

➤ Plant phenotyping data management

Focus on advantages as well as pragmatic and effective solutions



www.inrae.fr



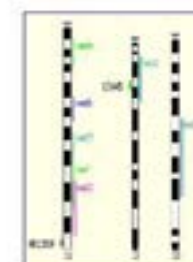
www.elixir-europe.org



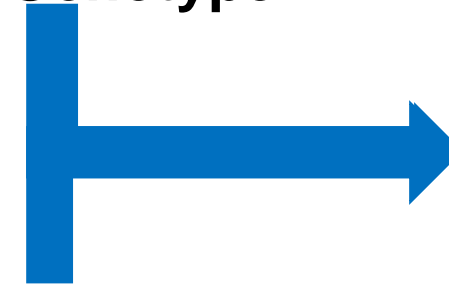
emphasis.plant-phenotyping.eu

Plant Phenotyping scope

- **Trait/Variable :**
 - definition of an observable characteristic
 - Yield
- **Phenotype : A trait/Variable with a value**
 - Yield = 6T by hect
- **Properties**
 - Morphological, physiological, biochemical or agronomic
- **Quantitative or qualitative**
- **Highly heterogeneous**
- **Environment**
 - Except primary phenotypes
- **$P = G \times E \times C$**
- **Polysemic**
 - Measure in a Phenotyping experiment
 - Characterisation of a Plant Genetic resource
 - Association with genetics (QTL, GWAS)
 - Association with a gene function



Plant Genotype



Phenotype



Environment



Climate



Cultural Practice



Soil



Pathogenes pressure

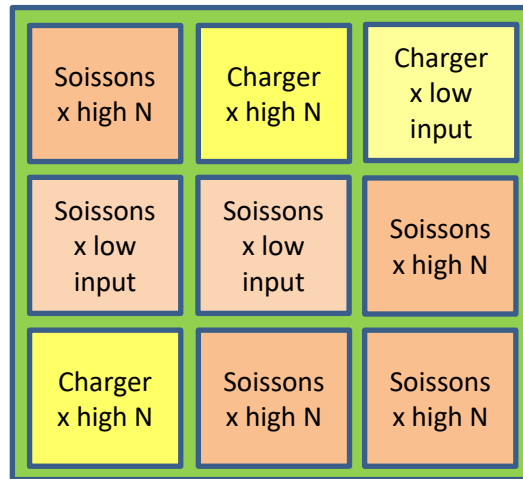
Phenotype data lifecycle

Data Acquisition

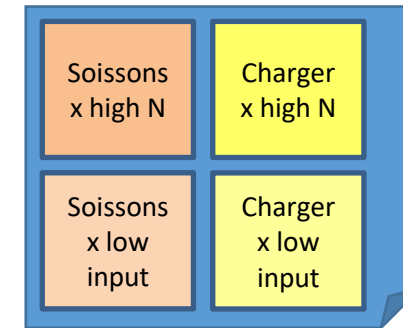
Data computation

« Raw » data, pheno/env measurement, variables

« Derived » data,
computed, reduced, indicators

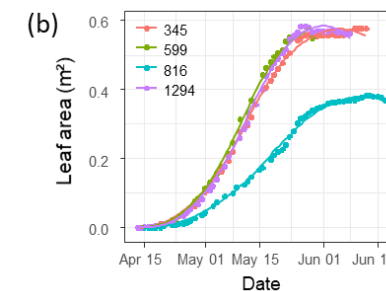


Derivation, Reduction



Genotype	Treatment	N input	Date	Rep	Fusariose
Soissons	low input	15,3225129	15/11/2011	1	5
Soissons	low input	15,3430556	16/11/2011	2	7

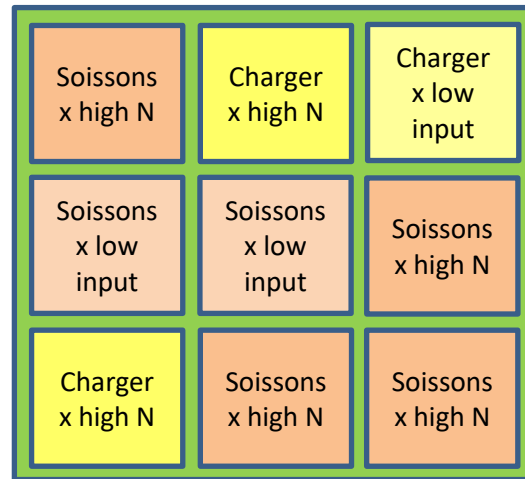
Genotype	Treatment	Fusariose
Soissons	low input	6



Phenotype data lifecycle

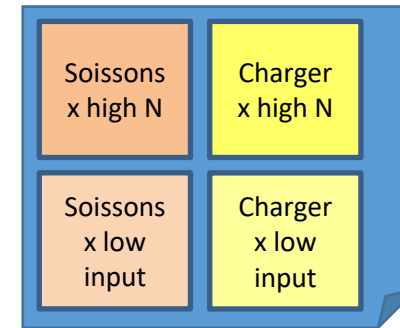


« Raw » data, pheno/env measurement, variables



Derivation, Reduction

« Derived » data,
computed, reduced, indicators

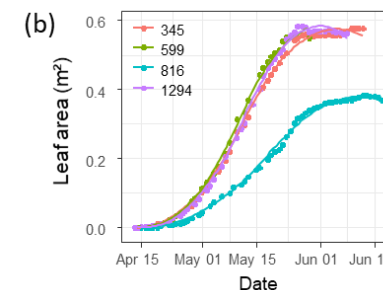


Publication



Genotype	Treatment	N input	Date	Rep	Fusariose
Soissons	low input	15,3225129	15/11/2011	1	5
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Genotype	Treatment	Fusariose
Soissons	low input	6

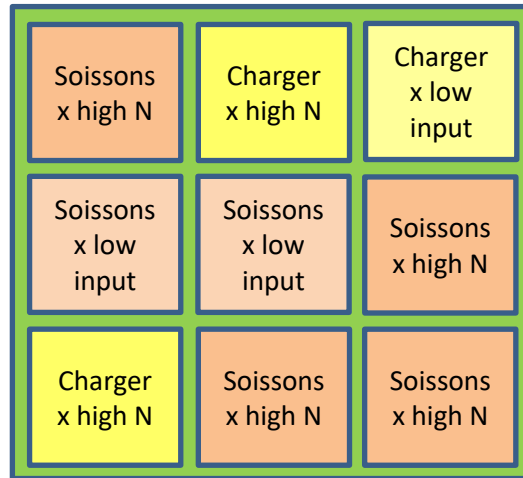


Wilkinson et al.
The FAIR Guiding Principles for scientific data management and stewardship.
Scientific Data 3 (2016)

Phenotype data lifecycle

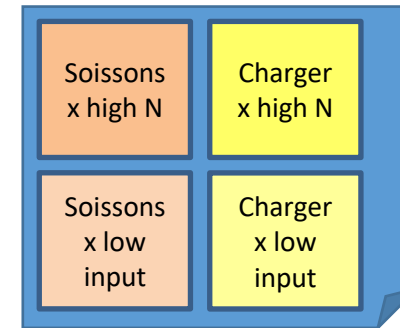


« Raw » data, pheno/env measurement, variables



Derivation, Reduction

« Derived » data,
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Publication



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Genotype	Treatment	Fusariose
Soissons	low input	6

VARIABLES

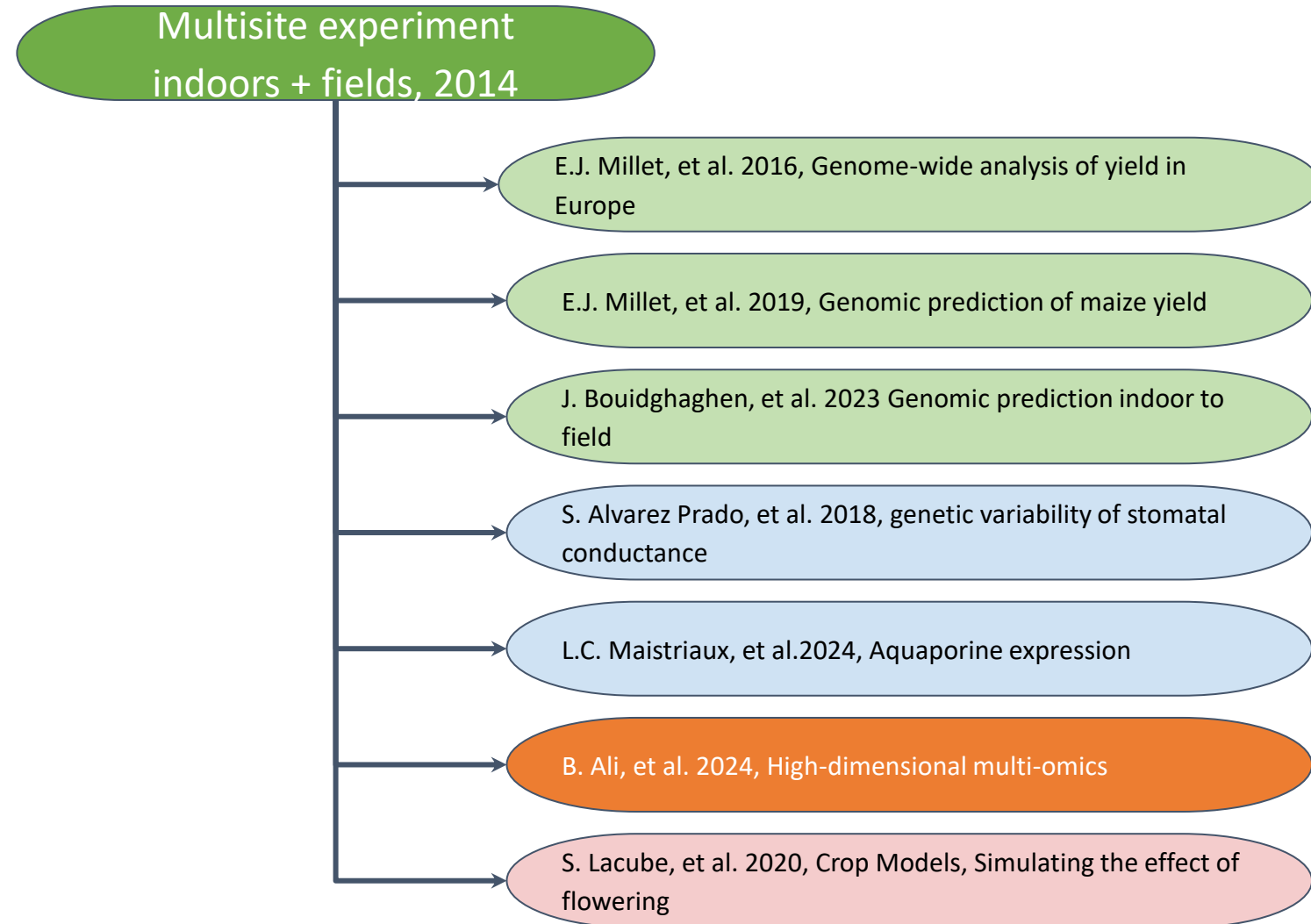
- Raw Measures Pheno & Env
- Data cleaning
- Traceability, Reproducibility & Provenance

