

# **“CIAT’s Cassava Breeding Approach to solve the CMD outbreak in SEA ”**

10<sup>th</sup> of September 2019  
Vientiane, Laos

**Luis Augusto Becerra  
Lopez-Lavalle**

**Molecular  
Geneticists/Breeder**

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Enhancement  
of Genetic  
Resources

RSA1

Partners and  
national systems  
released new CIAT  
developed cassava  
varieties  
(Contributions from  
RTB Flagships 1 and  
2)

Genetic sequencing,  
tools and protocols  
for genome editing  
and phenotyping

# CASSAVA BREEDING AT CIAT

## TABLE CONSUMPTION

- Low cyanogenic potential
- High carotenoids
- Mid- to high dry matter
- Easy cooking
- Acceptable root yield

## INDUSTRIAL USES

- High fresh root yield
- High/stable dry matter
- Erect plant architecture
- Fast sprouting
- Special starches

Rapid  
multiplication  
of materials  
to be released

Main  
targets  
regarding  
end-users

Uniform  
trials  
↓  
Elite clones  
shared with  
NARS

Advanced  
trials

Preliminary  
trials

Single  
row trials

Source germplasm  
shared with partners  
(e.g. resistance to CBSD)

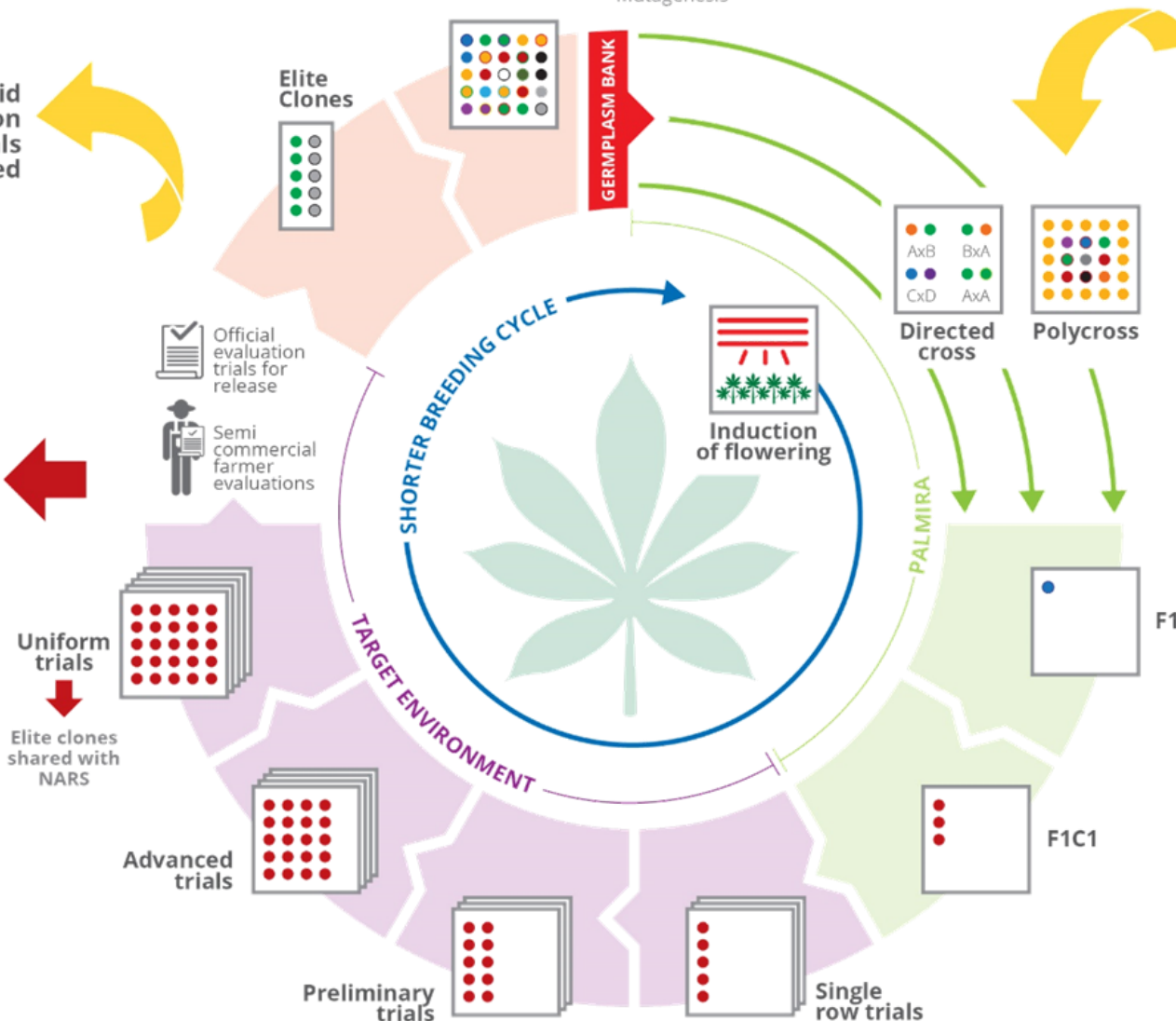
Wide  
genetic  
variability  
from  
germplasm  
collection

## SCREENING FOR USEFUL TRAITS:

- Nutrition: carotenoids, cyanogenic potential
- Plant health: whitefly, CBB, SED, thrips, mites, CBSD
- Starch quality: waxy starch & small granules
- Plant type: "asparagus" cassava
- Herbicide Tolerance

NEW VARIATION  
Mutagenesis

Gene editing technologies  
for target traits  
(e.g. nutrition, starch quality,  
herbicide tolerance)



