Viral diseases of banana and plantain

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Reported viruses infecting *Musa* spp

Virus	Occurrence	Transmission	Genome
BBTV	Asia, Australasia, Africa	Persistent, *P. nigronervosa*	DNA
CMV	worldwide	Non persistent, several aphid species	RNA
BSV	worldwide	Semi persistent, mealybug	DNA
BBrMV	Philippines, India, Vietnam, Sri Lanka, W. Samoa	Non persistent, 3 aphid species	RNA
BanMMV	Africa, Australia, Asia, Central & South America, Caribbean	Unknown	RNA
BVXV	Guadeloupe	Unknown	RNA

Banana bunchy top virus (BBTV)

- Family *Nanoviridae*
- Genus Babuvirus
- isometric particles
- Genome : 6 ss DNA components
- Transmitted on a non persistant mode by the aphid *Pentalonia nigronervosa*
- The most destructive virus infecting banana and plantain
- Widespread in Southeast Asia, the Philippines, Taiwan, most of the South Pacific islands, and parts of India and Africa.

BBTV symptoms

Bunchy top symptoms can be detected on young suckers

BBTV symptoms

Youngest leaves are bunchy

Infected plants are dwarfed and their emerging leaves small and narrow with brittle, yellow edges. The leaves grow upright and have a stunted, bunched appearance

BBTV “Morse code” symptoms on leaves

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“dots and dashes” along veins

BBTV symptoms on petioles

Healthy petiole : no streaking or mottling along veins

Diseased petiole : "Morse code" streaking, green mottling on veins

BBTV symptoms on male flowers

Mottling of a banana male flower infected with BBTV

Male flower from a healthy plant

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BBTV symptoms on fruits

Fruits are stunted and deformed

Banana plants may bear fruit if the plants are infected late enough in their development. However, in such cases the bunches and fruits may be stunted, twisted or otherwise deformed and of little use.

Impact of BBTV on the production of banana and plantain

- Banana plants that show symptoms rarely bear fruit

- Wherever reported, BBTV has seriously damages or wiped out the banana industry. It is considered the most destructive viral disease affecting banana and plantain, causing up to 100% losses in affected areas.

Transmission of BBTV by aphids

BBTV is transmitted on a semi persistent mode by the aphid *Pentalonia nigronervosa :*
Aphids acquire the virus after at least 4 hours of feeding on an infected plant and can retain the virus through their adult life, for a period of 15–20 days. During this time, the aphid can transmit the virus to a healthy banana plant by feeding on it.

Banana aphids often feed on tender tissues in protected areas of the plant, such as under leaf sheaths near the pseudostem

Transmission of BBTV by the exchange of infected germplasm

- Like any other virus infecting banana and plantain, BBTV is readily spread by the exchange of infected plant material

- It is therefore important to destroy any infected plant and to monitor closely

- It is equally important not to mass multiply any plant material that has not been thoroughly indexed

Control of BBTV

- No known resistant varieties, no chemical control
- Eradicate infected plants and all emerging suckers by herbicide injection
- Spray insecticide to destroy potential vectors
- Replace eradicated plants by certified virus-free material (either vitroplant or sucker)
- After planting, check new mats routinely for virus symptoms

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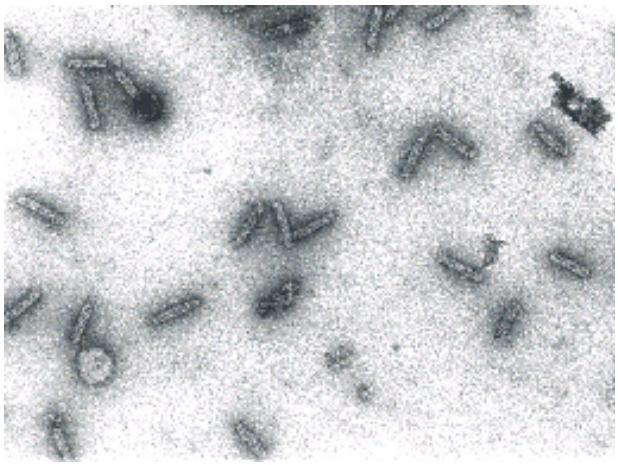
Banana streak virus (BSV)