INDICATORS

- New computation for each scientific question

➤ Plant Phenotyping data reuse, WHY ?

- One experimental dataset ➔ many papers/reuse
 - <https://doi.org/10.1016/j.tplants.2025.09.001>



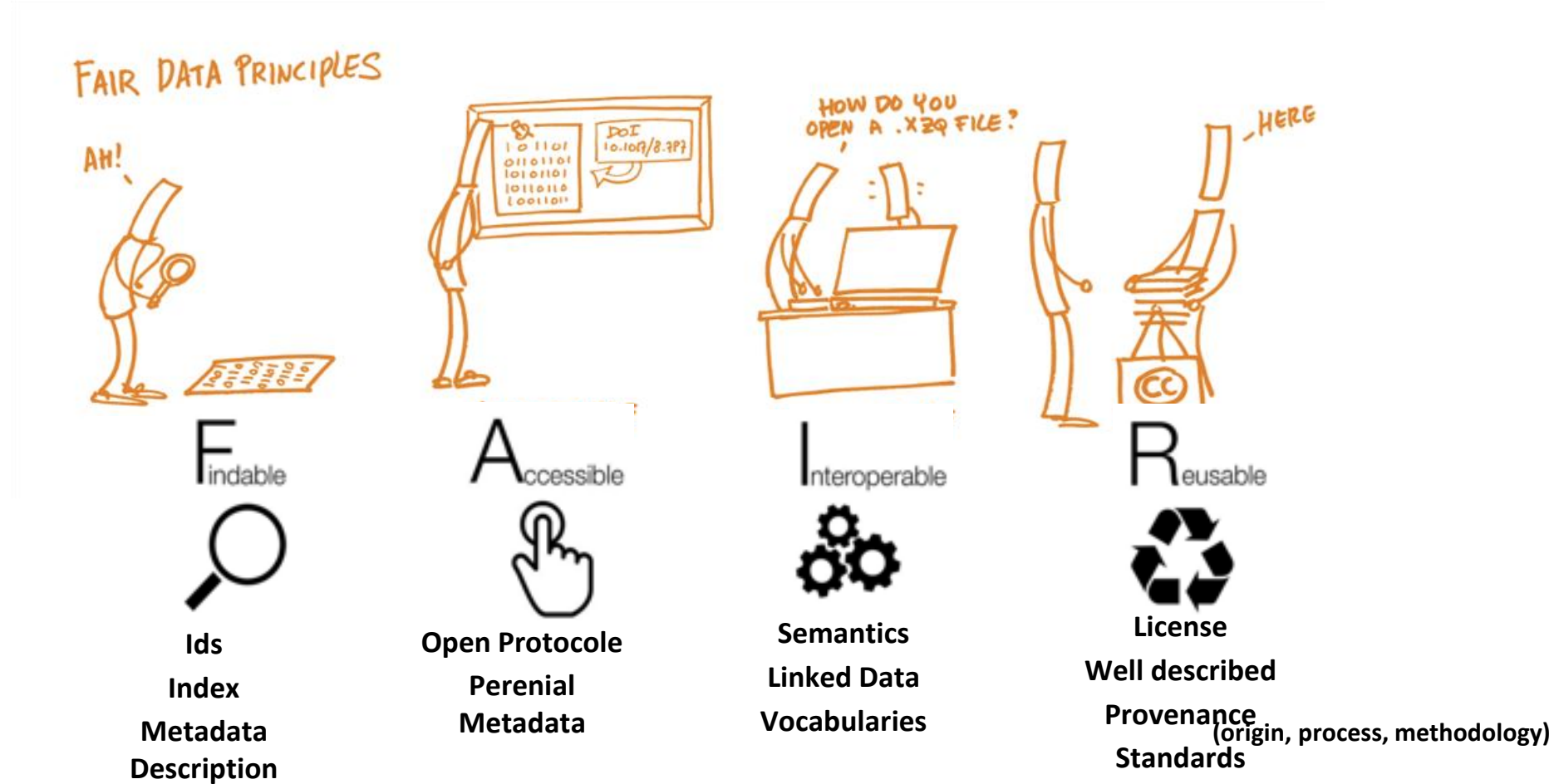
➤ Plant Phenotyping data reuse, HOW ?

- Document and trace Trait methods and protocols
- Agree on variable/trait methods and units
 - Final project meeting ➔ Oups, data cannot be compared among partners
- List and identify plant material
- Localise experiments
- Organise raw and derived data
- Document all data matrice columns
 - No PH_John1 and TGW_Jane2 columns
 - Anybody should understand your dataset without calling you

➤ Plant Phenotyping data reuse, in practice

- Open science based on FAIR Data principles

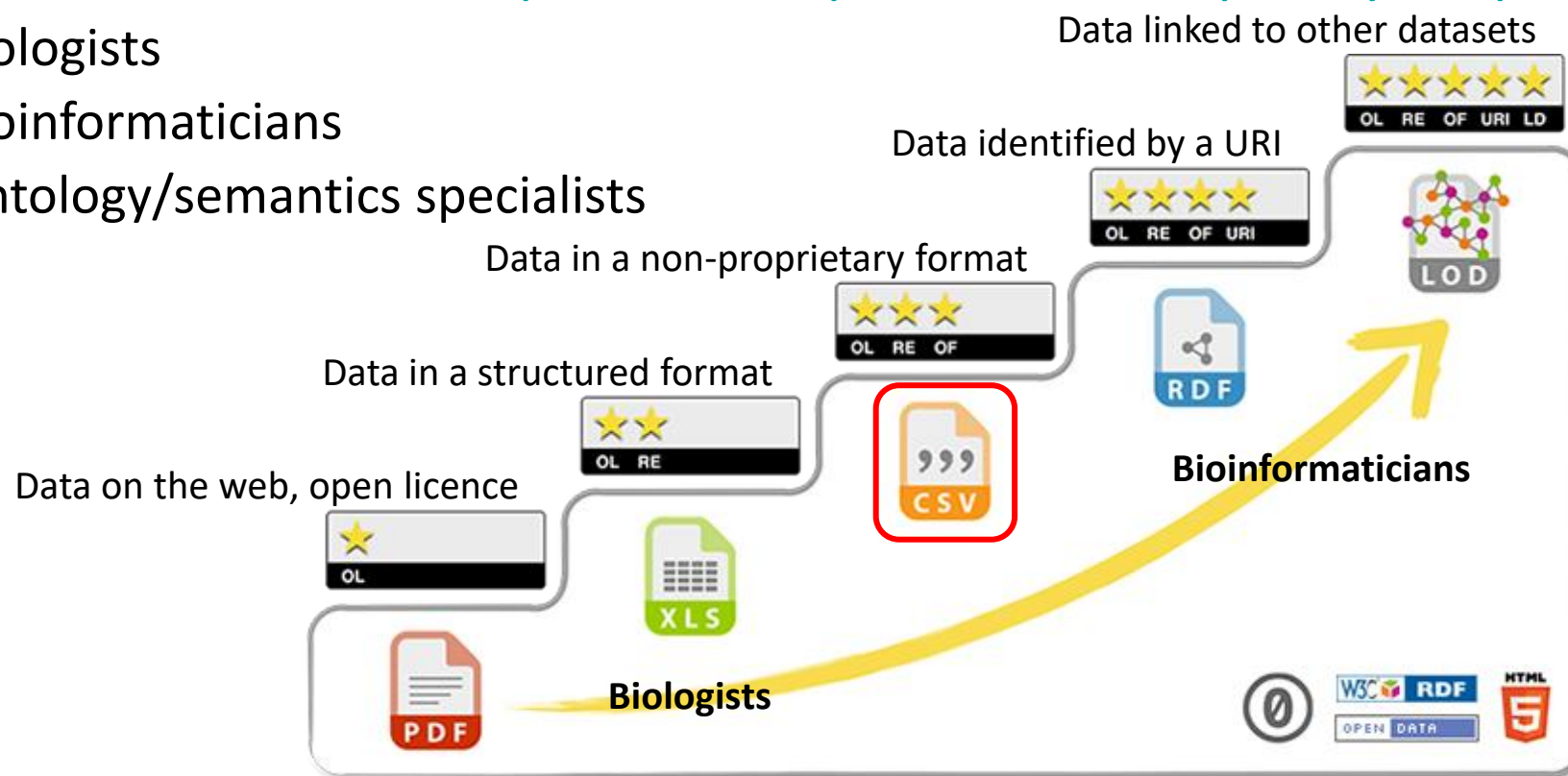
Wilkinson et al., *The FAIR Guiding Principles for scientific data management and stewardship*.
Scientific Data 3 (2016)



