Maize Research Institute ZEMUN POLJE Serbia, Belgrade

Violeta Andjelkovic
Chair Maize Working Group
MRIZP - SERBIA

ECPGR Activity Grant Scheme
Proposal Form
First Call – Phase XI (2024–2028)

European Cooperative Programme for Plant Genetic Resources
ECP/GR

Aranjuez, 04.03.2026

"**MA**ize **LA**ndraces traits phenomic prediction using **N**ear **I**nfra**R**ed **S**pectra" (**MALANIRs**) 2025-2027

Maize diversity
(Photos by V. Babic, Maize Research Institute, Serbia)

www.ecgpr.cgiar/working-groups/maize

Coordinator - Stéphane Nicolas
GQE- Le Moulon, INRAE - FRANCE

IDEEV
Institut Diversité, Ecologie et Evolution du Vivant

Génétique Quantitative et Évolution Le Moulon

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

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Vice Chair Maize Working Group
CREA Research Centre for Cereal and Industrial Crops –**ITALY**
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université PARIS-SACLAY | FACULTÉ DES SCIENCES D'ORSAY

INRAE

cnrs

AgroParisTech
Talents d'une planète soutenable

MAize LAndraces traits phenomic prediction using Near InfraRed Spectra

? MALANIRs main scientific questions ?

- How to use **genomic** and **phenomic prediction** based on **NIRs** to **characterize** agronomic traits including seed composition of **maize landraces from European Genebanks?**

- Could be **NIRs a low cost alternative to genotyping** for **predicting agronomic and quality traits** in **Genebanks**?

ECPGR Activity Grant Scheme: MALANIRs

Aranjuez, 04.03.2026

European Cooperative Programme for Plant Genetic Resources ECP/GR

MAize LAndraces traits phenomic prediction using Near InfraRed Spectra

Background

ECPGR Maize Working Group

ECPGR Homepage / ECPGR Working Groups / ECPGR Maize Working Group

Chair **Violeta Andjelkovic**

EVA

European Evaluation Network

Coordinator **Sandra Goritshchning**

MineLandDiv

Mining allelic diversity of maize landraces for tolerance to abiotic and biotic stresses

SusCrop ERA-NET

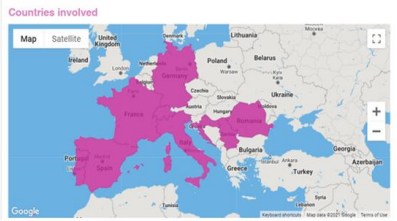
2022 Joint FACCE-JPI SusCrop Call on Agrobiodiversity

FACCEJPI

Coordinator **Stéphane Nicolas**

Mine - Mining
Land - Landraces
Div – Diversity
under abiotic and biotic stresses

EVA Maize Network



- 18 partners from 9 countries
  - 10 genebanks and/or research institutes
  - 8 breeding companies

Politécnico de Coimbra, BAYER, CSIC, INRAE, mas seeds, Limagrain, Lidea, IPK Gatersleben, MAIZE RESEARCH INSTITUTE ZEMUN POLJE Belgrade - Zemun, Instituto Nacional de Investigação Agrária e Veterinária, I.P., RAGT SEMENCES, KWS, Agronomski fakultet Zagreb, BRGV Suceava, crea, Schweizerische Eidgenossenschaft, Confédération suisse, Confederazione Svizzera, Confederaziun svizra

