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VIRUSES THAT THREATEN BANANA AND PLANTAIN PRODUCTION IN THE CARRIBEAN

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ABSTRACT

Virus diseases that have the potential to cause significant damage to banana and plantain production in the Caribbean fall into two categories: those that are not known to be present in the region and those that are present but have not been investigated in detail. The first group includes *Banana bunchy top virus* (BBTV) and *Banana bract mosaic virus* (BBrMV), while *Banana streak virus* (BSV), *Cucumber mosaic virus* (CMV), and *Banana mild mosaic virus* (BanMMV) and similar unidentified viruses comprise the second group. It is of the highest importance to prevent the introduction of BBTV and BBrMV, which can be spread rapidly by their aphid vector *Pentalonia nigronervosa*, which occurs throughout the region. Additional research on the incidence and impact of BSV, BanMMV, and other unidentified viruses would be of value.

INTRODUCTION

Four groups of pathogens attack and can cause significant damage to *Musa* spp. (banana, plantain, and bluggoe) cultivated as food crops. These pathogen groups are fungi (e.g., *Mycosphaerella*, *Fusarium*), bacteria (e.g., *Ralstonia*), nematodes (e.g., *Radopholus*, *Meloidogyne*), and viruses. Viruses differ from the other pathogens in two respects that are of critical importance. The first difference is that viral infections cannot be eliminated by chemical treatment; the second difference is that *in vitro* propagation procedures used routinely to produce pathogen-free propagules for crop establishment or for trans-border germplasm movement are ineffective in eliminating viruses, in contrast to their well-documented efficiency in preventing movement of fungal, bacterial, and nematode pathogens of *Musa*. The practical consequences of these differences between viruses and other pathogens are that first, control of diseases caused by viruses must be based on preventing infection (prophylaxis), rather than on chemical intervention to cure the disease (chemotherapy), and second, sensitive and reliable virus indexing procedures need to be employed in order to eliminate or greatly reduce the possibility of international or even in-country movement of viruses that have the potential to cause significant crop losses.

VIRUSES INFECTING *MUSA* SPP: DISTRIBUTION, EPIDEMIOLOGY AND POTENTIAL THREAT TO FOOD CROP PRODUCTION IN THE CARIBBEAN

Virus diseases that have the potential to cause significant damage to banana and plantain production in the Caribbean fall into two categories: those that are not known to be present in the region and those that are present but have not been investigated in detail. The first group includes *Banana bunchy top virus* (BBTV) and *Banana bract mosaic virus* (BBrMV); the second group includes *Banana streak virus* (BSV), *Cucumber mosaic virus* (CMV), and *Banana mild mosaic virus* (BanMMV).