FAIR 5 * Open Data → be pragmatic

Progress towards FAIR and Open Data requires multidisciplinary cooperation

- Biologists
- Bioinformaticians
- Ontology/semantics specialists

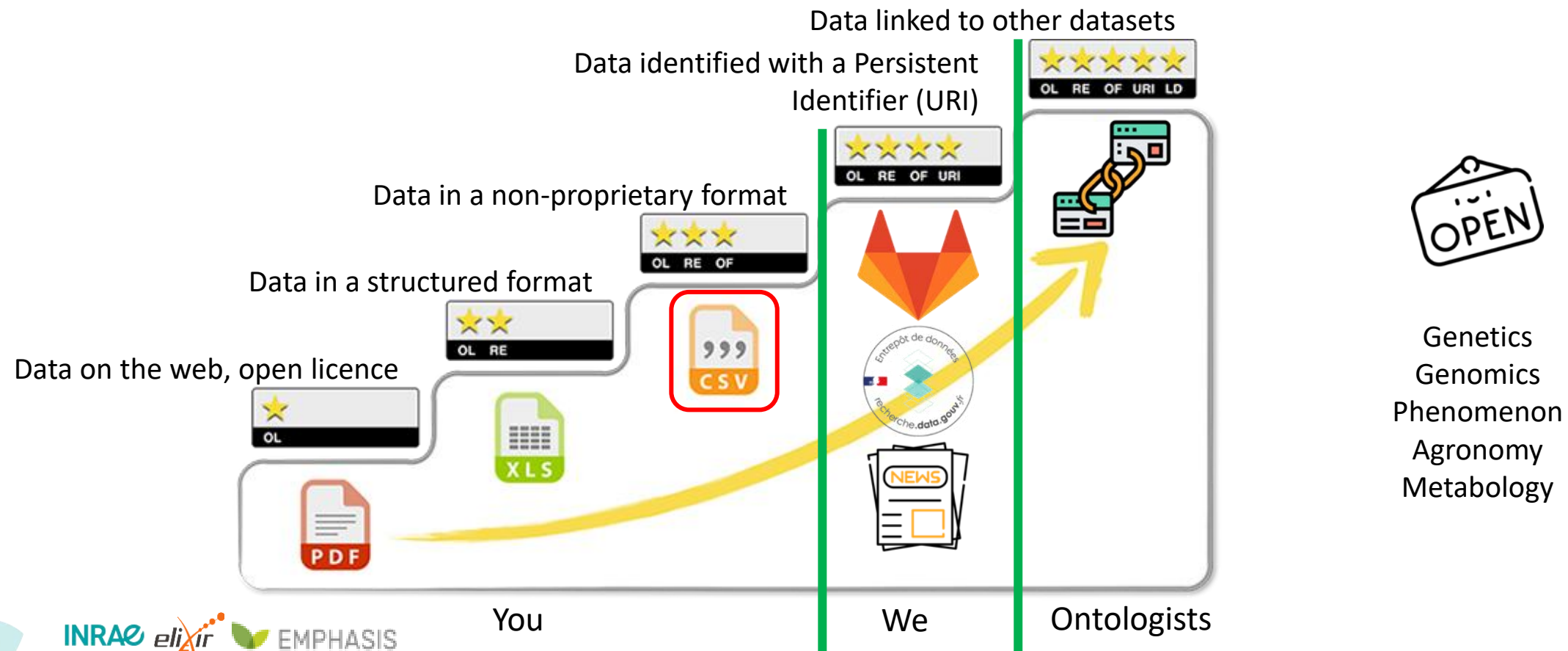


Progressing towards FAIR and Open Data requires a multidisciplinary cooperation :

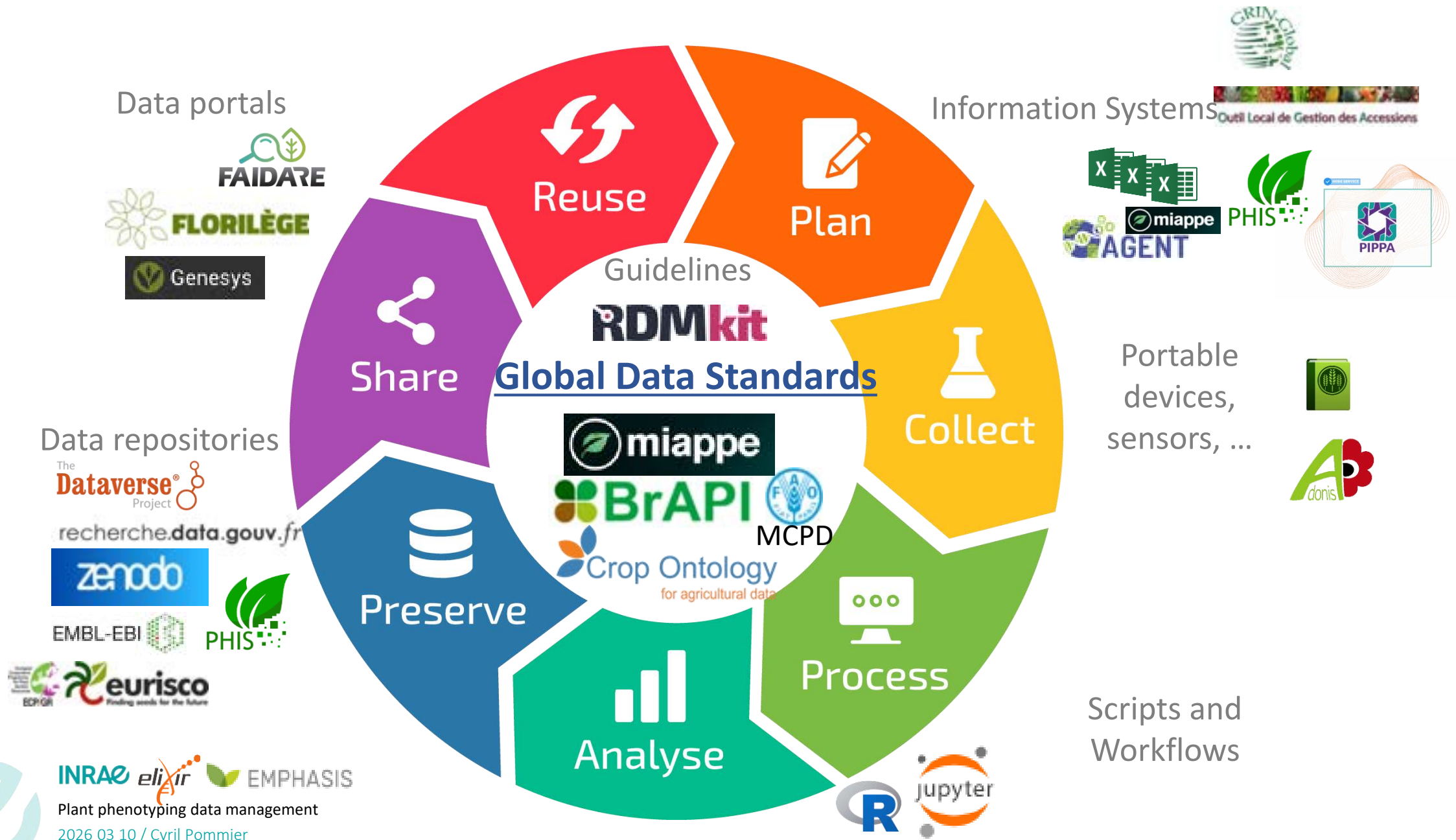
- Biologists
- Bioinformaticians
- Specialists of ontologies/semantics

FAIR 5 * Open Data

Progress towards FAIR and Open Data requires multidisciplinary cooperation



Plant Phenotyping data reuse, (really) in practice



Structure

- Formatting and Organizing
 - Data
 - Dataset description & Metadata
 - Data Models, templates
 - Phenotyping Variable, Biological Material
- Standards : VCF, GFF, MIAPPE, etc...
- Biologist & Computer scientist driven*



Technical

- Data integration and sharing
- Interoperability : tools and systems
 - GA4GH
 - Breeding API www.brapi.org
 - *Computer scientist driven*



Persistent Unique
Identifiers

Cultivars,
Accessions, MCPD

...



