Potato Breeding and Genetics
Agriculture and Agri-Food Canada

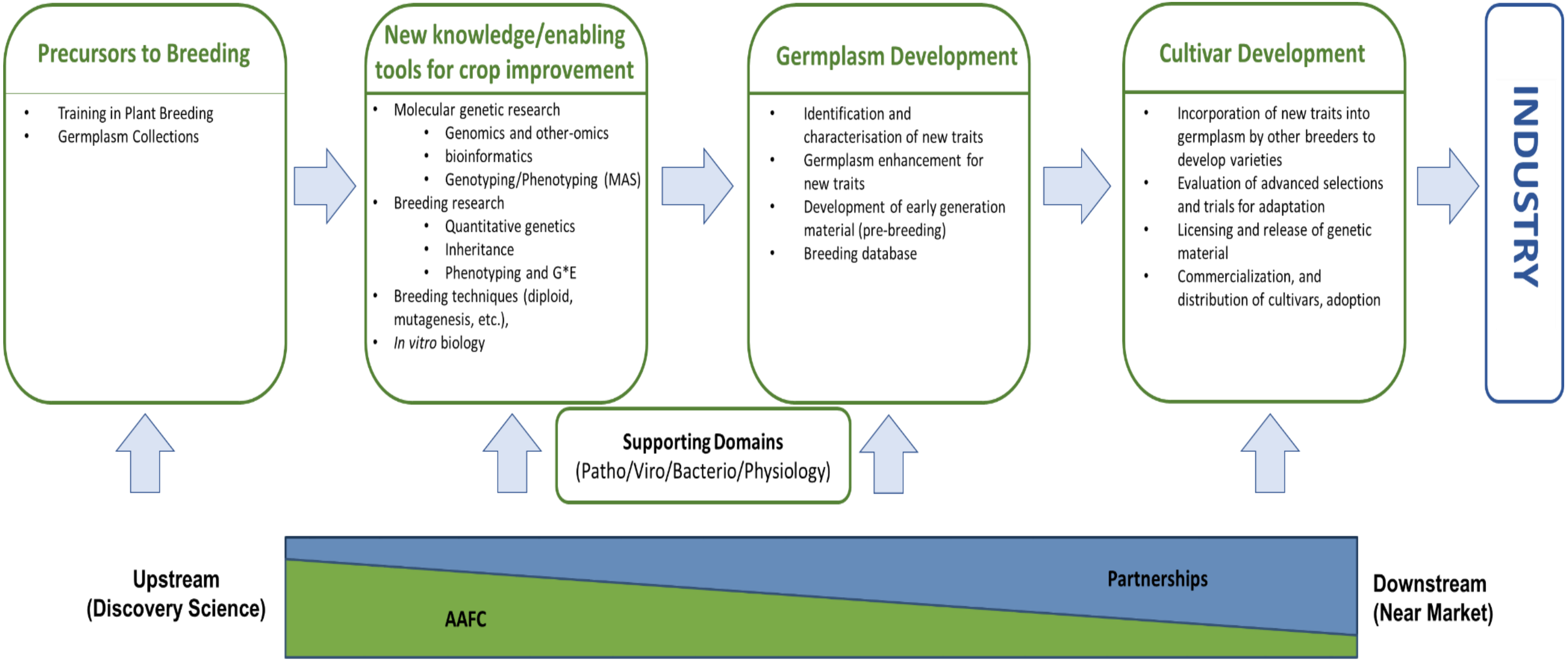
Crops to End Hunger

April 18, 2024





The breeding continuum



Updated Breeding Pipeline

Botanical Seed → Greenhouse Seedlings

Year 1 — 1-4 hills

Family rep

Year 2 — Seed & Eval

Augmented

Year 3

Germplasm Varieties → Hybridization

Year 4 — Preliminary Trials

NBB & ABV

Row-column p-rep

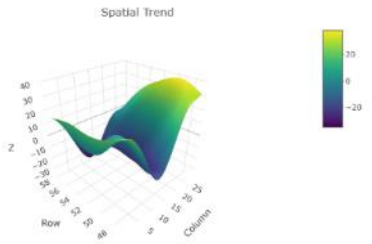
DNA markers

Year 5, Year 6 — National Trials

PE,NB,QC,ON,MB,SK,AB

RCBD or p-rep

Industry Trials & TC Introduction



BREEDBASE

National sites for breeding research and trials

Agriculture and Agri-Food Canada's Strategic Plan for Science: 2022 report

Mission 1:
Mitigating and adapting to climate change

Climate adaptation solutions

- Improved stress tolerance and adaptation to climate change

Sustainable food production in the North

- Earlier varieties and true potato seed

Importance of the National Trials

- Power in testing clones in more diverse locations to compare performance under different conditions
  - Soil, water, temperature, length of season, regional production practices
  - Assess resilience and performance under climate stress
- Identify selections to advance in the product development cycle
  - Far greater confidence in the data supporting a clone
- Provide industry members opportunities to participate in selection decisions and give feedback on clones
  - A key modernization goal is to engage with end users to ensure that selections are relevant and meet target profile standards

Mission 2:
Increasing the resiliency of agro-ecosystems

Enhance biodiversity to stimulate productivity and resilience

- Leveraging potato genetic resources for resilient crops

Reduced impacts of pests and diseases through a biovigilance approach

- Expand resistance to biotic and abiotic factors

Potato wart resistance testing in Newfoundland

Photo credit: G. Brinson

Disease data

Disease	Marker	Prelim 1 (Year 3) tested (planned)	R	Prelim 2 (Year 4) tested (planned)	R	Tier 1 (Year 5) tested (planned)	R	Tier 2 (Year 6) tested (planned)	R	Year 1 Release (Year 7) tested (planned)	R
PVY	Ry-ADG	69	0	33	0	9	1	3	0	1	0
PVY	Ry-STO	78	1	33	1	9	0	3	0	1	0
PVX	Rx1	77	7	32	3	9	0	3	2	1	0
Golden Nematode	H1/TG689	75	8	33	0	9	0	3	0	1	0
Wart	Sen3	77	10	33	0	9	1	3	0	1	0
Wart	Sen1	74	4	29	0	2 (7)	0	0 (3)		0 (1)	
Disease	**Assay Type**										
PVY (Ntn)	plant (graft)	2	1	2	0	2 (7)	0	3	0	1	0
Late Blight (US23)	Detached Leaf	22 (57)	3	9 (24)	1	7 (2)	0	3	0	1	0
Fusarium Dry Rot	Tuber			32	4	9	1	3	1	1	1
Scab	Field (Tuber)	69	14	33	10	9	3	3	1	1	1
Verticillium	plant										
Colorado Potato Beetle	Detached Leaf	0 (3)									