ECP/GR

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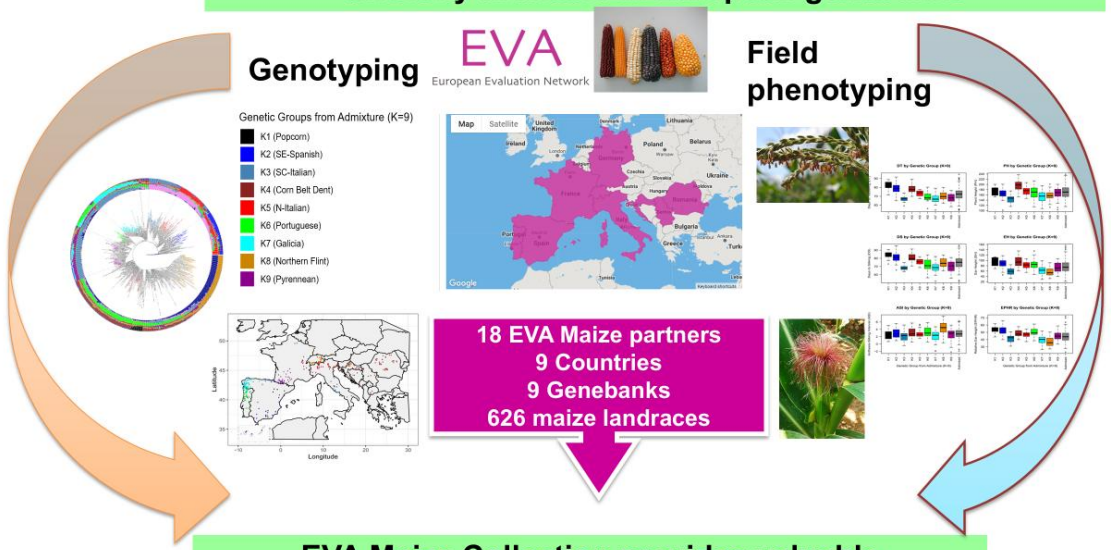
Aranjuez, 04.03.2026

European Cooperative Programme for Plant Genetic Resources
ECP/GR

Background

EVA
European Evaluation Network

➢ **TAKE HOME MESSAGE**
Public-private partnerships exploring maize genetic diversity available in European genebanks



EVA Maize Collection provides valuable pre-breeding sources of diversity for facing climate change due to the varieties local adaptation

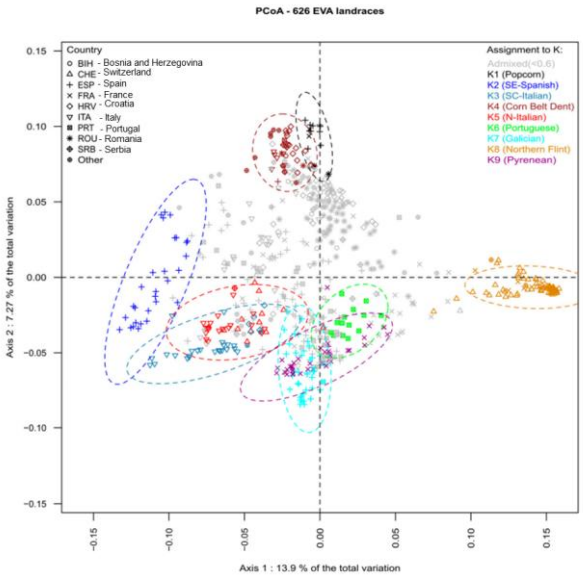
biology

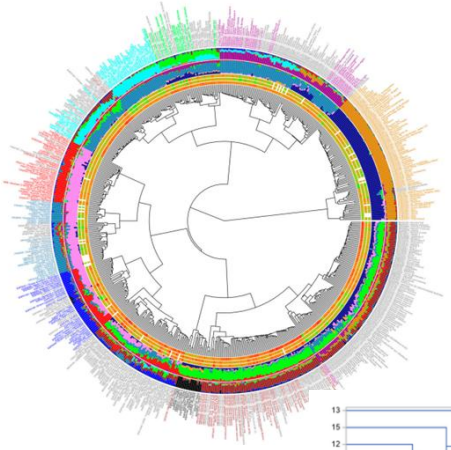
Biology **2024**, *13*, 454. https://doi.org/10.3390/biology13060454

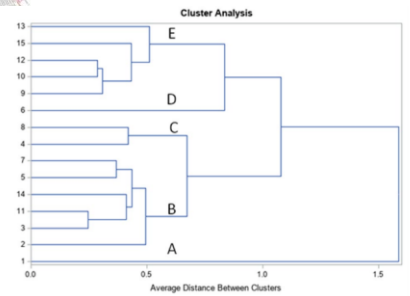
Article

Genetic and Phenotypic Evaluation of European Maize Landraces as a Tool for Conservation and Valorization of Agrobiodiversity

