IHC 2022
HORTICULTURE FOR A WORLD IN TRANSITION
ANGERS – FRANCE

Contact: frederic.salmon@cirad.fr

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agAP INSTITUT
Amélioration génétique et adaptation des plantes méditerranéennes et tropicales

Banana breeding at CIRAD: creating resistant new varieties to avoid the use of pesticides

F. Salmon, F. Bakry, J.C. Efile, S. Ricci, L. Toniutti and J.P. Horry

Banana genetics and breeding team (GABA)
Institute of Genetic Improvement and Adaptation
of Mediterranean and Tropical Plants (AGAP institut)

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MINISTÈRE DE L'AGRICULTURE ET DE L'ALIMENTATION
Liberté
Égalité
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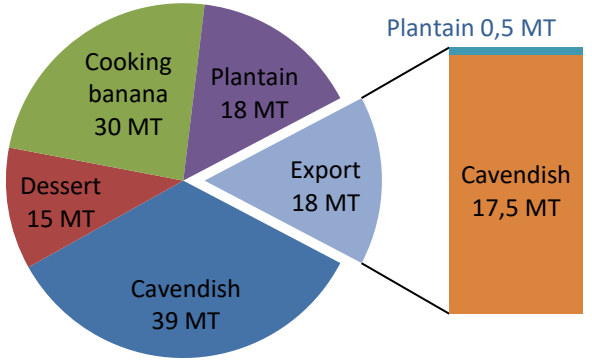
Context

- **Global production 120 MT**
  - For the most, relies on a limited number of varieties
  - *Cavendish* subgroup : 47 % of global production
  - 85% dedicated either to self-consumption, local and regional markets
  - the dominant export system relies on the mono-varietal monoculture of *Cavendish*



- **Vulnerable to diseases and pests**
  - genetic base extremely narrow
  - high adaptive capacities of pathogens

- **High environmental and economical impacts**

- ***Black Leaf Streak (Pseudocercopora fijensis)***
  - ➢ control through the use of fungicides
  - ➢ control by managing the disease in the field
  - ➢ reduced productivity

- ***FOC TR4 (Fusarium oxysporum sp. Cubense Tropical Race 4)***
  - ➢ No chemical control / Jeopardize world production
  - ➢ Gros Michel devastated by Panama disease

➡ **Introduction of varietal diversity based on the development of multi-resistant varieties**

Challenges for breeding

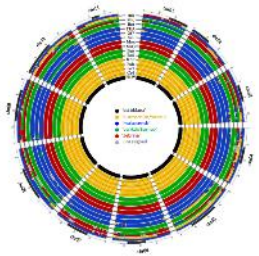
Develop improved varieties to contribute to sustainable production systems

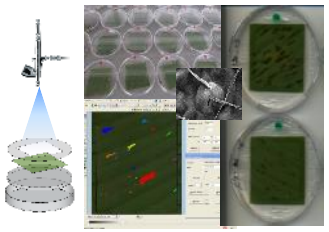
- Environmental constraints, including actual and emerging pests and diseases, climate change
- Supply chains expectations, notably productivity
- Consumers demand, notably fruit quality, organic production

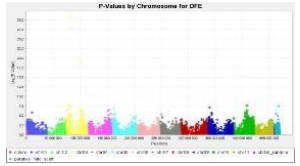
Objectives: to create and select new varieties

- Dessert bananas for export markets (AAA), or for domestic markets (AAA or AAB)
    - Resistance to main diseases (BLS, fusariosis)
    - Fruit quality and productivity
- Cooking Bananas : Plantain (AAB) and others (AAB/ABB)
    - Robustness
    - Tolerance to pests (weevils, nematodes)
    - Fruit quality and processing ability (cooking, flours…)

Banana genetic improvement







Genomics and genetics

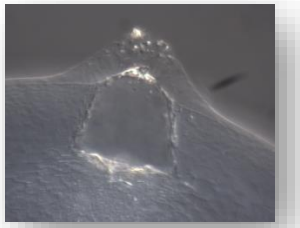
Upstream research

Overcome sterility barriers

Breeding and selecting

Scaling-up & development of the adapted production system

Fine tuning, Development of post-harvest system adapted & adapted marketing



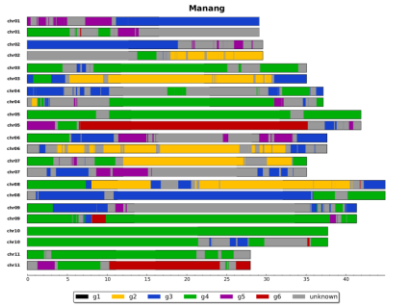
Banana genetic improvement

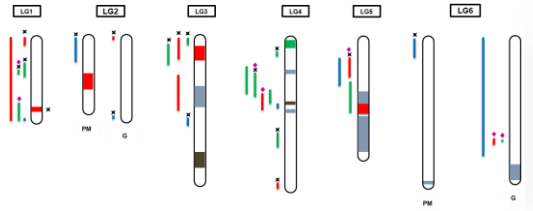
Upstream research → Breeding and selecting → Scaling-up & development of the adapted production system → Fine tuning, Development of post-harvest system adapted & adapted marketing