## HIGH THROUGHPUT PHENOTYPING



Carotenoids  
quantification  
by NIRS



Ground  
penetrating  
radar

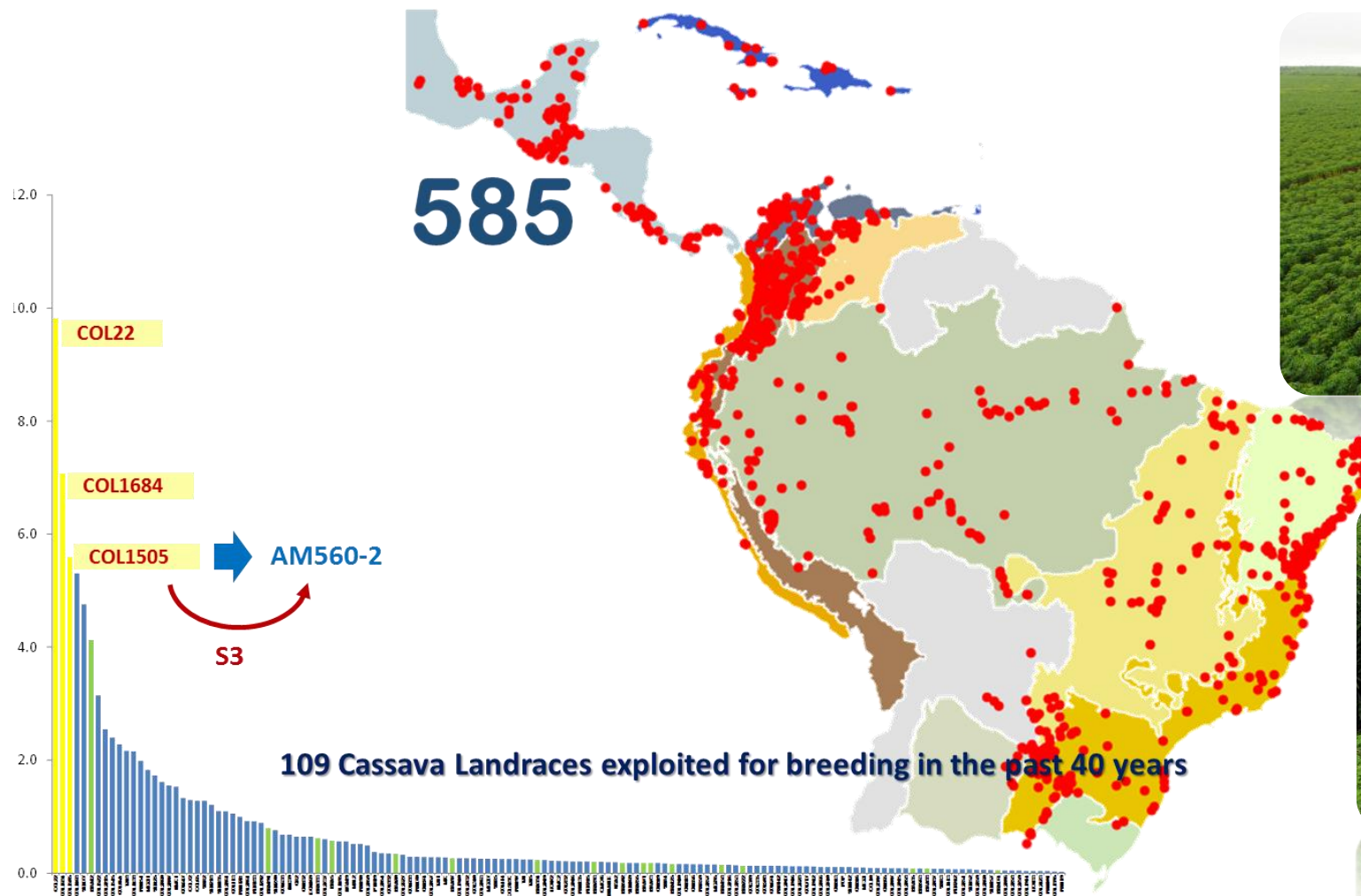


Canopy  
scanning  
with drones

CIAT



# Cassava breeding program founders from GRU



# CIAT's GRU hosts the largest gene diversity in LAC



**305 *M. esculenta* Landraces clones**

258 *M. esculenta* Elite LAC clones

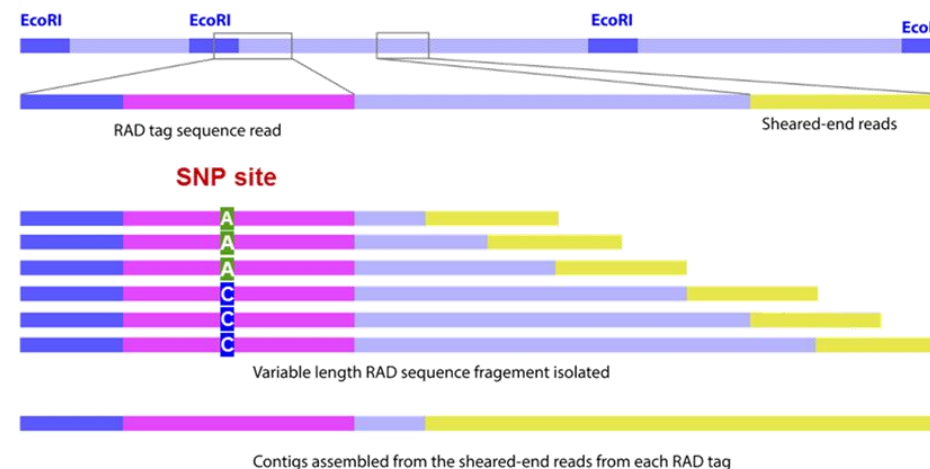
397 *M. esculenta* Elite CIAT clones

**280 *M. esculenta* Core collection**

55 wild *Manihot* accessions across 18 species

- Duplicated genotypes
- Kin relationship genotypes (kinship)
- Unrelated genotypes

## Restriction-site Associated DNA (RAD) sequencing





# Cassava in the Post Genomic Era



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**Actions**

- Revise query
- Launch Jalview
- Find related ... ▾
- Add to cart
- Composite family

**My Data (0)**

- View cart
- Add to cart
- Upload user data
- Send to BioMart
- Send to PhytoMine
- Get from PhytoMine
- Quick download

**Info**










***Manihot esculenta* v6.1 (Cassava)**

[Keyword search](#)
[BLAST search](#)
[BLAT search](#)
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[Bulk data](#)

**Overview**

Cassava (*Manihot esculenta* Crantz) is grown throughout tropical Africa, Asia and the Americas for its starchy storage root day. Farmers choose it for its high productivity and its ability to withstand a variety of environmental conditions (including However, it has low protein content, and is susceptible to a range of biotic stresses. Despite these problems, the crop prod capacity to grow in a variety of environmental conditions makes it a plant of the future for emerging tropical nations. Cass contain 20-40% starch that costs 15-30% less to produce per hectare than starch from corn, making it an attractive and str

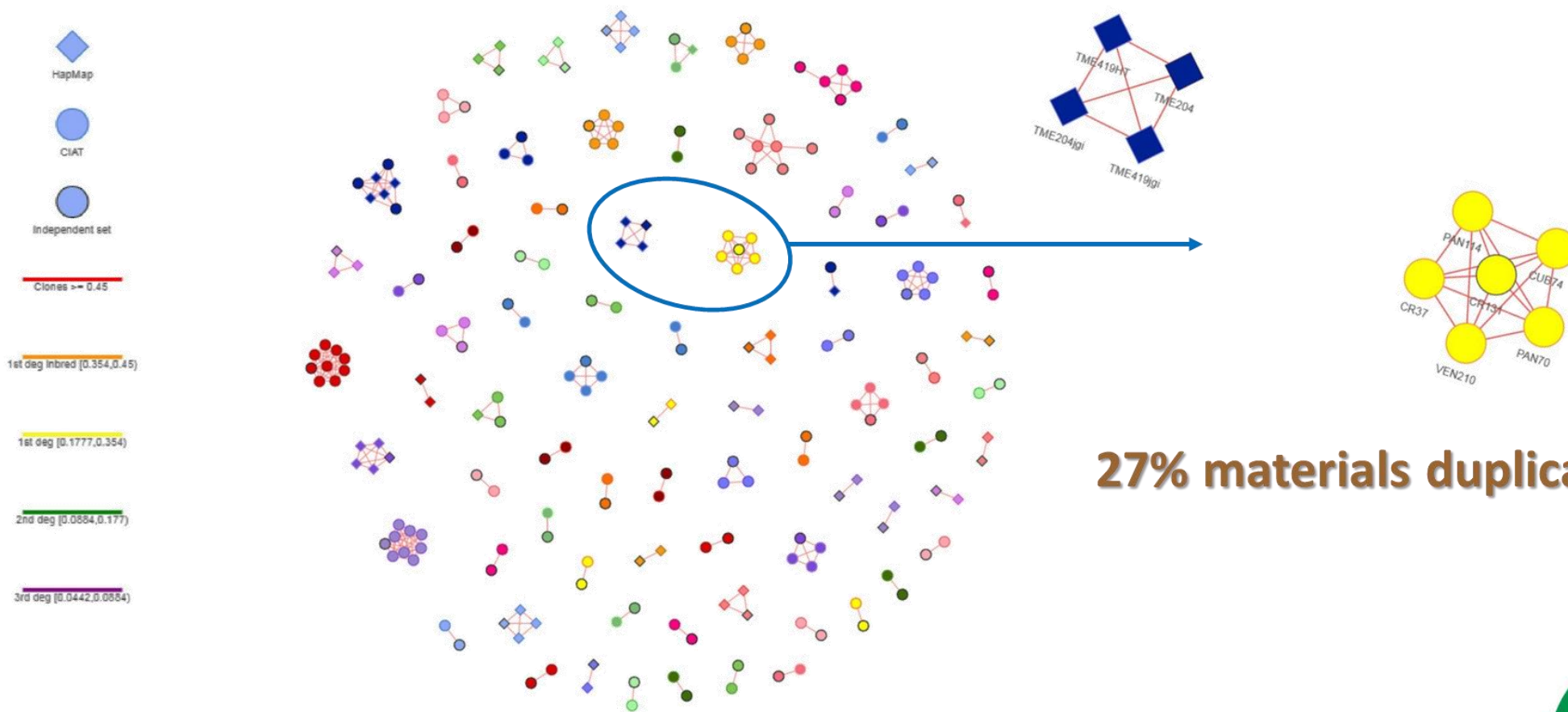
The cassava genome project has built upon a pilot initiated through the DOE-JGI Community Sequencing Program (CSP) b Tohme and Pablo Rabinowicz. This pilot project produced a little under 1x coverage from over 700,000 Sanger shotgun re insights into the overall characteristics of the cassava genome, and a valuable source of Sanger paired-end sequences to l generated (v4.1) in a project led by Steve Rounsley, Dan Rokhsar, Chinnappa Kodira, and Tim Harkins, This began in Spring partnered with DOE-JGI to provide the resources for a whole genome shotgun sequencing of cassava using the 454 GS FL

**AM560-2**

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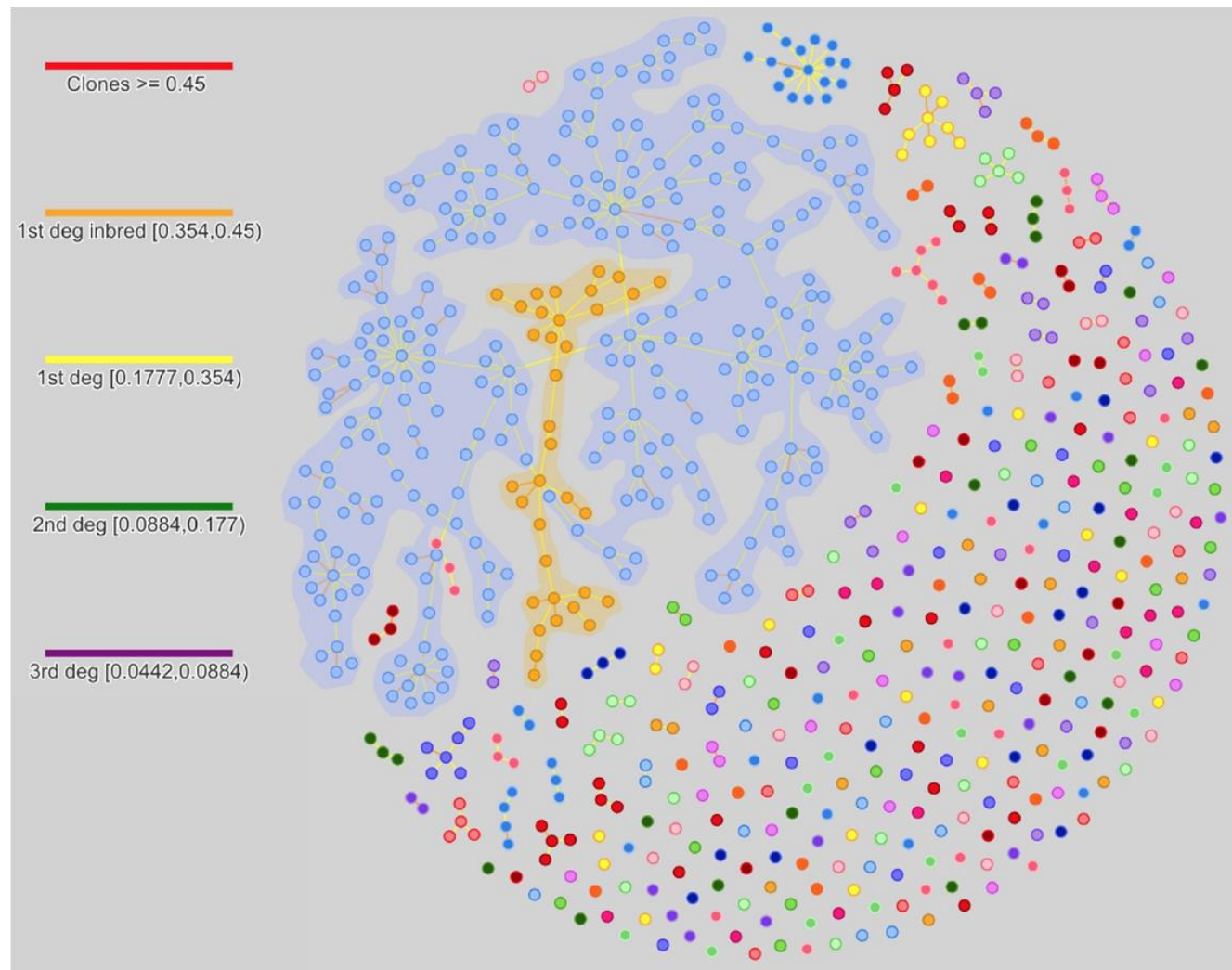
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# Kin relationship analysis: CIAT and HAPMAP



