Review on Diseases Affecting the Major Food Crop: Banana

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Abstract

The most important primary agricultural commodities in the world is banana and plantain (a form of cooking banana). Banana and plantain (a type of cooking banana) rank among the world's most valuable primary agricultural commodities. Bacteria cause significant impacts on bananas globally and management practices are not always well known or adopted by farmers. Bacterial diseases in bananas and enset can be divided into three groups: (1) Ralstonia associated diseases (Moko/Bugtok disease and banana blood disease); (2) Xanthomonas wilt of banana and enset, and (3) Erwinia-associated diseases (bacterial head rot or tip-over disease Erwinia carotovora ssp. carotovora and E. chrysanthemi), bacterial rhizome and pseudostem wet rot (Dickeya paradisiaca formerly E. chrysanthemi pv. paradisiaca). Other bacterial diseases of less widespread importance include: bacterial wilt of abaca, Javanese vascular wilt and bacterial fingertip rot. Banana is vegetatively propagated using suckers or tissue culture plants that grow, mature and fruit without seasonality throughout the year. Banana production has been vulnerable by a series of abiotic and organic stresses such as fungi, nematodes, bacterial wilt and viruses. Viral diseases are thought of a serious concern for banana production because of their effects on yield and quality. There are several (about 20) totally different viruses reported to infect banana worldwide. However, the economically most significant viruses are: Banana bunchy top virus (BBTV), Banana streak viruses (BSV), Banana bract mosaic virus (BBrMV) and Cucumber mosaic virus (CMV). Among these, BBTV and BSV are major threats for banana production. Of the two, BSV exist as episomal and endogenous forms and more widely spread worldwide than BBTV. Due to lack of durable virus resistance in the Musa spp., measures such phytosanitation, use of virus free planting material, strict regulation on movement of infected planting materials are effective means to control viral diseases in banana. This paper presents a review of the diseases affecting the musa species.

Keywords — *Musa acuminate; Musa balbsiana; pseudostem; Banana Xanthomonas wilt.*

INTRODUCTION

Banana is a perennial herbaceous monocotyledon plants in the genus Musa (Musaceae, Order: Zingiberales). It is one of the oldest fruits which was originated from Malaysia through a complex hybrization process [62]. Cultivated banana is a triploid derived from two diploid species that is Musa acuminata (Malaysia) and Musa balbsiana (India) [29]. The production of bananas is laid low by diseases of fungal, bacterial and viral origins. Banana Xanthomonas wilt (BXW) also known as banana bacterial wilt (BBW) caused by Xanthomonas vasicolapv musacearum(Xvm) (formerly Xanthomonas campestrispv musacearum) [89] is an emerging disease of bananas in East Africa. Asia is the main continent for banana which contributes more than half of the world banana production. The total export value of banana was estimated to be US$894.6 million in 2011 [21]. Most of the cultivated varieties of banana are sterile, parthenocarpic triploids, and derived from the two seedy species, Musa acuminate and M.balbisiana, contributing the A and B genomes, respectively [64]. Banana plants are vegetatively propagated which grow, mature, and fruit throughout the year. Suckers spring up from the underground rhizome to replace the main shoot that withers after fruiting, and this process of succession continues indefinitely [60]. Farmers usually use young suckers removed from the old plantations to establish new fields. This practice has been among the major causes of outbreaks of several banana diseases and pests around the world [38] particularly viruses that are perpetuated together with the planting material. About 20 different virus species representing five different families have been reported to infect banana worldwide. However, the foremost economically important viruses are banana bunchy top virus (BBTV, genus Babuvirus, family Nanoviridae), banana streak virus (BSV, genus Badnavirus, family Caulimoviridae), banana bract mosaic virus (BBrMV, genus Potyvirus, family Potyviridae), and cucumbermosaic virus (CMV, genus Cucumovirus, family Bromoviridae). Other viruses of minor significance are abaca bunchy top virus (ABTV, genus Babuvirus), abaca mosaic disease caused by a distinct strain of sugarcane mosaic virus (SCMV) designated as SCMV-Ab (genus Potyvirus), banana mild mosaic virus

(BanMMV), and banana virus X (BVX), the latter two being unassigned members in the family Betaflexiviridae. Viral diseases are a major concern for banana production because of their effects on yield and quality.