Carlotta Balconi [1,*,†], Agustin Galaretto [2,†], Rosa Ana Malvar [3], Stéphane D. Nicolas [2], Rita Redaelli [1], Violeta Andjelkovic [4], Pedro Revilla [3], Cyril Bauland [2], Brigitte Gouesnard [5], Ana Butron [3], Alessio Torri [1], Ana Maria Barata [6], Natalija Kravic [4], Valérie Combes [2], Pedro Mendes-Moreira [7,8], Danela Murariu [9], Hrvoje Šarčević [10], Beate Schierscher-Viret [11], Morgane Vincent [5], Anne Zanetto [5], Bettina Kessel [12], Delphine Madur [2], Tristan Mary-Huard [2,13], André Pereira [7,8], Domnica Daniela Placinta [9], Alexandre Strigens [14], Alain Charcosset [2] and Sandra Goritschnig [15,*]







Connection of **MALANIRs** with projects MineLandDiv and ECPGR EVA maize

2023-2027
Coordinator: S. Nicolas

MineLandDiv
Mining allelic diversity of maize landraces for tolerance to abiotic and biotic stresses

- Design **Targeting sequencing**
- Pipeline for calling SNP from targeted sequencing
- **Field trial network** for training **genomic / phenomic prediction model**
- Development of **genomic / phenomic prediction methods**

EVA
European Evaluation Network

2020-2025
Coordinator: S. Goritshnig

- **Field trial data** for training **genomic / phenomic prediction model**
- European **Genebank Network**

MALANIRs (2024-2027)

Proof-of-concept for phenomic to predict traits using grain from Genebanks seed stocks

- **Extending targeting sequencing genotyping** to 500 new landraces
- **Extending Field trial network** for evaluating landraces from MineLandDiv panel and local landraces in new environments

- **NIRs characterization** of 1440 samples from **Field trial**
- **NIRs characterization** of 2105 samples from **Genebank** for phenomic prediction and prediction of biochemical composition
- **Standardization of NIRs** devices accross network

- **Common meetings of MALANIRs, MineLandDiv & ECPGR**

ECPGR Activity Grant Scheme: MALANIRs

Aranjuez, 04.03.2026

A network of 15 partners including 10 national European genebanks

Chair Maize Working group:**Violeta Andjelkovic (MRIZP)** & ECPGR representant: **Sandra Goritshchning**

Partner ID	Responsible	Institute	Country
1	Stéphane NICOLAS Coordinator	Institut National de la Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE)	France
2	Natalija KRAVIC	Maize Research Institute Zelmun Polje (MRIZP)	Serbia
3	Domagoj SIMIC	Agricultural Institute Osijek	Croatia
4	Hrvoje ŠARČEVIĆ	University of Zagreb	Croatia
5	Danela MURARIU	Suceava Genebank (SVG)	Romania
6	Rosa Ana MALVAR	Misión Biológica de Galicia - CSIC	Spain
7	Carlotta BALCONI	Council for Agricultural Research and Economics (CREA) - Bergamo	Italy
8	Ana Maria BARATA	Banco Português de Germoplasma Vegetal - (BPGV-INIAV)	Portugal
9	Beate SCHIERSCHER VIRET	Agroscope	Switzerland
10	Zoran JOVOVIĆ	University of Montenegro	Montenegro
11	Najada KADIASI	Agricultural University of Tirana	Albania
12	Pedro MENDES MOREIRA	Politécnico de Coimbra – Escola Superior Agrária de Coimbra (ESAC-IPC)	Portugal
13	Gönül CÖMERTPAY	Eastern Mediterranean Agricultural Research Institute (DATAEM)	Turkey
14	Sylvia VOGL	Austrian Agency for Health and Food Safety (AGES)	Austria
15	Elisabetta FRASCAROLI	University of Bologna	Italy

ECPGR Activity Grant Scheme: MALANIRs

Aranjuez, 04.03.2026

European Cooperative Programme for Plant Genetic Resources ECP/GR

MAize LAndraces traits phenomic prediction using Near InfraRed Spectra

Objectives and context:

MineLandDiv
Mining allelic diversity of maize landraces for tolerance to abiotic and biotic stresses

EVA
European Evaluation Network

1. **Extending genomic characterization of 500 new landraces** from European using DNA bulk targeted sequencing approach designed in **MineLandDiv** project (**Task 1**)