**27% materials duplicated**

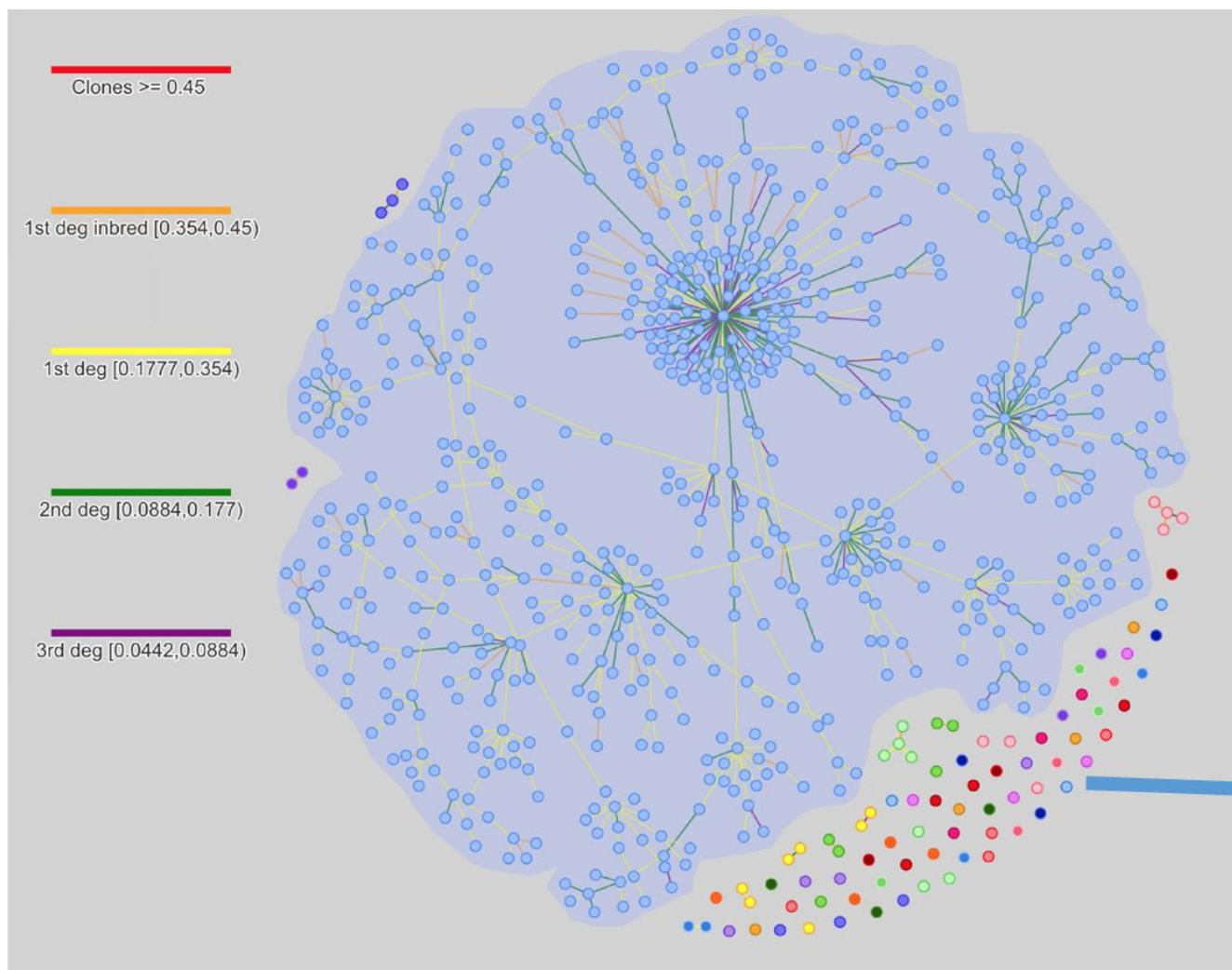
# Kin relationship analysis: CIAT and HAPMAP



**35% of cassava materials  
are related in first degree  
kinship**



# Kin relationship analysis: CIAT and HAPMAP

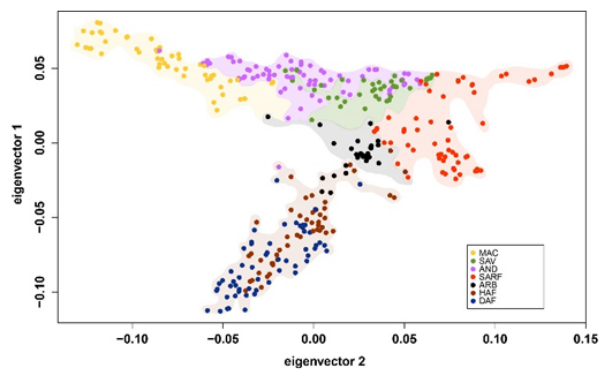


**88% of cassava materials  
are related at third degree  
of kinship**

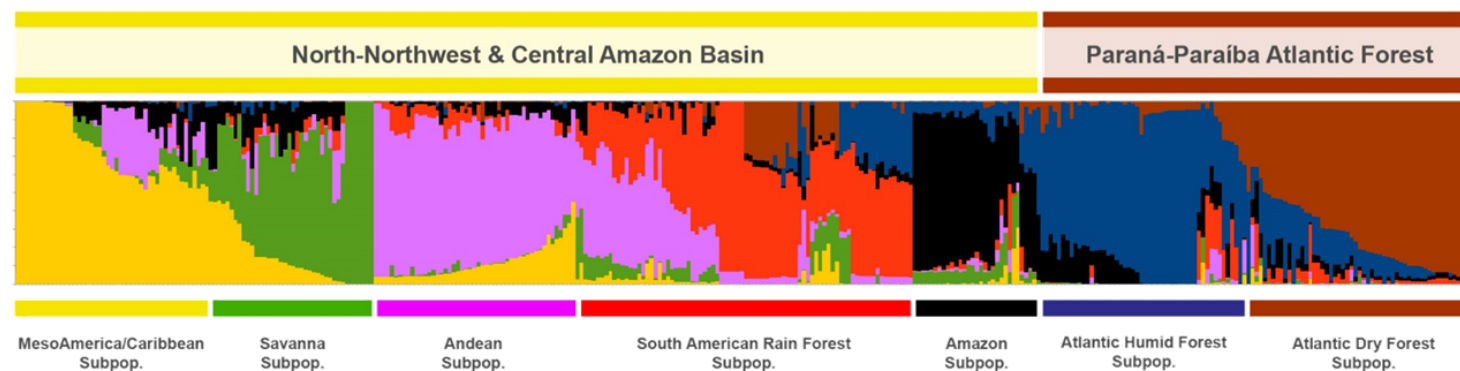
**12% of cassava materials  
are unrelated**