Semantic

- Description of the data
- Controlled vocabularies: term name and definitions
- Phenotyping Variables (trait+method+scale)
- Ontologies: semantic links between terms
- *Biologist driven*



- INRAE *elixir* EMPHASIS
Plant phenotyping data management
2026 03 10 / Cyril Pommier

O. 13

MIAPPE Implementations & Technical Standards

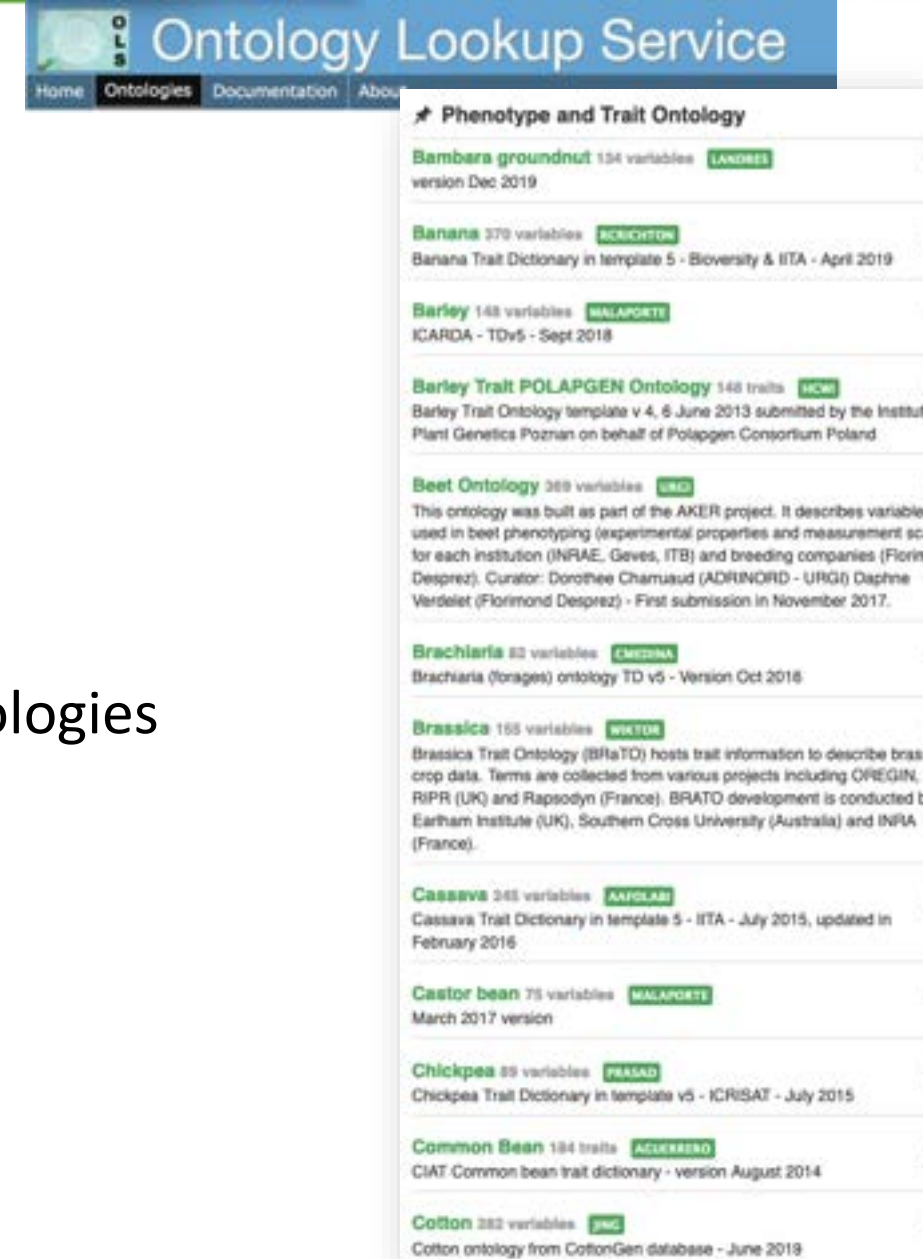
- **Databases and data repositories**
 - Any Breeding API (BrAPI) compliant DB (GnpIS, PHIS, PIPPA, ...)
 - Generic data repositories (Dataverse, Zenodo, e!Dale, ...)
- **Web Services**
 - Breeding API www.brapi.org
 - International collaboration
 - Standard Open Web Service API
 - Information Exchange, Main target: Breeding
 - ELIXIR, EMPHASIS, Excellence in Breeding platform (CGIAR, Cornell Peter Selby)
- **File Exchange**
 - MIAPPE XLSX Templates <https://github.com/MIAPPE/MIAPPE/Templates>
 - Project workflows
 - ISA Tab: data + metadata
 - RO Crate
- **Ontology, OWL Implementation**
 - <https://github.com/MIAPPE/MIAPPE-ontology>
 - <http://agroportal.lirmm.fr/ontologies/PPEO>
 - Data model representation, Formal concepts and constraints



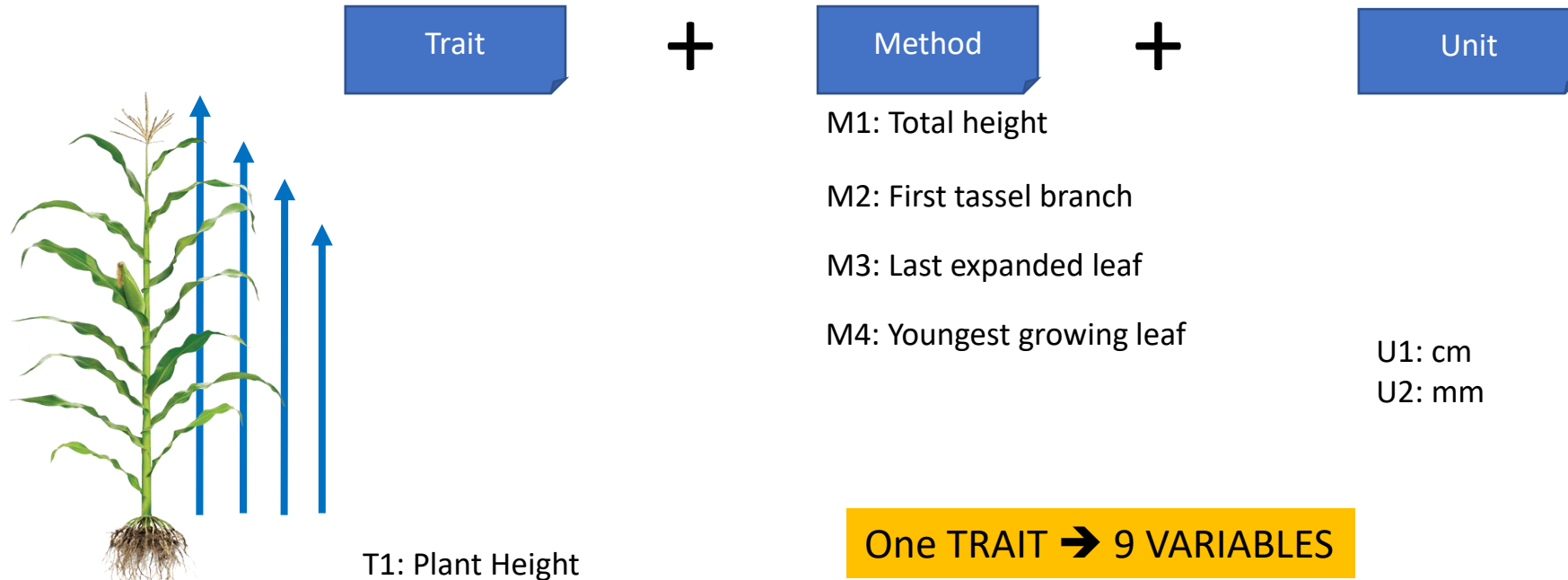
Phenotype Semantic Standard: Ontologies



- Description of plant traits and characteristics
- www.croponontology.org
 - Representation model, ie Framework
 - Trait + Method + Scale
 - Scale: unit, rating scale
 - Trait: Entity (e.g. leaf) + Characteristic (surface)
 - Collection of ontologies by species
- Ontology creation by Community/Project possible
 - Recommended in certain cases
 - Solves : Potentially time-consuming contribution to ontologies
 - Publication
 - Agroportal
 - <https://entrepot.recherche.data.gouv.fr/dataverse/vo-inrae>
 - [Vitis Organ ontology](#)
 - [Wheat Crop Ontology](#)
 - [Walnut Trait Ontology](#)
 - [Woody Plant Ontology](#)



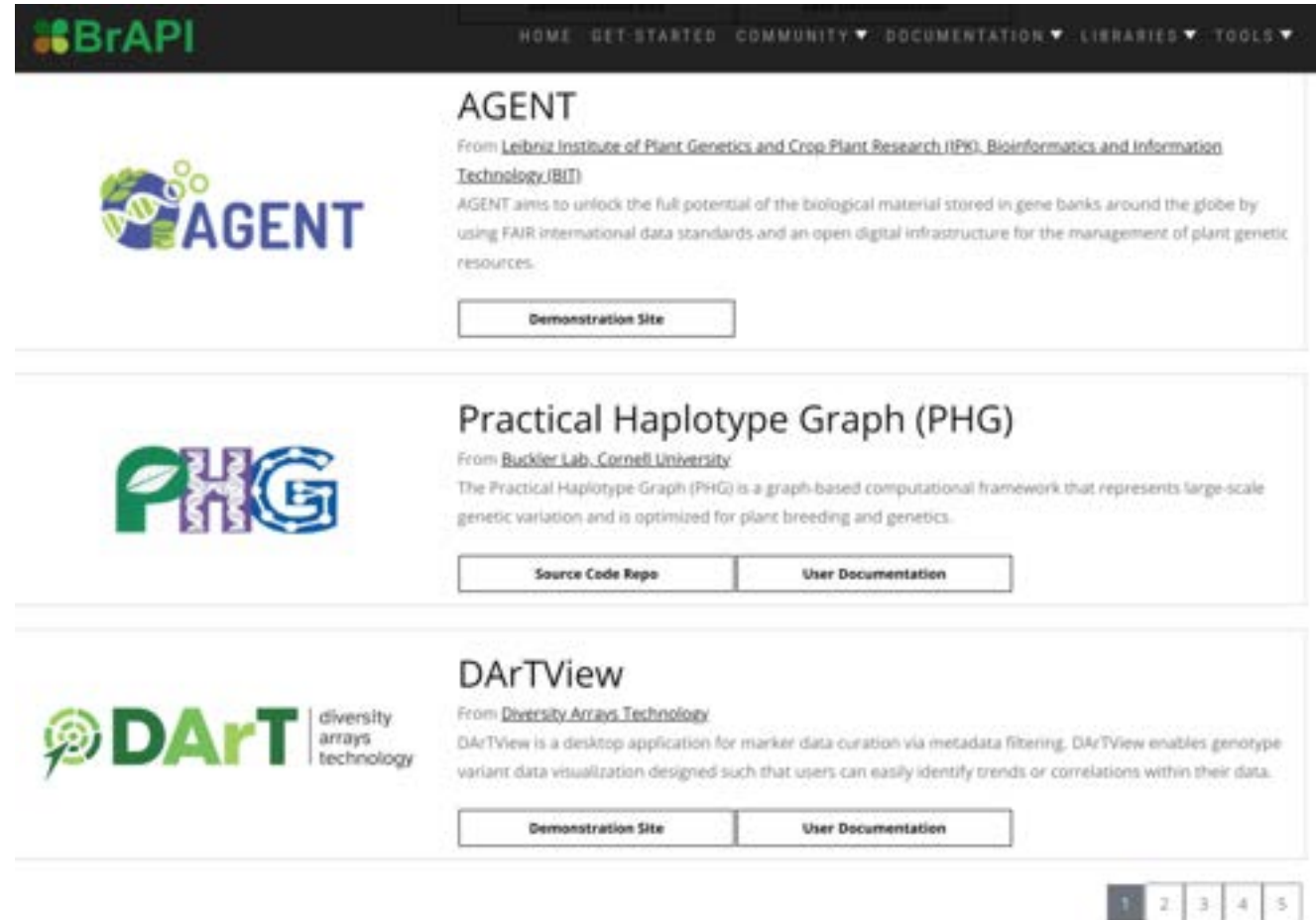
Phenotyping/environment variable = *Trait + Method + Unit/Scale*