BANANA BRACT MOSAIC DISEASE

Banana bract mosaic disease, caused by the banana bract mosaic virus (BBrMV), was first noted on several banana cultivars in the Philippines (island of Mindanao) in 1979 and thought to be different from all other recognized viruses of banana [58],[71]. Later, BBrMV was found widespread throughout the Philippines. The disease was given the name bract mosaic at a meeting of banana virologists held in Los Baños in 1988 and includes a list of viruses of quarantine importance. Occurrence of the virus was discovered in other Asian countries including India, Samoa, Sri Lanka, Thailand, and Vietnam [15],[71],[72]. In Latin America, BBrMV occurrence was first reported from Colombia [66]. BBrMV belong to the genus Potyvirus and family Potyviridae. Flexuous filamentous virus particles measuring 750 × 11 nm have been detected.[4] Purified virions contain a major coat protein of 38–39 kDa. The virus genome consists of single-stranded positive-sense RNA of 1197 nucleotides long excluding the 3'-terminal poly(A) tail. The virus typically caused distinctive mosaic patterns on bracts. Spindle-shaped purplish streaks on bracts pseudo stems, midribs, peduncles, and even fruits are characteristic symptoms of the virus [71],[75],[86]. In some cases, symptoms on the pseudo stem are chlorotic on red background and reddish, yellow, or chlorotic on a green background. The symptom color may darken through red to brown and even black. Occasionally, chlorotic and spindle streaks appear on the leaves running parallel to the veins. Petiole and peduncles of Nendran banana become brittle, and fruits of infected plant rarely get to maturity. Bunches from infected plants unusually contain a long or very short peduncle, and in some cultivars, such as Nendran, the leaves appear as "traveler'spalm" plant [2]. Necrotic streaks on fruits, leaves, pseudo stems, and midribs have also been recorded [75]. The primary source of infection occurs through virus-infected vegetative planting material. The BBrMV is transmitted by several aphid species (P. nigronervosa, Rhopalosip hummaidis, Aphis gossypii, A. craccivora) in a nonpersistent manner [74]. The host range of this virus is mainly restricted to Musa spp. including abaca. Small cardamom in India [79] and flowering ginger, A. purpurata, in Hawaii [91] are reported to be the natural hosts of BBrMV.

BANANA MOSAIC OR INFECTIOUS CHLOROSIS DISEASE

The disease, first described in 1930 from Australia [55], is one of the common viral diseases affecting banana and plantain worldwide. Banana mosaic is also known as infectious chlorosis, heart rot, sheath rot, and cucumber mosaic.Banana mosaic disease is caused by the cucumbermosaic virus (CMV) which is a member of Cucumovirus group [95]. Spherical virus particles of 28–30 nm in size have single-stranded positive-sense RNA as genome. Most of the CMV genome consists of three genomic and one sub genomic RNA species [24]. In some isolates, fifth RNA species have been reported to be linked with symptom expression in some host plants. CMV isolates are grouped into two major subgroups I and II based on serology and molecular characters. Most of the CMV isolates from banana have been identified as subgroup I. The virus causes variable symptoms from mild chlorosis to severe chlorotic streaks on leaf lamina depending on the pathogen strain and the weather conditions. Symptoms are known to fluctuate during the growing season depending on the temperature and rainfall. Leaf deformation and curling are occasionally observed in the infected plants. This virus induces visible symptoms sporadically in the field, and majority of leaves did not show any symptom. Sometimes mosaic symptoms have been observed on fruits of infected plants. Generally, the symptoms are more severe in wintertime when temperatures fall below 24 °C in the tropics and subtropics. Symptoms are more pronounced which include necrosis of emerging leaves and internal tissues of pseudo stem when banana plants are infected with severe strains of the virus. Fruits may show mosaic symptoms and bunches may bear malformed fruit or no fruit. Plant death may occur in very severe cases especially when plants get infected with severe strain soon after planting. The spread of the disease occurs in nature through vegetative planting material and by over 60 different species of aphid vector including Aphisgossypii, A. craccivora, Rhopalosip hummaidis, R. prunifolium, and Myzuspersicae [68]. CMV has a wide host range, infecting over 900 species in almost every region of the world. Aphids usually acquire the virus from diseased weed and other crops growing nearby and spread to banana plantation due to migration of viruliferous vectors from diseased areas. However, most of the aphid species do not colonize on banana, but they may be able to transmit the CMV with relatively less efficiency during their exploratory visit to banana. A higher incidence of CMV was noticed in a newly planted field may be because of lack of alternative host for viruliferous aphid vectors within the field. However, a better understanding of disease epidemiology and aphid vector ecology is required.

BANANA DIEBACK DISEASE

The disease was first reported from Nigeria in 1996. The purified virions from infected plants were 28 nm isometric particles. This virus has been shown to have some serological relationship with certain nepoviruses [33]. Leaf chlorosis, wrinkling, marginal necrosis, and dieback of the cigar leaf are the symptoms induced by this virus. Infected suckers from the same mat become progressively more stunted and even the mother plant dies. Similar symptoms have also been noted in Ghana and Cameroon [33]. This disease can be mechanically transmitted to a limited range of herbaceous indicator plants [34].

