arcad

a structuring node in the French plant genetic resource conservation system

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agropolis fondation
Supporting agricultural research for sustainable development

ARCAD

- A node within a decentralized system
- Building on historical assets
- Facilities, research, training
- Scientific focus
- Some ongoing activities

The French plant genetic resource conservation system

- No national genebank = Decentralized system
- Temperate and Mediteranean species:
  - A specific conservation network for each of the main species (maize, wheat, grapvine, etc) which associates public and private partners
- Tropical species
  - Collections mainly built in the 80’s
  - Maintained in Montpellier, Indian Ocean and French West Indies
  - Labelled Biological Resource Centers ensure high conservation standards
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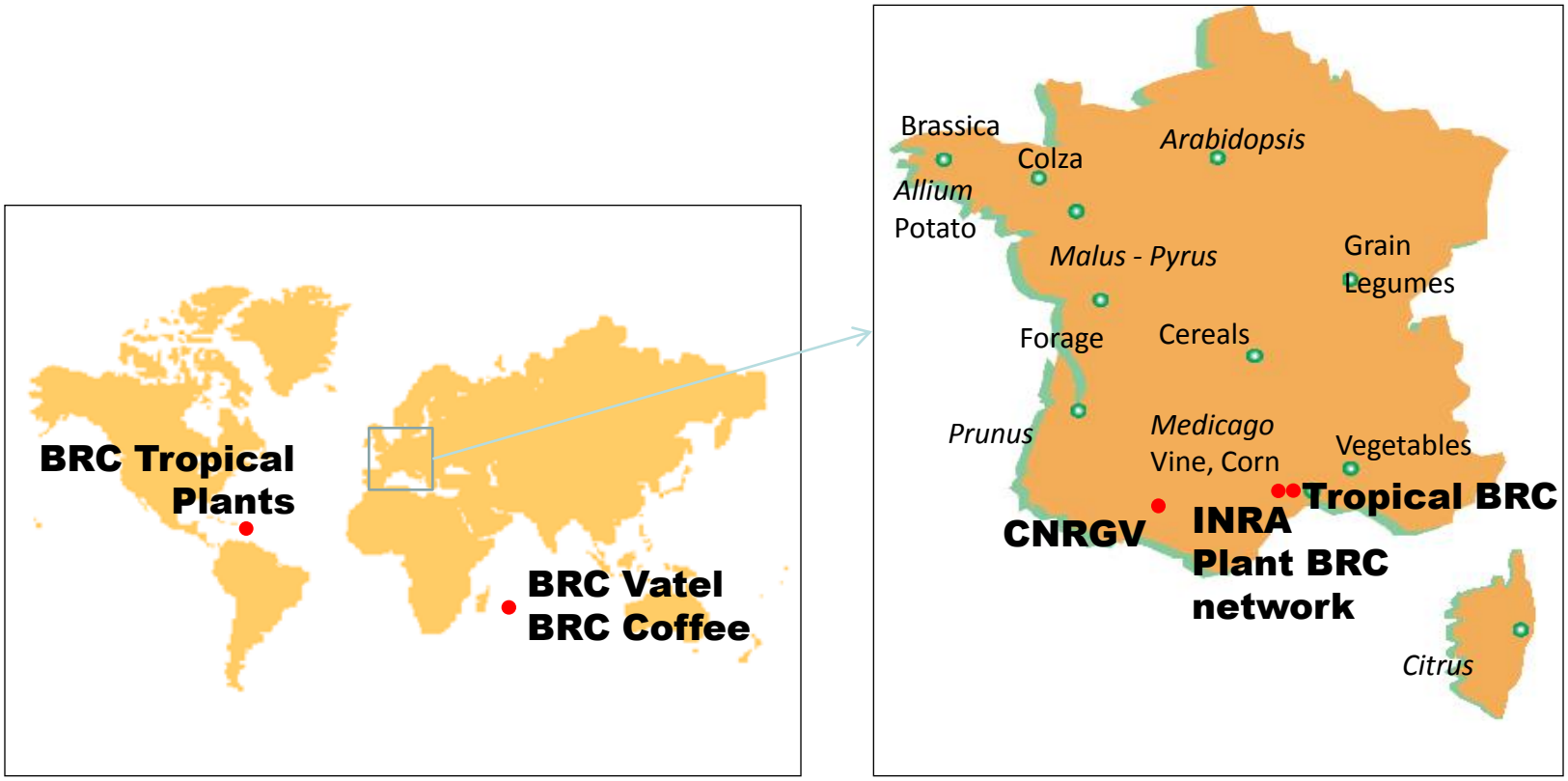

BRC Tropical Plants
BRC Vatel
BRC Coffee
Brassica
Colza
Arabidopsis
Allium
Potato
Malus - Pyrus
Grain Legumes
Forage
Cereals
Prunus
Medicago
Vine, Corn
Vegetables
Tropical BRC
CNRGV
INRA Plant BRC network
Citrus

Plus and Minus of a decentralized system

- **Plus**
  - Resilience
  - Various stakeholders involved
  - Scientists involved in conservation : links w/ research
- **Minus**
  - Lack of coordination (no national information system)
  - Lack of visibility in the international environment in front of « big players »
  - Not a strong voice in international debates
  - New tools

Agropolis, Montpellier: historical assets

- PGR collections
  grapevine, rice, maize, pearl millet, sorghum, Medicago, etc): >100 000 accessions

BRC name	Institute	Collections	Number of accessions	IBiSA certified
Coffee Tree (Reunion Island & Montpellier)	IRD	Coffee tree	840	Yes
Tropical Plants (Guadeloupe & Martinique)	Cirad-INRA	Pineapple	500	Yes
		Banana	400	
		Sugarcane	1 200	
		Herbarium	10 000	
		Yam	500	
		Mango	100	
Tropical (Montpellier)	Cirad	Rice	50 000	Yes
		Sorghum	30 000	
VATEL (Reunion Island)	Cirad	Vanila	700	Yes
		Tropical garlic	40	
		Underutilized vegetables	120	
INRA Network of Crops BRCs (distributed on 10 locations)	INRA	*Arabidopsis sp*	70 000	Yes
		Medicago truncatula	14 500	
		Corn	5 200	
		Sunflower	5 480	
		Vine	8 250	
		Cereals	31 200	
		Vegetables	14 200	
		Grain legumes	15 900	
		Brassica sp & rape	1 830	
		Potato	10 500	
		Malus & *Pyrus*	7 800	
		Prunus	5 300	
		Forages	3 500	
	INRA & CIRAD	*Citrus*	1 020	