2. **Predicting traits in contrasted environments of these 500 landraces using a genomic prediction** models trained on genotyping and trait measured on landraces in **Maize EVA Network** and **MineLandDiv** and **MALANIRs** field trials (**Task 1**)

3. **Evaluating use of NIRs in place of genomic data to predict agronomic traits** in contrasted environment using a phenomic prediction models trained on NIRs of kernel lots harvested and agronomic traits mesured in **MineLandDiv** and **MALANIRs** field trials (**Task 2**)

4. **Evaluating the proof-of-concept of using individual near infrared spectra (NIRs)** on grains **from genebank seed stocks to predict agronomic traits and grain composition** of maize landraces (**Task 3**)

MAize LAndraces traits phenomic prediction using Near InfraRed Spectra

Action plan:

MineLandDiv
Mining allelic diversity of maize landraces for tolerance to abiotic and biotic stresses

EVA
European Evaluation Network

- **Task 1 – Targeting sequencing of landraces for genomic prediction**
- **Task 2 – NIRs of kernels harvested in field trials**

- **Task 3 – Phenomic prediction of traits and grain composition based on individual NIRs of kernels from genebank seed stocks**

- **Task 4 – Feeding EURISCO Database**

eurisco
Finding seeds for the future

- **Task 5 – Face Meetings and training**

➢ Task 1 – Targeting sequencing of landraces for genomic prediction

FOCUS - Predict traits of landraces in Genebank with genomic selection using DNA bulk (MineLandDiv and EVA)

Combine landraces phenotypic with genotypic data to predict traits in landraces

=> Development of a genomic approach to predict traits in landraces

(A.O. Galaretto)

(S. Ben Sadoun)

The training set of the GBLUP model

171 landraces from Europe (129) and America (42) evaluated in 1998 at two locations **for flowering time** (Moulon, Mauguio) with 2 replicates
Genotyped with 50K

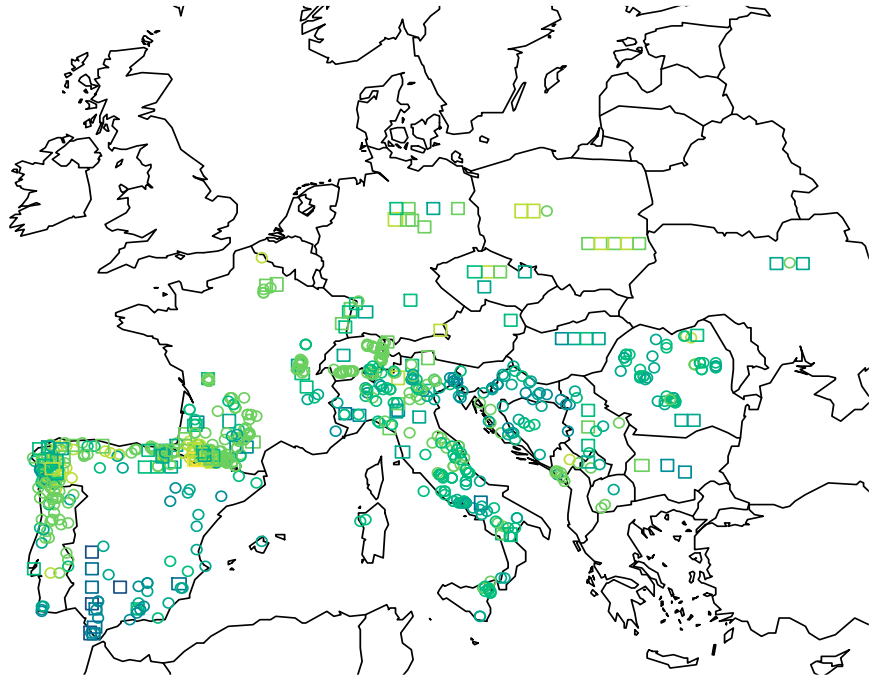
MineLandDiv
Mining allelic diversity of maize landraces for tolerance to abiotic and biotic stresses