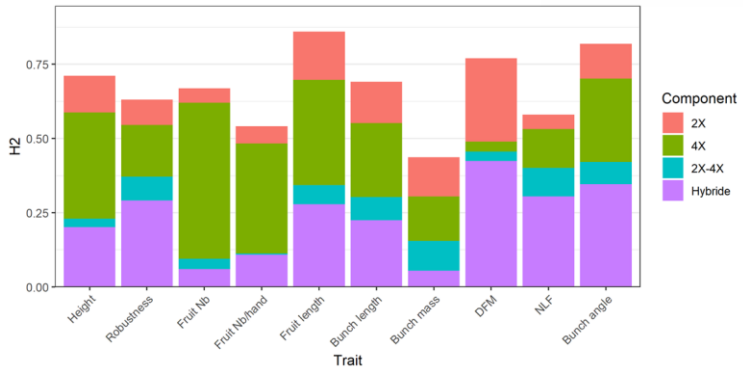
Genomics and genetics

- Species complex diversity, organization and evolution
  - ➢ identify the contributions of the ancestors to present day cultivars
- Genome organization and dynamics
  - ➢ impact on recombination and chromosome distribution
- Genetic basis and transmissions of traits
  - ➢ estimate heritability, predict the value of crosses
  - ➢ develop marker-assisted selection (SAM)

→ **select and manage parents in pre-breeding and breeding**







Toniutti et al., IHC 2022

Reconstructive breeding scheme

Upstream research → Breeding and selecting → Scaling-up & development of the adapted production system → Fine tuning, Development of post-harvest system adapted & adapted marketing

WAGENINGEN UNIVERSITY & RESEARCH

Screening genitors
for fusarium resistance
under controlled conditions.
WUR – Cirad partership

IDN110
Resistant

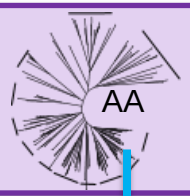
Pisang Lilin
Susceptible

Female and male fertility

Resistant to :
- BLS
- nematodes (*R.similis* and *P. coffeae)*
- FOC Race
- FOC TR4

AA improvement:
resistances
+ fruit quality
+ fertility

Prebreeding



AA AB BB

Selected AA Selected AB Selected BB

Chromosome doubling

AAAA AABB

Breeding
(4X x 2X crosses)

AA → AAA AAB

BB → AAB ABB

Selection phases
3x hybrid populations

AB / BB Improvement:
- eBSV

Mol Breeding (2016)36:74
DOI 10.1007/s11032-016-0493-8

Marker-assisted breeding of *Musa balbisiana* genitors devoid of infectious endogenous Banana streak virus sequences

Marie Umber · Jean-Philippe Pichaut · Benoît Farinas · Nathalie Laboureau · Bérenger Janzac · Kaïssa Plaisir-Pineau · Gersende Pressat · Franc-Christophe Baurens · Matthieu Chabannes · Pierre-Olivier Duroy · Chantal Guiougou · Jean-Marie Delos · Christophe Jenny · Marie-Line Iskra-Caruana · Frédéric Salmon · Pierre-Yves Teycheney

Selection in 4 phases

Upstream research

Breeding and selecting

Scaling-up & development of the adapted production system

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Partnership

Phase I

Negative selection
1 plant / hybrid

Characterization of heritable traits

Phase II

Positive selection
Microplot (25 ex./hyb)

Evaluation of the overall potential

- productivity
- commercialization
- consumer acceptability

Phase III

Variety development
Multi-site

Optimization of pre- and post-harvest technical itineraries

- different environmental conditions
- different farming systems
- tests in controlled conditions

Phase IV

Commercial Launch

Definition of the specific conditions of the partner's marketing channels

- segmentation
  - by production mode
  - by taste and shape
  - by geographical target

Selection of multi-resistant varieties

Upstream research → Breeding and selecting → Scaling-up & development of the adapted production system → Fine tuning, Development of post-harvest system adapted & adapted marketing

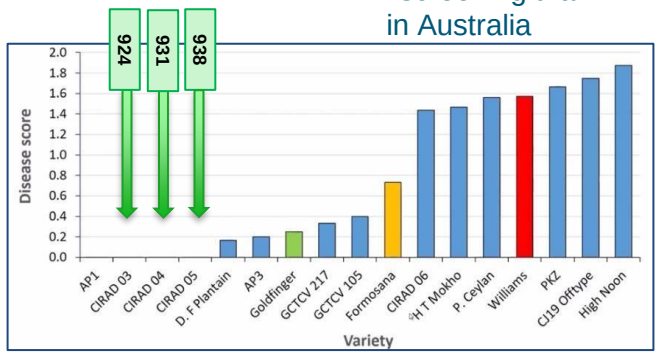
hybrids
AAA

	Resistance	938	924	931	Cavendish (cv 902)
Diseases	Black sigatoka	PR+	PR+	PR+	sensible
	E. musae	PR+	PR+	PR+	sensible
	FOC _ race 1	R	R	HR	sensible
	FOC _ TR 4	R	Tolerant	HR	sensible
	Freckle	R	R	R	sensible
Plant*	Height (cm)	450	400	500	275
	Girth (cm)	62	66	83	72
Bunch*	Nb. hands	10	14	17	11
	Nb. fingers	175	250	350	200
	Weight (kg)	25	25	32	30
Fruit*	Length (mm)	200	180	180	220
	Grade (mm)	32	36	31	34
	Weight (g)	130	120	100	200

