BBTV, CMV AND OTHER VIRUSES AFFECTING BANANA IN ASIA AND THE PACIFIC

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ABSTRACT

Banana is the most important fruit of the Asia and Pacific region. Cavendish clones are grown for the export market, but many indigenous cultivars are produced and consumed locally. Banana agriculture is subject to many natural calamities, but diseases constitute a major problem. Virus diseases are serious, as insect vectors are abundant and there are many alternate hosts.

Banana bunchy top is the most important virus disease of banana is the region. Its vector, the banana aphid, is an efficient transfer agent and is believed to have coevolved with the crop in its center of origin in Southeast Asia. Banana mosaic is cosmopolitan, and is found wherever bananas are grown. The virus has many alternate hosts and can be readily transferred by a number of insect vectors. Fortunately, it causes only minor problems except for occasional outbreaks when alternate host crops are grown close to banana plantings. Banana streak is another virus disease of minor importance in the region, and is found mainly in the cultivar Mysore. The virus disease causing most concern is banana bract mosaic, which affects many cultivars and is spreading rapidly throughout the Philippines and India. Bract mosaic causes a marked reduction in yield and is transmitted by the banana aphid as well as corn and cotton aphids.

BANANA PRODUCTION IN THE REGION

Banana is the premier fruit of Asia and the Pacific. It is the most important fruit of Indonesia, Thailand, Vietnam, Bangladesh, the Philippines, the South Pacific island countries and also India, where recently banana has been surpassing mango, traditionally the dominant fruit. Banana also occupy an important position in the agricultural economies of Australia, Malaysia, Taiwan, Sri Lanka, and southern China. While Taiwan and the Philippines derive substantial earnings from their banana export industries, the great bulk of bananas produced in our region are traded and consumed in domestic markets. Unlike fruit markets in temperate countries, where Cavendish clones predominate, Asian and Pacific consumers are offered a wide choice of banana and plantain cultivars of varying color (yellow, red, orange and green), flavor, texture, size and shape. Many cultivars are consumed fresh as dessert fruit, while a great number of culinary varieties are also produced for the hundreds of recipes which use cooking bananas and plantains.

Many problems affect banana agriculture. Natural calamities such as typhoons, floods, droughts and occasional volcanic eruptions cause devastating losses in banana production. Biotic factors caused by pests and diseases present constant threats to banana farmers. Some of the major disease problems are caused by viruses. BBTV (banana bunchy top virus), CMV (cucumber mosaic virus), BSV (banana streak virus) and BBMV (banana bract mosaic virus) are the four most important virus diseases affecting

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bananas. Unfortunately, they are all present in the Asia and Pacific region.

BANANA BUNCHY TOP

History, Distribution and Economic Importance

Bunchy top is considered the most serious virus disease affecting banana worldwide. The disease was first recognized in Fiji in 1889, at a time when a serious epidemic threatened the island's banana export industry. Subsequent records are from Taiwan in 1890, Egypt in 1901 and Australia in 1913, where the work of C.J.P. Magee established the viral nature of the disease problem and showed that it is transmitted by the aphid vector *Pentalonia nigronevosa*. However, the international spread of BBTV is primarily through infected planting materials (Wardlaw 1961).

The disease was introduced to Sri Lanka from Fiji in 1913, and later transmitted to southern India about 1940. Upon gaining entry into the Indian subcontinent, the virus spread to the vast banana-growing states of the country and later crossed into Bangladesh. In the other parts of the region, BBTV was recorded in the Philippines by Castillo and Martinez in 1961, in Vietnam by Vakili in 1969, and in Indonesia (Java) by Sulyo *et al.* in 1978. The presence of BBTV in Thailand and peninsular Malaysia remains controversial. No typical symptoms have been observed in either country, but tests using monoclonal antibodies developed in Taiwan indicated the presence of BBTV. Perhaps mild strains of the virus are carried by symptomless plants. However, the occurrence of BBTV has recently been confirmed in the eastern Malaysian state of Sarawak in Borneo (Doon 1995). In the Pacific island countries, BBTV is present in Hawaii, Guam, Western Samoa, American Samoa, Tonga, Tuvalu and Kiribati. It has also been reported to be present in China and Myanmar, but the most devastating effects of BBTV in recent years have been seen in Pakistan, where the virus has decimated the country's banana industry. It is not present in Latin America or the Caribbean (Jones 1993).