- Family *Caulimoviridae*
- Genus Badnavirus
- Bacilliform particles
- Genome : ds DNA ca 7.4 kbp



- Most badnaviruses infect tropical crops (cocoa, yam, sugarcane, pineapple…)
- Several badnaviruses (including BSV) are transmitted by mealybugs (semi persistent transmission)

BSV symptoms on leaves

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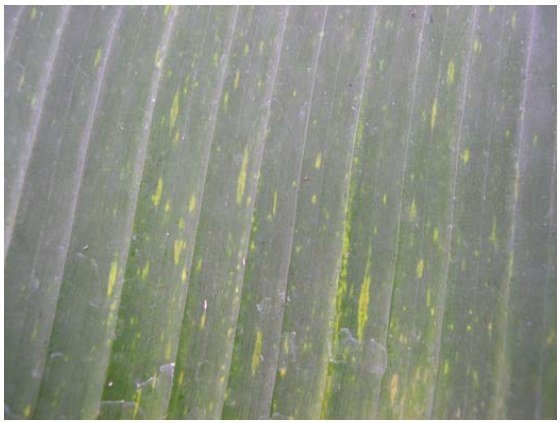

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typical streaks …

… that may lead to necrosis

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BSV symptoms on petioles

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Discrete dark spots may appear on the petiole of infected plants

BSV symptoms on pseudostem

BSV infections cause pseudostem splitting

BSV symptoms on fruit bunches

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In severe cases, fruit bunch emerges from pseudostem

BSV symptoms on fruit

BSV infection may cause cracks on the skin of fruits, which become impossible to commercialize

Impact of BSV on the production of banana and plantain

- High impact on yield and plant mortality when infection spreads, especially on *M. acuminata* spp (East Africa, Ecuador, Peru)

- There is a risk of spreading BSV through the distribution of interspecific (AAB, AAAB) hybrids, but this risk must be evaluated

BSV transmission by mealybugs

- At least 4 species of mealybug can transmit BSV : *Planococcus citri*, *P. ficus*, *Saccharicoccus sacchari*, and *Dysmicoccus brevipes*

- Mealybugs can be spotted under the leaves of banana and plantain, and under leaf sheaths near the pseudostem

- BSV is transmitted under the semi-persistent mode : the virus does get into the vector's digestive track but does not multiply in th vector

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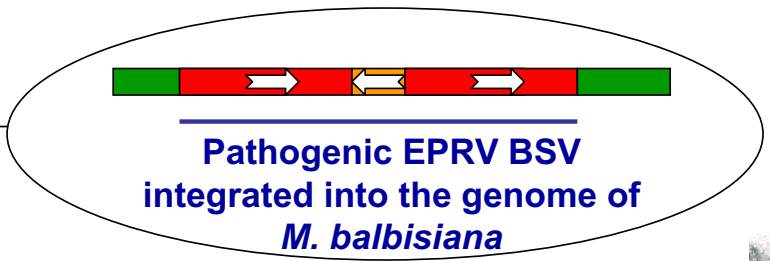
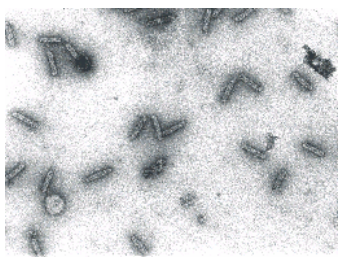
BSV transmission through the activation of viral sequences integrated into the genome of *Musa balbisiana*

AAB / AAAB hybrid



Pathogenic EPRV BSV integrated into the genome of *M. balbisiana*

Activating stress



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BSV infectious viral particles

Activating stresses include:
- interspecific genetic crosses
- temperature differences
- *in vitro* culture

http://paradigm.cirad.fr

In vitro multiplication of AAB & AAAB species and hybrids can lead to the diffusion of BSV

- Vitroplantlets from either interspecific hybrid species and "natural" accessions display episomal BSV particles after *in vitro* multiplication

- The observed increase in BSV-positive plantlets is clearly correlated with increasing numbers of sub-cultures

- Distinct BSV integrated sequences coresponding to different BSV species (BSOLV, BSGFV) behave similarly during *in vitro* culture

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VITROPIC S.A.