EVA
European Evaluation Network

Genomic prediction on 1047 temperate landraces genotyped with 50K using GBPLUP

$$y = Xb + Za + \varepsilon$$

Map variation of **male flowering time range** across **Europe**



Days to Male Flowering
- Observed
- Predicted
- 55-60
- 60-65
- 65-70
- 70-75
- 75-80
- 80-85
- 85-90
- 90-95
- 95-100
- 100-105

Predicting agronomic performance of maize land-races in various and future environments by combining genomic prediction and ecogenetics

Agustin O. Galaretto, Marie Pégard, Rosana Malvar, Laurence Moreau, Ana Butrón, Pedro Revilla, Delphine Madur, Valérie Combes, Carlotta Balconi, Cyril Bauland, Pedro Mendes-Moreira, Hrvoje Šarčević, Ana M. Barata, Danela Murariu, Beate Schierscher-Viret, Alex Stringens, Violeta Andjelkovic, Sandra Goritschnig, Brigitte Gouesnard, Alain Charcosset, Stéphane D. Nicolas

➢ Task 1 - Targeting sequencing of 500 new landraces from different Genebanks for diversity analysis and genomic prediction

Selection of 500 MALANIRs among 643 proposed by 11 partners for targeted sequencing

Seed reception of 643 candidate landraces from 10 partners including new accessions
+ EVA European Evaluation Network accessions for **NIRs analysis** (Agroscope + University of Zagreb)

Seed reception of 643 new landraces in GQE

(L. Nunes)

DNA extraction of 543 new landraces extracted by GQE

(D. Madur, V. Combes, W. Cornette)

Country	Institute Name	Institute Code	Accessions received (seeds)	DNA extracted in MRS	Accessions retained for tGBS
Austria	AGES	AUT001	44	44	44
Croatia	AIO	HRV021	21	21	21
Albanie	PGRC	ALB026	45	45	45
Italy	CREA	ITA386	83	53	61
Montenegro	University of Montenegro	MNE001	55	55	55
Switzerland	Agroscope	CHE001	119	50	40
Portugal	BPGV - INIAV	PRT001	40	40	40
Portugal	IPC	PRT053	28	28	25
Serbia	MRIZP	SRB001	150	149	51
Croatia	University of Zagreb	HRV041	58	58	58
France	INRAE (CRB GAMèt)	FRA014	0	0	60
TOTAL			**643**	**543**	**500**

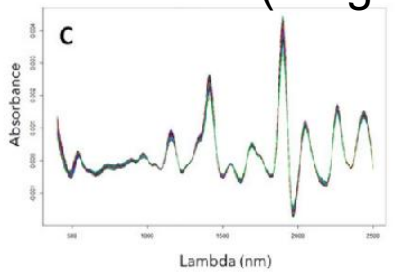
➢ Task 2 - NIRs of kernels harvested in field trials and from Genebank stocks

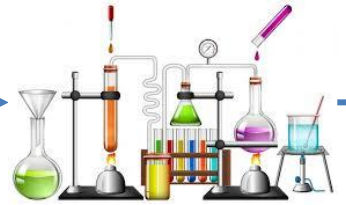
FOCUS - Predict seed composition of landraces by NIRs

NIRs a **low cost** and **non destructive approach** used in breeding programs to evaluate **seed biochemical composition** (or digestibility) using **NIRs on seeds** (or silage) harvested. The biochemichal characterization is based on **a model trained on a set of seed** (silage) samples **that are analyzed both with NIRs and with wet lab**

Training set

NIRs Infratec NOVA



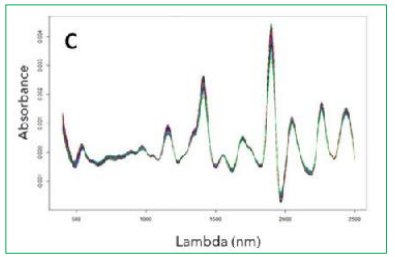


Calibrate NIRs equation with Partial Least Square model (PLS, Neutral network) Y ~ NIR wavelength
Y = Protein content,…