Agropolis: historical assets

- PGR collections
  (grapevine, rice, maize, pearl millet, sorghum, Medicago, etc)
  >100 000 accessions
- Expertise in genetics, genomics and evolutionary biology

Agropolis, Montpellier: historical assets

etc

2004

Consortium international

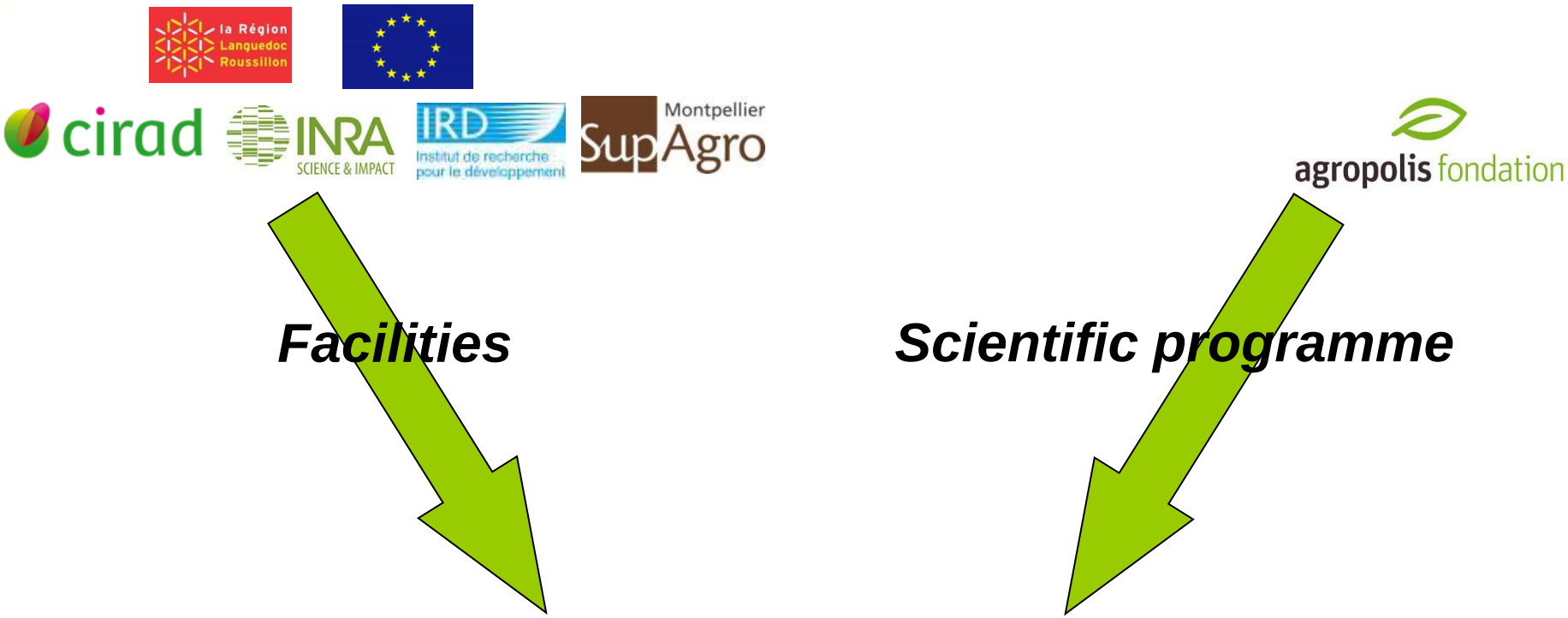
First crop genome sequence
France: chromosome 12