# Eco-geographic signature of the crop's domestication patterns



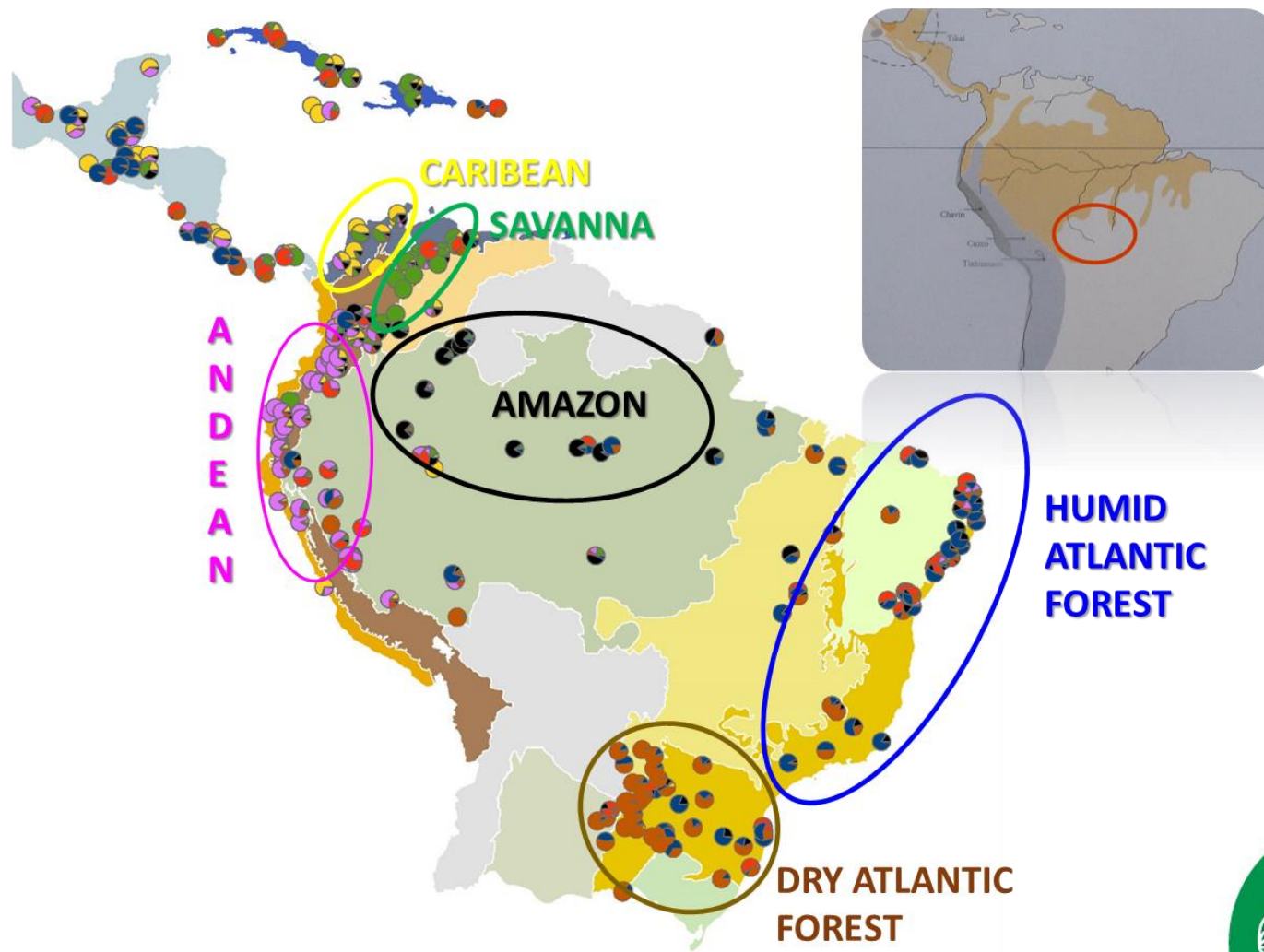
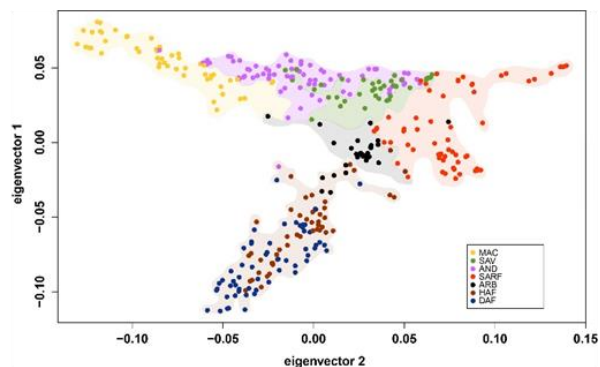
K7



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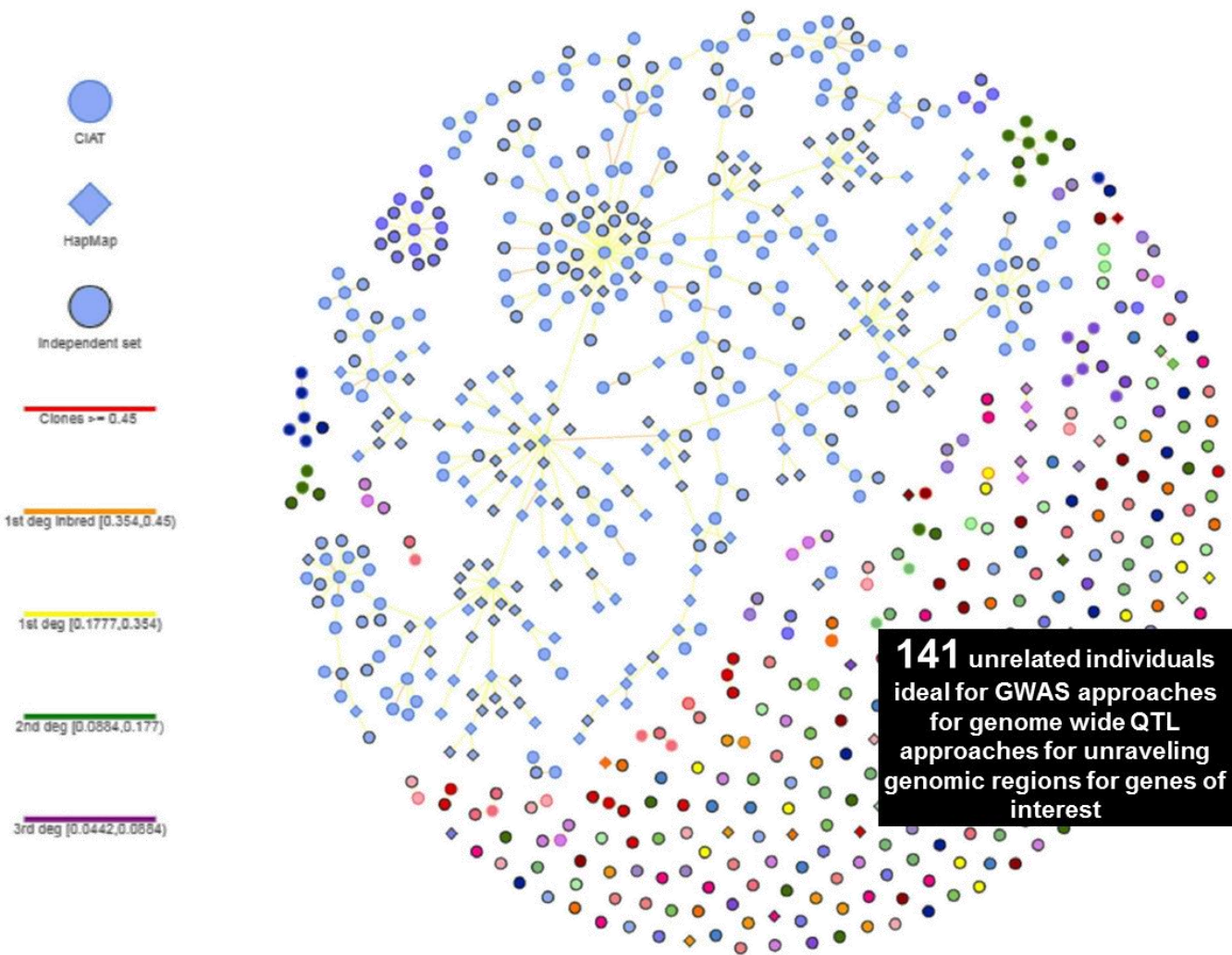




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# CIAT Trait Discovery Pipeline: Genomic-based screening



- Flowering
- High Cyanide
- Starch accumulation
- Frogskin disease
- Postharvest physiological deterioration (PPD)
- Carotenoids accumulation
- Cooking time
- Pectin content
- Whitefly resistant response

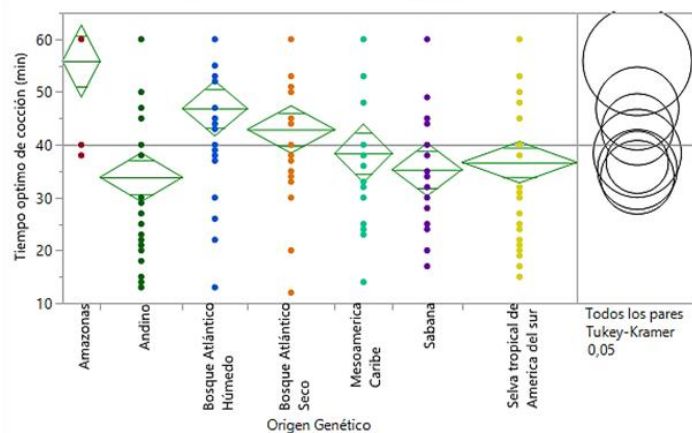
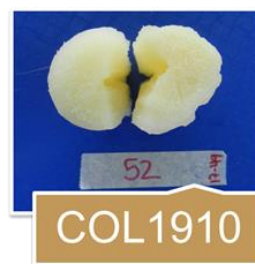