ABACA MOSAIC DISEASE

This disease is caused by abaca mosaic virus (AbaMV) which is a member of Potyvirus and first recorded in the Philippines in 1925 [19]. This disease is so far reported from the Philippines alone, where 25–50 % losses were observed in new plantings. Whitish small dots later elongate and turn into spindle-shaped yellow chlorotic streaks on leaves, petioles, and midribs. The symptoms appear first parallel to minor leaf veins. As disease progresses, these chlorotic areas may turn in with rusty brown borders and extend from the midrib to the leaf margin. The infected leaves subsequently develop extensive yellow or pale-green stripes across the width of the leaf lamina. The causal virus is a flexuous filamentous particle of about 680 nm long with single-stranded RNA as genome and closely related to sugarcane mosaic potyvirus [19]. The host of this virus is mainly restricted to monocotyledonous plant. Natural hosts recognized so far include Musa textilis, Marantaarundinacea, and Canna indica. The primary transmission of AbaMV is by vegetative propagation, and natural field spread of the virus occurs by aphids (mainly R. maidis and A. gossypii) in a non-persistent manner [15].

BANANA MILD MOSAIC DISEASE

The disease is caused by banana mild mosaic virus (BanMMV) which appears to occur in Australia, Africa, Asia, Central and South America, and the Caribbean. The economic impact of this disease is not well known. The symptoms of this virus are uncertain and often symptomless infection occurs in Musa spp. Mild chlorotic mosaic and streaks have been observed on highly susceptible cultivars such as Ducasse (AAB, PisangAwak) and Daluyano (AAB, plantain subgroup). Mixed infection with BSV, BBrMV, and CMV has been reported [37]. Necrotic streaks have been reported in case of mixed infection with CMV in Guadeloupe [36]. The causal virus particles are flexuous filamentous measuring about 580 × 14 nm with a coat protein of about 27 kDa. The genome of BanMMV is a single-stranded RNA of about 7.4 kb and contains five ORFs [25]. The virus is classified as an unassigned virus in the Betaflexiviridae [43]. BanMMV is transmitted through the vegetative propagation of planting materials. The spread of the virus in nature has not been identified. However, the high heterogeneity of the viral genome and the temporal increase in disease incidence within a field imply the natural transmission of BanMMV is occurring through some unknown mechanism [84].

BACTERIAL DISEASES AFFECTING THE MUSA SPECIES

Ralstonia solanacearum Causing Moko and Bugtok Diseases

Ralstonia solanacearum, the causal agent of bacterial wilt, is currently found on all continents and numerous islands located between the tropics of Cancer and Capricorn, causing disease on more than 200 plant species in over 50 families [41],[31],[6]. R. solanacearum is considered as one of the world's most important/damaging phytopathogenic bacteria due to its lethality, broad geographic distribution and wide host range [20,59]. In reference to the high geographic and pathogenic diversity of the species, [9] stated that "there are many bacterial wilts and there are many 'Pseudomonas solanacearums' (syn. R. solanacearum). They have originated and evolved in widely different places and they have different capabilities with both native flora and introduced hosts and presumably with different soils and environmental conditions." This diversity results in variable disease expression and disease potentials for each host/parasite genotype interaction [9],[6]. In some countries of Latin America and the Caribbean, Moko, caused by R. solanacearum is considered a threatening disease to bananas and plantains, together with black sigatoka (M. fijiensis; [47],[76]. In Colombia, the disease has seriously affected the banana and plantain production and losses up to 100% in some areas have been reported [6].

Ralstonia syzygii Subsp. celebesensis Causing Banana Blood Disease

Banana blood disease is thought to have originated on Salayar Island near Sulawesi, where it was first reported after the introduction of dessert bananas in the early 1900s [18],[88]. The disease was confined to Salayar for many years due to the strict quarantine regulations implemented by the Dutch. However, it had become widespread on local cooking banana cultivars in southern Sulawesi (formerly Celebes) by 1920 [27],[81],[20] and then probably spread throughout the island until its discovery in Java in the late 1980s [88]. Unfortunately, the pathogen has since continued its spread to most of the larger Indonesian islands, where average yield losses

often exceed 35% [82]. These outbreaks were associated with the transmigration of people from Java to less populated islands in Indonesia [65]. The banana blood disease is currently spreading in peninsular Malaysia where it coexists with the Moko and Fusarium wilt diseases [83].

Dickeya paradisiaca Causing Pseudostem and Rhizome Rot

Pseudostem wet rot was first reported in the Cauca Valley of Colombia [49],[22], where it caused serious losses in nearly 2000 hectares of plantains. The disease is widely distributed in plantain and banana in Guatemala [92], Cuba [69],[78],[63],[22, (Rivera, 1978), Jamaica [78], Haiti, Venezuela [63] ,Colombia [22] Ecuador and Peru and Nicaragua, Panama and Dominican Republic [16]. In the 1970s, the disease caused serious damage in plantains in Cuba, with incidence in some fields of up to 75%. Currently, the disease seriously affects plantations of plantain in El Salvador, Nicaragua, Panama and Dominican Republic [16], where losses up to 50% were informally reported.

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