2012

France Génomique 2013 contributes re-sequencing of 7500 rice accessions

Genome analysis

key to access to genetic diversity



ARCAD : a multi institutional initiative on agrobiodiversity

Objective

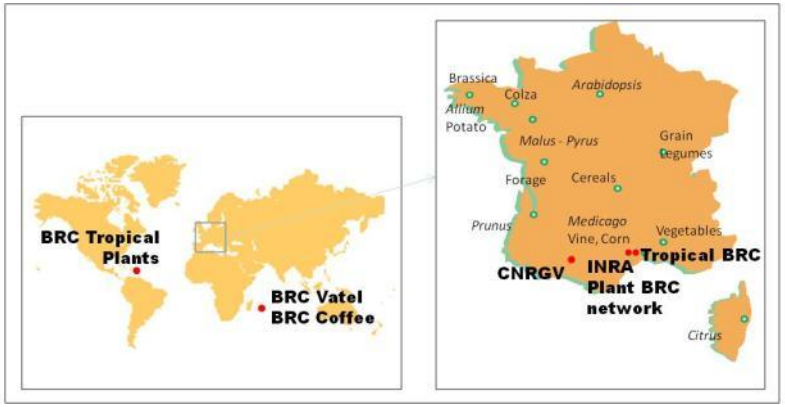
2100m² 50 scientists M€ 10

Conservation + DNA Technologies

Research + Training

Bring Together

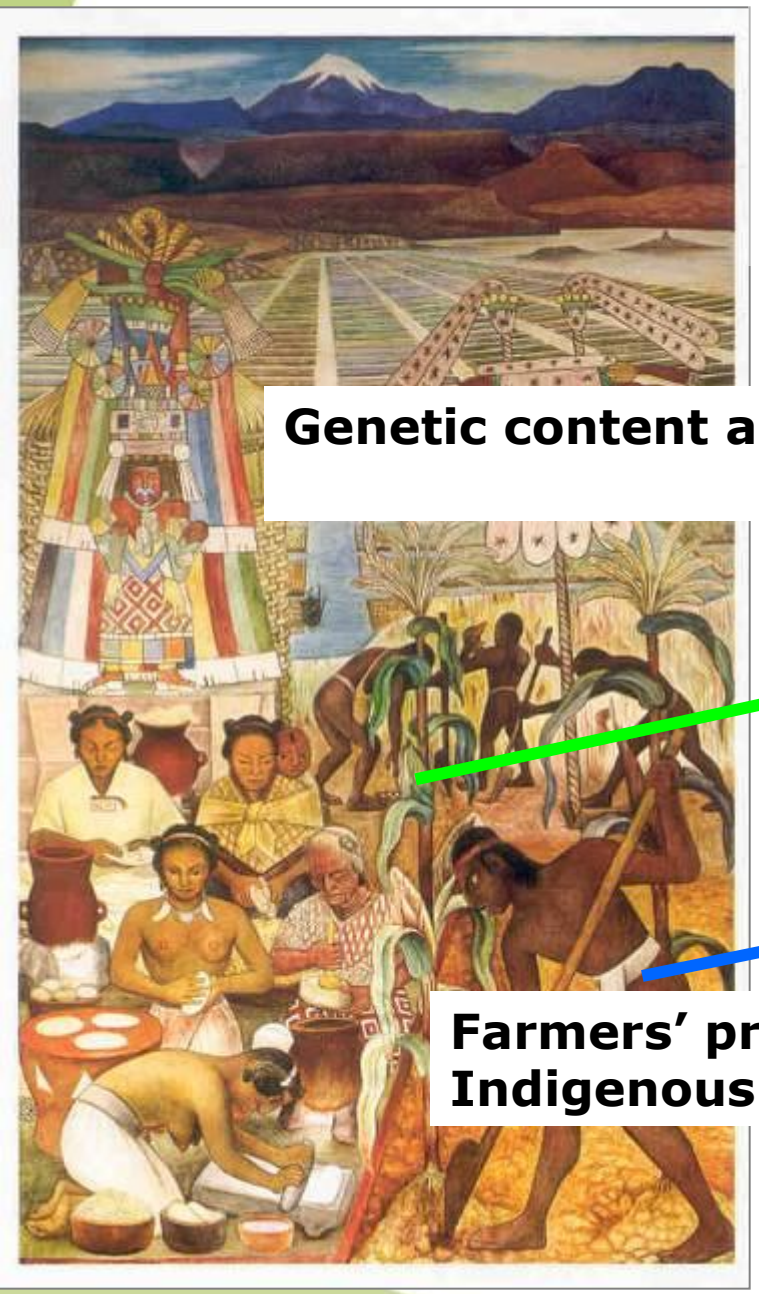
- Germplasm collections
- Technologies
  - Genomics
  - Bioinformatics
- Information systems
- Scientists and disciplins
  - Biological sciences
  - Social sciences



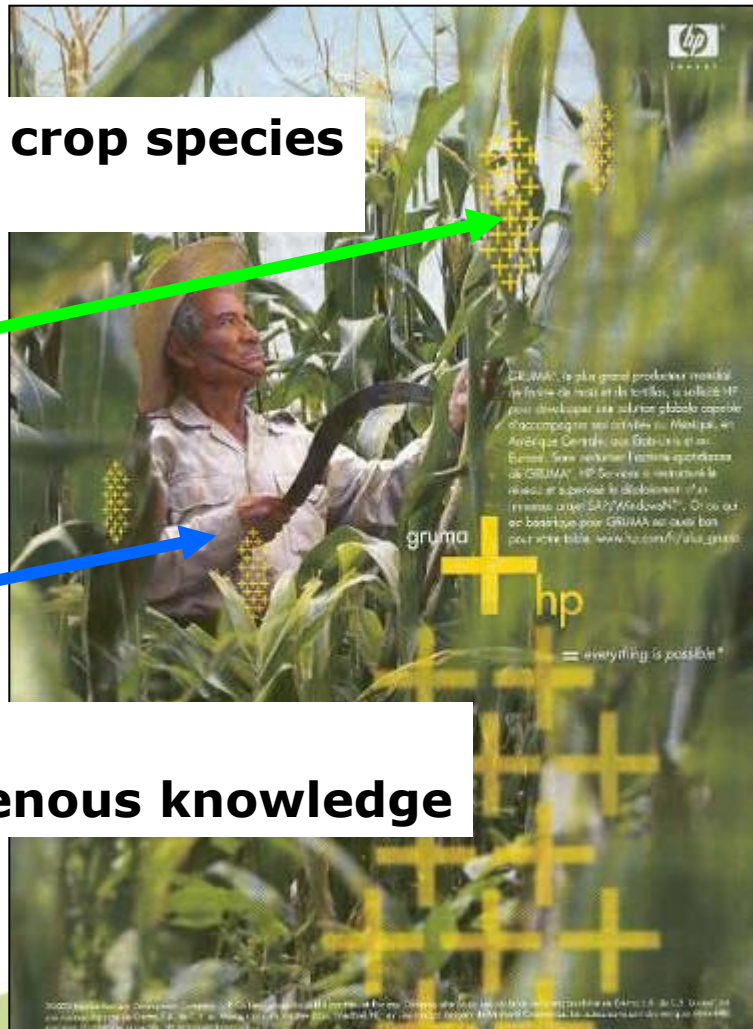
Innovate

- Optimising conservation
  - Grain seeds
  - Cryopreservation
  - DNA
  - Duplications (France, South)
- Automation
- Methods for diversity analysis
  - HTTP genomics, fine scale diversity analysis

