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Management of viral diseases of banana

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INTRODUCTION

Viruses infecting banana can have a direct effect on production by reducing plant growth and yield. They can also have important indirect effects by restricting germplasm movement and by predisposing plants to damage by other biotic and abiotic stress factors. These diseases differ from those caused by fungal and bacterial pathogens in two fundamental and critical respects. The first and most important, is that viral infections can not be eliminated by chemical treatment (chemotherapy), which means that control of viral diseases must be based on preventing infection rather than on curing the disease. The second difference is that, whereas fungal and bacterial diseases may cause dramatic short-term damage, viral infections often result in long-term debilitating effects since the clonal progeny of infected plants are automatically infected by the virus.

Five viruses are known to cause diseases in banana. These are *Cucumber mosaic virus (CMV), Banana bunchy top virus (BBTV), Banana streak virus (BSV), Banana bract mosaic virus (BBrMV)* and *Banana mild mosaic virus_BanMMV).* Techniques for effective management and control of each of these virus disease differ because these viruses differ in their biological properties, epidemiology and distribution, and it is essential to know the characteristic of each virus. In addition the effective practical control of these viral diseases depends on the availability of reliable virus detection methods and on appreciation of the risk factor that each of these diseases poses. The application of these principles to understanding and managing each of the five viral diseases is presented below.

CUCUMBER MOSAIC VIRUS

Mosaic of infectious chlorosis of banana has been known for a long time to be caused by *Cucumber Mosaic virus* (CMV), and occurs throughout the world (14). From the standpoint of disease management the critical features of this disease are the variability and biological properties of the pathogen. Most strains of the virus are so-called "common" strains, which do not produce severe symptoms or cause significant crop damage (14). Symptoms consist of foliar mosaic and occasional leaf deformation, especially in young suckers developing from infected mother plants. Mosaic symptoms are most pronounced during cool weather but do not persist, in contrast, the severe of heart rot strains of CMV (1, 16) can cause damaging symptoms, which include chlorosis, cigar leaf necrosis, internal pseudostem necrosis and plant death (Figure 1). While they differ in the amount of damage they cause, both types of CMV share the same biological properties and epidemiology and the approach to disease control is the same for both. CMV occurs naturally on very wide range of plant species, including cultivated crops (e.g. tomato, pepper, cucurbits) and weeds, which serve as reservoirs of infection for banana. The virus is transmitted in a non-persistent manner by several aphid species (e.g. *Aphis gossypi, Myzus persicae)* which colonize a wide range of source plant species and visit but do not colonize banana. As a result, infection of banana CMV occurs almost exclusive by aphid transmission from other plant species rather than from banana to banana. Therefore management of CMV infection banana, regardless of which virus strain is involved, is based primarily on eliminating or reducing external sources of infection (i.e. weeds) and secondarily on

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controlling aphid vector populations. In the majority of situations effective control of CMV can be achieved by weed control to eliminate adventitious plant species which serve as reservoirs for both virus and aphid vectors, It should be noted however that while other species are primary source of virus for infection of bananas, banana itself can serve to introduce CMV into new areas. From infected banana the virus can speed into a variety of weed and crop species, which in turn became permanent reservoir of infection for banana. This scenario is especially dangerous where severe or heart-rot isolates of CMV are involved, and as CMV occurs ubiquitously and may therefore not be regarded as a quantitative risk, it is important to recognize the potential danger of introducing serve or strains of the virus into new areas in infected banana plant material. Fortunately, in terms of determining plant health status and strain identification, routine detection of CMV can be done by a variety of methods including enzyme immunoassays and PCR (8), so that there is no reason why potential damaging strains of the virus should not be excluded from virus-free area of banana cultivation.

BANANA BUNCH TOP VIRUS

Bunchy top disease of banana (Figure 2), caused by *Banana bunchy top virus*, like mosaic or infectious chlorosis caused by CMV, is a disease, which has been known for a long time (16, 19). This disease however, differs from mosaic in several important respects, and we can highlight these differences to illustrate the basic point made in the introduction, namely that viral disease management in banana is determined by the distribution, biology and epidemiology of the pathogen and the disease. First, whereas CMV occurs world wide, BBTV occurs only in the old world tropics and subtropics (Asia, Australasia and Africa) (19) and has not been reported in the banana producing areas of the Americas. Second, whereas, CMV occurs naturally in a wide range of plant species, BBTV is known to occur only in banana. Third, CMV is transmitted in a non-persistent manner by a variety of aphid species which colonize a variety of plant hosts, but not banana, whereas BBTV is transmitted in a persistent manner by a single aphid species, *Pentalonia nigronervosa*, the black banana aphid (Figure 3)

Figure 1. Cigar-leaf necrosis in Cavendish banana (Williams) caused by a severe or heart-rot strain of CMV introduced into Morocco in infected planting material.