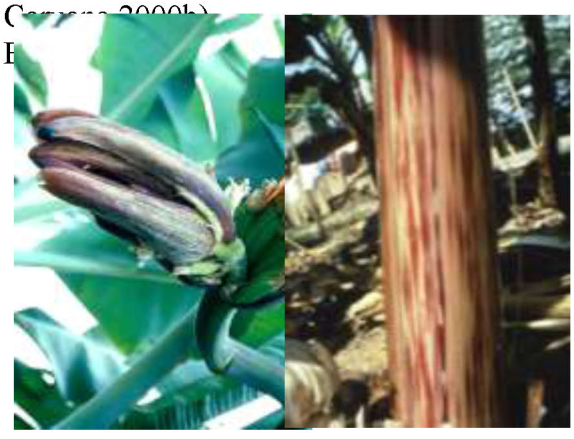
***Banana Bunchy Top Virus* (BBTV)**

Bunchy top of banana, caused by BBTV, is undoubtedly the most dangerous threat to banana production in the Caribbean since this disease frequently causes total crop loss. This virus occurs in Asia, Australasia, and in isolated pockets in Central Africa and Egypt (Thomas and Iskra-Caruana 2000a). The virions of BBTV are spherical, 20nm in diameter (Thomas and Dietzgen 1991), and the genome consists of six circular single-stranded DNA molecules, each 1000–1100 nucleotides in length (Lockhart and Iskra-Caruana 2000a). The virus is transmitted by vegetative propagation and in a persistent manner by the black banana aphid, *Pentalonia nigronervosa*, the only known vector. Because BBTV infects only *Musa* spp. and is insect-transmitted only by *P. nigronervosa*, which colonizes primarily *Musa* spp., the spread of bunchy top occurs only from infected to healthy banana. Accidental introduction of BBTV into the Caribbean region can rapidly result in catastrophic crop losses, as occurred in Sindh Province in Pakistan in the 1990s (Khalid and Soomro 1993; Khalid, Soomro, and Stover 1993), for the following reasons. First, the aphid vector, *P. nigronervosa*, occurs commonly throughout the region (see Commonwealth Institute of Entomology, Distribution Maps of Pests, Series A, Map No. 242). Second, the vast majority of banana cultivars, (i.e., Musa AAA genotypes), including those most widely cultivated in the region, are highly susceptible to bunchy top (Thomas and Iskra-Caruana 2000a). Third, bunchy top epidemics and consequent crop destruction occur in monoculture agrisystems, in which the pathogen insect vector and very susceptible host plant are in close contact. For these reasons, large-scale plantings of very susceptible bananas common in the Caribbean region, would very likely suffer catastrophic losses following the introduction of this virus. This scenario can be contrasted with the situation in west central Africa (Republic of Congo, Rwanda, and Burundi), where BBTV was introduced, most likely in *Musa* germplasm imported from Asia or Australasia for breeding purposes in the mid-twentieth century. In these areas, bananas are grown in diverse mixed-cropping systems in small-holdings separated by native vegetation that harbor neither BBTV nor the aphid vector, and the disease has not spread to any appreciable extent in the past several decades. Whereas production of bananas (i.e., *Musa* AAA genotypes) would be very seriously impacted by the introduction of BBTV into the Caribbean region, a quite different picture emerges in the case of plantain (*Musa* AAB) and bluggoe (*Musa* ABB) cultivars. These B-genome-containing (i.e., *M. balbisiana*) interspecific hybrids, are generally not affected by bunchy top disease, either because of immunity or a high degree of tolerance to BBTV infection (Thomas and Iskra-Caruana 2000a). In summary, the overall potential impact of BBTV on crop production in the region would depend on the relative proportions of different *Musa* genotypes, and the scale and diversity of the cropping systems used.

Bunchy top symptoms in Cavendish banana

***Banana Bract Mosaic Vvirus* (BBrMV)**

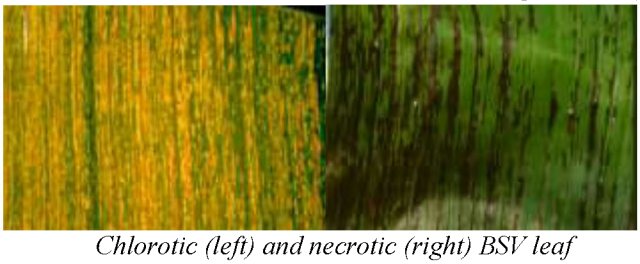
Banana bract mosaic virus (BBrMV), like BBTV, is known to occur naturally only in Asia (Philippines, Vietnam, Western Samoa, India, Sri Lanka) (Thomas and Iskra-Caruana 2000b), and has not been detected in the Caribbean. Unlike BBTV, BBrMV has filamentous virions containing a single-stranded RNA genome typical of virus species in the family *Potyviridae*. Also unlike BBTV, BBrMV is transmitted by at least three aphid species, (*P. nigronervosa*, *Aphis gossypii*, and *Rhopalosiphum maidis*) in a non-persistent manner (Thomas and Iskra-Caruana 2000b) and by vegetative propagation. However, because only *Musa* spp. (banana, plantain, abaca), movement of the virus is, like BBTV, exclusively from infected to healthy plants. Unlike BBTV, which affects only bananas (i.e., *Musa* AAA), no resistance or immunity to BBrMV has been observed in any *Musa* spp. As a result, whereas BBTV would pose a threat only to banana cultivation, BBrMV would spread to banana, plantain, and bluggoe throughout the Caribbean region. Fortunately, plant damage and crop losses resulting from BBrMV infection are far less serious than those caused by BBTV. However, while BBrMV would be incapable of inflicting the total crop loss caused by BBTV, it has the potential of causing significant damage to the full range of *Musa* genotypes cultivated in the region. Reduction in bunch yield of up to 40% has been reported, sucker production and vigor may be reduced, and misshapened or discolored fingers can reduce the marketability of fruits (Thomas and Iskra-Caruana 2000b).