ACTIVITY in PROGRESS =>

Sample ID	Starch content (%)	Oil content (%)	Water Content (%)	Protein Content (%)	TKW (g)
1237	73,0	4,0	16,3	9,5	227,3
1109	72,6	4,6	15,4	8,6	262,3
1219	72,5	4,3	15,2	8,7	374,7
1118	71,8	4,7	15,1	9,4	311,3
1144	72,4	4,7	15,0	8,2	280,9
1222	71,4	4,8	14,9	9,4	364,1
1246	71,7	4,8	15,8	9,3	313,9
1239	71,9	4,5	15,3	9,0	331,4
1147	71,4	4,6	15,2	9,7	365,0
1152	73,6	4,5	16,3	7,6	293,4

Samples to predict



Experimental station DiaScope

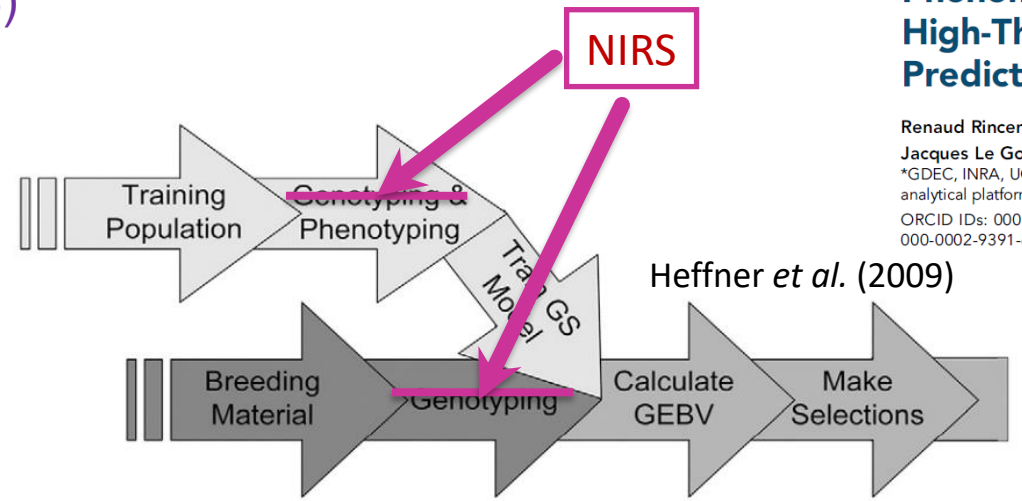
⇒ DEVELOPMENT OF AUTOMATED HIGH THROUGH-PUT PORT HARVESTED DEVICES FOR NIRs, Seed morphology (UE DIASCOPE, F. Meunier) / AGAP Institute (M. Ecarnot)

? MALANIRs main scientific questions ?

- Could be **NIRs a low cost alternative to genotyping** for **predicting agronomic and quality traits** in **Genebanks**?

MAIN FOCUS: Principle of **phenomic selection**, a low-cost and efficient **alternative to genomic selection** (Rincent, Segura et al., 2018)

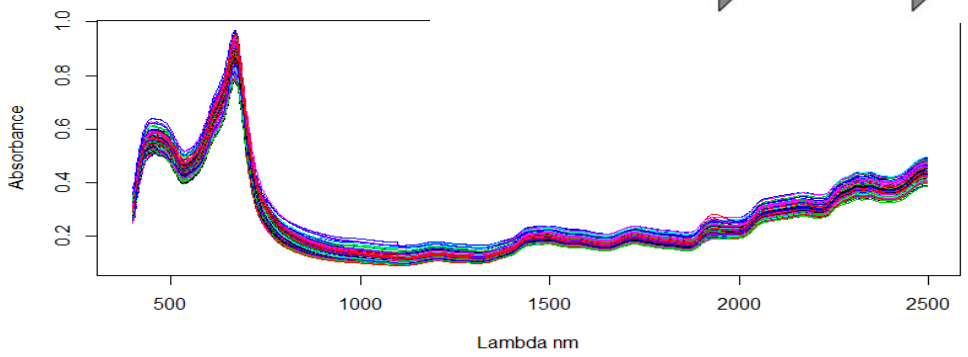
(R. Rincent)



Heffner *et al.* (2009)

Phenomic Selection Is a Low-Cost and High-Throughput Method Based on Indirect Predictions: Proof of Concept on Wheat and Poplar