Figure 2. Severe stunting of banana (East African AAA) caused by BBTV infection in western Rwanda.

Figure 3. The banana aphid, Pentalonia nigronervosa colonizing young banana plant in Colombia. (Photo courtesy Helena Reichel).

which colonizes only banana almost exclusively. As a result, BBTV spreads only from banana to banana and banana is the only source of infection. Since the aphid vector *P. nigronervosa* occurs throughout the banana growing areas of America it is of paramount to exclude BBTV from the region. Introduction of this disease could result in catastrophic losses since most cultivation of banana in this region occurs in pure stands, which would facilitate rapid disease spread by the aphid vector. Because of the increasing globalization of the production and movement of tissue cultured banana plants, greater attention needs to be paid to the exclusion of BBTV from the Americas. Sensitivity reliable methods for BBTV detection should are available, and should be used in all cases. All cultivated *Musa* AA and AAA cultivars are believed to be susceptible to BBTV, while some degree of resistance appears to occur in interspecific A x B hybrids (19). However, AAA genotypes differ in their level of tolerance to BBTV. The Cavendish subgroup, which includes the majority of cultivars grown for export are highly susceptible to BBTV, while others such as Gros Michel are much more tolerant. The susceptibility of particular AAA cultivars to BBTV would therefore have to be considered in assessing the risk of accidental introduction of this virus into New World production areas. Development of BBTV-resistant bananas incorporating viral genomic sequences represents a potentially effective method of BBTV control in both existing and new areas of disease incidence. Whether such genetically modified genotypes would find popular and commercial acceptance remains to be seen.

BANANA STREAK VIRUS

Unlike mosaic and bunchy top, banana streak disease (Figure 4), caused by *Banana streak virus* (BSV) is a relatively new disease of banana (10,11) although there is evidence that it may have been diagnosed previously as a form of mosaic caused by CMV (15). This disease, and the virus that causes it differ significantly from mosaic caused by CMV and bunchy top caused by BBTV, and approaches to managing this disease are consequently different from those discussed above. Similar to BBTV, and unlike CMV, BSV infects only banana. It can be transmitted by mealybugs (figure 5), which, unlike the aphid vectors of CMV and BBTV do not disperse rapidly or over long distances and there is not too much evidence that significant spread of BSV by mealybug occurs in nature. *Sugacane bacilliform virus* (SCBV) (12) occurs widely in sugarcane (2), is closely related to BSV, and can be transmitted by mealybugs from sugarcane to banana, producing symptoms similar to those caused by BSV. There is however no evidence that significant spread of SCBV from sugarcane to banana occurs in nature, or that the presence of SCBV in sugarcane needs to be considered in the epidemiology and control of BSV infection in banana. Dissemination of BSV occurs primarily in infected planting material, and in the absence of alternate hosts and mobile insect vectors, control of this disease is based on the use of virus free planting materials. This simple premise is however complicated by the fact that for several reasons it may be difficult to detect BSV routinely in plant materials or in the mother plant. Selected

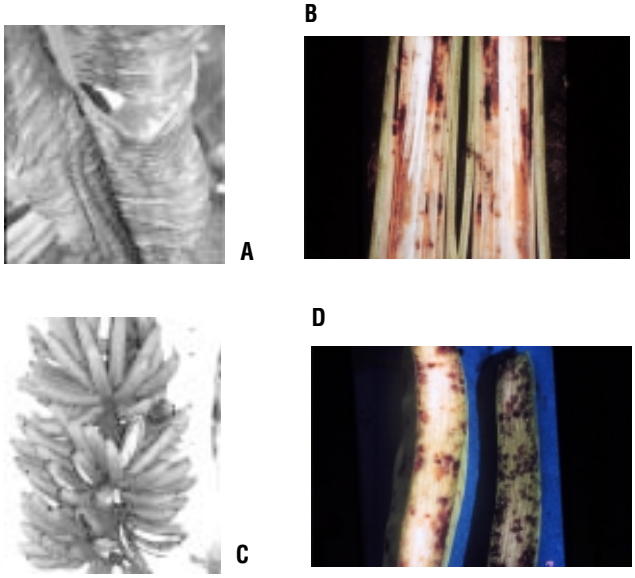

Figure 4. Leaf (4A), pseudostem (4B) and bunch (4C, 4D) symptoms caused by BSV infection in Cavendish banana (Grand Nain). (Photos courtesy Cornelia Pasberg-Ganhl).

