

# Progress and challenges in genetic improvement of yam (*Dioscorea alata* L.)

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# Greater yam- a food crop of great potential

- Second to *D. rotundata* in the in volume of production
- Long storability of tubers
- High yield potential
- Ease of propagation
- Early growth vigour for weed suppression

# Major constraints

- Polyploid species ( $2n=40,60,80$ )
- Low fertility of cultivars
- Dioecy
- Reduced synchrony periods between males and females cultivars
- Less quality than *D. rotundata*
- Anthracnose disease: caused by fungal *Colletotrichum gloesporioides*.

# Most important criteria of breeding

- Tolerance to Anthracnose (*Colletotrichum gloesporoides*)
- Tuber quality
- High yield and stability yield

# Genetic Resources

- About 200 accessions (8 different species)



D. Nummularia

D. alata

D. rotundata

- *D. alata* cultivars with different ploidy level ( $2n=40, 60, 80$ ) from Vanuatu, Pacific South (diversification center)
- Large diversity for important traits: tuber quality, yield potential, tolerance to anthracnose (many resistance sources)



Flesh color



Anthracnose

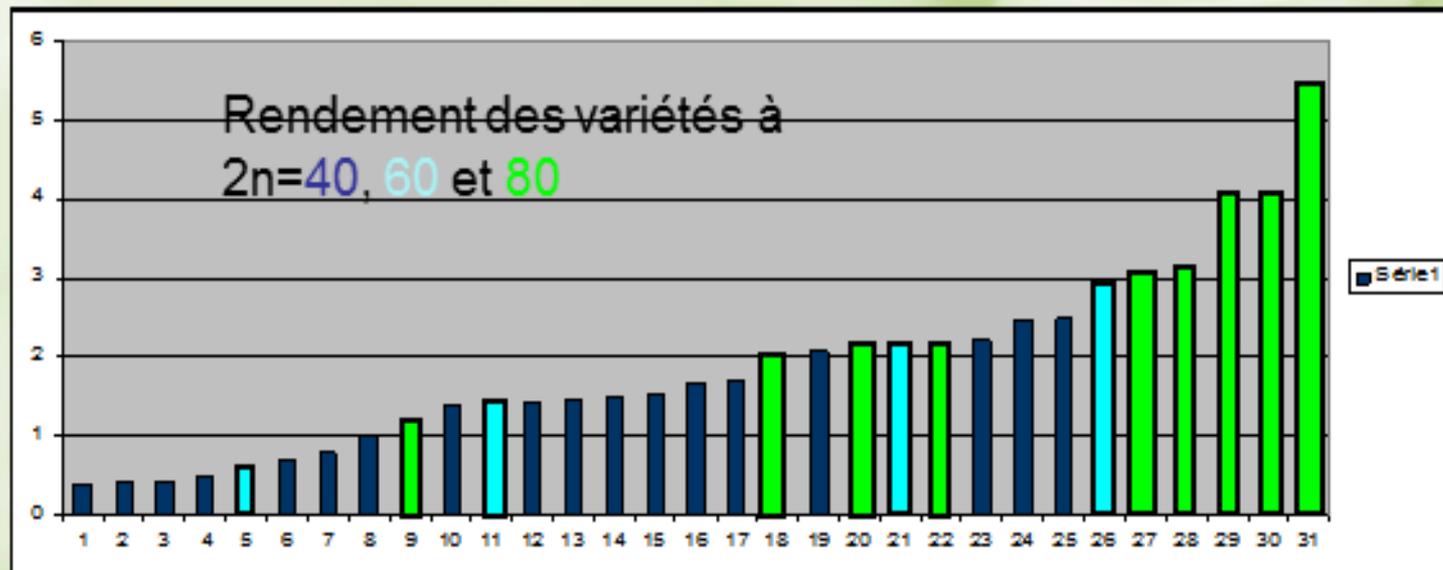
# Facilities

- Important yam collections (working collection, CRB-PT- Biological resources Centre for Tropical Plants INRA-CIRAD)
- C.I.V lab
- BM Lab
- Flow cytometry
- Field trials
- Different research Instituts (INRA, CIRAD, University)

# Breeding Approach:

## Production of polyploids (3x and 4x)

- **Ploidy increased in *D.alata* is correlated with better agronomic performances** : higher and more stable tuber yield and increased tolerance to abiotic and biotic stress



(Malapa et al., 2005; Lebot, 2009; Arnau et al., 2010; Arnau et al., 2014)

# Main Achievements:

**1-** Useful knowledges for the genetic improvement programs were acquired by using cytogenetic techniques and molecular markers.