Renaud Rincent,* Jean-Paul Charpentier,†,‡ Patricia Faivre-Rampant,§ Etienne Paux,* Jacques Le Gouis,* Catherine Bastien,† and Vincent Segura†,1
*GDEC, INRA, UCA, 63000 Clermont-Ferrand, France, †BioForA, INRA, ONF, 45075 Orléans, France, ‡GenoBois analytical platform, INRA, 45075 Orléans, France, and §EPGV, INRA, CEA-IG/CNG, 91057 Evry, France
ORCID IDs: 0000-0003-0885-0969 (R.R.); 0000-0002-6029-0498 (J.-P.C.); 0000-0002-3094-7129 (E.P.); 0000-0001-5726-49
000-0002-9391-6637 (C.B.); 0000-0003-1860-2256 (V.S.)



Estimation of a similarity matrix based on **NIRs spectra instead** of genomic data to calibrate model and predict trait using HBLUP

$$H(i,j) = \frac{\sum_{k=1}^{n_w} [S(i,k) \times S(j,k)]}{n_w},$$

ACTIVITY in PROGRESS =>

➢ Task 3 - Proof-of-concept of phenomic prediction of traits and grain composition of landraces based on individual NIRs of kernels from Genebank seed stocks

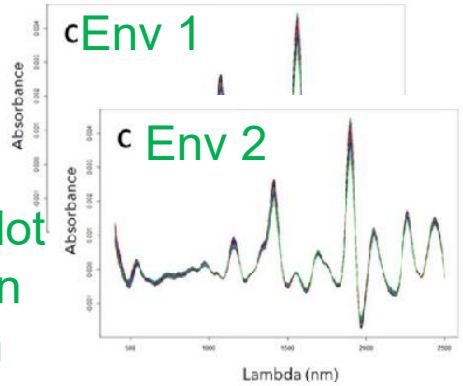
Objective: Evaluate feasability of combining NIRs of seed lots from field trials and from Genebanks to predict agronomic traits and grain composition (oil, starch, protein)

MineLandDiv
Mining allelic diversity of maize landraces for tolerance to abiotic and biotic stresses

Traits (incuding biochemical composition of grain)

UE Diascope

NIRs from grain harvested in each plot for 300 landraces in different trials with automated devices



Estimation of similarity between NIR spectra

$$H(i,j) = \frac{\sum_{k=1}^{n_w} [S(i,k) \times S(j,k)]}{n_w},$$

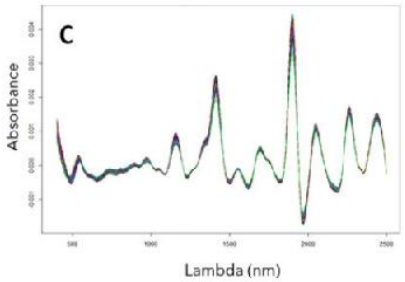
(R. Rincent)

Train a HBLUP model using phenotyping data from trial to predict trait

$$y = Xb + Za + \varepsilon$$

Genebanks (ECPGR MALANIRs, AGAP Institute)
NIRs of new landraces maintained in Genebank

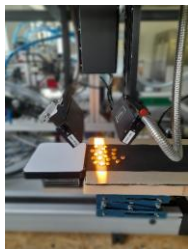
NIRs of seeds from genebank



Estimation of NIR spectra similarity of grain with NIR spectra from field trial

Predict traits (including biochemical composion of grain) of landraces maintained in genebank based on their NIR spectra

(M. Ecarnot)