- **<u>Crop domestication</u> : the start of a never-ending story**

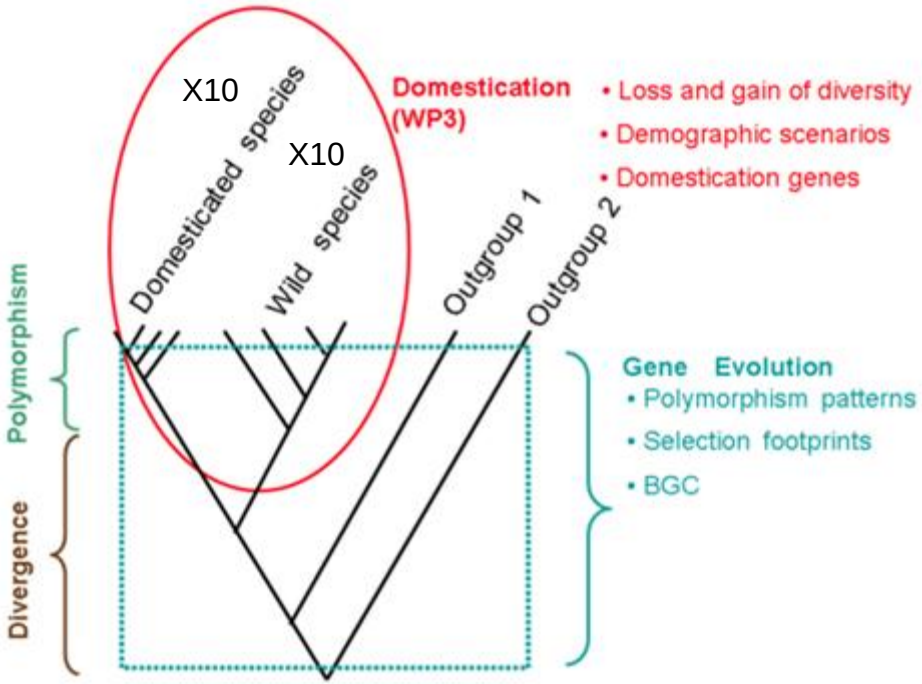


Genetic content and structure of crop species



Farmers' practices
Indigenous and non-indigenous knowledge

Comparative population genomics of crops and their wild relatives



→ Transcriptome sequencing

- Evolution of genetic diversity
  - Loss and recovery
  - Domestication scenarios
- Selection during domestication
  - Domestication genes
  - Cost of domestication
- Comparative approaches
  - Effects of life history traits
  - Convergent evolution
- Comparative evolution of gene families

Species and data acquisition

Banana	Monocot	Perennial	Outcrossing
Palm tree	Monocot	Perennial	Outcrossing
Yam*	Monocot	Annual	Out/clonal
Einkorn	Monocot	Annual	Selfing
Pearl millet	Monocot	Annual	Outcrossing
African rice	Monocot	Annual	Selfing
Sorghum	Monocot	Annual	Selfing
Fonio millet*	Monocot	Annual	Selfing
Cocoa	Dicot	Perennial	Outcrossing
Coffee	Dicot	Perennial	Outcrossing
*Coton**	Dicot	Perennial	Selfing
Olive tree*	Dicot	Perennial	Outcrossing
Alfalfa	Dicot	Perennial	Outcrossing
Grappe vine	Dicot	Perennial	Outcrossing
Tomato	Dicot	Annual	Selfing