Folliot *et al*., unpublished

inibap

BSV constraints for the movement, multiplication and improvement of *Musa* germplasm

- ***In vitro*** **multiplication is one of the main abiotic stresses triggerig the production of infectious BSV particles from integrated BSV sequences**

- **BSV has become the major viral constraint for the multiplication and exchange of Musa germplasm**

- **BSV has also become the major viral constraint for the genetic improvement of *Musa* spp**

Control of BSV in dessert banana (*M. acuminata*)

- Early detection of symptoms
- Eradication of infected plants and surrounding plants by insecticide injection
- Insecticide treatment targeted towards mealybugs and ants
- Fallow (>6 months)
- Replacement of infected plants by certified virus-free plants

Strategies for fighting BSV in AAB & AAAB hybrid species

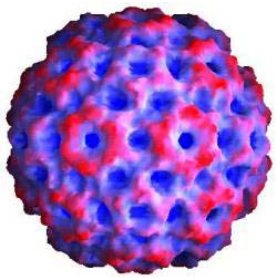
- **Mass multiplication by horticultural methods (corm splitting) rather than *in vitro* culture, which strongly activates BSV EPRVs**

- **Monitoring of plots for visual symptoms of BSV, especially when temperature (day/night) differences are important**

- **Observations suggest that impact of BSV might be more important in created than in natural interspecific AAB / AAAB hybrids**

➢ *Cucumber mosaic virus* (CMV)

- Family *Bromoviridae*
- Genus Cucumovirus
- Icosaedric particles



- Genome : 3 ssRNAs
- The most widespread plant virus, infecting over 1,000 different species !!
- Transmitted by a wide range of aphid species

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CMV symptoms

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- CMV infection causes typical leaf mosaic symptoms

- Mosaic may become necrotic when mixed infection occurs (with BanMMV or BSV)

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Impact of CMV on the production of banana and plantain

- Young plants display strong symptoms

- On Cavendish, symptoms weaken as infected plants grow older

- Overall, CMV has a low impact on production as it can be well controled

Transmission of CMV

- Several species of aphids can transmit CMV on a non persistant mode

- These include :
  - *Myzus persicae*

  - *Aphis gossypii*

  - *Ropalosiphum padi*

- Aphids acquire immediately when feeding on an infected plant and remain infectious as long as viral particles are present on their stylets. During this time, aphids can transmit the virus to a healthy banana plant by feeding on it.

- Weeds are important reservoirs for CMV

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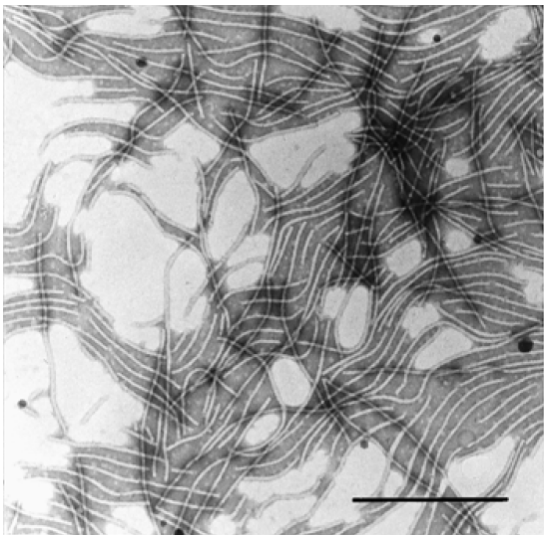
Strategies for fighting CMV

- Eradication of infected plants
- Replacement of infected plants by certified virus-free plants
- Herbicide treatments to destroy weeds (potential reservoirs)
- Insecticide treatments to control aphid populations

Banana bract mosaic virus (BBrMV)

- Family *Potyviridae*
- Genus potyvirus
- Flexuous rod particles



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- Genome : ssRNA ca 10 kb

- Transmitted by aphids species *Rhopalosiphum maidis Fitch*, *Aphis gossypii Glover* and *Pentalonia nigronervosa* (non persistent transmission)

BBrMV symptoms on bracts

Typical mosaic symptoms on bracts

BBrMV symptoms

BBrMV infection causes spindle shaped lesions on the lamina of young leaves, and mosaic on the petioles and pseudostem (visible when the old leaf sheaths are pulled away)