Symptoms

The characteristic symptoms of bunchy top are distinctive, and vary little from one cultivar to another. In advanced cases, the infected plants show a congested rosette appearance with narrow, upright leaves, giving rise to the common name 'bunchy top'. Dark green streaks are present on the midrib and petiole of the leaves, extending down into the pseudostem. A more diagnostic symptom is the presence of short, dark green dots and dashes along the minor leaf veins, which are best observed when the leaf is viewed from the underside. Plants infected at an early stage remain stunted and do not produce fruit. A virus characterized by small (18 to 20 nm), isometric particles and a multi-component ssDNA genome has been purified from infected plants (Thomas *et al.* 1994).

Disease Transmission, Virus and Vector Relationship, and Host Range

All attempts at mechanical transmission have failed. There is no evidence that BBTV is spread through infected implements used in cultural or harvesting operations. The disease is not soil-borne, and the only means of transmission is through its insect vector, the banana aphid (*Pentalonia nigronervosa* Coq).

The aphids are usually found clustered around the unfurled heart-leaf and the sheathing leaf-base of petioles, ideal locations for feeding and protection. They are also found on the base of the pseudostem and on very young suckers. The aphids flourish throughout the year, but are more numerous during the rainy season. Both winged and wingless individuals occur in a normal aphid colony. Banana aphids produce large quantities of "honey-dew" which attracts ants. The presence of ants is a good indication of the presence of aphids on a banana plant. Banana aphids are seldom found on plants other than banana, although colonies of the aphid are sometimes observed on members of the banana family, such as *Heliconia*, *Strelitzia* and *Ravenala*. They are also occasionally found on *Canna* and *Zingiber* but do not colonize these plant species for extended periods of time.

Experimental transmission of banana bunchy top through its aphid vector provided the first clue of the viral nature of the disease. Infective aphids allowed to feed on diseased plants and later transferred to healthy plants transmitted the bunchy top disease. On the other hand, when a large number of aphids obtained from healthy plants were transferred to healthy seedlings, no bunchy top symptoms developed after an extended observation period, although some injury was observed from heavy infestation and feeding of the aphids.

Further studies on BBTV transmission in Australia by Magee showed that to become infective, the aphids require a feeding period of at least 17

hours on diseased host plants. To transmit the virus, infective aphids require a minimum feeding period of 1.5 to 2 hours on susceptible plants. Magee's experiments indicated that an average of about 25 days' incubation is necessary for the development of banana bunchy top symptoms. He also found that young, newly infected plantlets transmit the virus more readily than adult plants, and that nymphs are more effective vectors than mature aphids. The success of the banana aphid in transmitting the virus is attributed to its very fine setae*. These can penetrate the phloem, the tissue believed susceptible to virus inoculation. Researchers in the Philippines reported that 12 hours was long enough for the vector to become viruliferous, and that the aphid can retain the virus for five days (Quebral 1963). Similarly, Magnaye (1979) showed that BBTV was readily transmitted when the vector was allowed access for 14 - 48 hours, and that BBTV is retained in the vector for more than 12 days when serially transferred daily to healthy host plants.

Control Measures

No cultivar has so far been identified which is resistant to BBTV. The disease can be effectively controlled by eradication of diseased plants and the use of virus-free planting materials. For eradication to be effective, plants must be uprooted and chopped into small pieces, or killed by herbicide sprays. All new growth must be destroyed. Control should cover the entire production area to prevent infection of virus-free planting materials. Government legislation is necessary to control the production and movement of planting materials, and the eradication of diseased plants.

Tissue culture is now standard practice in banana propagation. To insure that the nursery stock is clean and free from latent infection of BBTV, an Elisa test using the monoclonal antibodies developed by Dr. H.J. Su and now manufactured as a commercial product by General Biological Corporation of Taiwan, or Dr. Thomas' test kit manufactured by Agdia®, is recommended. Samples for Elisa testing should be collected from the petioles of the youngest leaves, as it has been shown that the concentration of virus is highest in this part of the plant. Virus diseases can be transmitted through tissue culture. Studies are being conducted on how to eliminate the virus from planting stock. Ramos and Zamora (1990) at the University of the Philippines at Los Baños demonstrated that extended exposure of shoot tip cultures of Lakatan banana to high temperatures considerably reduces infection with BBTV. A subsequent report by Wu and Su (1991) showed that the exposure of proliferating tissue cultures to heat results in the production of BBTV-free primordial cells, which then develop into healthy plants.