Aranjuez, 04.03.2026

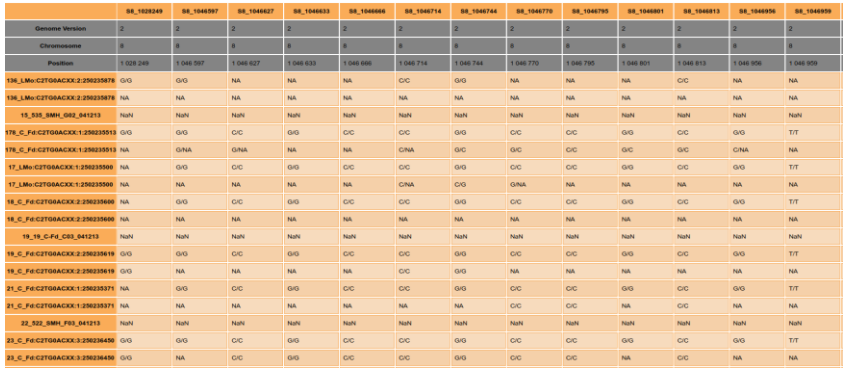
ACTIVITY in PROGRESS =>

➢ Task 4 - Feeding EURISCO database

eurisco
Finding seeds for the future

FOCUS Sharing data using ThaliaDB for genotyping and for phenotyping

- ➢ **Establish a good traceability of landraces analyzed in MALANIRs + Sharing genotyping data in a secured way**
  - ❑ **Use of official Accession code from each genebank + seed-lot (year of multiplication…)**
  - ❑ **Minimal description dataset - Accession code and name, passport data, Genebank seed-lot, multiplication year, collection site with geolocation, collection date...**
  - ❑ **If possible / available: human uses, human practices**
  - ❑ **Using ThaliaDB (https://thalia.moulon.inra.fr) for genotyping and phenotyping data**



ACTIVITY in PROGRESS => Each MALANIRs Partner => Fill information in Thalia DB account

ECPGR Activity Grant Scheme: MALANIRs

➢ Task 5 – Face Meetings and training

Joint EVA MAIZE Network and MALANIRs
Annual Meeting - Bergamo – ITALY - 26-27 February 2025

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

European Cooperative Programme for Plant Genetic Resources
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ECPGR Activity Grant Scheme: MALANIRs

EVA
European Evaluation Network

➢ Task 5 – Face Meetings and training

Joint ECPGR Maize WP, EVA Maize Network and MALANIRs Meeting - Belgrade – SERBIA - 2 October 2025

Gantt Chart – Where we are?

Task Description		2024	2025				2026				2027		
		Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Task 1	Targeting sequencing of 500 landraces												
	Genomic prediction for 500 landraces												
Task 2	Field trials												
	NIRs of kernels harvested in field trial												
	Phenomic prediction in fields												
Task 3	NIRs of kernels from seed stock in genebank												
	Phenomic prediction in genebank												
Task 4	Feeding and sharing data												
Task 5	Meeting in person / videoconference												

ECPGR Activity Grant Scheme: MALANIRs

Acknowledgements

Génétique Quantitative et Évolution Le Moulon

Stéphane Nicolas
Charcosset A.
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Madur D.
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Combes V.

Ben Sadoun S.

Arca M.
Mary-Huard T.

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Fievet J.

Galaretto A.O.

Rincent R.
De Oliviera. Y
M. Tenaillon

Génétique Quantitative et Évolution Le Moulon

IDEEV Institut Diversité, Écologie et Évolution du Vivant

université PARIS-SACLAY FACULTÉ DES SCIENCES D'ORSAY

agap

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EPGV

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Hissinger D.
Bérard A.
Chevreau A.

UE SMH
Palaffre C.

UE Diascope
R. Chapuis
F. Meunier
P. Sartre

INRAE

cnrs

CSIC Consejo Superior de Investigaciones Científicas

100 Centenario MBG Misión Biológica de Galicia

A. Butron
P. Revilla
R.A Malvar

crea Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

Gianfranco Mazzinelli

Alessio Torri

Rita Redaelli

Carlotta Balconi

European Cooperative Programme for Plant Genetic Resources ECP/GR

ECPGR
S. Goritschning

Violeta Andelkovic MRIZP
ECPGR Maize WG Chair

Funding

- Amaizing
- Diversity Zea
- ECPGR EVA maize
- Dromamed
- MineLandDiv

aMaizing

Investissements d'Avenir

EVA European Evaluation Network

European Cooperative Programme for Plant Genetic Resources ECP/GR

dromamed

MineLandDiv
Mining allelic diversity of maize landraces for tolerance to abiotic and biotic stresses

INRAE

ANR Agence Nationale de la Recherche

PROmaïs

FranceAgriMer

AND all people who collected, maintained landraces and inbred lines collection in different European Genebanks and in France Center of genetic resources CRB Gamèt at Montpellier and lines collection at Experimental unit Saint Martin de Hinx

AgroParisTech Talents d'une planète soutenable

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