Late Blight

Fusarium Dry Rot

CPB

Resistant

Susceptible

Mission 3:
Advancing the circular economy

Diverse production systems with multiple outputs and co-benefits

- Emerging food and bioproduct opportunities

Growth of the circular bioeconomy in the agricultural and agri-food sector

- Enhanced quality, longer shelf life, and reduced food-loss
- Improved product recovery (fewer defects, longer storage, resistance to storage pests/diseases)

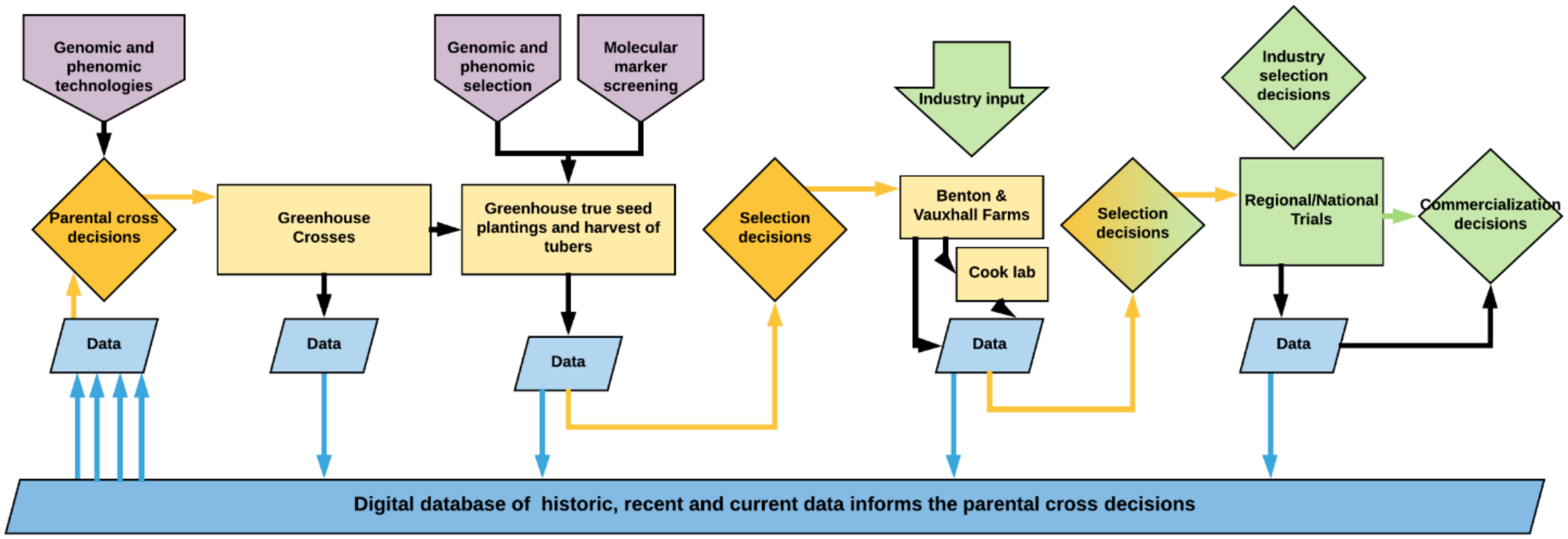
Mission 4 Accelerating the digital transformation of the agricultural sector

- Enhanced data-driven agriculture systems
  - Adopting data science fundamentals to breeding and germplasm development
  - Increasing open-Omics data science and digital dexterity
  - Increasing visibility of AAFC's collected data to increase collaboration

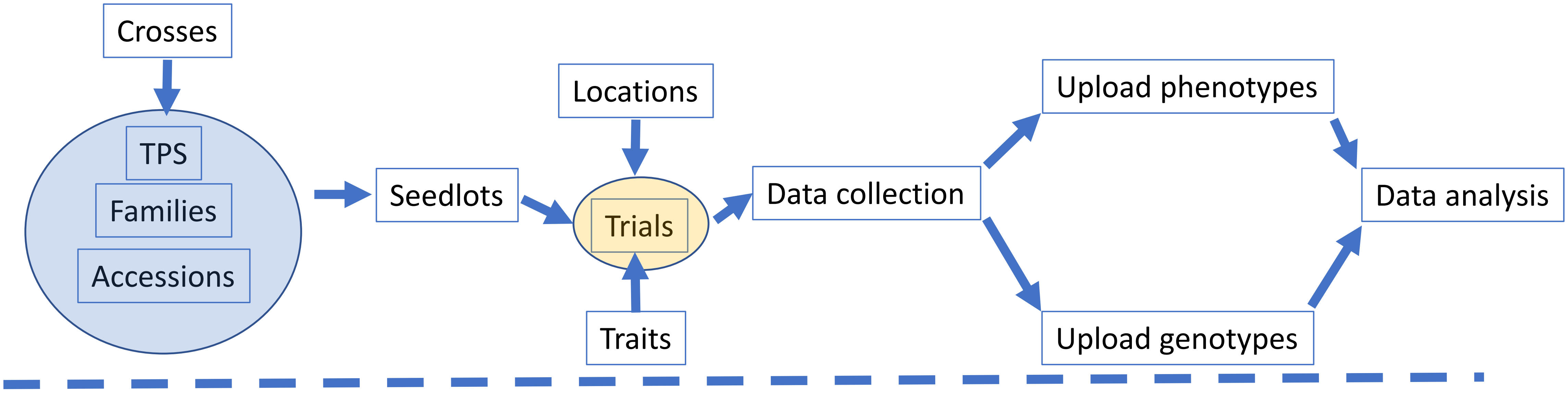
Data is critical along the breeding continuum

- Optimize operations and create new opportunities
  - Genomics to commercialization