# CIAT Trait Discovery Pipeline: Genomic-based screening

10-15 min cooking time



>60 min cooking time

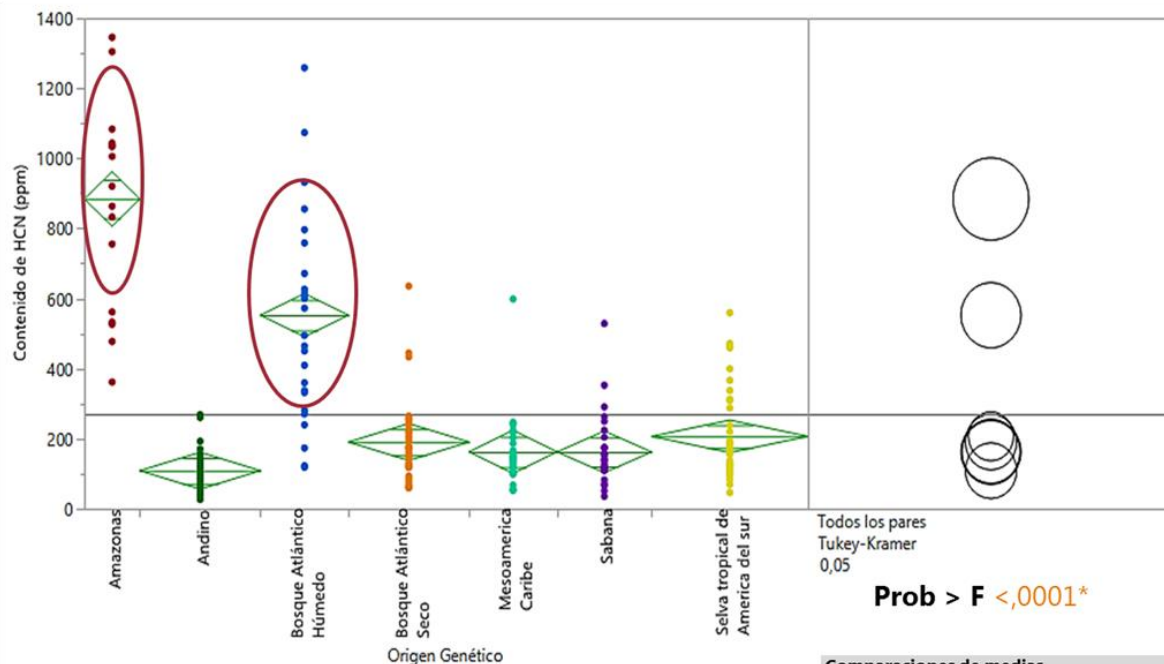


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# CIAT Trait Discovery Pipeline: Genomic-based screening

## CYANIDE CONTENT



Nivel	Número	Media	Extremo inferior del IC al 95%	Extremo superior del IC al 95%
Amazonas	17	884,529	806,75	962,31
Andino	37	109,108	56,39	161,83
Bosque Atlántico Húmedo	27	553,000	491,28	614,72
Bosque Atlántico Seco	37	190,919	138,20	243,64
Mesoamerica Caribe	27	163,000	101,28	224,72
Sabana	29	162,724	103,17	222,27
Selva tropical de America del sur	48	207,146	160,86	253,43

Comparaciones de medias	Media
Amazonas A	884,52941
Bosque Atlántico Húmedo B	553,00000
Selva tropical de América del sur C	207,14583
Bosque Atlántico Seco C	190,91892
Mesoamerica Caribe C	163,00000
Sabana C	162,72414
Andino C	109,10811

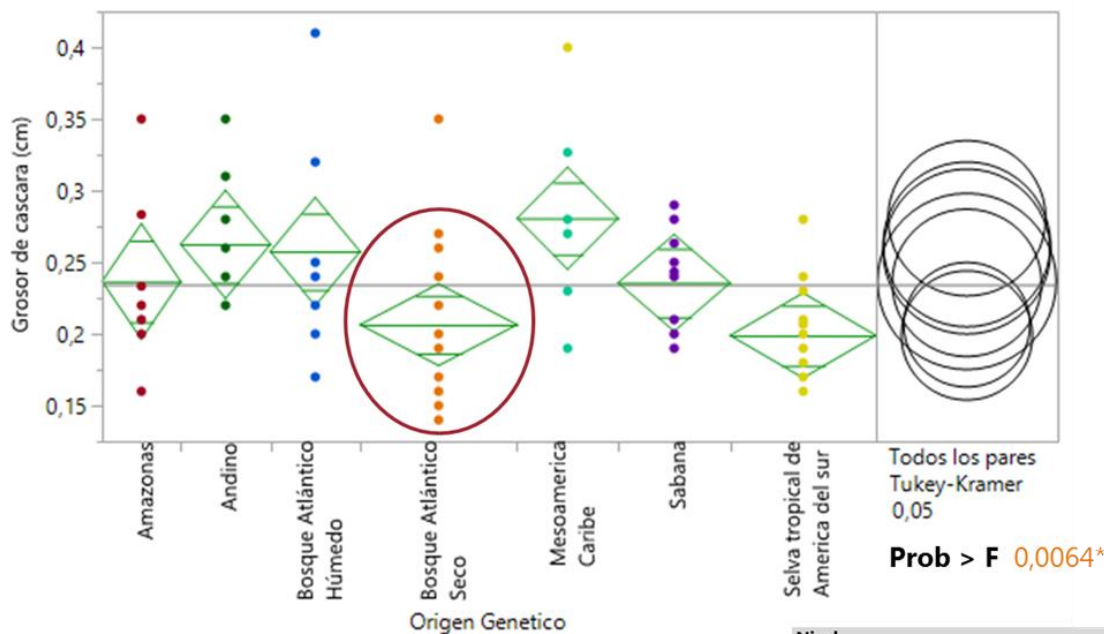
Los niveles no conectados por la misma letra son  
significativamente distintos



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# CIAT Trait Discovery Pipeline: Genomic-based screening

## PEEL THICKNESS



Nivel	Número	Media	Extremo inferior del IC al 95%	Extremo superior del IC al 95%
Amazonas	7	0,236667	0,19630	0,27703
Andino	8	0,262500	0,22474	0,30026
Bosque Atlántico Húmedo	8	0,257500	0,21974	0,29526
Bosque Atlántico Seco	14	0,206429	0,17789	0,23497
Mesoamerica Caribe	9	0,280741	0,24514	0,31634
Sabana	10	0,235667	0,20190	0,26944
Selva tropical de America del sur	13	0,198974	0,16936	0,22859

Nivel	Media
Mesoamerica Caribe	A 0,28074074
Andino	A B 0,26250000
Bosque Atlántico Húmedo	A B 0,25750000
Amazonas	A B 0,23666667
Sabana	A B 0,23566667
Bosque Atlántico Seco	B 0,20642857
Selva tropical de America del sur	B 0,19897436

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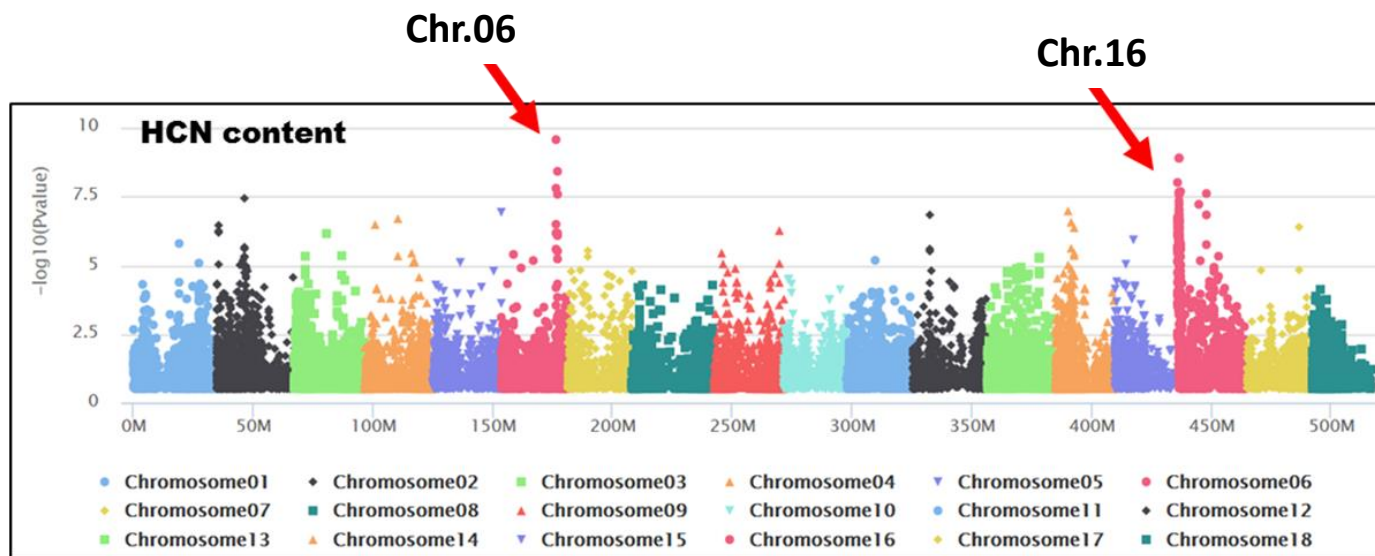