**2-** Advances in breeding

# Revision of the basic chromosome number of *D. alata*

- $x = 20$  and not  $x=10$

$$2n = 40 = 4x? \rightarrow 2x$$

$$2n = 60 = 6x? \rightarrow 3x$$

$$2n = 80 = 8x? \rightarrow 4x$$

- by microsatellite segregation analysis on several progenies

*Arnau et al., 2009 Theor Appl Genet.*

# Type of inheritance of tetraploid varieties (auto or allo- tetraploid)

- The tetraploid **varieties are autopolyploid**
- by cytological analyses and microsatellite marker segregation analysis.

Abraham et al., 2012 *Genetic Res and Crop Evol*; Nemorin et al., 2013 *Mol Breeding*.

# Understanding the origin of polyploid spontaneous (3x, 4x)

- Evidence of the **formation of unreduced gametes**
- and **endosperm incompatibility phenomena**
- by analyzing the heterozygosity transmitted and the endosperm incompatibility phenomena, in several progenies (intra and intercytotypes).  
Nemorin *et al.*, 2013 *Annals of Botany*

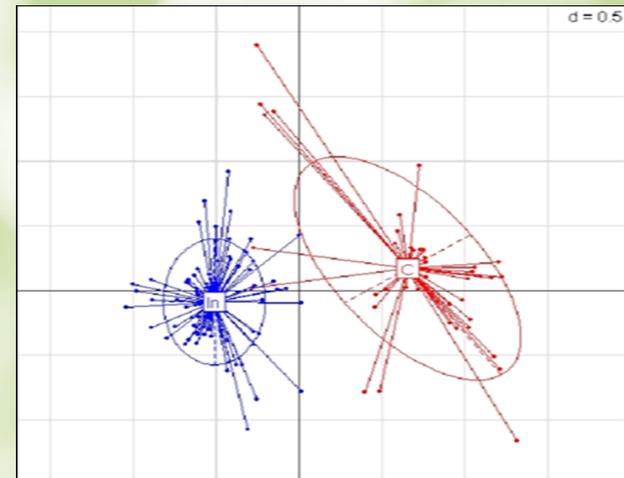
# Acquisition of knowledge about crosses allowing to obtain polyploids

Crosses		Expected hybrids	Expected ploidy of endosperm	Ratio GM/GP	hybrids obtained
Female	Male				
$2x(n)$	$2x(n)$	$2x$	$3n$	2 : 1	$2x$
$2x(2n)$	$2x(n)$	$3x$	$5n$	2 : 1	$3x$
$2x(n)$	$2x(2n)$	$3x$	$4n$	2 : 2	$3x$ SEI
$2x(2n)$	$2x(2n)$	$4x$	$6n$	2 : 1	-
$2x(n)$	$4x(2n)$	$3x$	$4n$	2 : 2	$3x$ SEI
$2x(2n)$	$4x(2n)$	$4x$	$6n$	2 : 1	$4x$
$4x(2n)$	$2x(n)$	$3x$	$5n$	4 : 1	rien
$4x(2n)$	$2x(2n)$	$4x$	$6n$	2 : 1	$4x$
$3x(2n)$	$2x(2n)$	$4x$	$6n$	2 : 1	rien
$3x(2n)$	$4x(2n)$	$4x$	$6n$	2 : 1	rien
$4x(2n)$	$4x(2n)$	$4x$	$6n$	2 : 1	$4x$

GM / GP: maternal genome / paternal genome; SEI: immature embryo rescue

# D. Alata diversity and conservation

- 4 collections from  
IITA  
CRB-TP  
CTCRI  
CIRAD
- Genotyping with SSRs
- Identification of  
Worldwide genetic diversity  
Worldwide structure  
Duplicates