M5: Highest pixel
corresponding to plant

U3: pixel

- Transparent for users
 - Using data standards without noticing it
- BrAPI Implementation = MIAPPE Compliant
- Databases
 - FAIDARE (incl GnpIS)
 - PHIS/Sixtine
 - European SI ELIXIR and EMPHASIS
 - VIB, NIB, ITQB, WUR, ...
 - CGIAR
 - Breedbase
 - Solegenomics
 - ...
 - FAIRDOM-Seek
 - Generic data repositories (Dataverse, Zenodo)
- BrAPi tools
 - <https://brapi.org/compatibleSoftware>



The screenshot shows the BrAPI website with a dark header containing the BrAPI logo and navigation links: HOME, GET STARTED, COMMUNITY, DOCUMENTATION, LIBRARIES, and TOOLS. The main content area features three tool cards:

- AGENT**: From [Leibniz Institute of Plant Genetics and Crop Plant Research \(IPK\), Bioinformatics and Information Technology \(BIT\)](#). AGENT aims to unlock the full potential of the biological material stored in gene banks around the globe by using FAIR international data standards and an open digital infrastructure for the management of plant genetic resources. A button for [Demonstration Site](#) is present.
- Practical Haplotype Graph (PHG)**: From [Buckler Lab, Cornell University](#). The Practical Haplotype Graph (PHG) is a graph-based computational framework that represents large-scale genetic variation and is optimized for plant breeding and genetics. Buttons for [Source Code Repo](#) and [User Documentation](#) are present.
- DArTView**: From [Diversity Arrays Technology](#). DArTView is a desktop application for marker data curation via metadata filtering. DArTView enables genotype variant data visualization designed such that users can easily identify trends or correlations within their data. Buttons for [Demonstration Site](#) and [User Documentation](#) are present.

A pagination bar at the bottom right shows numbers 1, 2, 3, 4, and 5, with '1' being the active page.

➤ MIAPPE SPECIFICATIONS

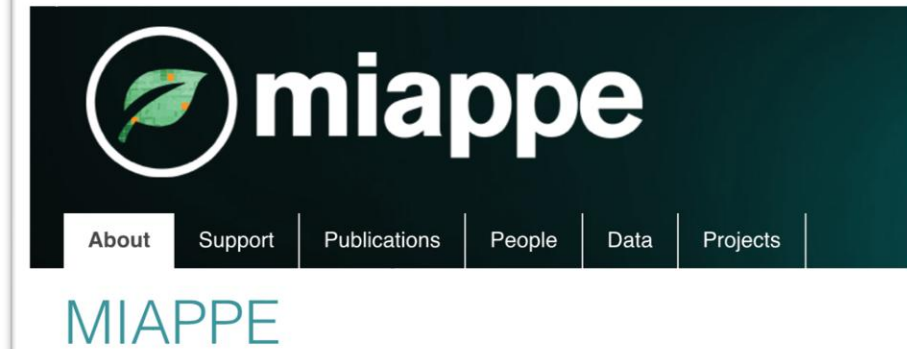


MIAPPE Specifications

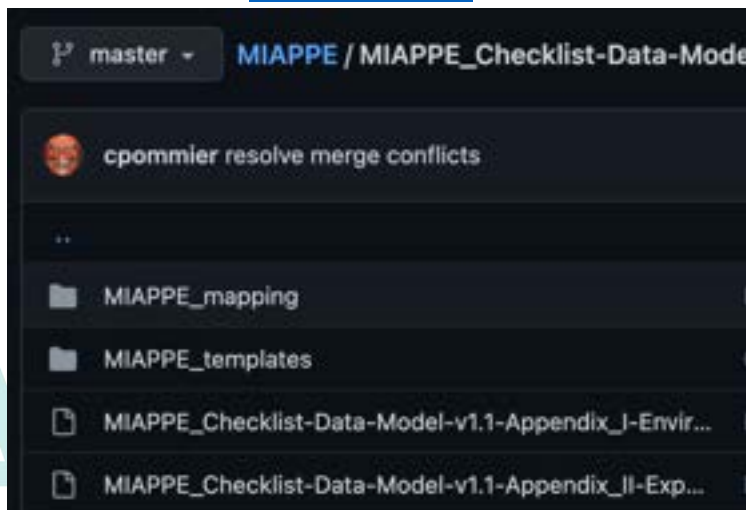
MIAPPE primers

See the [support page](#) for full informations

- The latest specifications, [data model overview](#)
- The latest specifications [field list with descriptor](#)



- www.miappe.org



New Phytologist

Methods | [Open Access](#) | [CC](#) | [i](#)

Enabling reusability of plant phenomic datasets with MIAPPE 1.1

Evangelia A. Papoutsoglou✉, Daniel Faria, Daniel Arend, Elizabeth Arnaud, Ioannis N. Athanasiadis, Inês Chaves, Frederik Coppens, Guillaume Cornut, Bruno V. Costa, Hanna Ćwiek-Kupczyńska, Bert Driesbeke, Richard Finkers, Kristina Gruden, Astrid Junker, Graham J. King, Paweł Krajewski, Matthias Lange, Marie-Angélique Laporte, Célia Michotey, Markus Oppermann, Richard Ostler, Hendrik Poorter, Ricardo Ramírez-Gonzalez, Živa Ramšak, Jochen C. Reif, Philippe Rocca-Serra, Susanna-Assunta Sansone, Uwe Scholz, François Tardieu, Cristobal Uauy, Björn Usadel, Richard G. F. Visser, Stephan Weise, Paul J. Kersey, Célia M. Miguel, Anne-Françoise Adam-Blondon, Cyril Pommier✉ ... [See fewer authors](#) ^

First published: 14 March 2020 | <https://doi.org/10.1111/nph.16544> | Citations: 10

MIAPPE Specifications



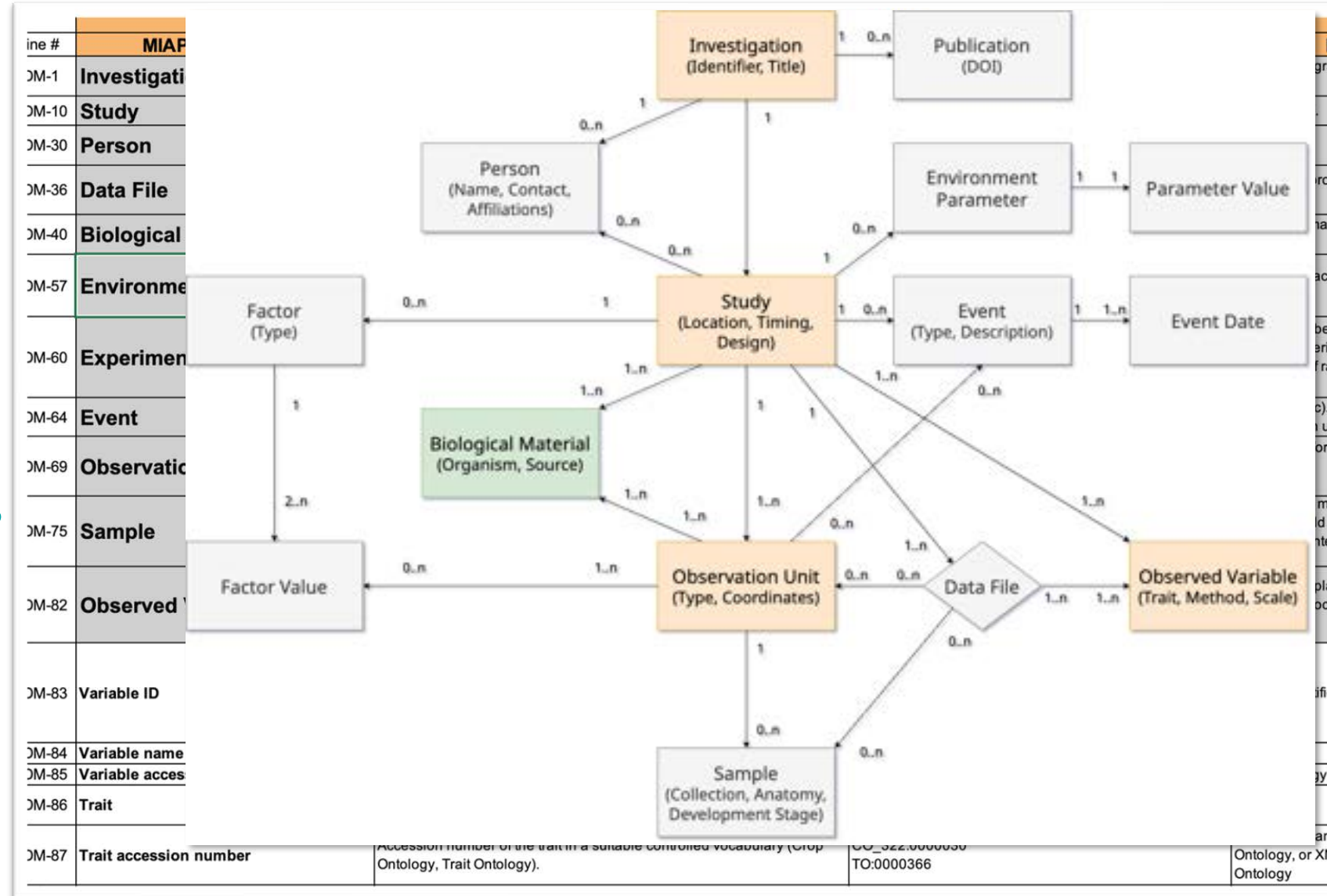
- Specifications table
- 11 Sections
- Metadata Fields
- Definitions
- Examples
- Cardinalities