Impact of BBrMV on the production of banana and plantain

- No reliable data available

- Losses of up to 40% reported in the Philippines on local cultivars

Transmission of BBrMV

- Several species of aphids can transmit CMV on a non persistant mode
- These include :
  - *Aphis gossypii*

  - *Pentalonia nigronervosa*

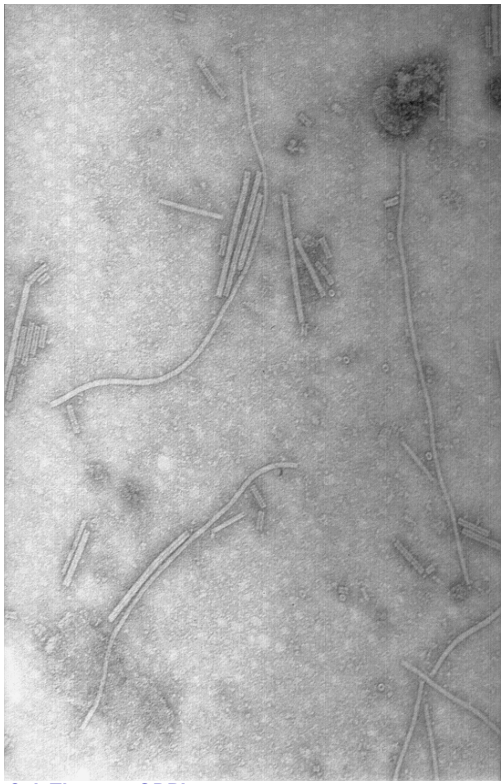
  - *Ropalosiphum maidis*

Strategies for fighting BBrMV

- Remove infected plants by immediately excavating the infected plants, cutting into pieces to dry
- Replace infected plants by certified virus-free plants
- Control weeds by mechanical methods or herbicide treatments
- Control aphid populations by insecticide treatments
- Avoid intercropping banana with cucurbits or other alternate hosts of the virus

Banana mild mosaic virus (BanMMV)

- Unassigned member of the family *Flexiviriade*
- Flexuous viral particles
- Genomic RNA+ 7.3 kb
- Unknown mode of transmission
- Important prevalence in the *Musa* germplasm
- Single infections cause little or no symptoms
- Co-infections (CMV, BSV, BBrMV) cause important synergistic symptoms



BanMMV symptoms

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Single infection causes mild mosaic on leaves of susceptible cultivars

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Mixed infections (here with CMV) can cause necrotic lesions on leaves

Impact of BanMMV on the production of banana and plantain

- None reported in single infection

- Difficult to evaluate in mixed infection, although BanMMV enhances symptoms of co-infecting viruses

Transmission of BanMMV

- **Molecular evidence for plant-to-plant transfer**
- **No known vector**
- **Vegetatively propagated through the distribution of infected germplasm**

Journal of General Virology (2005), 86, 3179–3187 DOI 10.1099/vir.0.81197-0

High genetic variability and evidence for plant-to-plant transfer of *Banana mild mosaic virus*

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BanMMV constraints for the exchange and distribution of *Musa* germplasm

- **BanMMV displays high levels of prevalence in the Musa germplasm (up to 12% of INIBAP's accessions, which are being replaced by healthy individuals)**

- **Distributing infected plant material leads to increased symptoms and impact when mixed infections (with CMV, BSV or BBrMV) occurs**

Banana virus X (BVX)

- **Unassigned member of the family *Flexiviriade,* discovered 2005 in Guadeloupe**

Arch Virol (2005) 150: 1715–1727
DOI 10.1007/s00705-005-0567-0

Archives of Virology
Printed in Austria

Molecular characterization of banana virus X (BVX), a novel member of the *Flexiviridae* family

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- **Unknown mode of transmission, unknown prevalence in Musa germplasm**
- **No symptom could be associated with the virus**
- **Genomic RNA+**

CONCLUSIONS

- Several viral diseases hamper the production of banana and plantain worldwide

- Some of these viral diseases are very damaging, have a strong economical impact and/or are threatening major production areas

- There is no chemical control for viruses infecting plants. Control strategies are primarily based on eradication of infected plants and use of certified virus free material

- Control strategies rely on sensitive and specific detection techniques