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# CIAT Trait Discovery Pipeline: Genomic-based screening

## CYANIDE CONTENT -GWAS



### Biosynthesis of the Cyanogenic Glucosides Linamarin and Lotaustralin in Cassava: Isolation, Biochemical Characterization, and Expression Pattern of CYP71E7, the Oxime-Metabolizing Cytochrome P450 Enzyme<sup>[1][OA]</sup>

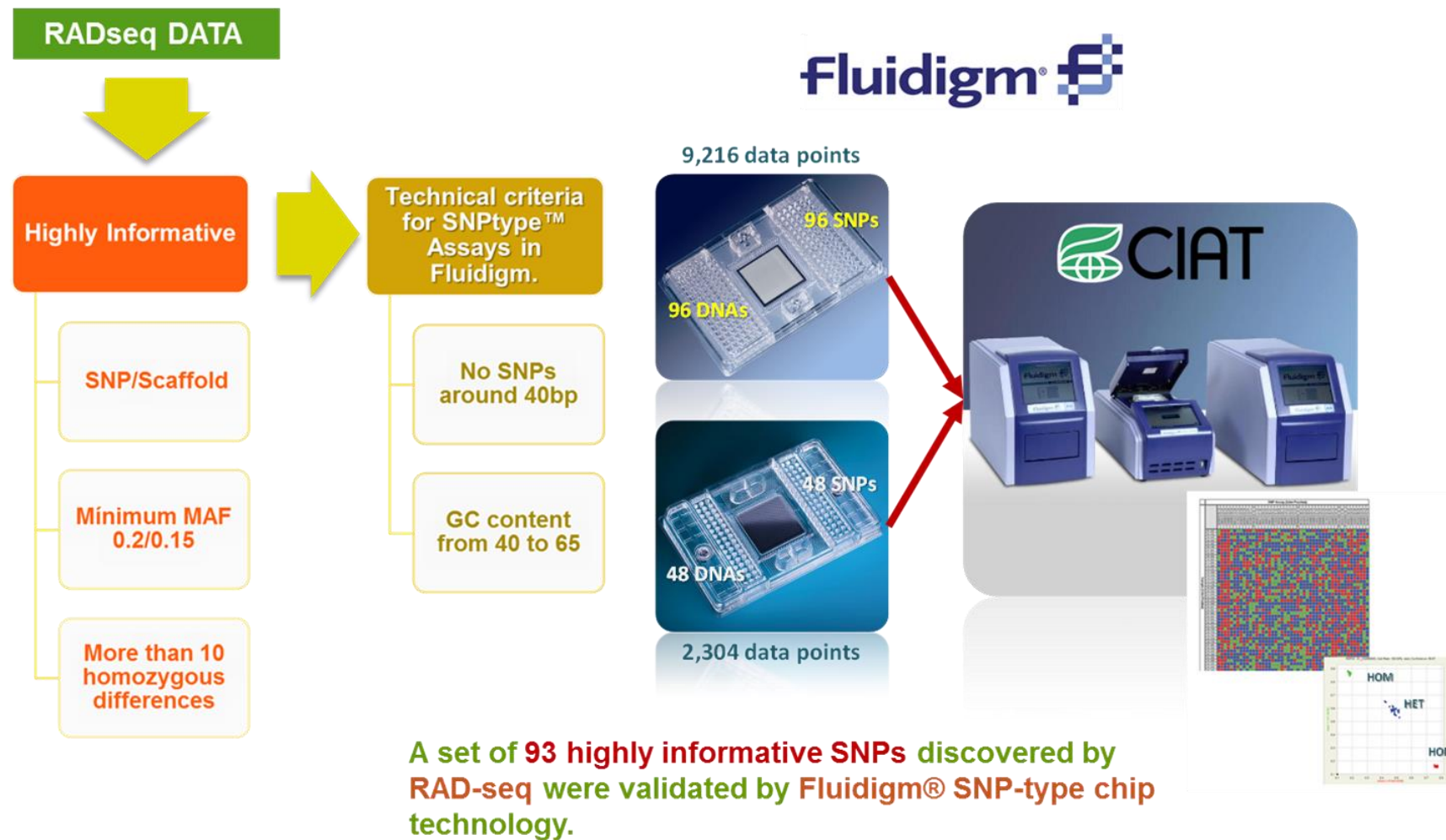
Kirsten Jorgensen, Anne Vinther Morant<sup>2</sup>, Marc Morant<sup>3</sup>, Niels Bjerg Jensen, Carl Erik Olsen, Rubini Kannangara, Mohammed Saddik Motawia, Birger Lindberg Møller, and Søren Bak\*

Plant Biochemistry Laboratory, Department of Plant Biology and Biotechnology, Villum Kahn Rasmussen Research Centre "Pro-Active Plants" (K.J., A.V.M., M.M., N.B.J., R.K., M.S.M., B.L.M., S.B.), Center for Synthetic Biology (K.J., M.S.M., B.L.M., S.B.), and Department of Basic Sciences and Environment (C.E.O.), University of Copenhagen, DK-1871 Frederiksberg C, Copenhagen, Denmark



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# Cassava SNP-type chip for variety identification