A

B

Figure 5. The citrus mealybug, Planococcus citri (5A), and the pink sugarcane mealybug, Saccharicoccus sacchari (5B), two vectors of BSV.

in vitro propagation. These factors include sporadic and unpredictable appearance of visible foliar symptoms (3, 6) low virus concentration in infected plants and a high degree of serological and generic heterogeneity among isolates of virus (13, 17). Although improvements in the BSV detection is based on enzyme immunoassay and PCR protocols have been described recently, these techniques still suffer from drawback imposed by the highly variable nature of the virus. Because of this reliable detection of BSV remains a problem. An additional and more intractable problems posed by the BSV is the fact that de novo infection can arise from viral sequences integrated into the *Musa* genome (9, 18). This unusual phenomena occurs however, only in interspecific *M. acuminata X M. balbisiana* hybrids (7), and poses a serious problems for triploid (AAB) and tetraploid (AAAB) hybrids produced in breeding programs during the past ten years. Unfortunately, activable BSV sequences are not present in *M. acuminata* (7), and this phenomenon therefore does not occur in AAA bananas grown for export.

BANANA BRACT MOSAIC VIRUS

Bract mosaic caused by banana bract mosaic virus (BBrMV) was first recorded in the Phillipines in 1979. The virus is known to infect only banana, and can be transmitted in a non-persistent manner by at least three species of aphid, *Aphis gossypi, Rhopalosiphum maidis and Pentalonia nigronervous.* Infection by BBrMV can result in growth defects, reduced suckering and misshapen, unmarketable fruit, therefore this disease has the potential to cause economic loss (20).

Fortunately, BBrMV like BBTV, is not known to occur in the new world tropics and has been identified only in the Phillipines, India, SriLanka, Vietnam and Western Samoa. This disease would therefore be most effectively controlled by exclusion. As in the case of BBTV, attention must be paid to the source of imported banana planting material particularly plants produced by *in vintro* propagation. Routine indexing of germplasm for BBrMV infection can be reliable by enzyme immunoassay or RT-PCR.

BANANA MILD MOSAIC VIRUS

Banana mild mosaic caused by *Banana mild mosaic virus* (BanMMV) (Figure 6), is the most recently described viral disease of banana (21), and there is very little information on the potential impact of this disease on banana production. One reason for this is that BanMMV occurs very frequently in mixed infections with BSV or CMV, and possible symptoms and/or effects of BanMMV may be masked. The most distinctive symptoms caused by BanMMV alone consist of fine silvery continuous or discontinuous streak, which are more pronounced at the leaf, tips that towards the

Figure 6. Symptoms caused by BanMMV in Pisang seribu (AAB).

base. As is the case for several other viral diseases of banana these foliar symptoms develop at periods of the year when temperatures are lowest. Although firm experimental evidence is lacking, there are indications that BanMMV infection by itself, or in combination with BSV may have a deterious effect on growth and productivity of some banana cultivars AAB genotype in particular, and it would therefore be prudent to consider this disease as a potential threat to banana production. There is also very little information on the biology or epidemiology of BanMMV. Banana is the only know host of this virus, and attempts to transmit BanMMV by mechanical inoculation mealybugs *(Planococcus citri)* and aphids (*Pentalonia nigronervosa*) have been unsuccessful, BanMMV is widely distributed (Africa, Australia, Asia, Central and South America and the Caribbean) and therefore exclusion would not be the primary method to control. This virus is most probably spread mainly inadvertently in infected planting material because it is not widely recognized as a potential pathogen of banana. The virus can be detected reliably by both immunoenzymatic and PCR assays, and should be included in the list of potential pathogens during screening of banana germ plasm for exchange, propagation and planting.

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