Bract and pseudostem symptoms of bract mosaic in plantain

***Banana Streak Virus* (BSV)**

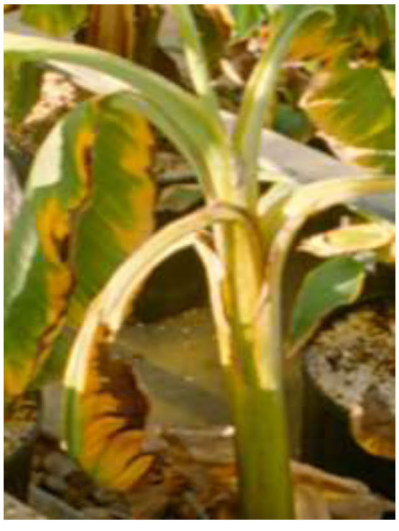
BSV has been isolated (Lockhart 1986) and is now documented as the most-widely distributed virus in edible *Musa* cultivars, occurring in every production area throughout the world (Lockhart and Jones 2000a). Virions of BSV are bacilliform in shape, non-enveloped, and contain a circular double-stranded DNA genome (Ndowora et al. 1999). In its epidemiology BSV differs from BBTV and BBrMV, which are spread both by vegetative propagation, and more importantly, by efficient aphid vectors (Thomas and Iskra-Caruana 2000a, 200b). The insect vectors of BSV are mealybugs (*Psuedococcidae*) (Lockahrt and Jones 2000a), which do not share the high fecundity and dispersal capacity of the aphid vectors of BBTV and BBrMV, rendering this mode of field spread of limited importance. The spread of BSV occurs primarily by vegetative propagation and by a mechanism unique to the plant virus family *Caulimoviridae*, of which BSV (genus *Badnavirus*) is developed, resulting from the activation of the BSV genomic sequence integrated in the *Musa* genome (Ndowora et al. 1999). These activatable integrated viral



Chlorotic (left) and necrotic (right) BSV leaf symptoms in banana

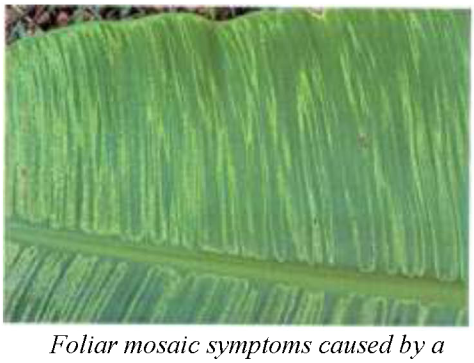
sequences, referred to as endogenous pararetroviruses, or EPRVs, occur in the *Musa* B genome (i.e. *M. balbisiana*) but not in the *Musa* A genome (i.e., *M. acuminata*) (Ndowora et al. 1999; Thomas and Dietzgen 1991). The result of this strict distribution of activatable EPRVs among *Musa* genotypes means that while BSV infection from EPRVs cannot occur in banana (i.e. *Musa* AAA), all interspecific AxB hybrids (plantain, AAB, and bulggoe, ABB) are prone to this mode of BSV infection. This includes all improved *Musa* tetraploid (AAAB, AABB) or triploid (AAB) hybrids produced by plantain breeding programs around the world (e.g., Honduras, Nigeria, Cameroun, Guadeloupe, and Brazil). Deployment of these improved plantain hybrids to increase food crop production in the Caribbean region will bring with it the risk of BSV disease outbreaks arising from integrated viral sequences present in the B genome component. Such events occur sporadically, and although some predisposing factors (e.g., seasonal temperature fluctuations, tissue culture (Bouhida and Lockhart 1990)) have been identified, further studies are needed in order to permit more realistic assessment of the risk of importing and planting these improved AxB hybrids.

