Molecular epidemiology, genetic diversity and dissemination routes of CMGs in sub-saharan Africa and the South-west Indian Ocean islands

Jean-Michel LETT

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Work place

► Reunion Island
French overseas department in the Southwest Indian Ocean

► Plant Protection Center
- Dedicated to the protection of agro-ecosystems and tropical natural ecosystems
- Hosts more than 100 scientists and technicians from many institutions
Importance of cassava

- Important staple food in sub-Saharan Africa
- Annual production of 134 MT (Faostat, 2012)
Cassava mosaic disease (CMD)

- However, cassava is severely affected by CMD which is endemic in Africa

- With losses estimated to up to 45 MT each year (Tresh et al., Afr. J. Root Tuber Crops 1997)
Cassava mosaic geminiviruses (CMGs)

Pathogen agents responsible of CMD

*Begomovirus* Genus : Family *Geminiviridae*

Old World Bipartite ssDNA genome

Transmitted by whitefly *Bemisia tabaci* (*Aleyrodidae*) and use of infected cuttings
Until 2012, a complex of SEVEN distinct CMG species have been described in association with CMD in Africa (ACMV, EACMV, EACMVC, EACMMV, EACMKV, EACMZV, SACMV)
What is the status of CMD and CMGs in Burkina Faso, Central African countries and SWIO islands (Madagascar, Comoros and Seychelles)?
To answer this question:

**Molecular epidemiology of CMGs in Burkina Faso, Central African countries and Madagascar**

Welcome of four African PhD students at CIRAD in Reunion Island:

- Fidèle TIENDREBEOGO (2006-2009)
- Innocent ZINGA (2009-2012)
- Mireille HARIMALALA (2009-2012)
- Adonise VALAM-ZANGO (2014)
Molecular epidemiology and diversity of CMGs in Burkina Faso

Fidèle TIENDRÉBÉOGO
Molecular characterization of CMGs

Complete genome cloning and sequencing

Tiendrébéogo et al. Plant Pathol 2009

► First description of ACMV and EACMV-UG in West Africa
► Detection of Mixed infections which represents a Major risk for cassava production
Description of a new CMG species called African cassava mosaic Burkina Faso virus

Tiendrébéogo et al., Virology Journal 2012

Demonstrate the interspecific recombination origin of ACMBFV between bipartite and monopartite African begomoviruses

Evolution of African cassava mosaic virus by recombination between bipartite and monopartite begomoviruses

http://virologyjournals.com/content/9/1/67
Molecular epidemiology and diversity of CMGs in Central African countries

Innocent ZINGA - Adonise VALAM-ZANGO
Countrywide survey of cassava pests and diseases in CAR

**CMD Incidence 85% !**

- **CMD Incidence (%)**
  - GF: 100%
  - SU: 90%
  - SG: 80%

- **Symptomatic plants infected by cutting or whitefly (%)**
  - GF: 100%
  - SU: 90%
  - SG: 80%

**Infected cuttings 94% !**

Epidemiological assessment of cassava mosaic disease in Central African Republic reveals the importance of mixed viral infection and poor health of plant cuttings

- **CMD represents the major constraint to cassava with an average incidence of 85%**

- **Importantly, 94% of diseased plants had cuttings-derived CMD infection suggesting that farmers mostly use virus-infected cuttings for planting**

- **Highlight, the Urgent need of CMD-free material**
Diversity of CMGs in Central African Republic, Chad and Equatorial Guinea

▶ ACMV et EACMV-UG involved in CMD
▶ Which confirms the westward spread of the Ugandan strain of EACMV in Africa
Epidemiological survey of CMD in CAR

58% of CMD samples collected in the field present mixed infections

Confirming that mixed infections and synergism are responsible for more severe symptoms of CMD

Zinga et al., Crop Protection, 2012
Genetic diversity and phylogeography of CMGs in Madagascar

Mireille HARIMALALA
Countrywide survey in Madagascar

- About 700 samples with/without CMD symptoms were collected.
Five CMG species were detected in MG

Harimalala et al., *Plant Pathology, 2015*
21% of positive samples were mixed infected

Positive correlation between mixed infection by several viruses and symptom severity

Harimalala et al., Plant Pathology, 2015
Visual assessment of the origin of CMD infection: cuttings or whiteflies

Healthy plant  Infected by cutting  95%  Infected by whitefly  5%

_neurons_

▶ Infected cuttings are the primary source of CMD transmission (similar CAR)

Harimalala et al., Plant Pathology, 2015
Significant geographical distribution of CMGs in Madagascar:

- **SACMV** is present in all regions.
- **ACMV** mainly in the highlands but also in the northern coastal region.
- **EACMV-like viruses** mainly in coastal regions.

**Distinct geographical distribution of CMGs in Madagascar**
Description of a new CMG species: Cassava mosaic Madagascar virus

A novel cassava-infecting begomovirus from Madagascar: cassava mosaic Madagascar virus

Mireille Harimalala, Pierre Lefevre, Alexandre De Bruyn, Fidèle Tiendrébéogo, Murielle Hoareau, Julie Villemot, Sahondramalala

Archives of Virology
Official Journal of the Virology Division of the International Union of Microbiological Societies
ISSN 0304-8608
Volume 157
Number 10
DOI 10.1007/s00705-012-1399-3

Harimalala et al., Archives of Virology, 2013

Genetically related to monopartite begomoviruses mainly described on tomato
Genetic diversity and phylogeography of CMGs in Comoros and Seychelles islands

Alexandre De Bruyn (PhD)

INRAPE
Presence of three coexisting EACMV-like virus species

114 DNA-A, 41 DNA-B full sequences

EACMV, EACMKV and EACMCV

Variability in species composition between islands and a clear difference with the epidemiological situation described in Madagascar (6 species)
Phylogeographic reconstruction of major migration routes

- Multiple recent introductions from East Africa
- Many migrations between islands
- Main routes of viral movements correspond with the major routes of human movement and commercial trade

De Bruyn et al., BMC Evol. Biol., 2012
CONCLUSION
Diversity and distribution of CMGs

- Widespread of EACMV-UG in Central and West Africa
- Madagascar hot spot of CMG diversity with 6 species
- Differential geographical distribution of each species

The high diversity of CMGs and the mixed infections represent a major risk for cassava production in Africa
CONCLUSION
Impact of CMD and Needs

▸ CMD represents a major constraint to cassava in West, Central Africa and SWIO

▸ Farmers mostly use virus-infected cuttings for planting

▸ Urgent need of Virus-free certified material of farmer-preferred landraces

▸ Urgent need of a Pan-African Cassava Surveillance Network (PACSUN)
谢谢
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