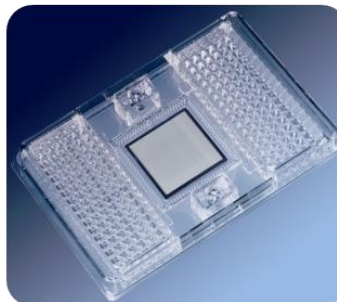


# Practical use of our genomic resources

Highly informative SNP  $MAF > 0.20$

**Fluidigm®**

**180 SNPs**

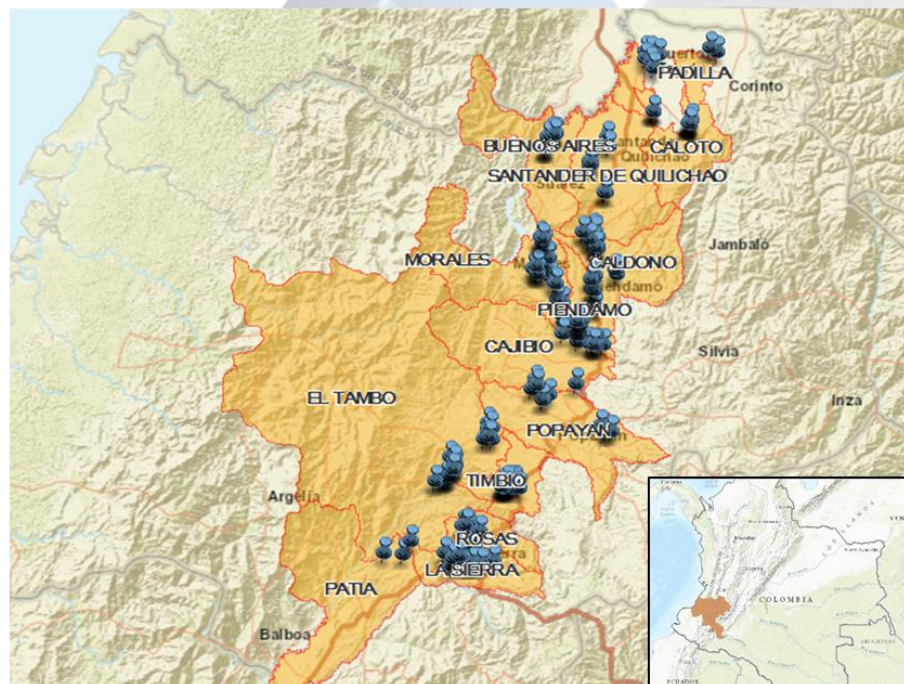


**217 households**

**1,200 samples**

**117 unique names**

**Varieties**





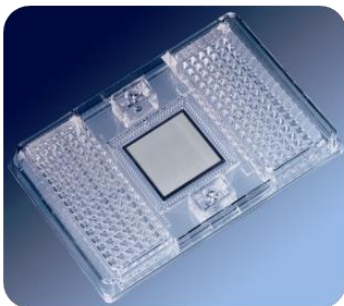
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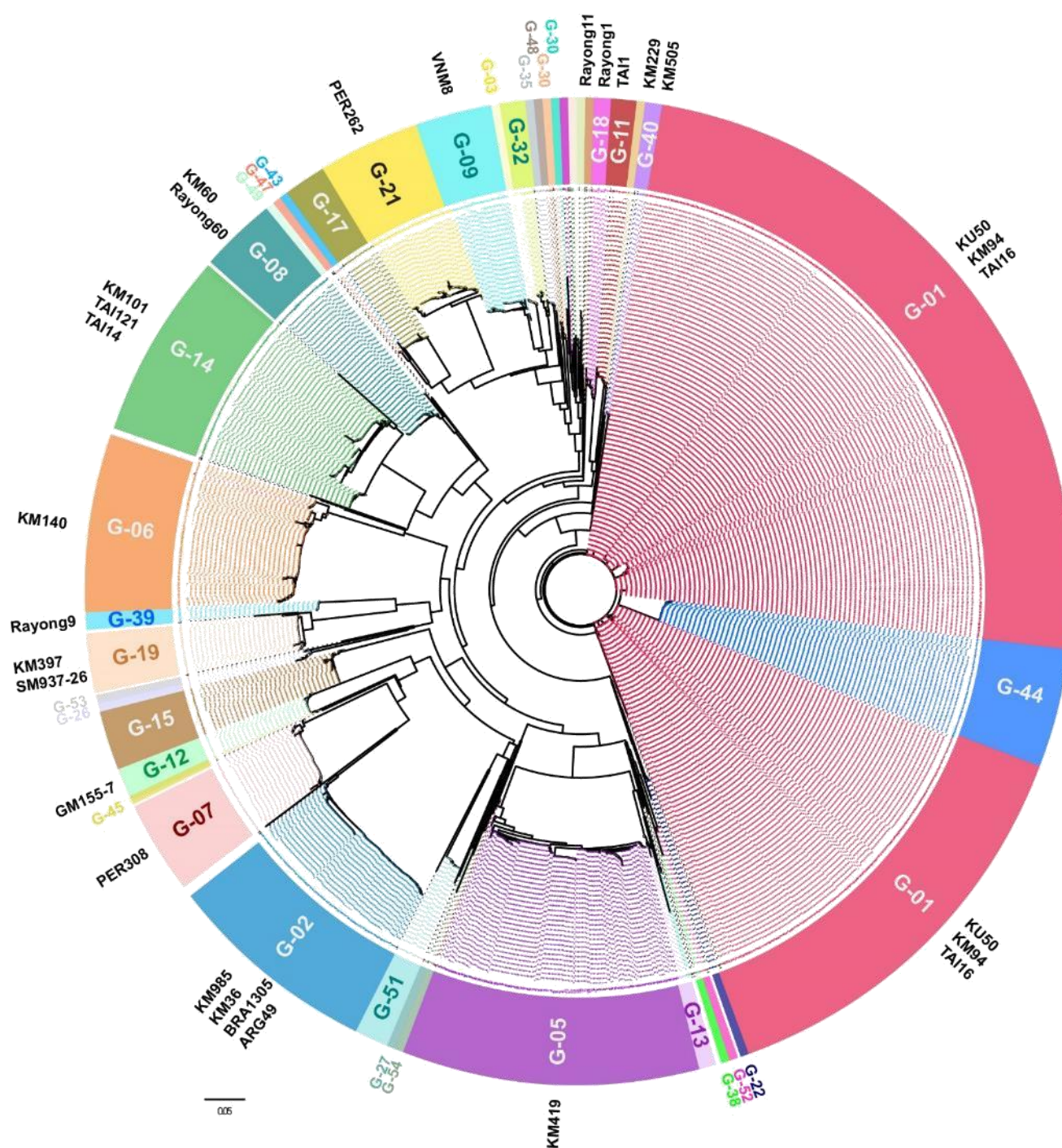


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## Variety identification





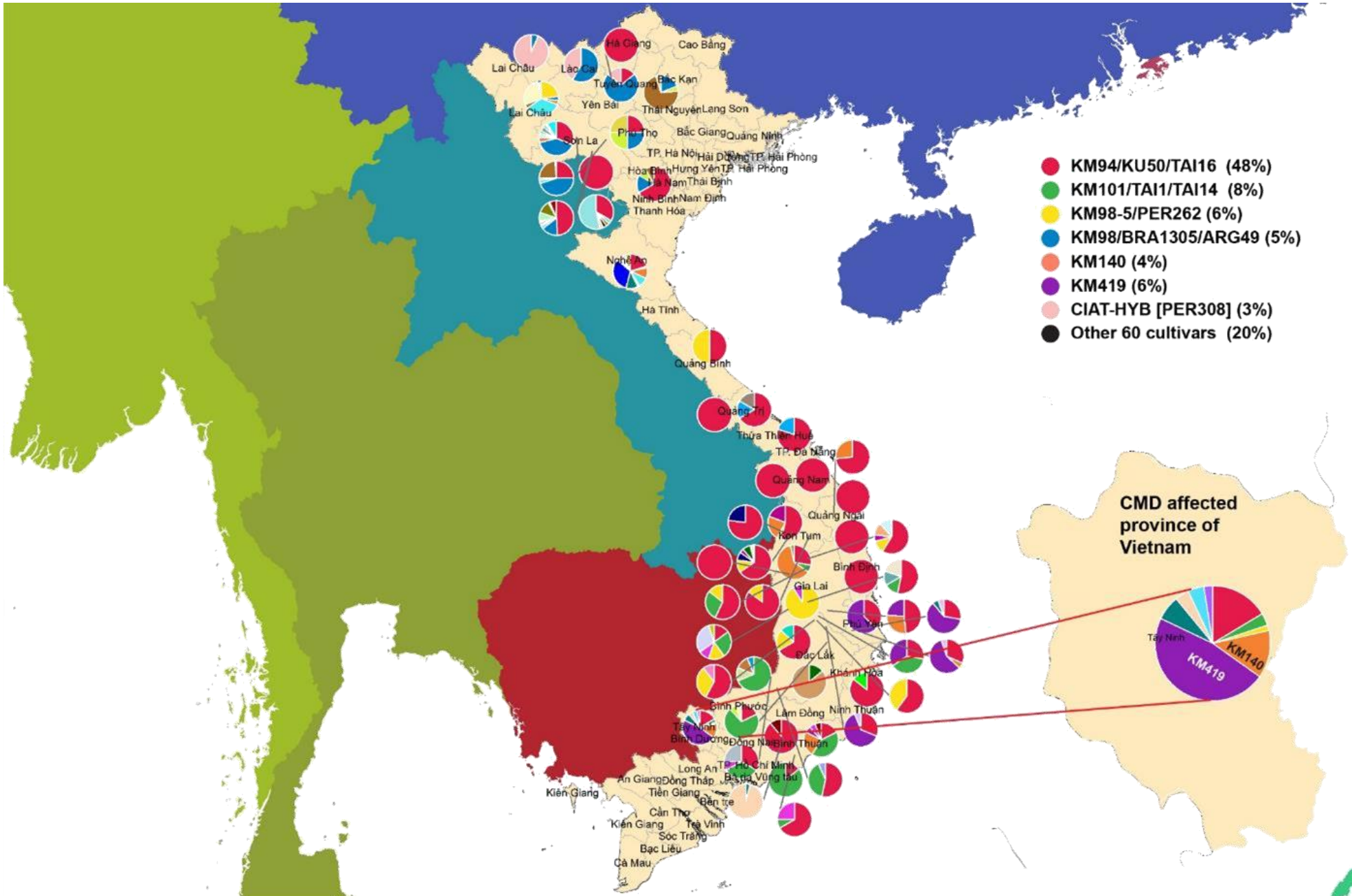
# Variety Composition across the landscape