* Additional species

Sequencing running













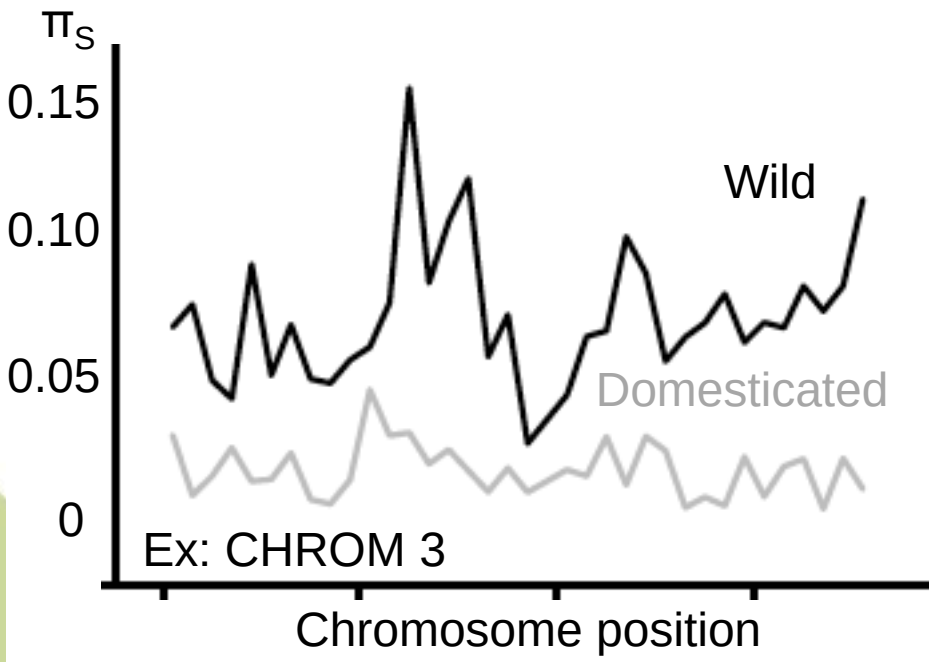


African rice domestication

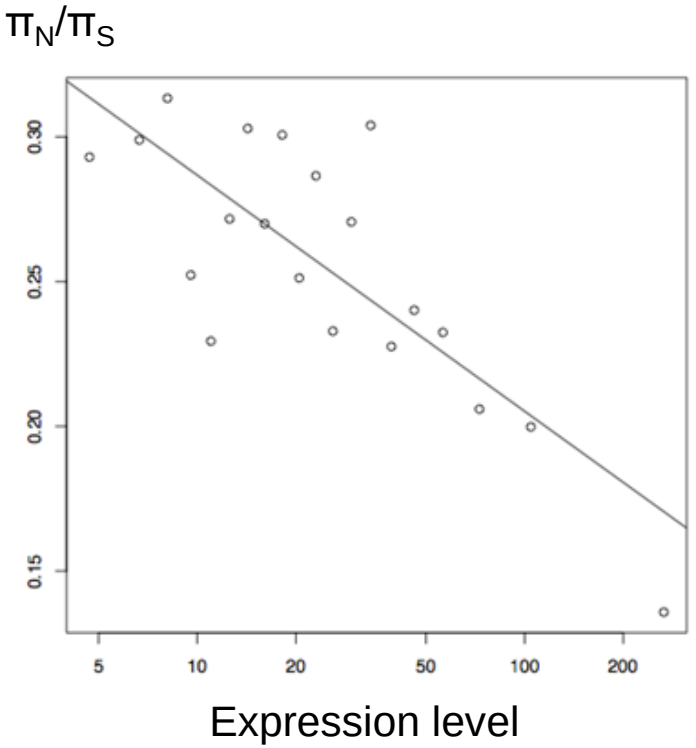
> 12000 genes *> 12Mb* *> 24000 SNPs*

Global polymorphism patterns

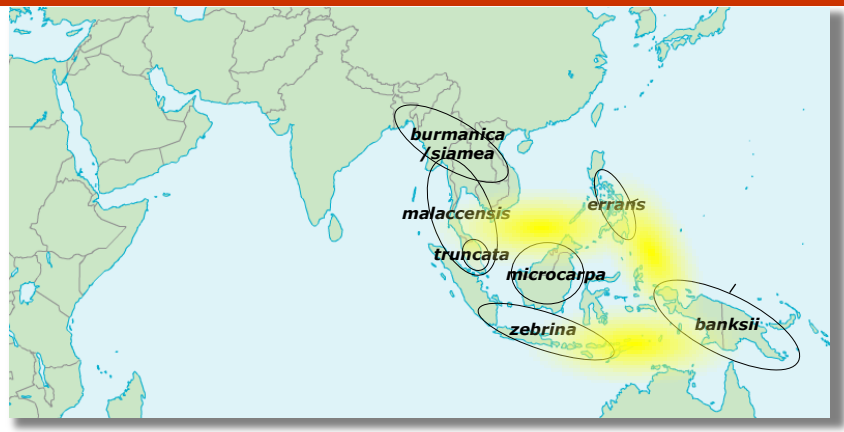
➔ Massive loss of diversity

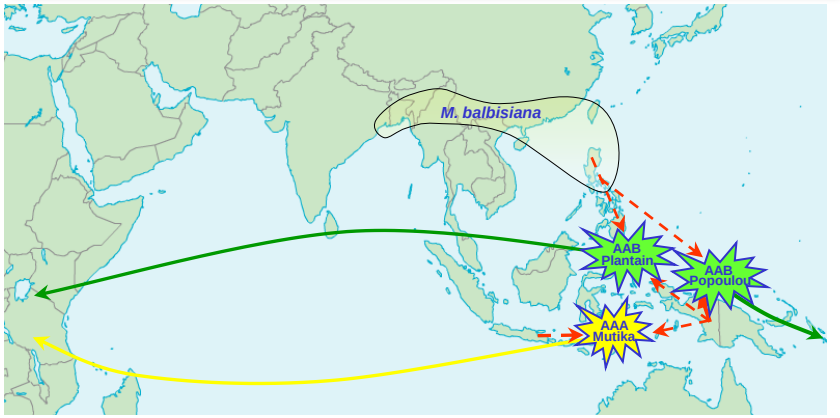


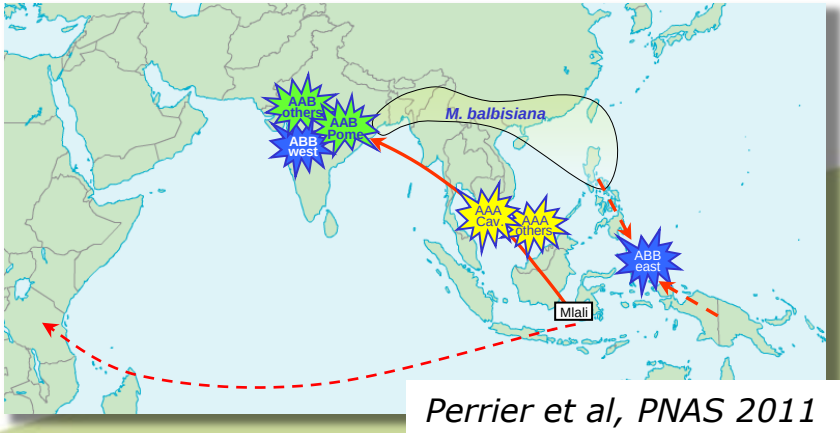
➔ Highly expressed genes are more constrained



Radiation of wild Musa/Domestication







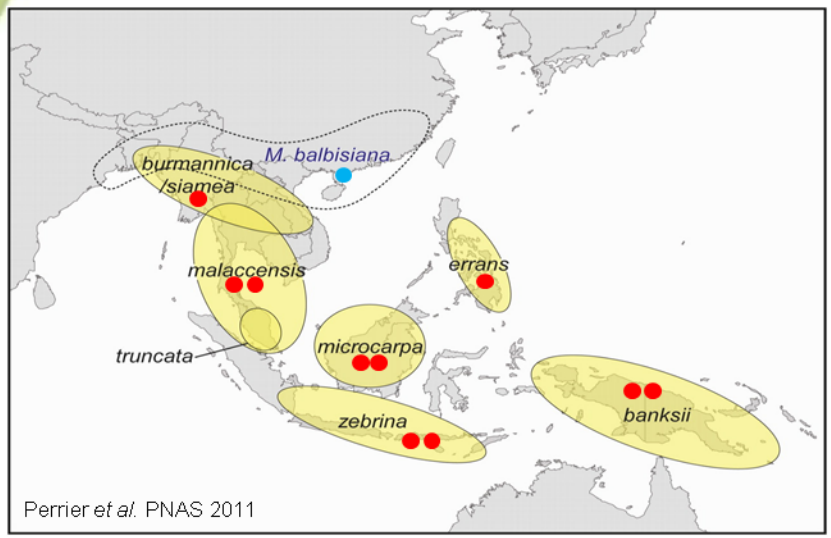
Domestication involved:

- **hybridization** between species and subspecies made possible by **human migration**

- selection of **diploid and triploid, seedless, parthenocapic hybrids** by early farmers

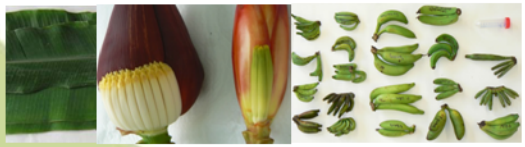
Perrier et al, PNAS 2011

Musa diversity and evolution



✓ Transcriptome sequencing (RNASeq)

- 10 wild *Musa acuminata* diploids
- 10 cultivated *Musa acuminata* diploids
- *Musa balbisiana, Musa beccarii* (outgroups)



Collection Guadeloupe and CARBAP Cameroun

✓ SNPs from coding sequences

>15 000 genes

⇩

➢ Level of gene sequence diversity within and between wild and cultivated *Musa* diploids?