line #	MIAPPE			
	MIAPPE Check list	Definition	Example	Format
DM-1	Investigation	Investigations are research programmes with defined aims. They can exist at various scales (for example, they could encompass a grant-funded programme of various components comprising a peer-reviewed publication, or a single experiment).		
DM-10	Study	A study (or experiment) comprises a series of assays (or measurements) of one or more types, undertaken to answer a particular biological question.		
DM-30	Person	A human involved in the investigation or specifically any of its studies.		
DM-36	Data File	A file or digital object holding observation data recorded during one or more assays of the study, typically in tabular form. Multiple data files may be provided per observation unit; each file can include observations for several observation units and several observed variables.		
DM-40	Biological Material	The biological material being studied (e.g. plants grown from a certain bag or seed, or plants grown in a particular field). The original source of that material (e.g. the original plant cloned) is called the material source, which, when held by a material repository, should have its stock identified.		
DM-57	Environment	Environmental parameters that were kept constant throughout the study and did not change between observation units or assays. Environment characteristics throughout the study, i.e. environmental variables, should be recorded as Observed Variables (see below).		
DM-60	Experimental Factor	The object of a study is to ascertain the impact of one or more factors on the biological material. Thus, a factor is, by definition a condition that varies between observation units, which may be biotic (pest, disease interaction) or abiotic (treatment and cultural practice) in nature. Depending on the level of the data, an experimental factor can be either "what is the factor applied to the plant" (i.e. Unwatered), or the "environmental characterisation" (i.e. if no rain on unwatered plant : Drought ; if rain on unwatered plant : Irrigated)		
DM-64	Event	An event is discrete occurrence at a particular time in the experiment (which can be natural, such as rain, or unnatural, such as planting, watering, etc). Events are the realization of Factors or parts of Factors, or may be confounding to Factors. Can be applied at the whole study level or to only a subset of observation units.		
DM-69	Observation Unit	Observation units are objects that are subject to instances of observation and measurement. An observation unit comprises one or more plants, and/or their environment. There can be pure environment observation units with no plants. Synonym: Experimental unit.		
DM-75	Sample	A sample is a portion of plant tissue harvested, non-harvested or extracted from an observation unit for the purpose of sub-plant observations and/or molecular analysis. A sample must be used when there is a physical sample that needs to be stored and traced. Otherwise, observations made at the sub-plant level should be recorded at the observation unit level observations using the observed variables to characterize the object of the observation (e.g. Berry sugar content, Fruit weight, Grain Protein content, Leaf area, Leaf width, Leaf 2 length).		
DM-82	Observed Variable	An observed variable describes how a measurement has been made. It typically takes the form of a measured characteristic of the observation unit (plant or environment), associated to the method and unit of measurement. Multiple variables with the same combination of trait, method and scale can be used in association with an observation unit (plant parts (leaf 1, leaf 2), when this distinction is necessary for observations referring to different parts of the same observation unit).		
DM-83	Variable ID	Code used to identify the variable in the data file. We recommend using a variable definition from the Crop Ontology where possible. Otherwise, the Crop Ontology naming convention is recommended: <trait abbreviation>_<method abbreviation>_<scale abbreviation>. A variable ID must be unique within a given investigation.	Ant_Cmp_Cday	Unique identifier
DM-84	Variable name	Name of the variable.	Anthesis computed in growing degree days	Free text
DM-85	Variable accession number	Accession number of the variable in the Crop Ontology	CO_322:0000794	Crop Ontology term
DM-86	Trait	Name of the (plant or environmental) trait under observation	Anthesis time Reproductive growth time	Free text
DM-87	Trait accession number	Accession number of the trait in a suitable controlled vocabulary (Crop Ontology, Trait Ontology).	CO_322:0000030 TO:0000366	Term from Plant Trait Ontology, or XML Environment Ontology

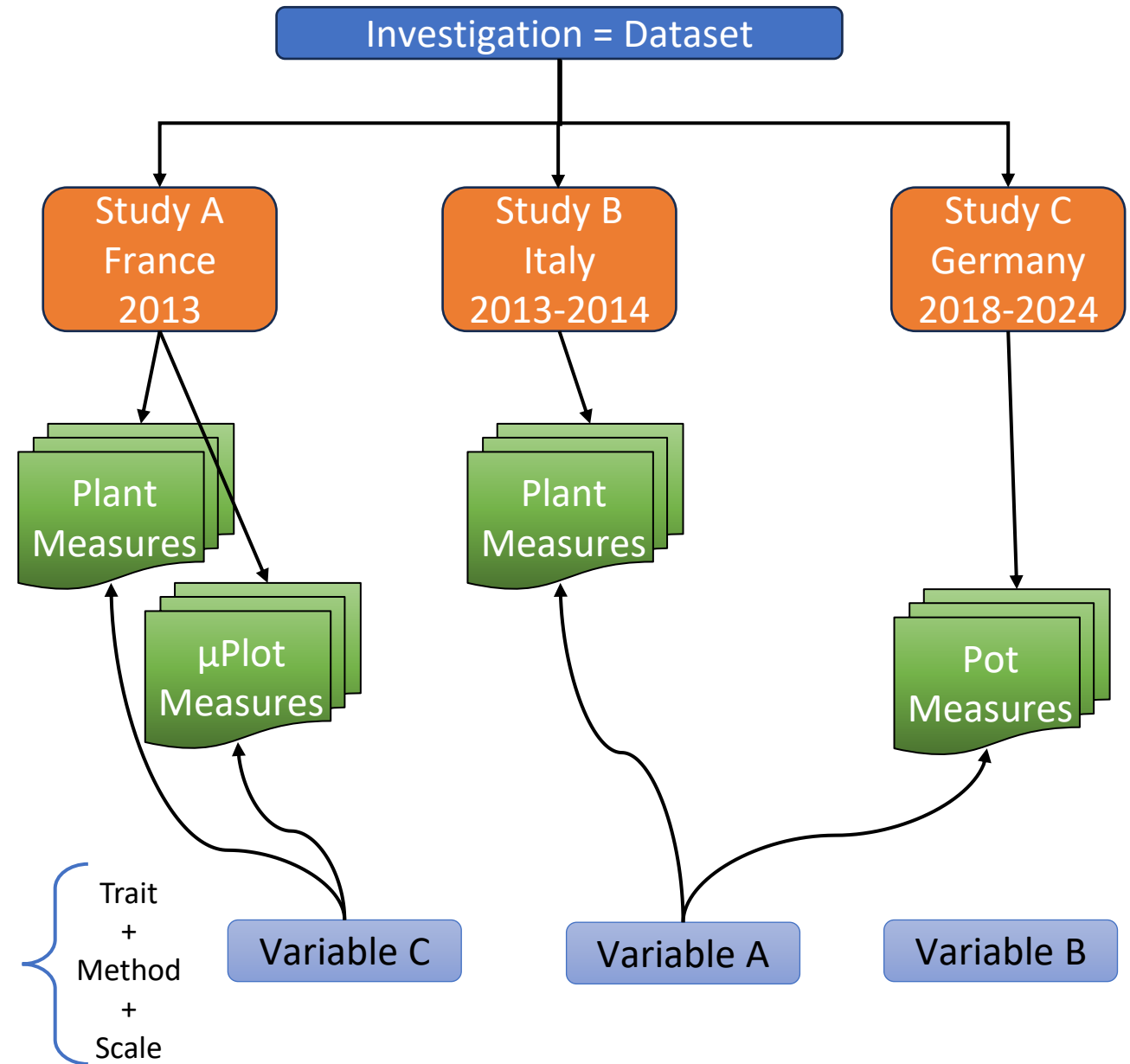


MIAPPE Specifications

- Specifications table
- 11 Sections
- Metadata Fields
- Definitions
- Examples
- Cardinalities
- Data model : Links between sections/concepts



- **Investigation:** full dataset
 - fields, greenhouse, ...
 - One to many location
 - One to many years
- **Study:** experience
 - One location/site
 - One or more years
- **Assay:**
 - trait or indice (Pheno or Env)
 - Trait + Method + Scale/Unit



➤ MIAPPE TEMPLATE EXAMPLE



Only mandatory sheets

A multi-site experiment in a network of European fields for assessing the maize yield response to environmental scenarios

Version 5.0



Millet, Emilie J.; Pommier, Cyril; Buy, Mélanie; Nagel, Axel; Kruijer, Willem; Welz-Bolduan, Therese; Lopez, Jeremy; Richard, Cécile; Racz, Ferenc; Tanzi, Franco; Spitkot, Tamas; Cané, Maria-Angela; Negro, Sandra S.; Coupel-Ledru, Aude; Nicolas, Stéphane D.; Palafre, Carine; Bauland, Cyril; Praud, Sébastien; Ranc, Nicolas; Presterl, Thomas; Bedo, Zoltan; Tuberosa, Roberto; Usadel, Björn; Charcosset, Alain; van Eeuwijk, Fred A.; Draye, Xavier; Tardieu, François; Welcker, Claude, 2019, "A multi-site experiment in a network of European fields for assessing the maize yield response to environmental scenarios", <https://doi.org/10.15454/4/IASSTN>, Recherche Data Gouv, V6, UNF:6:mz1xgNNn0BwYj7ym9d9TA== [fileUNF]

Cite Dataset +

Learn about [Data Citation Standards](#).