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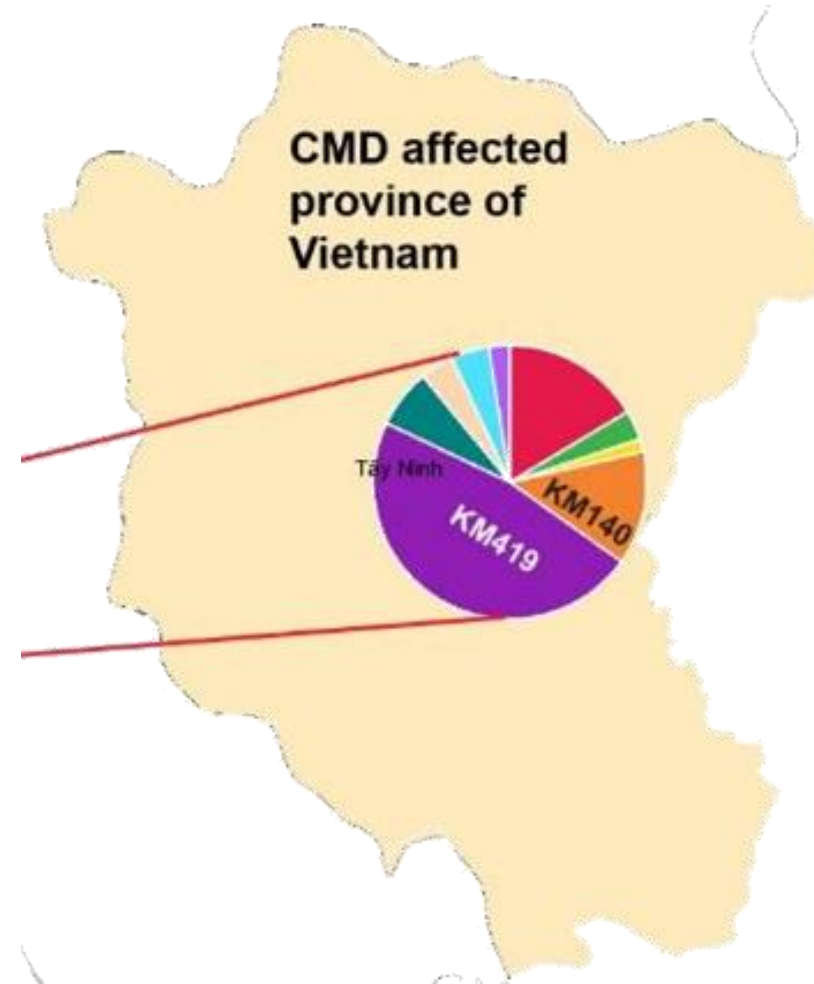
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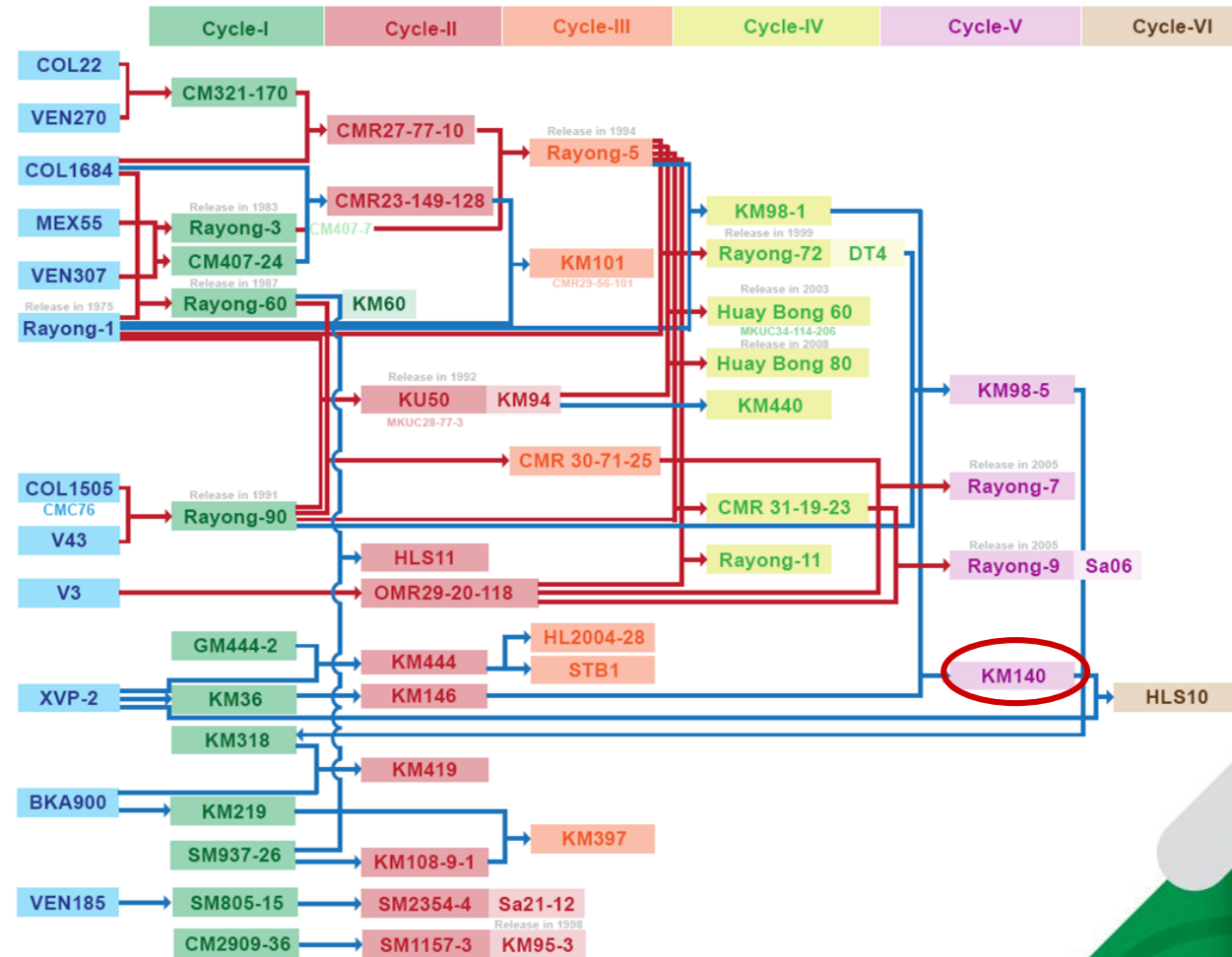
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## THAILAND and VIETNAM breeding pedigrees





# Cassava Variety Carrying CMD-2 gene based on available molecular markers

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**102 cassava cultigenes (1980 in total)**



Total	450 plants
-------	------------

(In word: Four hundred fifty plants)

Planting area: Agricultural Genetics Institute

Scale: 450 m2

2. For Importation procedure, AGI must follow plant ordinance, the plant protection law, phytosanitary law and other related laws.
3. AGI has responsibility to report the outcomes of importation and use of the aforementioned varieties to Department of Crop Production (Address No.2 Ngoc Ha road, Ba Dinh, Hanoi, Tel: 0243.8237.033, Fax: 0243.7344.967), Department of Agriculture and Rural Development at testing location.
4. Validity date of this permit ends on 30<sup>th</sup> of June, 2019

**Recipient:**

**On behalf of Head of Department**

## PLANT IMPORT PERMIT

In response to Decision No. 929/QĐ-BNN-TCCB, dated March, 24<sup>th</sup> 2017, defining functions, duties, powers and organizational structure of Department of Crop Production;

In response to the application for plant import permit by National Key Laboratory for Plant Cell Biotechnology (NKLPCB) - Agricultural Genetics Institute (AGI) No. 07/VDT-PTNTD, September, 11<sup>th</sup> 2018,

Department of Crop Production allow to permit NKLPCB to import 102 clones with 1530 plants (detail in Appendix):

Purpose of importation: Evaluation

Permitted time of importation: from signed day to 31/12/2019

Import place: Noi Bai international airport



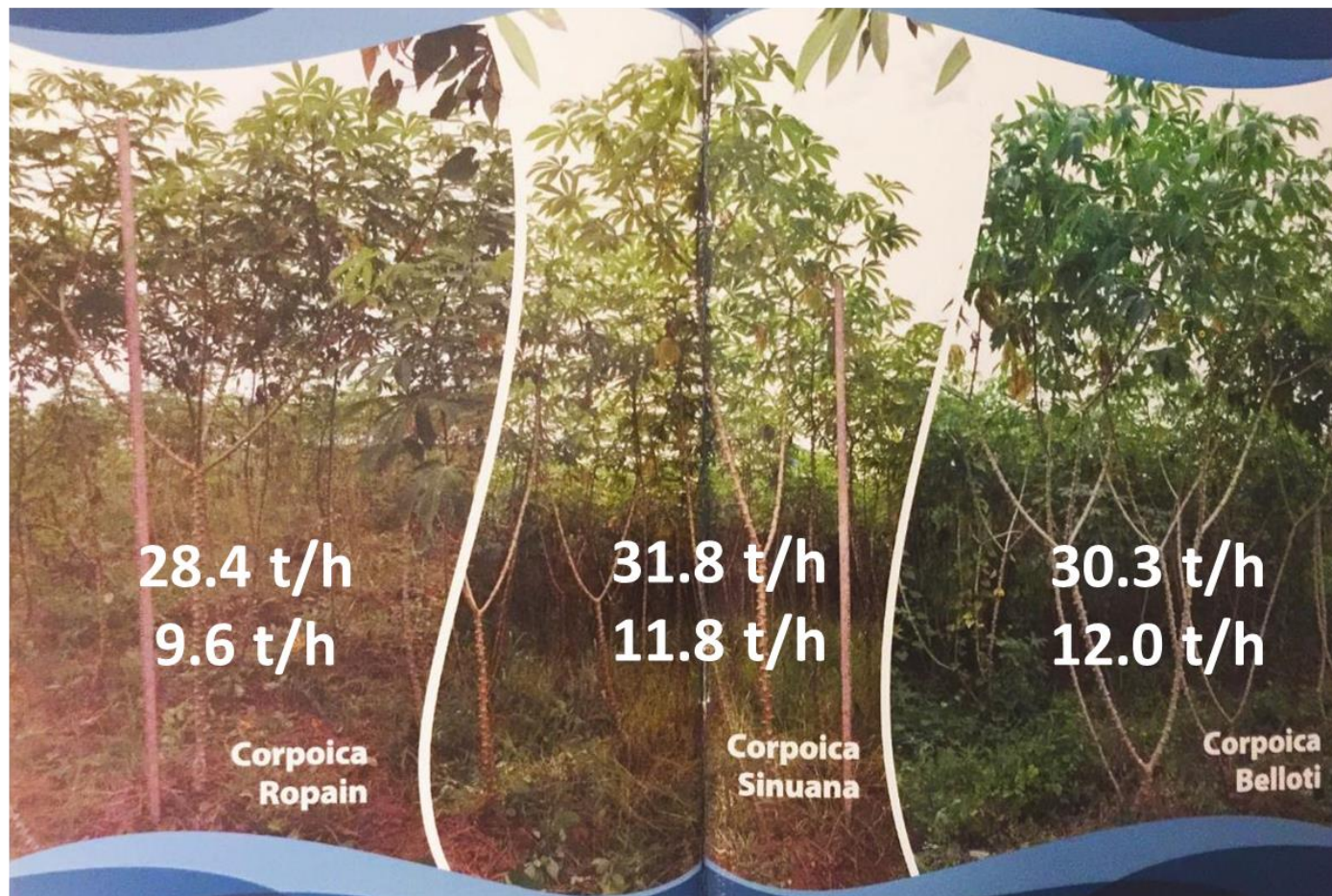
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# 2017's released cassava varieties



RESEARCH  
PROGRAM ON  
**Roots, Tubers  
and Bananas**







International Center for Tropical Agriculture  
*Since 1967 Science to cultivate change*



A CGIAR Research Center

Headquarters  
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P.O. Box 6713, Cali, Colombia  
Phone: +57 2 445 0000

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# THANK YOU