➢ Origin and architecture of the genome of cultivated hybrids

Crop adaptation to climate change

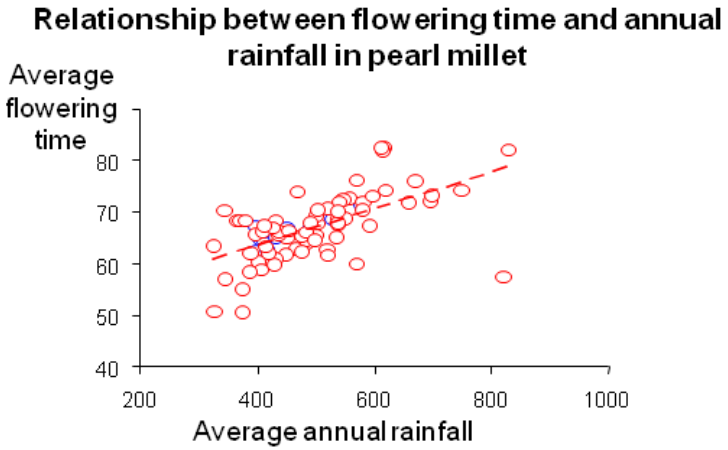
Studying genetic and evolutionary processes of adaptation

→ a focus on phenological responses

Spatial gradients:

populations/varieties collected along climatic gradients.

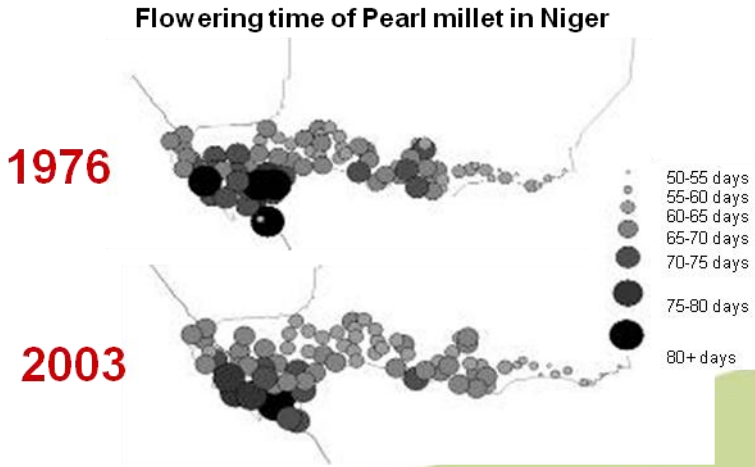
- ***M. truncatula*** : Latitudinal variation around the Mediterranean basin
- **rice** : altitudinal variation (Madagascar)
- **pearl millet and sorghum** : latitudinal gradient in West Africa.



Temporal gradients :

comparing current populations/varieties and populations collected 20-30 years ago on the same site/village

- ***M. truncatula***
- **pearl millet**
- **rice**



Searching for selective sweeps throughout spatial gradients

Searching for selective sweeps

- comparison of patterns of diversity for the whole genome
- differentiation between demographic factors affecting polymorphism at the genome scale and effect of selection on candidates

Riz (*Oryza sp*)

Autogamous

Traditionnal cultivation

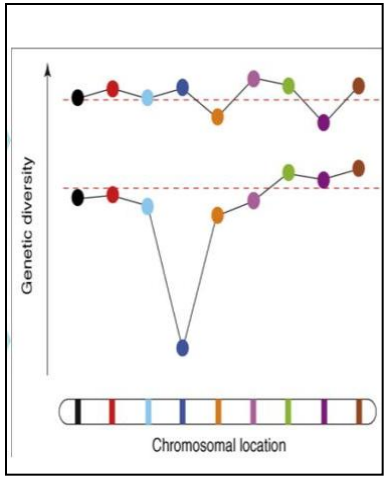
Medicago truncatula

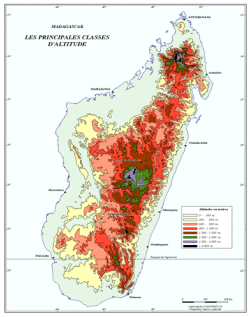
Autogamous

Natural populations

Whole genome

Candidates





Madagascar

Altitudinal variation

Mediterranean region

Latitudinal variation

(1000 genomes)

« ecological genomics »: establishing relationships between environmental and genetic variations

… due to their sensitivity, up-to-date studies might be more sensitive to undocumented demographic effects such as the pattern of migration and the reproduction regime.
In this study, we provide guidelines for the use of popular or recently developed statistical methods to detect footprints of selection.
We simulated 100 populations along a selective gradient and explored different migration models, sampling schemes and rates of self-fertilization. …

De Mitta et al, Mol Ecol 2013

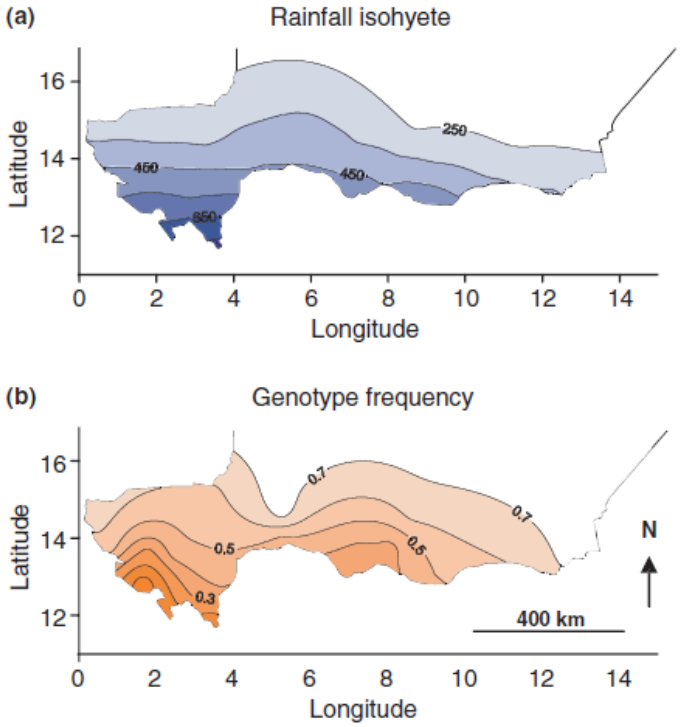


Fig. 5 Rainfall and *PgMADS11* allele frequency. Annual rainfall (in mm) was estimated based on average pluviometric data from 1976 to 2003. Genotype isofrequencies for the *PgMADS11* (M9LCDA2 marker) were calculated using SURFER V7.02. The genotype frequency in populations ranged from <4% to 75% and covaried with rainfall.