*2d cycle, station of Neufchâteau, Guadeloupe (FWI)

Varieties adapted for the local market

TR4 screening trial in Australia



924

938

Williams

940

A partnership network to evaluate selected hybrids

Upstream research → Breeding and selecting → Scaling-up & development of the adapted production system → Fine tuning, Development of post-harvest system adapted & adapted marketing

On going field trials | **Field trials in preparation** | **TR4 early screening**

Jamaïca
925, 938

Cuba
925, 938

Costa-Rica
925, 938, 931, 924

Guadeloupe
925, 938, 931, 924, PRAM 01

Martinique
925, 938, 931, 924 PRAM01

Colombia
931, 938, 924

Mayotte
925, 938, 931, 924 PRAM01

Nederlands

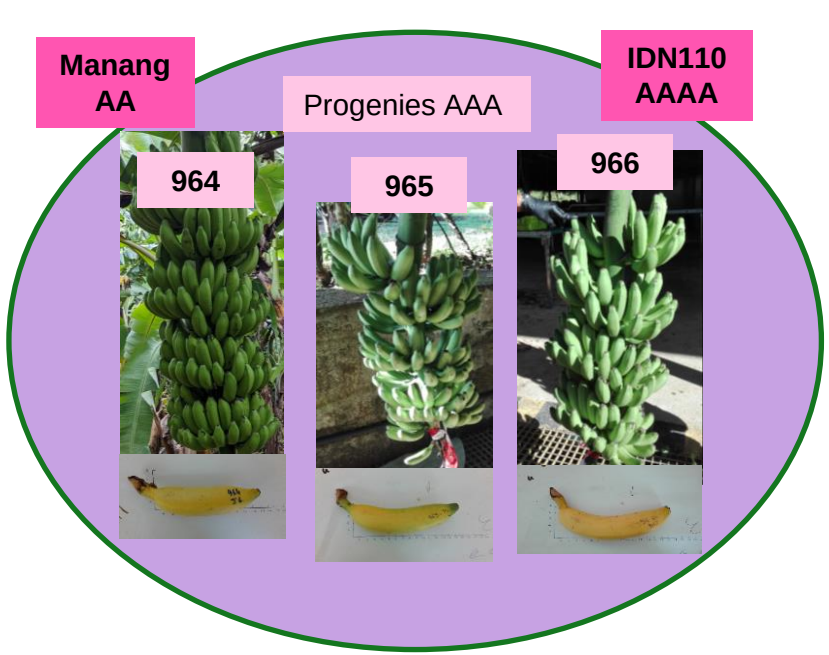
Australia
924, 931, 938, 940

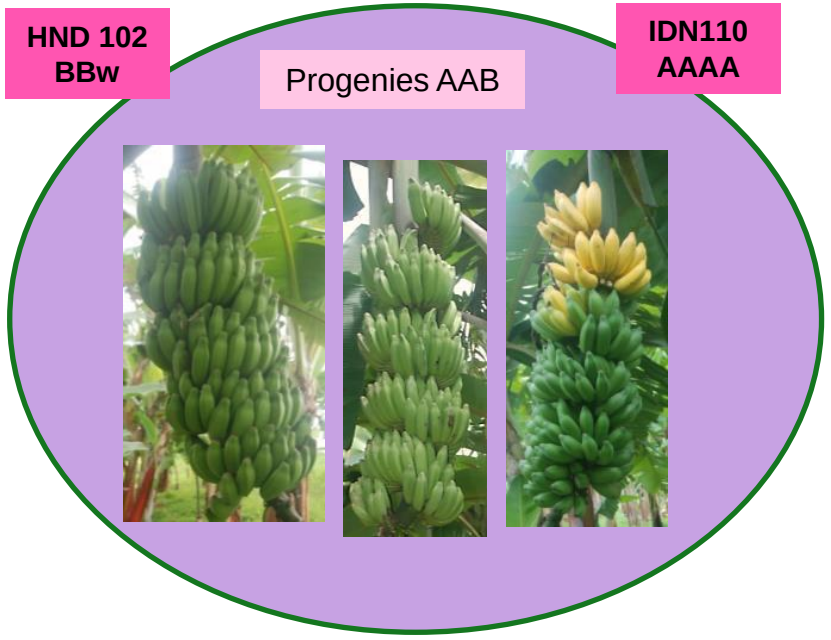
Montpellier

La Réunion
925,938, 931

Perspectives

- Other varieties in the pipeline





- Promoting variety diversification for more resilient production systems
- Global approach combining new varieties and cropping systems for sustainable resistance management

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Thank you for your attention

Agronomic evaluation of Cirad's hybrid at South Johnstone, Queensland, Australia
Courtesy Jeff Daniells, QDAF