Fruit symptoms caused by BSV infection in Grand Nain (Costa Rica)



BSV symptoms from integrated viral sequences (EPRVs) in improved plantain tetraploid hybrid (AAAB) following tissue culture

Cucumber Mosaic Virus (CMV)



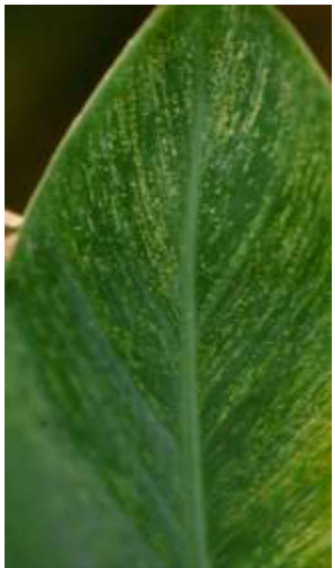
Foliar mosaic symptoms caused by a common strain of CMV in banana (banana mosaic)

Cucumber mosaic virus (CMV), like BSV, occurs worldwide (Lockhart and Jones 2000a). The virus has spherical 30nm particles that contain a segmented single-stranded RNA genome. In its epidemiology CMV differs from other viruses of *Musa* in infecting a very wide range of host plant species, including many cultivated crops (e.g., cucurbits, pepper, tomato) and weeds found commonly in banana and plantain fields (e.g., *Commelina*). The virus is transmitted in a non-persistent manner by a number of aphid species that colonize banana. The result is that unlike BBTV and BBrMV, which are spread by aphid vectors

Initial symptoms of systemic necrosis caused by a heart-rot strain of CMV in 'Williams' banana

only from banana to banana, CMV infection can, and most frequently does originate from a range of other plant hosts of the virus. The threat to food crop production posed by CMV arises from the existence of two distinct strains of the virus (Lockhart and Jones 2000a). Common strains of CMV cause mosaic symptoms that appear in a few leaves and normally cause no significant growth or yield effects. In contrast, heart-rot strains of the virus cause systemic necrosis, resulting in plant death or severe crop damage and yield loss. The threat posed by heart-rot strains of CMV quickly multiplies, because once introduced into an area, the virus is spread rapidly to a wide range of weed or crop species by a number of aphid vectors (Bouhida and Lockhart 1990).

Banana Mild Mosaic Virus (BanMMV)



BanMMV symptoms in Pisang seribu (Musa AAB)

Banana mild mosaic virus, BanMMV, is another virus of banana and plantain that was identified and described relatively recently (Thomas, Lockhart, and Iskra-Caruana 2000). The virus has not been studied extensively, and there are few experimental data on its epidemiology or effect on plant performance or crop yield. It occurs with great frequency in banana, plantain, and bluggoe throughout the Caribbean region (Anonymous 2008). Infection by BanMMV has been associated with distinct leaf symptoms only in a few cultivars, but other observations have suggested additional effects, including reduced plant growth (Anonymous 2008; Thomas, Lockhart, and Iskra-Caruana 2000). Wide distribution and high frequency of BanMMV infection in the region suggest that additional research on the epidemiology and the effect on plant performance and crop yield of this virus would be of value in assessing the level of risk it poses to banana and plantain production, which is currently unknown (Anonymous 2008).

REDUCING THE THREAT TO BANANA AND PLANTAIN PRODUCTION POSED BY VIRUSES

Based on the information and discussion presented above, it can be deduced that reducing any threats to banana and plantain production posed by the viruses mentioned would involve the following concrete steps:

1. Zero tolerance of BBTV and BBrMV presence in any *Musa* germplasm imported for field planting or plant breeding. The highest degree of risk of accidental entry of those viruses may be in Cavendish banana plantlets produced by *in vitro* propagation in commercial operations in countries where BBTV and BBrMV are known to be endemic (e.g., India and the Philippines). All rhizomes used for large-scale tissue culture multiplication should be certified virus-free by PCR testing (Thomas and Iskra-Caruana 2000a). The same certification standard should be applied to *Musa* germplasm introduced for breeding purposes.