Mariac et al, Mol Ecol 2010

Temporal gradients: pearl millet in Niger (1976-2003)

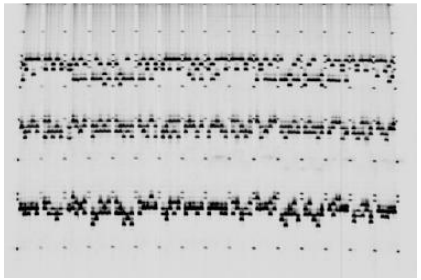
1976 germplasm collection

2003 Samples

Information on varieties

Conservation at 4ºC for 27 years

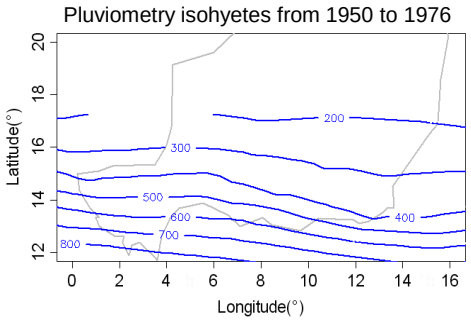
DNA marker analysis

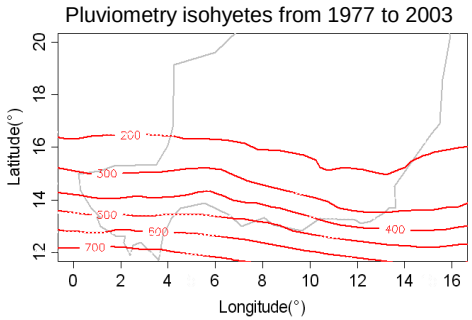


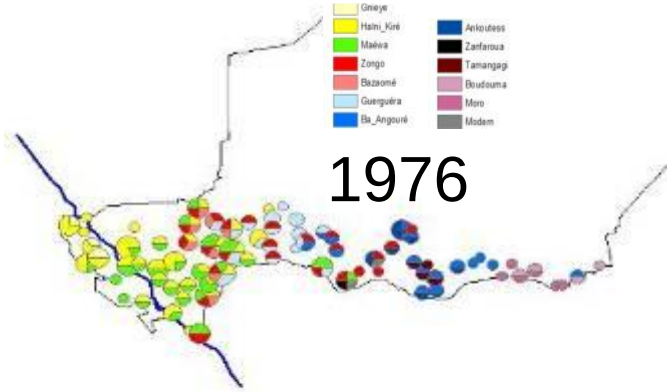
Morphological and phenological analysis

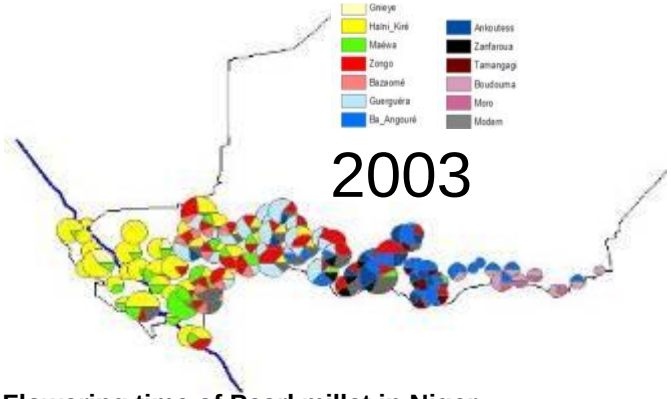
Temporal gradients: pearl millet in Niger (1976-2003)