Access Dataset +

Contact Owner

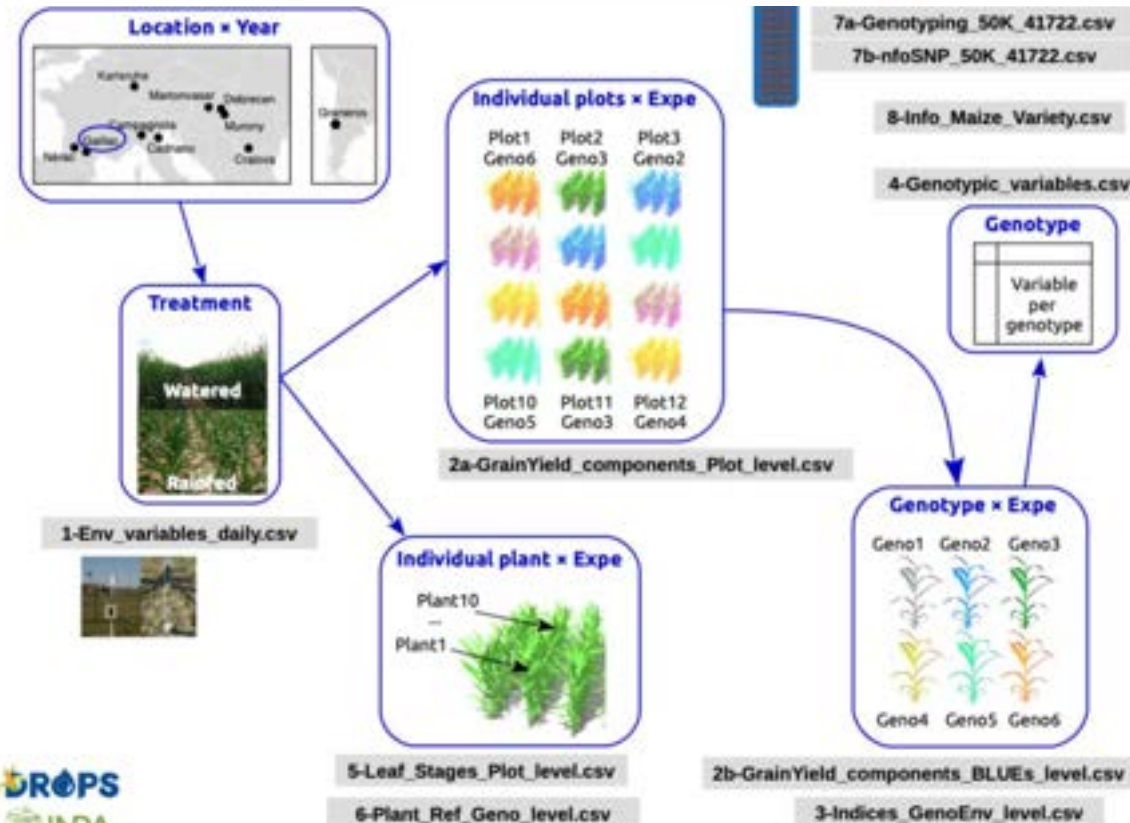
Share

Make Data Count (MDC) Metrics

since 2020-07-01

29,556 Views

13,831 Downloads (+ 742 pre-MDC)


<https://doi.org/10.15454/IASSTN>


➤ MIAPPE self documentation

MIAPPE Version 1.2			
README Here are described the different sheets of this template and their respective fields. Colour code for sheets and columns: - Red : mandatory - Green : recommended - Black : if available - Blue : read-only			
Investigation Investigations are research programmes with defined aims. They can exist at various scales (for example, they could encompass a grant-funded programme of work, the various components comprising a peer-reviewed publication, or a single experiment). This section is mandatory.			
Field	Investigation unique ID	Investigation title	Inv
Abbreviation	InvestigationId	InvestigationTitle	Inv
Definition	Identifier comprising the unique name of the institution/database hosting the submission of the investigation data, and the accession number of the investigation in that institution.	Human-readable string summarising the investigation.	Human-Inv
Example	EBI:12345678	Adaptation of Maize to Temperate Climates: Mid-Density Genome-Wide Association Genetics and Diversity Patterns Reveal Key Genomic Regions, with a Major Contribution of the Vgt2 (ZCN8) Locus.	The migr temperate : dramatic ee insight into adaptive t based genei investigat temper
Format	Unique identifier	Free text (short)	
Study A study (or experiment) comprises a series of assays (or measurements) of one or more types, undertaken to answer a particular biological question. This section is mandatory.			
Field	Study unique ID	Study title	
Abbreviation	StudyId	StudyTitle	
Definition	Unique identifier comprising the name or identifier for the institution/database hosting the submission of the study data, and the identifier of the study in that institution.	Name, human-readable text summarising the study	Human-rea
Example	EBI:12345678 ; http://phenome-fppn.fr/maugio/2013/12351	Maugio 2022	2002 evalua time for representing the experim
Format	Unique identifier	Free text (short)	
► README Investigation Study Person Data file Biological Material Environment Observation Unit Experi			

➤ MIAPPE Investigation

	A	B	C
1	investigationId	investigationTitle	investigationDescription
2	https://doi.org/10.15454/IASSTN	A multi-site experiment in a network of European fields for assessing the	This dataset comes from the European Union project DROPS (DROU
3			
4			

 **README** **Investigation** **Study** **Person** **Data file** **Biological Material** **Environment** **Observation Unit** **Experiment**

D	E	F	G
Barre de formule			
submissionDate	publicReleaseDate	license	miappeVersion
2018-10-10	2019-03-27	CC BY-SA 4.0	1.2

A	B	C	D	E	F
studyId	studyTitle	studyDescription	studyStartDate	studyEndDate	contactInst
Gai12	Biogemma Gaillac 2012	Maize European phen	14/05/2012	27/10/2012	Biogemma
Gai13	Biogemma Gaillac 2013	Maize European phen	13/05/2013	25/10/2013	Biogemma
Gra13	Biogemma Graneros 2013	Maize European phen	13/11/2013	03/04/2014	Biogemma
Ner11	Biogemma Nerac 2011	Maize European phen	13/05/2011	08/10/2011	Biogemma
Ner12	Biogemma Nerac 2012	Maize European phen	27/05/2012	10/10/2012	Biogemma
Ner13	Biogemma Nerac 2013	Maize European phen	15/05/2013	11/10/2013	Biogemma
Cra12	KWS Caracal 2012	Maize European phen	21/05/2012	18/09/2012	KWS

◀ ▶
README
Investigation
Study
Person
Data file
Biological Material

G	H	I	J	K
locationCountry	siteName	locationLatitude	locationLongitude	locationAltitude
FR	Gaillac	43.9	1.89	49
FR	Gaillac	43.9	1.89	49

• Plus additional descriptors

- expeDesignDesc, expeDesignType, obsUnitDesc, growthFacilityDesc, growthFacilityType, culturalPractice, expeDesignMap
- Project specific custom columns

B	C	D	E	F
personName	personEmail	personId	personRole	personAffiliation
		ORCID: 0000-0002-2913-4892	author	Biometris, Department of Plant Science, Wageningen University & Research

➤ MIAPPE Biological Material

- MIAPPE Mandatory (RED) and recommended fields (GREEN) + any additional information
- Material source: Genebank Accession (e.g. B73_INRAE) or cultivar (e.g. RENAN)
- Biological Material : Seed lot (e.g. B73_INRAE_2023)

biologicalMaterialId	organism	genus	species	infraspecificName	materialSourceId	materialSourceDoi	materialSourceAccNumber	AccessionHolding	Parent1	Parent1Synonym	Parent1Holding
11430_H	NCBITAXON:4577	Zea	mays	11430	inra:11430_H	https://doi.org/10.15454/MDSCXQ	11430_H	inra	11430_usda	11430_usda	USDA
A3_H	NCBITAXON:4577	Zea	mays	A3	inra:A3_H	https://doi.org/10.15454/GAHOFA	A3_H	inra	A3_inra	A3_inra	INRA
A310_H	NCBITAXON:4577	Zea	mays	A310	inra:A310_H	https://doi.org/10.15454/CNITVT	A310_H	inra	A310_inra	A310_inra	INRA
A347_H	NCBITAXON:4577	Zea	mays	A347	inra:A347_H	https://doi.org/10.15454/O8CNHP	A347_H	inra	A347_inra	A347_inra	INRA
A374_H	NCBITAXON:4577	Zea	mays	A374	inra:A374_H	https://doi.org/10.15454/7O0Y7F	A374_H	inra	A374_inra	A374_inra	INRA
A375_H	NCBITAXON:4577	Zea	mays	A375	inra:A375_H	https://doi.org/10.15454/IGF7DX	A375_H	inra	A375_inra	A375_inra	INRA
A554_H	NCBITAXON:4577	Zea	mays	A554	inra:A554_H	https://doi.org/10.15454/9E4IDY	A554_H	inra	A554_inra	A554_inra	INRA
ACE707_H	NCBITAXON:4577	Zea	mays	ACE707	inra:ACE707_H	https://doi.org/10.15454/11ADN1E2	ACE707_H	inra	ACE707_usda	ACE707_usda	USDA