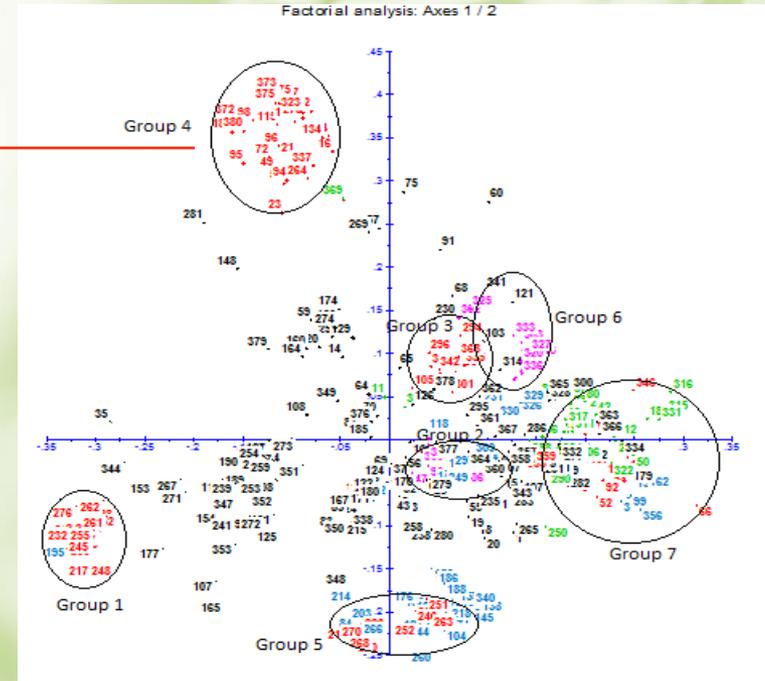


384 accessions x 24 SSRs

Results revealed a **significant structuring of diversity** that is linked to geographic origins, ploidy levels and morpho-agronomic characteristics.

# Arnau G, Bhattacharjee Sheela MM, Chair H et al. in prep

Collector	Accession code	Geographic origin	Local name	Type of access	level ploii	Study code	Identified groups
IITA	TDa-1209	Togo	TSROKPA 784	C	2	16	4
IITA	TDa-3207	Togo	TIFIUO BH-32 1125	C	2	21	4
IITA	TDa-3912	Benin	HAWAI	C	2	23	4
IITA	TDa-3764	Nigeria	Unknown	C	2	34	4
IITA	TDa-1065	Togo	DODGANON TSROKPA	C	2	49	4
IITA	TDa-1190	Benin	BE 114	C	2	51	4
IITA	TDa-3226	Togo	SAKATA KOUMONKOI	C	2	57	4
IITA	TDa-1196	Cote d'Ivoire	IC 28	C	2	75	4
IITA	TDa-1387	Nigeria	OBUNEYI	C	2	89	4
IITA	TDa-3902	Benin	BONIYOURO	C	2	94	4
IITA	TDa-4126	Sierra Leone	Unknown	C	2	95	4
CRB-PT	I-54	Caribbean (Ma)	ST VINCENT BLANC 2	C	2	72	4
CRB-PT	I-115	Caribbean (Pu)	SEA 144	C	2	96	4
CRB-PT	I-119	Unknown		C	2	97	4
CRB-PT	I-84	Caribbean (Gu)	DA 28	C	2	98	4
CRB-PT	I-34	Caribbean (Ste)	ST VINCENT YAM	C	2	115	4
CRB-PT	I-429	Unknown	TI JOSEPH	C	2	134	4
CRB-PT	I-59	Caribbean (Pu)	VINO WHITE FORME	C	2	151	4
CRB-PT	I-71	Caribbean (Pu)	SMOOTH STATIA	C	2	168	4
CRB-PT	I-452	Unknown		C	2	173	4
CRB-PT	I-62	Caribbean (Hai)	BACALA 2	C	2	175	4
CRB-PT	I-42	Caribbean (Ma)	ST VINCENT BLANC 1	C	2	181	4
CRB-PT	I-620	Caribbean (Gu)	St VINCENT MART.	C	2	278	4
CRB-PT	I-64	Caribbean (Ma)	ST VINCENT VIOLET	C	2	370	4
CRB-PT	I-69	Caribbean (Cu)	CUBA 1	C	2	371	4
CRB-PT	I-70	Caribbean (Cu)	MORADO	C	2	372	4
CRB-PT	I-79	Caribbean (Gu)	GRAND ETANG	C	2	373	4
CRB-PT	I-86	New Caledoni	WENEFELA BIS	C	2	374	4
CRB-PT	I-92	Caribbean (Pu)	PURPLE LISBON	C	2	375	4
CRB-PT	I-386	Caribbean (Gu)	SAINTE CATHERINE	C	2	380	4
CTCRI	Da322	india (Chattisg)	Unknown	C	2	212	4
CTCRI	Da330	india	Unknown	C	2	264	4
CIRAD	VU579	Vanuatu	LETSLETS BOKI	C	2	318	4
CIRAD	VU567	Vanuatu	LETSLETS BOLOS	C	2	323	4
CIRAD	VU678	Vanuatu	NOWANAO	C	2	337	4



The Data obtained will be useful for a better rationalization in the use of genetic resources in the breeding programs across different regions and improving the methods of conserving the genetic resources of this species

# Ongoing projects

- « **Africa yam project** » funded by the Bill and Melinda Gates Foundation

Meta-QTL analysis on four populations produced by IITA and CIRAD (two each) to acquire knowledge about control genetic of different characters that determine the tuber quality. Identify markers associated with the genomic regions that determine the quality.