Operational aspects of potato breeding



Overview of BreedBase pipeline and tools



Search

Manage

PhenoApps

Crop Ontology
for agricultural data

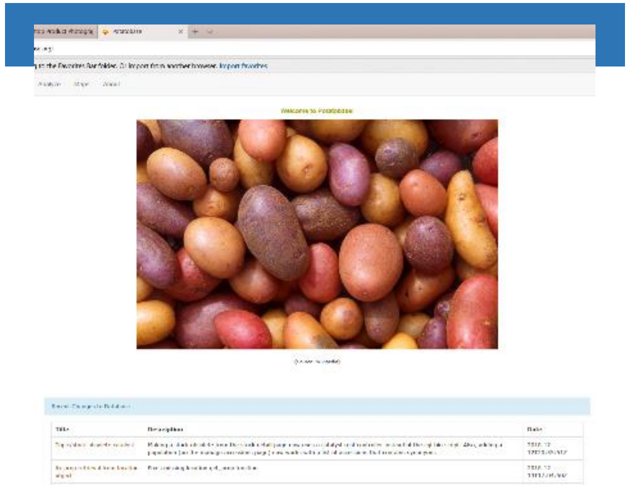
PHENOAPPS.org

BrAPI

Tools for Faster Reporting and Objective Data Collection

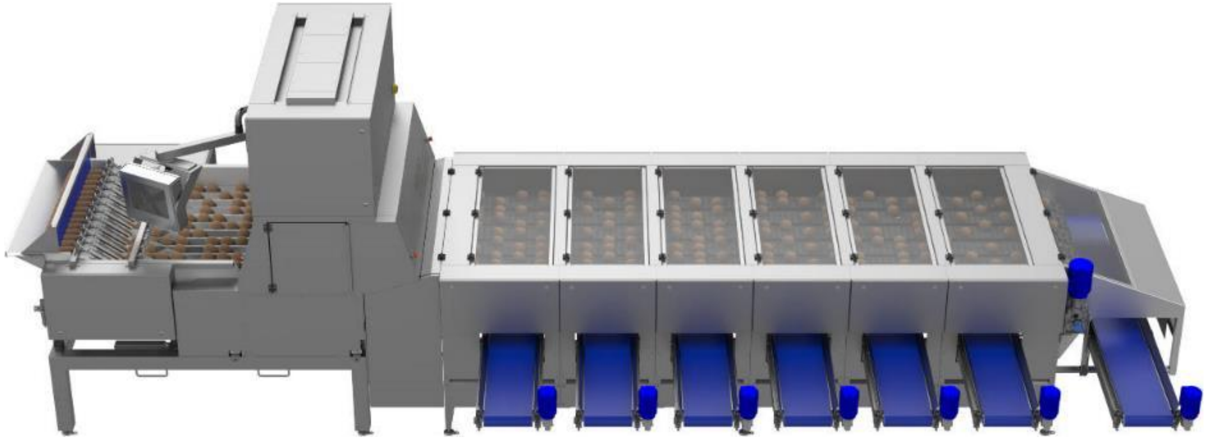
Image analysis
Hunter lab
Colorimeter

Potato Base



Optical Grader

Use of improved potato phenotyping technology will generate massive data sets



Potato Genotyping Platforms

- Low-density: KASP assays in-house and through Intertek.
  - Marker-assisted selection (MAS) for disease/pest resistance
- Mid-density: DArTag (2-4K SNPs)
  - Quality control, MAS -> genomic selection (Year 2 selections)
- High density: Neogen SNP array (~30K SNPs); GBS; FlexSeq
  - Genome-wide association analysis (GWAS); genomic selection (Year 3+) -> optimized parental and mate allocation

TOOLS FOR POLYPLOIDS

About EiB | Excellenceinbreeding

jendelman (Jeffrey Endelman) · GitHub

Thank you for your attention!

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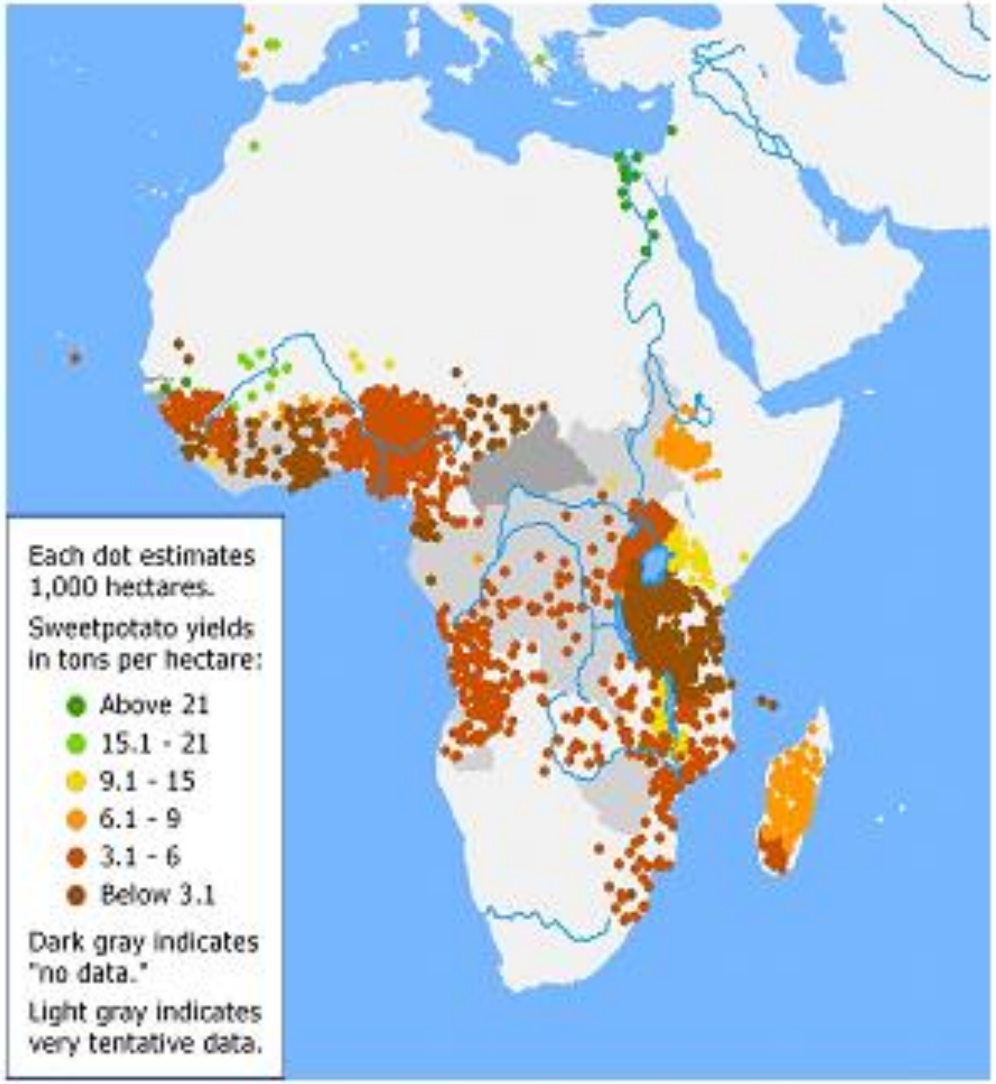
Sweetpotato Low and Mid Density Panels: Practical implications for breeding in Africa