BANANA MOSAIC

History, Distribution and Economic Importance

Banana mosaic has a global distribution, and has been called by various names: Infectious Chlorosis, Heart Rot, Cucumber Mosaic and Virus Sheath Rot. What used to be regarded as a single disease is now accepted as a complex of what seem to be closely related diseases. Banana mosaic was first described by M.J.P. Magee in Australia in 1930, but has since been recorded in many countries all over the world. It probably occurs in most areas where bananas are grown (Gowen 1995).

The incidence of banana mosaic varies from common to rare. The disease is often unnoticed, as the symptoms are not pronounced and tend to disappear and reappear periodically (Stover 1972). Mosaic is generally considered a nuisance to farmers rather than a serious disease problem. In Australia, banana mosaic is considered endemic, is not actively controlled, and is of little importance in banana cultivation (Jones 1991). In Taiwan, the disease was first observed in 1959, but it does not cause serious losses except in small outbreaks where intermediate host crops of CMV are grown in adjacent plantations. In the Philippines, banana mosaic is widespread, yet no serious outbreaks have been recorded except in South Cotabato, where the disease was reported to have a serious effect on Cavendish and Saba bananas. In Indonesia, banana mosaic is recognized as a minor disease, while in Thailand, mosaic is recorded as present but does not cause problems, nor is it spreading.

Symptoms

Banana mosaic is characterized by a conspicuous inter-veinal chlorosis of the leaves. In severe cases, this is accompanied by rotting of the heart-leaf and central cylinder. However, infection in plantations is highly localized, and seldom results in serious outbreaks. Mild attacks may lead to full

* Setae (plural, sing. seta): Slender maxillae of sucking insects such as aphids (Ed.).

recovery. Infected plants are often observed to have stunted growth and low yields.

Banana mosaic is caused by cucumber mosaic cucumovirus, which has a very diverse host range. The virus contains single stranded RNA and has isometric particles about 29 nm in diameter. Many different strains of CMV have been distinguished on biological and biochemical criteria (Gowen 1995).

Disease Transmission, Insect Vectors and Host Range

The cucumber mosaic virus in banana is readily transmitted by several species of aphids. The two most common aphids, and those with the widest host range, are the cotton aphid, *Aphis gossypii,* and the corn aphid, *Rhopalosiphum maidis*. Transmission has also been recorded by *Myzus persicae*, *Macrosiphum pisi* and *Rhopalosiphum prunifoliae*. The role of the banana aphid, *Pentalonia nigronervosa*, is controversial. Some investigators have reported success in transmission studies using the banana aphid, while many others have reported negative results.

Studies on banana mosaic outbreaks in Australia noted that these occurred in plantations near where cucurbits, tomato and other vegetables were being grown. This led to the suggestion that the main spread of mosaic is by aphids dispersing from vegetable crops to banana, and not between banana plants. Later evidence from Taiwan was consistent with this view. Infection was much less common in banana fields surrounded by crops of banana or rice, than in those near vegetable crops. In fact in Taiwan, a distinction is made between strains of the virus which originated in legumes, and the more virulent strains from cucumber (Gowen 1995). A high incidence of the disease is often observed in banana plantations where *Commelina* and other CMV infected weed hosts are prolific.

It seems therefore that banana mosaic is generally acquired from a wide range of host plants growing near banana fields, and is transmitted by a number of aphid vectors that do not usually colonize banana. Fortunately, the virus is non-persistent in aphid vectors, although readily transmitted in brief feeding probes. CMV can readily be transmitted mechanically to a wide range of hosts. It can be carried through *in vitro* culture, but seldom through plants grown by meristem culture. Banana mosaic is seedborne.

Control Measures

Specific control measures are not usually required against banana mosaic. However, there are obvious advantages in ensuring that only mosaic-free plants are used for propagation. Stock plants in nurseries are routinely screened against CMV, using antisera that can detect a wide range of CMV strains. Ideally, banana fields should be sited far from vegetables and legumes, which should not be grown as intercrops. There should also be good weed control in banana plantations.