Rapid changes in phenology of pearl millet landraces inNiger



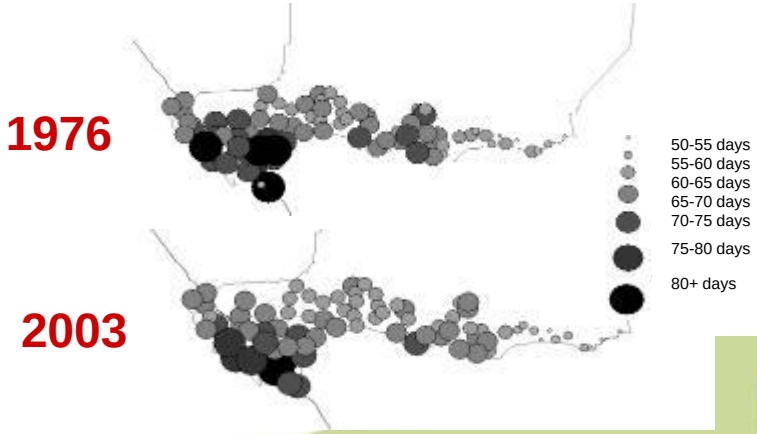






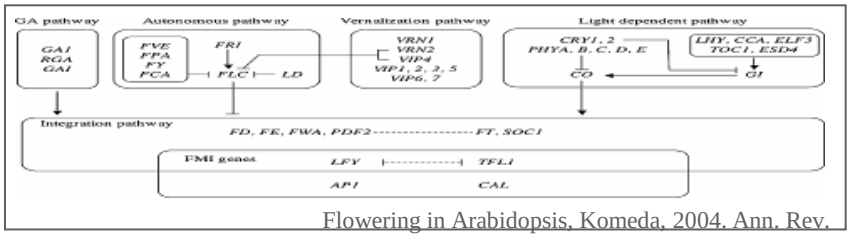
Flowering time of Pearl millet in Niger

cycle duration ↘

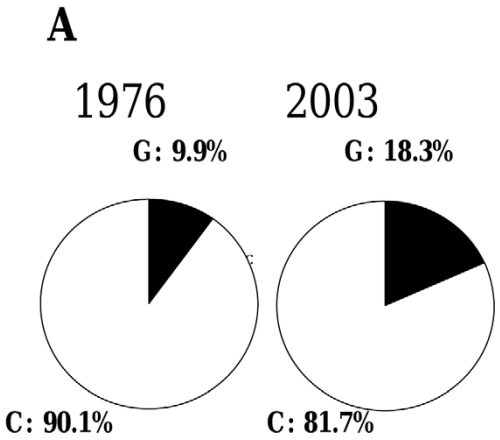


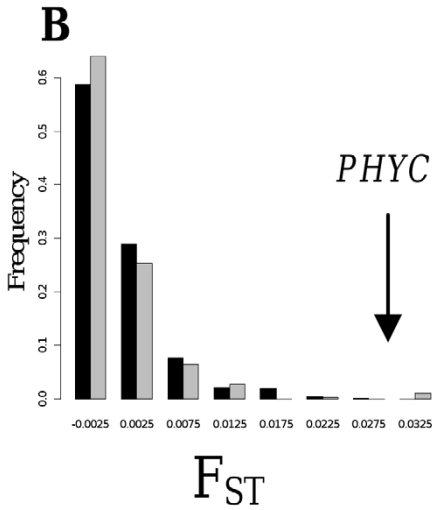
Bezancon et al. 2008, Vigouroux et al. in 2011

Temporal gradients: pearl millet in Niger (1976-2003)



Flowering in Arabidopsis, Komeda, 2004. Ann. Rev. Plant Biol.





1976- 2003 :
Increase in the frequency of the early-flowering allele of the PhyC gene

OPEN ACCESS Freely available online

PLoS one

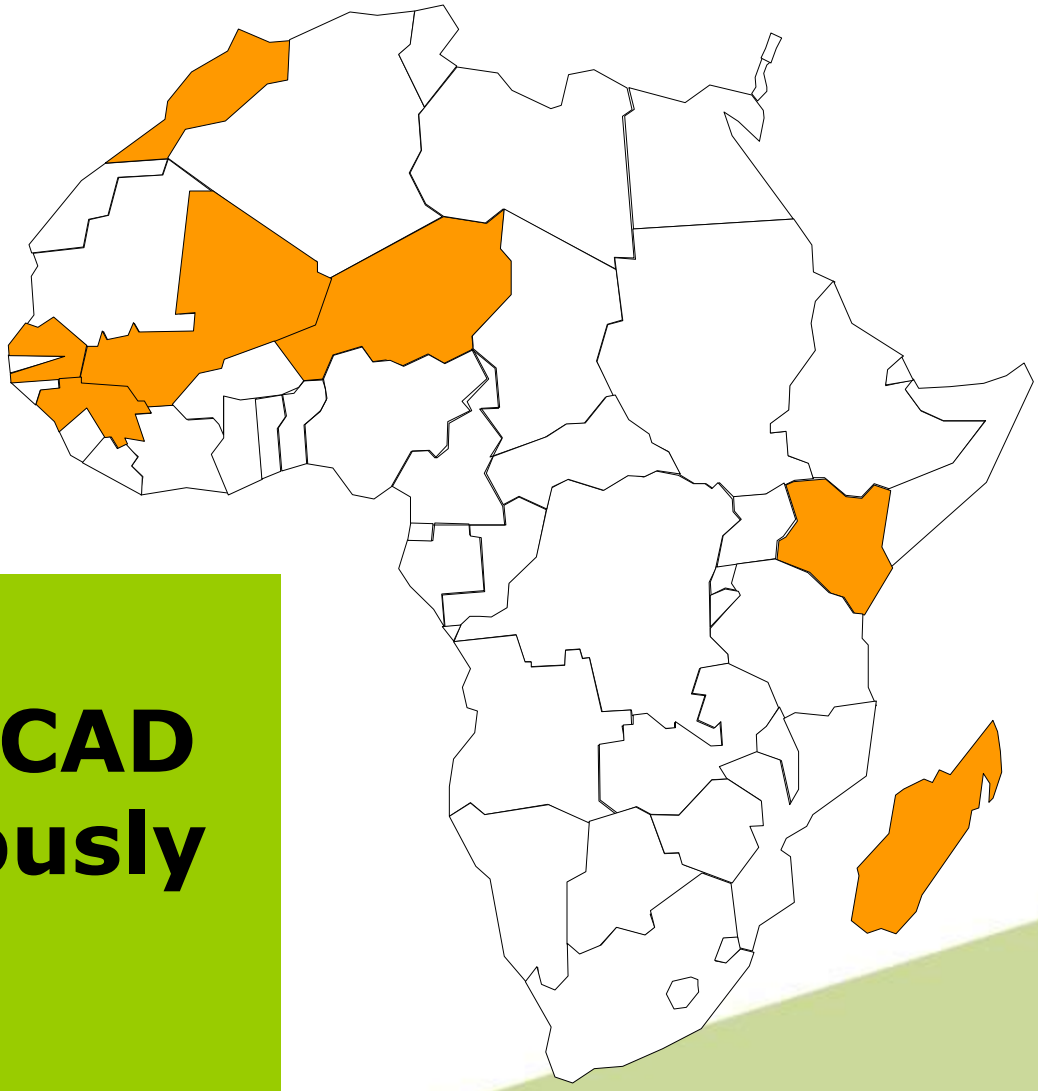
2011

Selection for Earlier Flowering Crop Associated with Climatic Variations in the Sahel

Yves Vigouroux[1,2]*, Cédric Mariac[1,2], Stéphane De Mita[1], Jean-Louis Pham[1], Bruno Gérard[3], Issoufou Kapran[4], Fabrice Sagnard[5], Monique Deu[5], Jacques Chantereau[5], Abdou Ali[6], Jupiter Ndjeunga[3], Viviane Luong[1], Anne-Céline Thuillet[1], Abdoul-Aziz Saïdou[1,2,7], Gilles Bezançon[2]

1 Institut de Recherche pour le Développement, Montpellier, France, **2** Institut de Recherche pour le Développement, Niamey, Niger, **3** International Center of Research for the Semi-Arid Tropics, Niamey, Niger, **4** Institut National de la Recherche Agronomique du Niger, Niamey, Niger, **5** Centre de Coopération Internationale en Recherche Agronomique pour le Développement, Montpellier, France, **6** Centre Régional AGHRYMET, Niamey, Niger, **7** Université Abdou Moumouni, Niamey, Niger

ARCAD : study countries (2013)



As an open platform, ARCAD will continuously seek new partnerships

Thank you