Reuben Ssali, Godwill Makunde and Breeding team

CIP INTERNATIONAL POTATO CENTER
CGIAR

Sweetpotato breeding in Africa

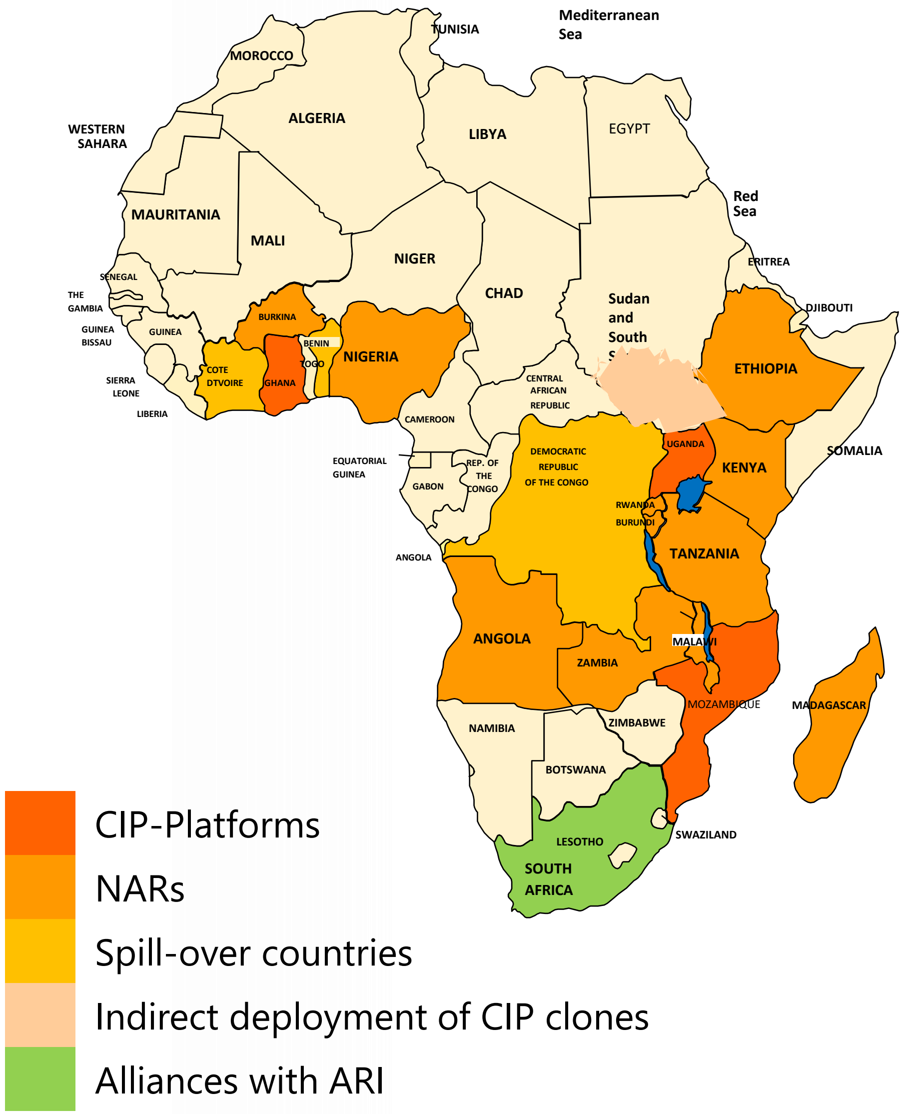


Sweet potato production in Africa

- Staple food crop with potential to reduce both hunger and malnutrition
- Low production below 6t/ha
  - Production system dominated by low yielding landraces
  - High virus and weevil pressure
  - Inadequate and variable rainfall
- Well-coordinated international breeding efforts with multiple partners
  - Community of practice
  - CGIAR-NARS breeding network
- Sub-regional population improvement platforms
  - East and central Africa (Uganda)
  - Southern Africa (Mozambique)
  - Pre-breeding and breeding methods/materials (Peru)
- Linked with national participatory variety development

Motivation for using low and medium density genotyping panels

- Marker assisted breeding
- Cost efficiency
- KASP Makers-QA/QC
  - Clone advancement
  - germplasm flow
- MDGP
  - Heterosis exploiting breeding scheme-gene pool separation
  - Genomic selection
  - Selection of multiple traits

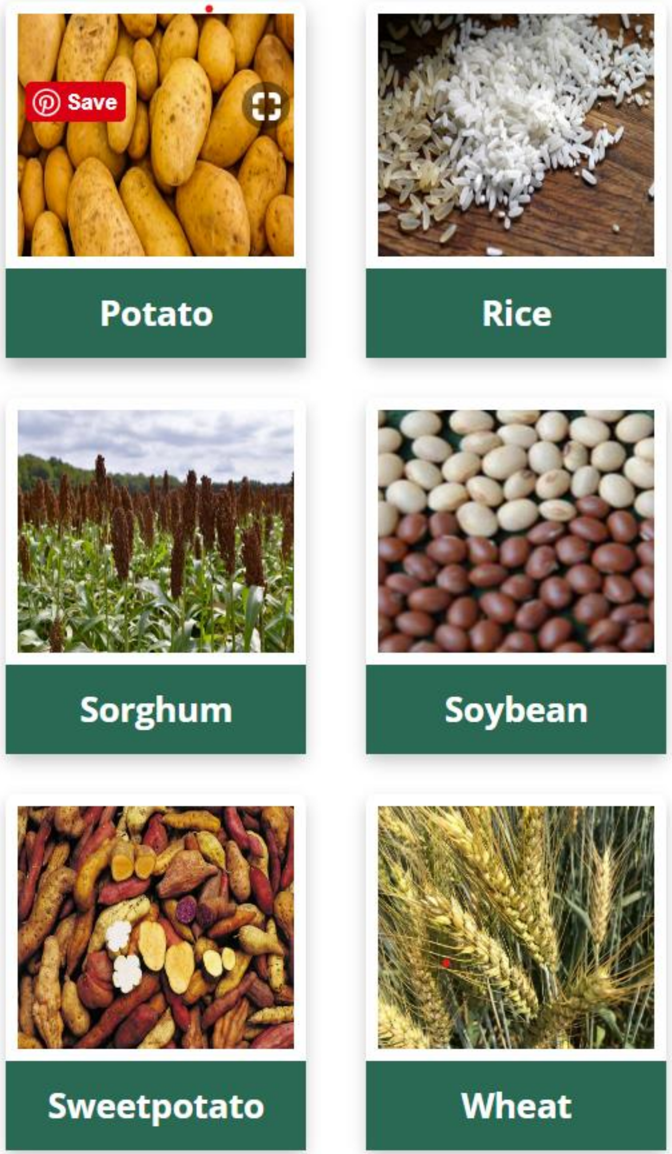


Sweetpotato low density genotyping

- **Kompetitive Allele Specific PCR (KASP)**, low density genotyping available for Sweetpotato for QA/QC

Uganda	Tanzania	Mozambique
QA/QC of the training population 16 plates	Germplasm collection 4 plates	Parents 4 plates
NaCRRI-parents-1 plate		
CIP-Uganda parents 3 plates(		

- 64 markers
- Genetic distances
- Presentation " KASP markers for QC in potato and sweetpotato: Lessons learned and perspectives' - Moctar Kante, Guilherme da Silva and Maria David, August 10, 2023



Sweetpotato mid density genotyping

SweetPotato_DArTag_BI_Cornell_University (1.0)

- Developed by Breeding insights at Cornell University
- Includes 3120 marker loci from 48 sweetpotato clones from North America

