of use	Trial evaluation
Status	Standard for INRA
Institution	INRA
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Date	13/03/2017
Crop	Woody Plant

**Nests presence TRAIT**

Identifier	WOODY:1000056
Name	Nests presence
Description	Presence or absence of nests
Main abbreviation	NID
Status	Standard for INRA
Class	Stress: Biotic stress

**Visual scoring METHOD**

Identifier	WOODY:2000003
Name	Visual scoring
Description	Visual assessment scoring scale
Class	Estimation

**Presence/ absence SCALE**

# MIAPPE v1.1 overview:

## Metabolomic

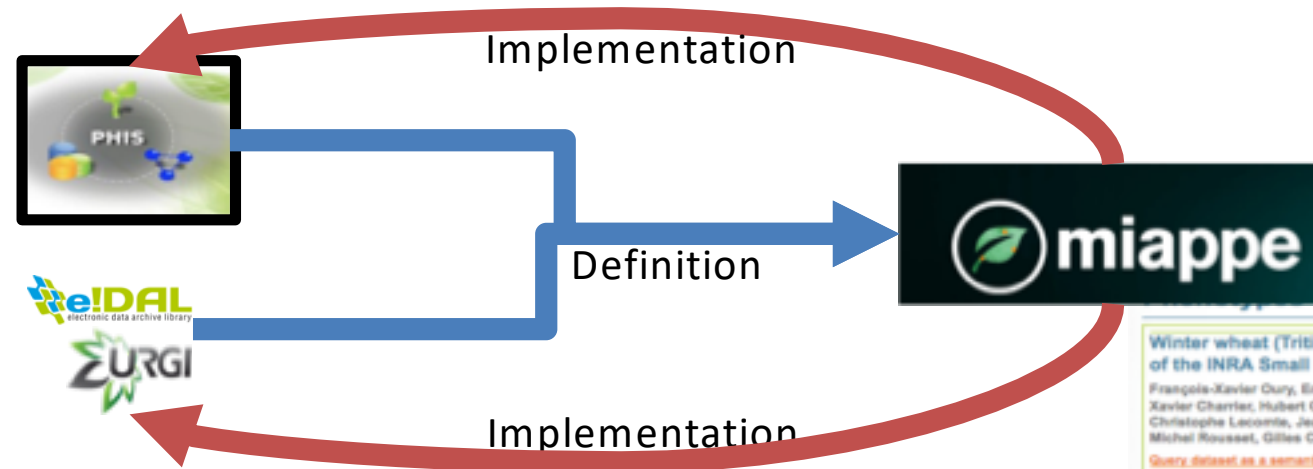
- Existing standards
  - ◆ Metabolights, Minimum information MSI
  - ◆ Full traceability
  - ◆ Sample treatment : temperature, tissue processing, molecule extraction protocol, measurement protocol....
- MIAPPE
  - ◆ Elaborated data
  - ◆ Elaborated, computed variables: Leaf Sugar content by microplot
  - ◆ Link to Metabo archive
    - Metabolight
    - Metabohub
    - ...

# MIAPPE DATA REPOSITORIES





# MIAPPE: Databases and Repositories



- Production databases
  - ◆ PHIS
- Cleaned data publication repositories
  - ◆ GnpIS
    - <http://dx.doi.org/10.15454/1.4489666216568333E12>
  - ◆ eDale
  - ◆ PlantPhenoDB
  - ◆ ...

Winter wheat (*Triticum aestivum* L.) phenotypic data from the multiannual, multilocal trial of the INRA Small Grain Cereals Network.

Frangola-Xavier Dury, Emmanuel Heumez, Bernard Rolland, Jérôme Auzanneau, Pierre Bérand, Maryse Brancourt, Xavier Charlier, Hubert Chiron, Camille Depatureaux, Laurent Falchetto, Olivier Gardet, Stéphane Gilles, Alex Girard, Christophe Lecomte, Jean-Yves Morlais, Pierre Pluchard, Didier Tropin, Maxime Trotlet, Patrice Walczak, Gérard Michel Rousselet, Gilles Charrel

Query dataset as a semantic graph.  
Or download the dataset as RDF archives.

Abstract  
Published 2015 by INRA

Back to Form

Search parameter(s):

Geolocation

DATA SETS: 4

Network Data Set :  
[INRA Wheat Network BPC accession \(A series\)](#)

Network Data Set :  
[INRA Small Grain Cereals Network](#)  
DOI: <http://dx.doi.org/10.15454/1.4489666216568333E12>

Network Data Set :  
[INRA Wheat Network not BPC accession \(B and C series\)](#)

Origin site Collecting site Evaluation site

Phenotyping campaign(s): 2000 x 2001 x 2002 x 2003 x 2004 x 2005 x 2006 x 2007 x 2009 x 2010 x 2011 x 2012 x 2013 x 2014 x 2015 x

remove all add all

Trial list Phenotypic data

Zurigo GnpIS B13 trials

Name	Campaign	Site	Geo 1 (lat)
B13: Champagne-côchelles_2004_Beta1	2004	Champagne-côchelles	
B13: Champagne-côchelles_2005_Beta1	2005	Champagne-côchelles	

