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

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Institute of Genetic Improvement and Adaptation of Mediterranean and Tropical Plants (AGAP institut)
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 fiensis*)
    - 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

Breeding and selecting

Genomics and genetics
Upstream research
Overcome sterility barriers

Scaling-up & development of the adapted production system

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

Overcome sterility barriers
Banana genetic improvement

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
Reconstructive breeding scheme

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

IDN110 Resistant

Pisang Lilin Susceptible

Female and male fertility
Resistant to:
- BLS
- Nematodes (R. similis and P. coffeae)
- FOC Race
- FOC TR4

Prebreeding

AA
Selected AA
AB
Selected AB
BB
Selected BB

Chromosome doubling

AAA
AAAA
AABB

Breeding

AAA
(4X x 2X crosses)
AAB
AB
ABB

Selection phases
3x hybrid populations

AA improvement:
- resistances
- fruit quality
- fertility

AB / BB Improvement:
- eBSV

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

Selection in 4 phases

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

Varieties adapted for the local market

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

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

hybrids AAA

TR4 screening trial in Australia

Upstream research Breeding and selecting Scaling-up & development of the adapted production system Fine tuning, Development of post-harvest system adapted & adapted marketing
A partnership network to evaluate selected hybrids

**Upstream research**

- **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

**Breeding and selecting**

- **Colombia** 931, 938, 924

**Scaling-up & development of the adapted production system**

- **Australia** 924, 931, 938, 940
- **Nederlands**
- **Montpellier**
- **La Réunion** 925, 938, 931

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

- **IT2** Institute of Tropical Medicine
- **Banamart**
- **AGROSAVIA**
- **ciram**
- **ciranet**

**Countries where the TR4 has been detected** (in chronological order)
- Telhoven (2017)
- Indonesia (2016)
- Philippines (2015)
- Jordan (2015)
- Uzbekistan (2015)
- Pakistan (2015)
- Laos (2015)
- Venezuela (2015)
- Thailand (2014)
- Columbia (2014)
- Guatemala (2014)
- Taiwan (2014)
- Peru (2014)

**Scaling-up**

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

**On-going field trials**

- **Jamaïca** 925, 938
- **Cuba** 925, 938
- **Costa-Rica** 925, 938, 931, 924
- **Guadeloupe** 925, 938, 931, 924, PRAM 01

**Field trials in preparation**

- **Colombia** 931, 938, 924

**TR4 early screening**

- **Australia** 924, 931, 938, 940
- **Nederlands**
- **Montpellier**
- **La Réunion** 925, 938, 931
- **Martinique** 925, 938, 931, 924 PRAM01

**Upstream research**

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

**The Banana Board**

**INIVIT**

**CORBANA**

**Plant Health Institute Montpellier**

**Armezihor**

**Ugban**

**Agrosavia**

**Cirad**

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**Agrosavia**

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

Thank you for your attention

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