2. Reduce spread of BSV by vegetative propagation by selecting virus-free mother plants. This frequently presents problems because BSV symptoms appear only periodically, so that plant selection on the basis of symptoms is highly unreliable. Serological (ELISA) assays are more reliable, but are compromised by the high degree of serological heterogeneity that exists among isolates of BSV (Ndowora and Lockhart 2000). PCR indexing is both sensitive and reliable, but this usefulness is limited to *Musa* AAA or AA genotypes due to the presence of integrated viral sequences and hence false positives in genomic DNA of any *Musa* AxB interspecific hybrid (James et al. 2011). The recent development of a rolling-circle amplification (RCA) protocol that distinguishes between episomal BSV (i.e., circular dsDNA) and integrated (i.e., linear) viral sequences, has made PCR detection of BSV in B genome-containing cultivars highly reliable (James et al. 2011).

3. Raise awareness of the threat posed by the heart-rot strain of CMV, and eliminate any infected plants to reduce the risk of the virus spreading into weed hosts that would serve as reservoirs of virus for transmission by aphids to bananas.

4. Initiate research on epidemiology and effects of BanMMV infection on banana and plantain in single or mixed infection with BSV. This will determine how much attention should be given to this widely-occurring virus.

REFERENCES

Anonymous. 2008. Pest risk assesment made by France on *Banana mild mosaic virus* (BanMMV) considered by France as harmful in French overseas departments of French Guiana, Guadeloupe, Martinique and Réunion. *The EFSA Journal* 652:1-21.

Bouhida, M. and B. Lockhart. 1990. Increase in importance of cucumber mosaic virus infection in greenhouse-grown bananas in Morocco. *Phytopathology* 80:981.

Dallot, S., P. Acuna, C. Rivera, P. Ramirez, F. Cote, B. Lockhart, and M. Caruana. 2001. Evidence that the proliferation stage of micropropagation procedure is determinant in the expression of *Banana streak virus* integrated into the genome of the FHIA 21 hybrid (*Musa* AAAB). *Virology* 146:2179-2190.

James, A.P., R. Geijskes, J. Dale, and R. Harding. 2011. Development of a novel rolling-circle amplification technique to detect *Banana streak virus* that also discriminates between integrated and episomal virus sequences. *Plant Disease* 95(1):57-62.

Khalid, S. and M. Soomro. 1993. Banana bunchy top disease in Pakistan. *Plant Pathology* 42:923-926.

Khalid, S., M. Soomro, and R. Stover. 1993. First report of banana bunchy top virus in Pakistan. *Plant Disease* 77:101.

Lockhart, B. 1986. Purification and serology of a bacilliform virus associated with banana streak virus disease. *Phytopathology* 76:995-999.

Lockhart, B. and D. Jones. 2000a. Banana mosaic. In *Diseases of Banana*, edited by D. Jones, Wallingford, UK: CABI Publishing.

Lockhart, B. and D. Jones 2000b. Banana streak. In *Diseases of Banana*, edited by D. Jones, Wallingford, UK: CABI Publishing.

Ndowora, T. and B. Lockhart. 2000. Development of a serological assay detecting serologically diverse banana streak virus isolates. In *Proceedings of the First International Conference on Banana and Plantain for Africa*, edited by K. Craenen, R. Ortiz, E. Karamura, and D. Vuylsteke. *Acta Horticulturae* 540:377-388.

Ndowora, T., G. Dahal, D. LaFleur, G. Harper, R. Hull, N. Olszewski, and B. Lockhart. 1999. Evidence for badnavirus infection in *Musa* originating from integrated viral sequences. *Virology* **255:**214-220.

Thomas, J. E. & Dietzgen, R. G. 1991. Purification, characterization and serological detection of virus-like particles associated with banana bunchy top disease in Australia. Journal of General Virology 72:217-224.

Thomas, J. and M. Iskra-Caruana. 2000a. Bunchy Top. In *Diseases of Banana*, edited by D. Jones, Wallingford, UK: CABI Publishing.

Thomas, J. and M. Iskra-Caruana. 2000b. Bract Mosaic. In *Diseases of Banana*, edited by D. Jones, Wallingford, UK: CABI Publishing.

Thomas, J., B. Lockart, and M. Iskra-Caruana. 2000. Banana Mild Mosaic. In *Diseases of Banana*, edited by D. Jones, Wallingford, UK: CABI Publishing.