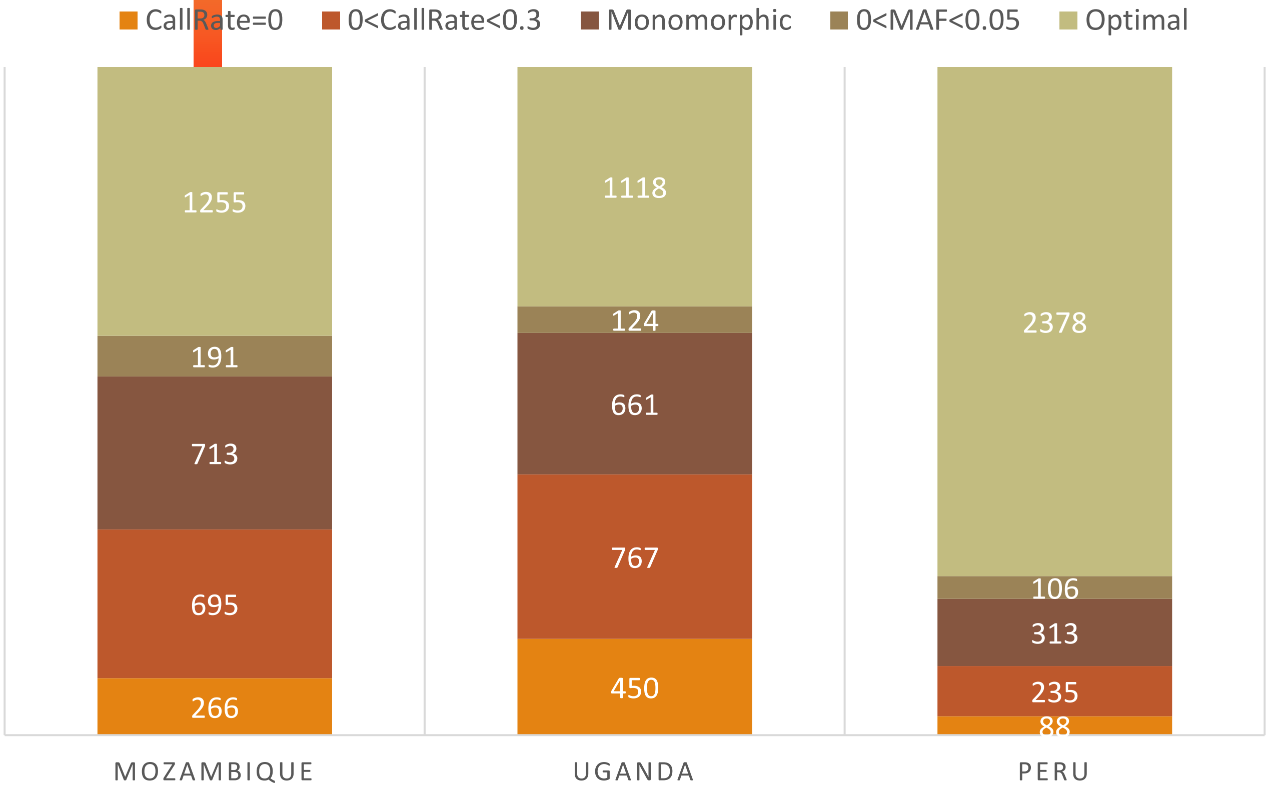
CIP in three breeding platforms

Variation in sample collection

Uganda & Mozambique –leaf discs punched before drying leaves

Peru- leaf discs punched after drying+ extra purification step

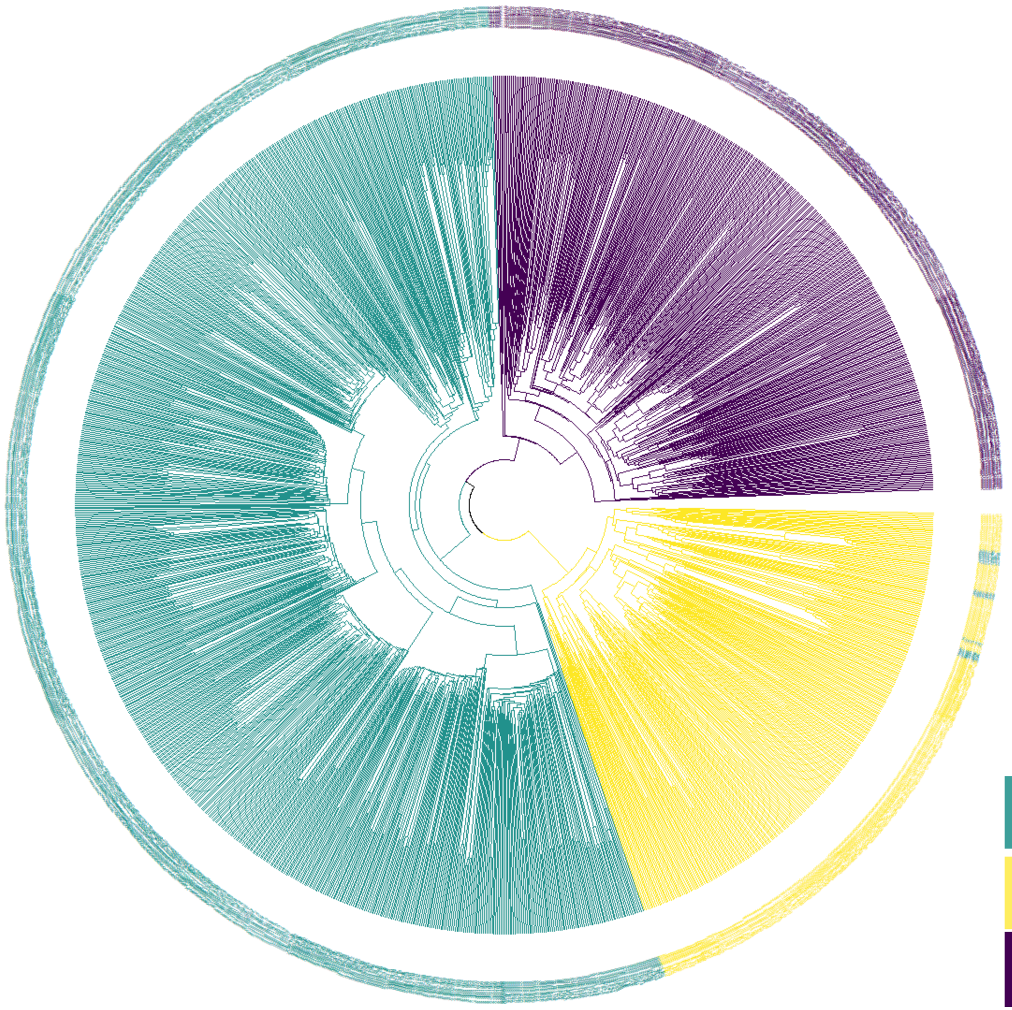
Platform	Uganda	Mozambique	Peru
Number of samples	282 samples	846 samples	376 samples
Description	**Parents** (40=H0, 40=H1,8=elite crosses) **PYT**-200)	Parents(40 GUR, 40 UMB), HIFE (700), 66 Landraces	138 Jewel 113 Zapallo, 44 PFSP 61 Advanced clones and varieties