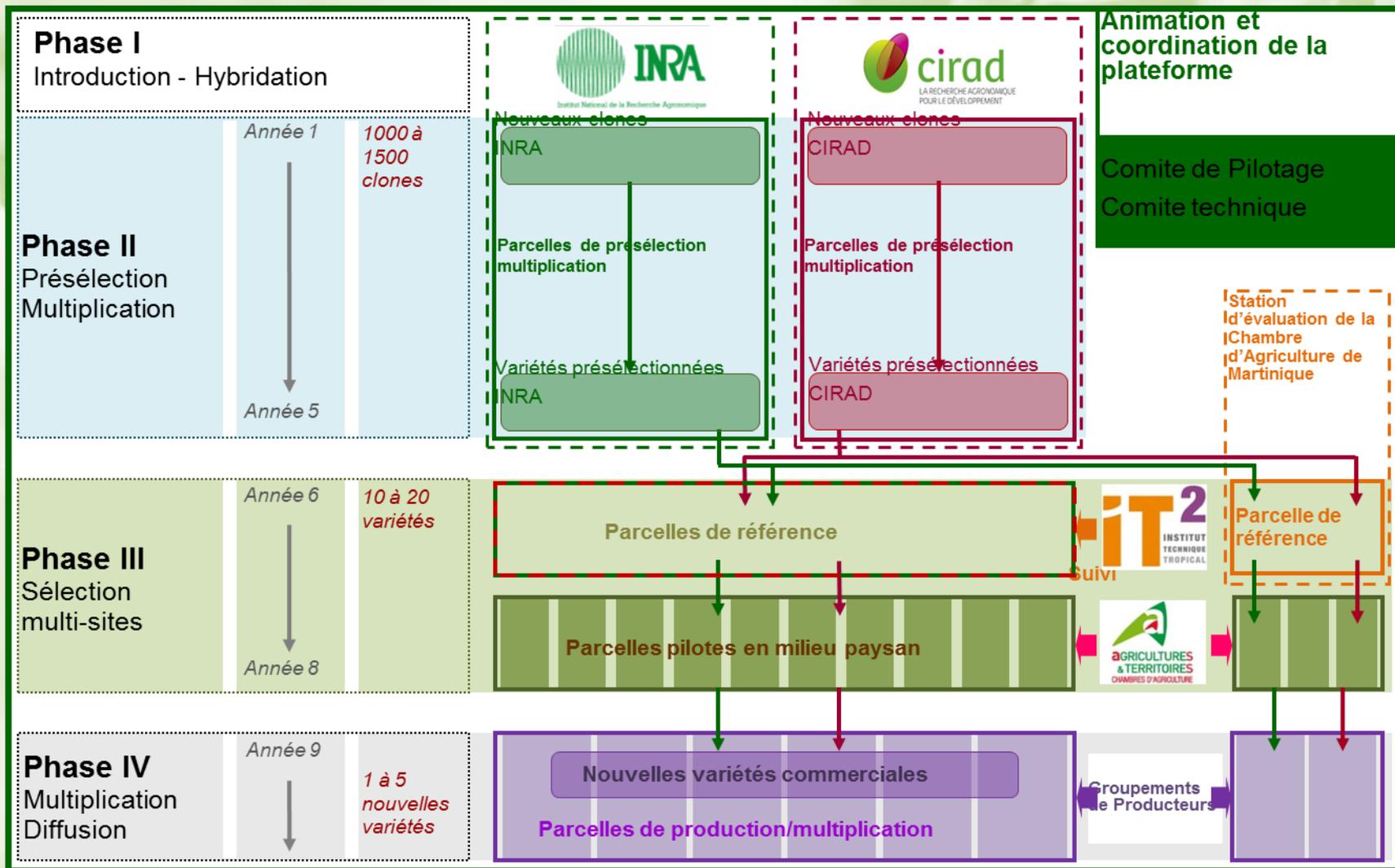
- « **Cavalbio project INRA-CIRAD** » funded by Région Guadeloupe

Meta-QTL analysis on populations produced by INRA and CIRAD to expand the knowledge about the anthracnose resistance sources useful for breeding

# Advances in polyploidy breeding

- During 2006-2009, a large scale of tetraploid were produced by crosses between selected tetraploid cultivars and evaluated at the CIRAD Station in Guadeloupe.
- Superior clones were selected and evaluated since 2012 in farming systems using a participatory approach in Guadeloupe and Martinique

# Participatory approach in Guadeloupe and Martinique



# Participatory approach in Guadeloupe and Martinique

First three improved tetraploid varieties will be released in 2016 (4x-438-Ciradienne, 4x-242-Dou, 4x-431-Roujol)



# Advances in polyploidy breeding

- Production of new tetraploid genitors by doubling chromosomal stock from elite diploid varieties (resistant to anthracnose) using treatment colchicine
- Production of new tetraploid progenies in 2014 by crossing elite parental genotypes generated

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