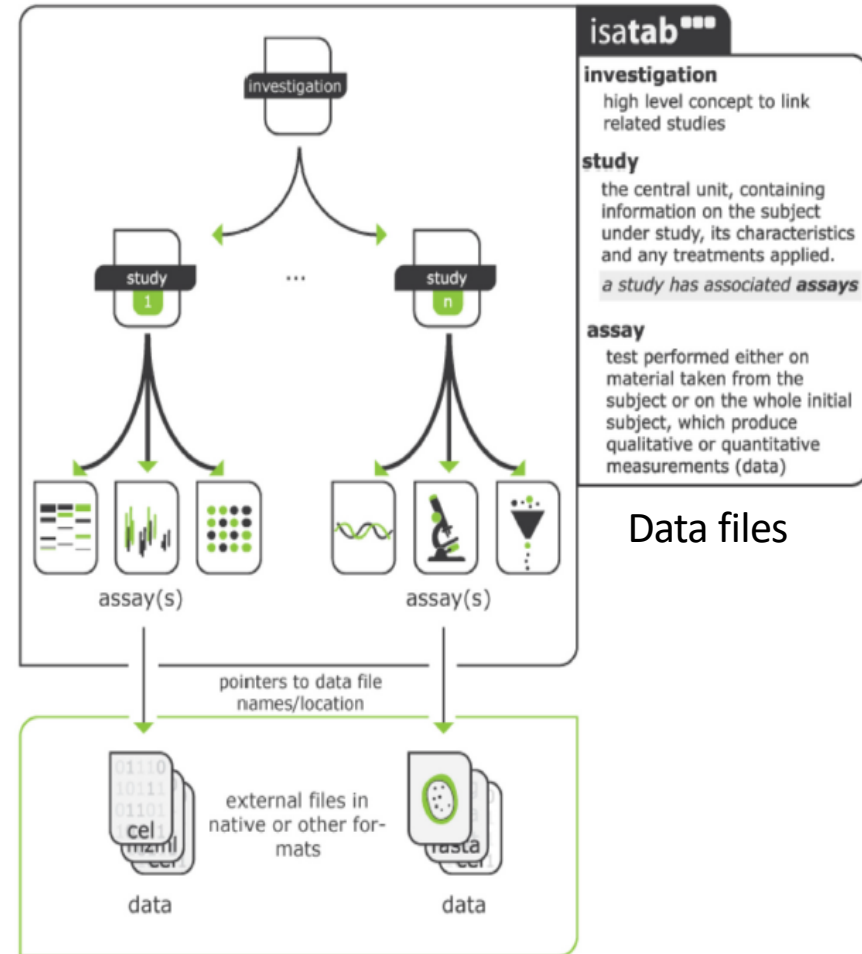
# MIAPPE FILE ARCHIVE



MIAPPE ISA Tab

# MIAPPE File Archive

- ISA Tab for Phenotyping
  - ◆ Investigation/Study/Assay
  - ◆ Zip Archive
    - MIAPPE Metadata
    - Raw data
      - CSV
      - Images or binary files
      - Reference to image archive (URI/URL)
    - Elaborated data
      - CSV
      - Provenance
- Training and improvements
  - ◆ File and metadata curation
  - ◆ BrAPI to IsaTab portable tool



## MIAPPE WEB SERVICES



- Breeding API
- International collaboration
  - ◆ Excellence in Breeding platform (CGIAR)
  - ◆ Coordinator : Peter Selby
  - ◆ Lead: Lukas Mueller, Jan Erik Backlund, Kelly Robbins
- Vision :
  - ◆ Standard Open API
  - ◆ Easy, secure, and efficient
  - ◆ Information Exchange
  - ◆ Between systems and applications
  - ◆ Breeding is the main target

Bill & Melinda Gates Foundation

CassavaBase

T3

IBP

JHI

Bioversity

CIRAD

INRA

IRRI

GOBII

Wageningen

CIP

DaRT

Cornell

iPlant



# MIAPPE STATUS AND PERSPECTIVES



# Adoption

- Plant community involved
  - ◆ Elixir (European bioinformatic infrastructure)
  - ◆ Emphasis (European Phenotyping infrastructure)
  - ◆ Bioversity international CGIAR
- Breeding API is Elixir official Phenotyping standard web service
- MIAPPE and BrAPI high collaboration
  - ◆ adoption and compliance
- Data repositories and management tools



- ◆ GnpIS <https://urgi.versailles.inra.fr/gnpis/>

- ◆ eDale <https://edal.iok-gatersleben.de/>

- ◆ PlantPhenoDB at IPGPAS <http://cropnet.pl/plantphenodb/>

- ◆ In progress: COPO, Elixir plant databases (iBet, WUR, VIB, ...), Brassica Information Portal, ...



# Perspectives

- Version 2 : Emphasis, Elixir, ...
  - ◆ Environment
  - ◆ Sensor traceability
  - ◆ Phenoharmonis Workshop Montpellier may 2018
- Elixir data lookup service, MIAPPE enabled.
  - ◆ Data discovery
  - ◆ Elixir
  - ◆ WheatIS & Emphasis ?
  - ◆ Open source software
- Dataset Validation
  - ◆ Elixir
  - ◆ File archive (ISA Tab) and BrAPI based





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