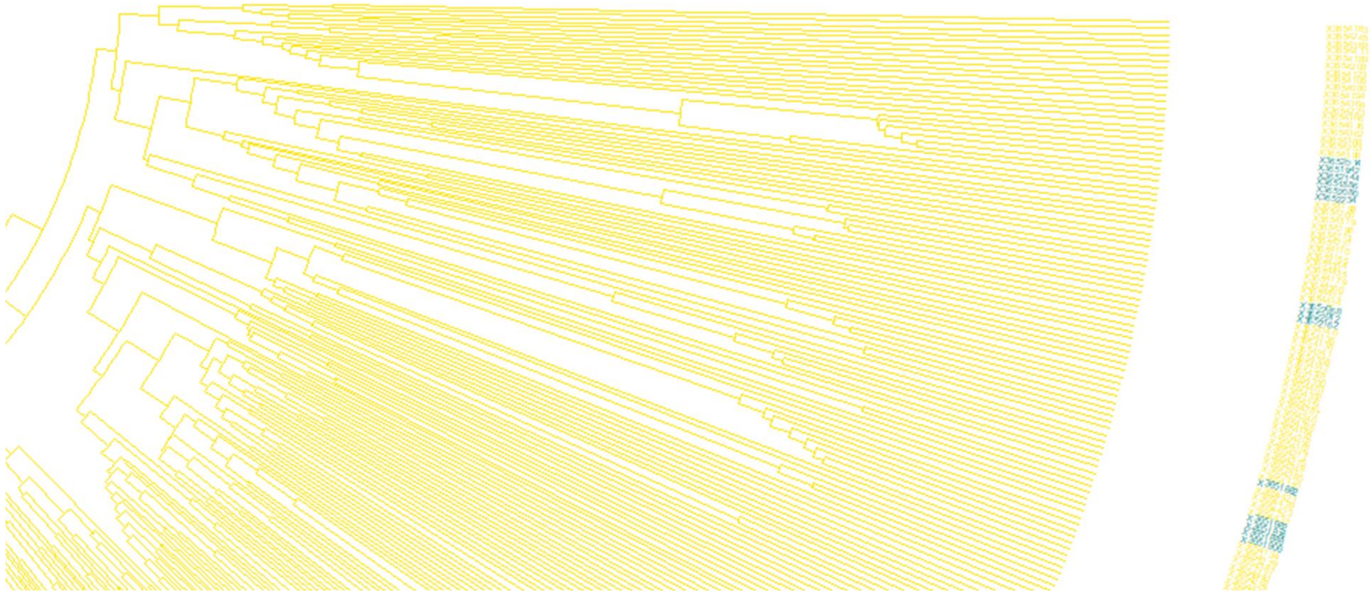


- Hexaploid dosage
- Genotyping results were filtered based on number of total counts, call rate and minor allele frequency (MAF).
- The total amount of common polymorphic markers obtained was 988.