BANANA STREAK

History, Distribution and Economic Importance

Banana streak disease was first reported in Morocco, where it is serious in Dwarf Cavendish plantings. The disease has since been identified in other countries in Africa, and in the Middle East. At present, its distribution includes Latin America, New Caledonia, Australia, Tonga, Western Samoa, Indonesia, Malaysia, Thailand, the Philippines, India and China. In some areas, it appears to be spreading and causing significant damage, while in others it is a minor problem which is found only in a few plants of certain cultivars, with no evidence of spread apart from in diseased planting materials. Banana streak is often found in the cultivar Mysore. On the Ivory Coast, where the disease is serious in commercial Cavendish plantations, yield losses vary between 7% in plants with mild symptoms to 90% in severely affected plants (Jones and Lockhart 1993).

Symptoms

Foliar symptoms resemble those of banana mosaic, especially in the early stages. However, later there is a development of necrotic streaks, which do not occur in banana mosaic infected plants. Another distinctive characteristic of banana streak disease is the periodicity of infection expression. Infected plants may not show streaks in all leaves, while for several months at a time, emerging leaves may be symptomless or show only slight symptoms. Banana streak can reduce plant growth and vigor, bunch weight and yield.

Banana streak disease is caused by a DNA virus that has bacilliform particles, 30 x 130-150 nm.

The banana streak virus (BSV) is a member of the badnavirus group, and is related to sugarcane bacilliform virus (ScBV).

Disease Transmission, Insect Vectors and Host Range

The banana streak virus is transmitted by the citrus mealybug, *Planococcus citri* from banana to banana. The pink sugarcane mealybug, *Saccharicoccus sacchari*, has been shown to transmit ScBV from sugarcane to banana. However, the principal means of dissemination is infected planting materials. There is strong evidence that BSV is seedborne. The virus is not soilborne, and is unlikely to spread mechanically on cutting tools.

Control Measures

Banana streak disease can be controlled by the eradication of infected plants, and the use of BSV-free planting materials. BSV can be carried in *in vitro* plantlets, as it is not eliminated by shoot-tip culture. Virus particles can only be detected in areas of leaf tissue with symptoms. Parts of leaves with pronounced symptoms should be used for serological indexing.

BANANA BRACT MOSAIC

Banana bract mosaic disease was first recognized in the Philippines in 1979 by Magnaye, and was later recorded in India, in Coimbatore and Bangalore, by Jones (1992). There has been a great deal of research on this disease (see e.g. Frison and Putter 1989, Magnaye and Espino 1990, Espino *et al*. 1990, Jones 1992, 1993; Magnaye 1994; M.L. Iskra-Caruana (France) and John Thomas (Australia), personal communications). A recent survey revealed that banana bract mosaic is widespread in the Philippines, where it is causing a marked decrease in yield. It affects many local cultivars but is most common in Saba and Cardaba clones (*Musa* BBB). The disease also attacks Cavendish varieties (*Musa* AAA). A serious outbreak in Cotabato, southern Philippines, necessitated the eradication of some 25,000 plants.

Symptoms

The name is derived from the conspicuous discoloration and necrotic streaks that develop on the bracts of the male bud. Early symptoms take the form of greenish to brownish spindle-shaped streaks irregularly scattered along leaf petioles. As the disease progresses, similar discolorations become very marked on the bracts of the male inflorescence, the fruit bunch, and even on the fruits themselves. A diagnostic symptom of the disease is the spindle-shaped streaks found on the pseudostem after removal of dried leafsheaths. Banana bract mosaic is caused by a flexous, filamentous virus particle that belongs to the potyvirus group.

Disease Transmission and Insect Vectors

Disease transmission is through aphid vectors, including *Rhopalosiphum maidis*, *Aphis gossypii* (Magnaye and Espino) and *Pentalonia nigronervosa* (M.L. Iskra-Caruana, personal communication).

Control Measures

Effective control of the disease is similar to that of other viral diseases. It requires early detection, and immediate eradication of infected plants. In establishing new banana plantings, only virus-free propagating materials should be used. Dr. Teresita Espino of the University of the Philippines at Los Baños (Philippines) has developed a diagnostic test for BBMV which is available to researchers upon request.

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