▶
README
Investigation
Study
Person
Data file
Biological Material
Environment
Observation Unit
Experimental Factor
Event
Sample
Observed

➤ MIAPPE Observed Variable

TRAIT + METHOD + UNIT

- Minimal template
- Fits most needs (including Prowild)

B	C	D	E	F	G	H	I	J	K	L	
variableId	variableName	variableAccNumber	traitName	traitAccNumber	methodName	methodAccNumber	methodDesc	methodRef	scaleName	scaleAccNumber	
Tnight	Night temperature	EIPO:0000001	Night air temperature	EIPO:0000006	Night temperature m	EIPO:0000011	Mean temperature (°C) during night (by considering time course of temperature against the light). Temperature should be recorded in a wheather station close to the field.		Celsius degree	EIPO:0000016	
Ri_w	Solar radiation	EIPO:0000002	Solar radiation	EIPO:0000007	Solar radiation meas	EIPO:0000012	Intercepted radiation.		W.m-2	EIPO:0000017	
Psi	Soil water potential	EIPO:0000003	Soil water potential	EIPO:0000008	Soil water potential m	EIPO:0000013	Average soil water potential, at three depths		m3.m-3	EIPO:0000018	
Check	microplot altered by environmental measure (s	EIPO:0000004	Experimental practice	EIPO:0000009	Compaction estimati	EIPO:0000014			Celsius degree	EIPO:0000016	
Tmax	Maximum air temperature	EIPO:0000005	Maximal air temperature	EIPO:0000010	Maximum air temper	EIPO:0000015	Measured temperature		Celsius degree	EIPO:0000016	
ASI_GDD8	Anthesis to silking interval GDD base 8, ASI	MIPO:0000001	Anthesis silking interval	CO_322:0000001	Anthesis silking inter	MIPO:2000001	Calculated as growing-degree units or growing degree days	Ritchie J, NeSmith D (19	GDD: growing	MIPO:3000001	
Investigation	Study	Person	Data file	Biological Material	Environment	Observation Unit	Experimental Factor	Event	Sample	Observed Variable	Appendix1 Er

➤ MIAPPE Observed Variable

Full Crop Ontology Template (not needed in Prowild)

Variable ID	Variable name	Variable synonyms	Context of use	Growth stage	Variable status	Variable Xref	Institution	Scientist	Date	Language	Crop
MIPO:0000001	ASI_GDD8	Anthesis to silking interval GDD base 8	Flowering			CO_322:0000800				EN	Maize
MIPO:0000002	FFLW_GDD8	Female flowering days to silking GDD	Flowering							EN	Maize
MIPO:0000003	MFLW8	Male flowering days to anthesis GDD	Flowering							EN	Maize

Trait ID	Trait name	Trait class	Trait description	Trait synonyms	Main trait ab	Alternative ti	Entity	Attribute	Trait status	Trait Xref
CO_322:0000	Anthesis silki	Phenological	Anthesis silking interval		ASI		Flower	Anthesis silking interval		
CO_322:0000	Silking time	Phenological	Silking time	Female flowering time	Silk	S, FFlw	Flower	Silking time		PO:0025599,
CO_322:0000	Anthesis tim	Phenological	Anthesis time	Male flowering time	Ant	MFlw	Flower	Anthesis time		PO:0025600,
CO_324:0000	Seedling Vig	Agonomical	Seedling vigor	Early vigor	EdingVig		Seedling	Vigor		

Method ID	Method name	Method class	Method description	Formula	Method reference
MIPO:2000001	Anthesis silking interval - Computation	Computation	Calculated as growing-degree units or growing degree days between sowing and 50% anthesis.	parameter values (Tb = 8~∞C and To = 30~∞C) that maximized correlations between sites	Ritchie J, NeSmith D (1991) Temperature and crop development. Modeling plant and soil systems American Society of Agronomy Madison Wisconsin USA. doi:10.2134/agronmonogr31.c4
MIPO:2000002	Growing degree days to anthesis - Corr	Computation	Calculated as growing-degree units or growing degree days between sowing and 50% anthesis.	parameter values (Tb = 8~∞C and To = 32~∞C) that maximized correlations between sites	Temperature and crop development. Modeling plant and soil systems American Society of Agronomy Madison Wisconsin USA. doi:10.2134/agronmonogr31.c4

Scale ID	Scale name	Scale class	Decimal plac	Lower limit	Upper limit	Scale Xref
MIPO:3000001	GDD: growing degree-days	Numerical				
MIPO:3000001	GDD: growing degree-days	Numerical				
CO_324:0000192	Vigor Score (1-5)	Ordinal		1	5	

- Dedicated Data sheet OR separated file
- Format not constrained in MIAPPE

Experiment	parent1	Code_ID	Variety_ID	AccessionNum	geno.panel	grain.yield	grain.number	seed.size	anthesis	silking	plant.height	tassel.height	ear.height
Bol12R	B73_inra	3001	B73	B73_H	DROPS	3.1590233775	1825.5245774144	174.9523625669	66.9378669488	73.5002131635	189.1917508011	242.5875442211	101.0284980914
Bol12R	PH207_usda	3002	PH207	PH207_H	DROPS	3.2188049945	1428.0880451715	226.8802324187	63.3702173692	68.5359644499	185.4705248732	239.4019519879	97.7519630507
Bol12R	Oh43_inra	3003	Oh43	Oh43_H	DROPS	3.4630791405	1879.5729642786	182.9189092138	65.7688479265	73.5747290953	194.5270878925	244.1690150634	94.4318046885
Bol12R	W64A_inra	3004	W64A	W64A_H	DROPS	2.7641927634	1453.1357318276	198.6247085424	63.7963221376	71.3115581604	180.7025314813	236.1710080804	94.9735286936
Bol12R	Oh33_inra	3005	Oh33	Oh33_H	DROPS	1.8138525165	1049.4362241012	181.3103299725	66.2103679269	74.7047640639	190.2073035414	244.3020422838	98.6451525855
Bol12R	EZ47_csic	3006	EZ47	EZ47_H	DROPS	1.5369407902	683.285948007	226.9105295456	65.0482903783	76.4378637056	186.2723395538	242.4930531552	86.8878074188

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[Person](#)
[Data file](#)
[Biological Material](#)
[Environment](#)
[Observation Unit](#)
[Experimental Factor](#)
[Event](#)
[Sample](#)
[Observed Variable](#)
[Data](#)
[Appendix1 Enviro](#)

- AGENT Example <https://doi.org/10.57745/1HLI7X>

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
StudyID*	AgentID*	Replicatio	Block	Micropl	Pot	EventType	EventDescription	EventDate	GY	GY.date	First-leaf_emerged	First_leaf_emerged.date	First_spikelet_of_he	First_spikelet_of_head_v
AGENT-Ta-[ITA383]-2022-[1]	AW_01184	1	1	1				2022-12-10	1,53	2023-11-28	13	2023-11-28	134	2023-11-28
AGENT-Ta-[ITA383]-2022-[1]	AW_12266	1	1	1				2022-12-10	1,44	2023-11-28	13	2023-11-28	136	2023-11-28
AGENT-Ta-[ITA383]-2022-[1]	ITA383-TA01453	1	1	1				2022-12-10	2,42	2023-11-28	11	2023-11-28	130	2023-11-28
AGENT-Ta-[ITA383]-2022-[1]	ITA383-TA01454	1	1	1				2022-12-10	1,70	2023-11-28	12	2023-11-28	133	2023-11-28
AGENT-Ta-[ITA383]-2022-[1]	ITA383-TA01456	1	1	1				2022-12-10	3,13	2023-11-28	17	2023-11-28	129	2023-11-28
AGENT-Ta-[ITA383]-2022-[1]	ITA383-TA01457	1	1	1				2022-12-10	2,16	2023-11-28	11	2023-11-28	136	2023-11-28
AGENT-Ta-[ITA383]-2022-[1]	AW_01114	1	1	1				2022-12-10	0,91	2023-11-28	12	2023-11-28		2023-11-28
AGENT-Ta-[ITA383]-2022-[1]	AW_01215	1	1	1				2022-12-10	1,11	2023-11-28	12	2023-11-28		2023-11-28
AGENT-Ta-[ITA383]-2022-[1]	ITA383-TA01460	1	1	1				2022-12-10	2,19	2023-11-28	14	2023-11-28	135	2023-11-28
AGENT-Ta-[ITA383]-2022-[1]	AW_12246	1	1	1				2022-12-10	1,01	2023-11-28	15	2023-11-28	146	2023-11-28

Aknowledgments & Questions



Elixir Plant community & platforms

Beier S., Gruden C., Pommier C., Coppens F, Scholz U.,
Lange M., Contreras B., Adam Blondon AF, Faria D,
Chavez I, Miguel C, Droedsbek B, Finkers R, Papoutsoglou
E, Olster R, Ramsak Z, Michotey C., ...
And many more!



Crop Ontology

Arnaud E, Laporte MA, ...



Emphasis

Tardieu F, Usadel B, Arend D, Junker A, Poorter H, Neveu P, Pierushka
R, Alic I, Tireau A., Kazemipour-Ricci F., R. van de Zedde ...
And many more!

MIAPPE community



ELIXIR Plant Community,
Krajewsky P, Cwiek H, Tardieu F, Usadel B, Arend D,
Arnaud E, Junker A, King G, Laporte MA, Poorter H, Reif J,
Rocca-Serra P, Sansone SA, Kersey P,
And many more!



Breeding API

Selby P, Mueller L, Robbins K,
Backlund JE, Boizet A., ... ,
And many more!

H2020 AGENT



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