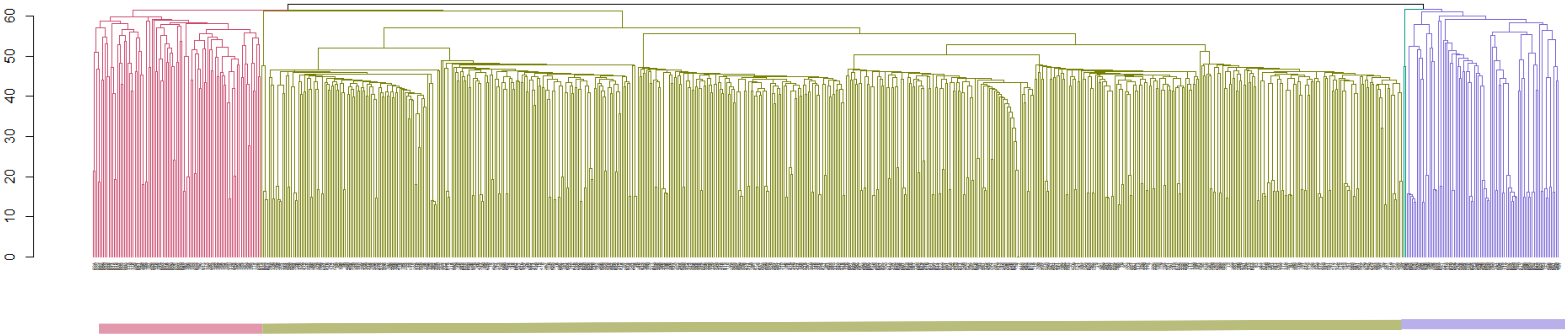
Clustering clones by platform

- Germplasm exchange among the platforms



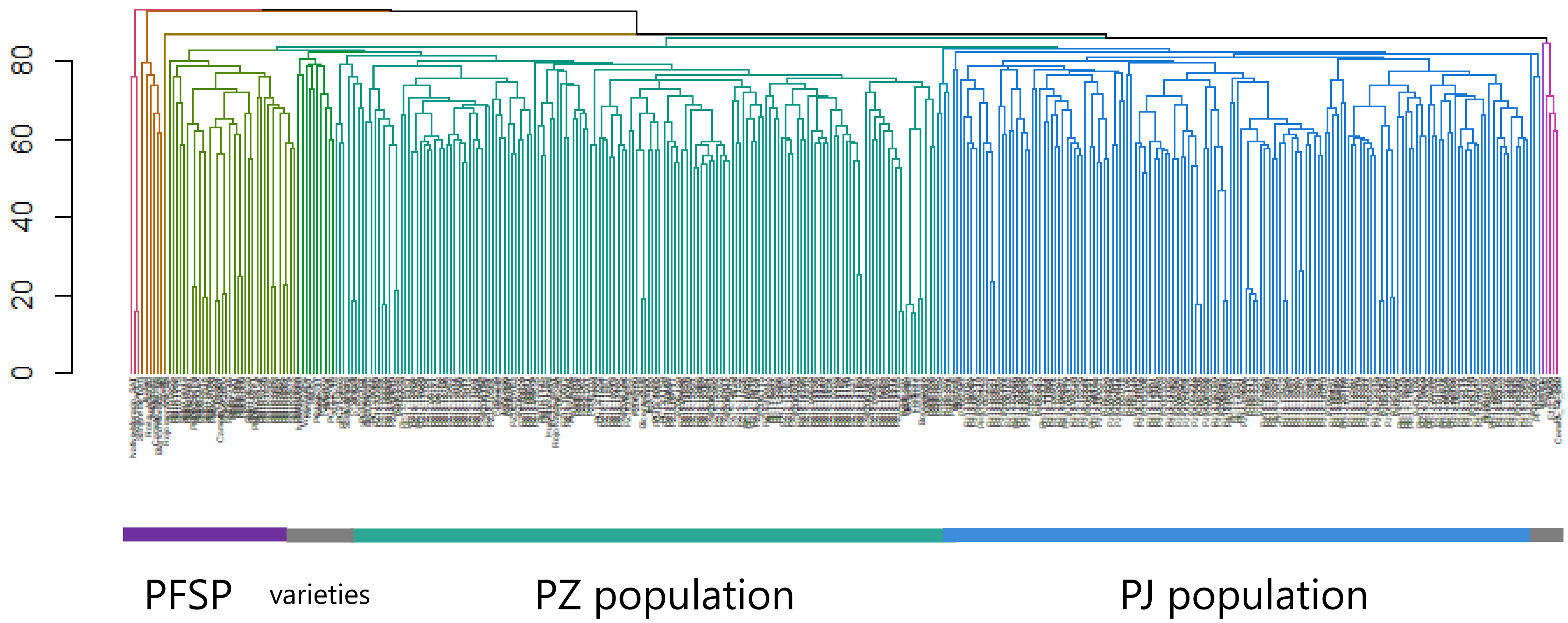


Mozambique



parents High Fe landraces

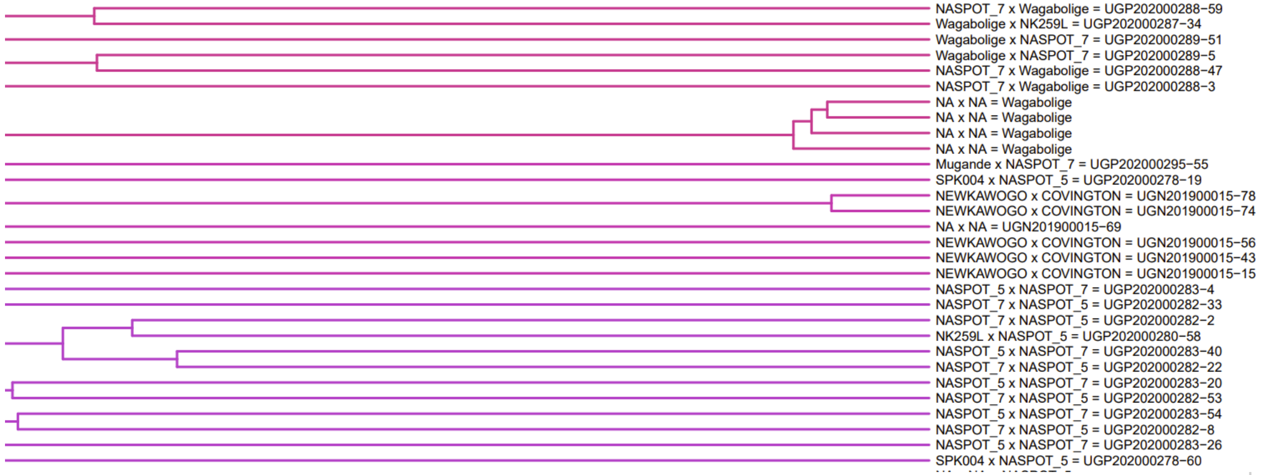
Peru

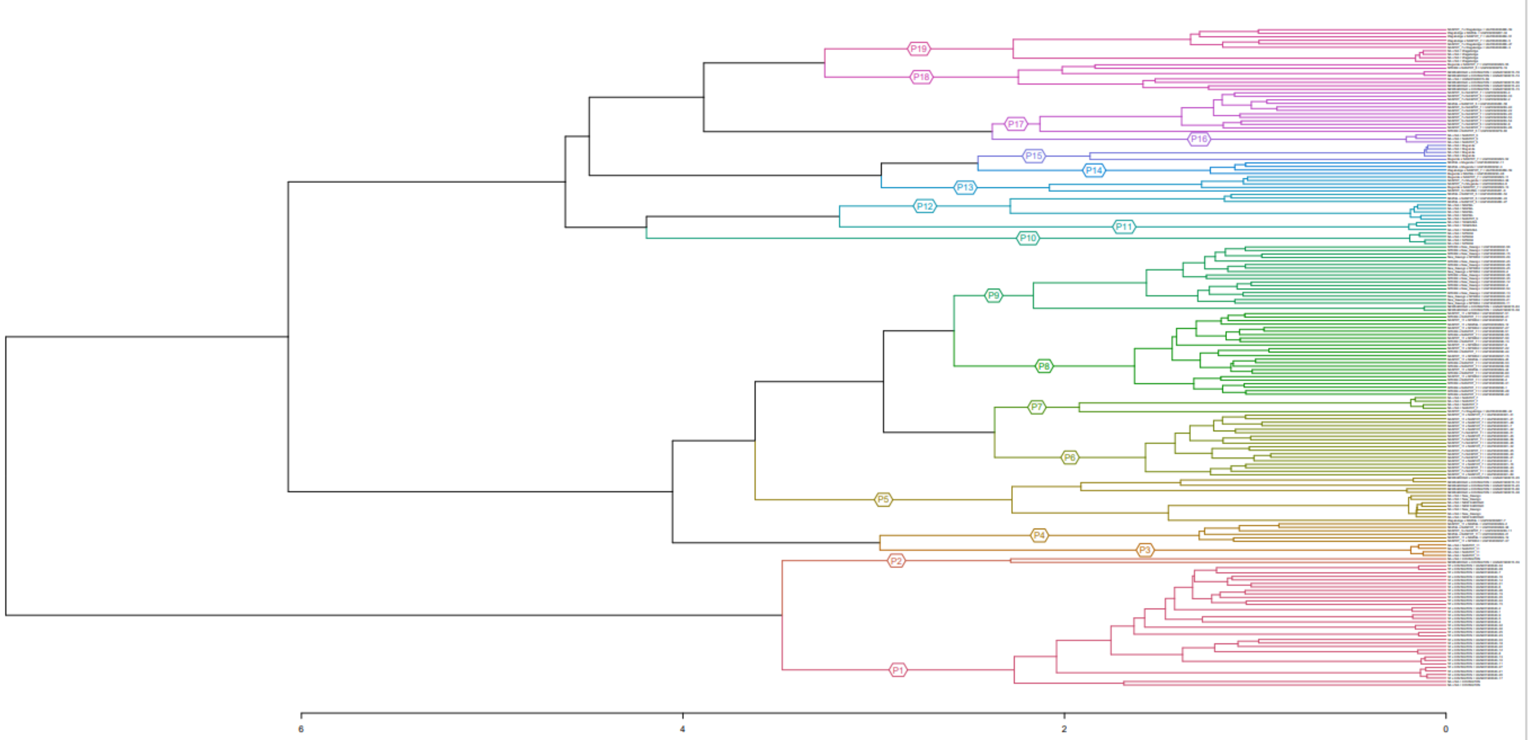


Pedigree confirmation –isolated & hand Bi-parental crosses

Isolated bi-parental crossing

Total number of markers	3120
Missing data(>20%)	73
Minor allele frequency (MAF<0.05)	658
Makers used	2389

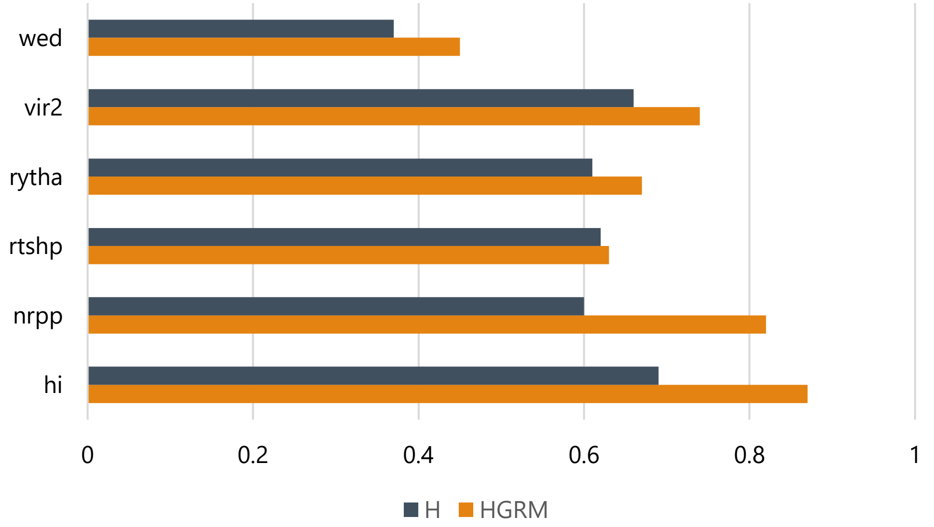


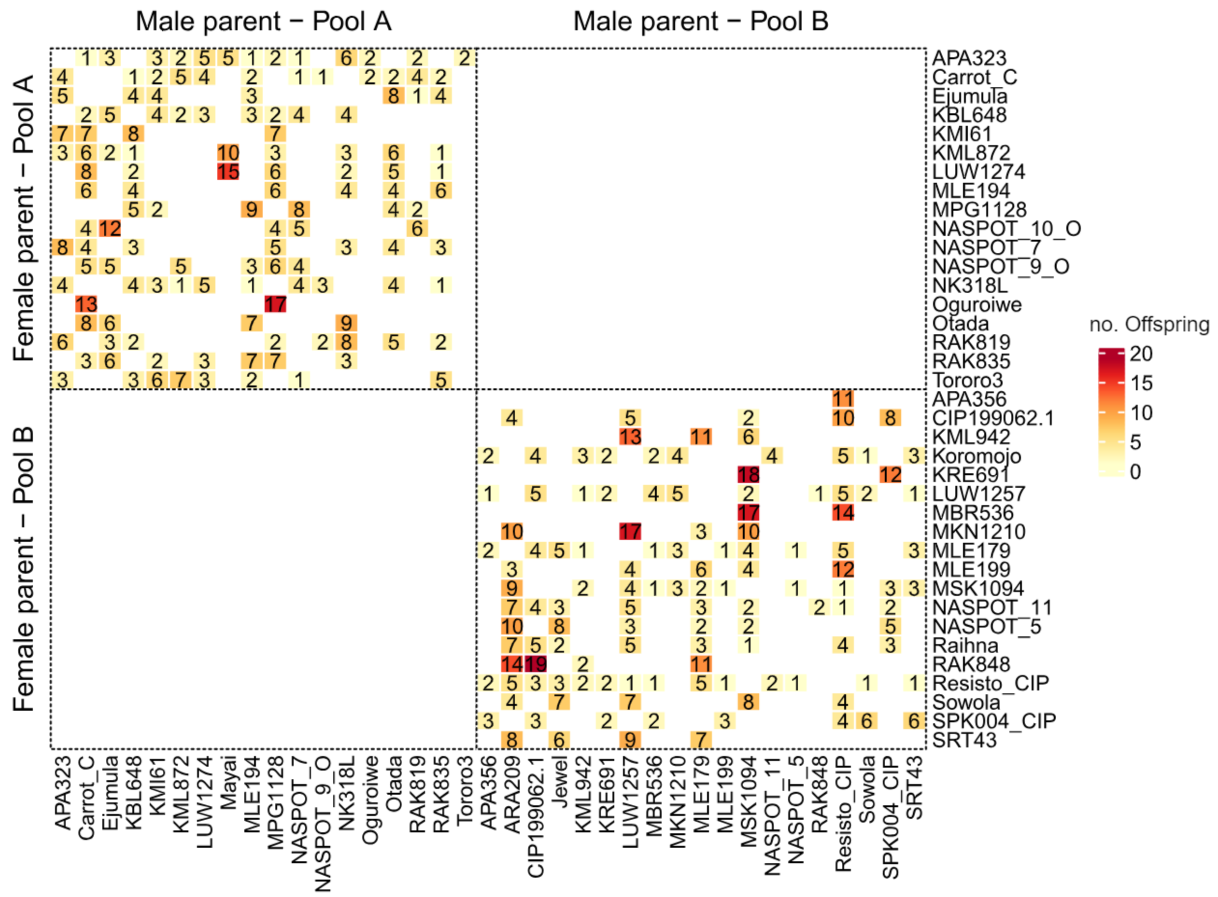


Families clustering together

CIP-Uganda training population

N = 1,138 progenies (biparental crosses 20A × 20A, 20B × 20B)
3 locations (row-column design with replicated 7 checks)
Improved heritabilities





Way forward

- DArTag markers for sweetpotato are suited to analyze genetic diversity and for selecting parents for crossings.
- Working with BI to update the panel
- Protocols need to be revised and homogenized for better data quality
- A smaller set of DArTag markers (like 150) would be useful for routine use such as identity verification.
- With Capacity building- enable NARS partners utilize

Thank you

The International Potato Center (CIP) was founded in 1971 as a research-for-development organization with a focus on potato, sweetpotato and Andean roots and tubers. It delivers innovative science-based solutions to enhance access to affordable nutritious food, foster inclusive sustainable business and employment growth, and drive the climate resilience of root and tuber agri-food systems. Headquartered in Lima, Peru, CIP has a research presence in more than 20 countries in Africa, Asia and Latin America.

www.cipotato.org

CIP is a CGIAR research center, a global research partnership for a food-secure future. CGIAR science is dedicated to transforming food, land and water systems in a climate crisis. Its research is carried out by 13 CGIAR Centers/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector.

www.cgiar.org

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