GEMINI VIRUS COMPLEX

Introduction

Gemini virus is a component of the Whitefly-Geminivirus complex. Since the beginning of the 1990s the whitefly-geminivirus complex has caused tremendous losses to several dicotyledonous crops known to provide food, fibre and ornamentals throughout the tropics and sub-tropics including Central America and the Caribbean.

Whitefly-Geminivirus is referred to as a complex because there are various races and biotypes of whitefly (*Bemisia tabaci)* (Hilje, 2002). The tobacco whitefly, *Bemisia tabaci,* is also known as silverleaf whitefly or the sweet potato whitefly. In Latin America and the Caribbean the whitefly has caused problems as a direct pest by sucking plant sap or by transmitting geminiviruses (WTGs), known as begomoviruses in some 23 crops particularly tomato, hot pepper, sweet pepper, bean, soyabean, melon, watermelon, squash, pumpkin, tobacco and cotton. (Hilje, 2002). The begomovirus is injected into the plant when the tobacco whitefly, *B. tabaci (*Gennadius) feeds on the host plant. *B. tabaci*, possibly the most important whitefly pest, has the ability to colonize numerous plant species and also transmit many viruses (**Figure1)**. It is known as the world's most important pest species. This is particularly so within areas of the world with intensive monoculture agriculture. (EWSN, 2002). Geminivirus derives its name from a unique virus particle that looks like two small balls (twins) stuck together (**Figure 2**). Geminivirus-induced diseases of economic importance have been recognized since the late 1800s, but the viruses themselves were not discovered until the late 1970s (Stevens, 1996). In the decade of the 1980s alone, geminiviruses caused hundreds of millions of dollars in vegetable crop losses around the world. There may be 50 to 60 different forms of the virus affecting crops worldwide (Stevens,1996). They mutate rapidly, attacking the phloem system. It is generally believed that tomato yellow leaf curl virus (TYLCV) may be the worst tomato virus in the world. It can cause 100% crop loss if it occurs early or in the middle of the growing season (Stevens, 1996). Solanaceous crops suffer tremendous losses due to the begomoviruses. The overall importance of diseases caused by geminiviridae transmitted by *Bemisia tabaci* on solanaceous crops is obvious as severe crop losses are reported from many parts of the world, but it is still very difficult to assess the relative importance of the various pathogens involved. In many instances, the emergence of these diseases is associated with the evolution of *B. tabaci* populations and in particular with the spread of the '*B*' biotype. The significance of some begomoviruses is clearly evident *e.g*. the EPPO considers Tomato mottle virus as an A1 Quarantine pest and Tomato yellow leaf curl as A2. (Hamilton 2002). For the majority of other species of begomoviruses the situation remains extremely complex.

Identity

Classification

Genome	: DNA
Family	: Geminiviridae
Genus	: *Begomovirus*
Synonyms	: Tomato yellow leaf curl virus (TYLCV), Pepper leaf curl virus (PepLCV), Bean golden mosaic virus (BGMV-PR), Bean golden mosaic virus – (BGMV-DR), Tomato mottle virus – (TMV)
Role	: Pest

Signs & Symptoms

Sengbusch (2001)

Symptoms vary from mosaic, yellow leaf, curling, rolling of leaves, thickening of veins, reduction of fruit set, yellow mottling, crinkling, severe stunting, reduced yields and at times death of plants. On infection typical mosaic-like leaf patterns of light and dark green occur (Sengbusch, 2001). The infection spreads often over the whole leaf beginning at the veins. Leaves that had been infected during their development are usually deformed or volute **(Figure 3).**

Frequently, lightened leaf areas, called chloroses, develop around the primary site of infection. Withered areas are called necroses. Chloroses are caused by a breakdown of the chlorophyll resulting in a decreased rate of photosynthesis. Heavy infections are characterized by a complete local loss of chlorophyll. Affected areas have a yellowish look as only the carotenoids remain.

Morphology

This group of viruses consists of approximately 38 species of extremely narrow host ranges. The group is peculiar and noted for its nucleic acid. Begomoviruses are single stranded deoxyribonucleic acid, (ssDNA) and are grouped as whitefly transmitted (WFT) viruses. Particles of gemini viruses are quasi-isometric and they are usually found in pairs, hence the name 'Gemini' **(Figure 2)**. Each particle has a diameter of just 15-20nm. Gemini viruses belong to the smallest virus particles able to multiply without a helper virus. They have a circular DNA with a molecular weight of 0.7– $0.8x10^6$ (2,500 base pairs). The genome of Gemini viruses consists of two molecules of DNA of almost equal size, but different sequences. The nucleotide sequences of some species are known. The isolated circular DNA alone is not infectious. In infected host cells, the nucleus holds the chief amount of viral DNA. It is therefore assumed that the nucleus is also the place of its replication. (Sangbusch, 2001).

Dispersal / vectors

The gemini virus complex is insect transmitted. Several biotypes of the whitefly – *Bemisia tabaci* act as vectors of the disease.

Management

It has been recognized that management of the whitefly- geminivirus complex demands a considerable amount of collaboration and coordination of research worldwide in developing sustainable management systems to control the whitefly insect vector and the geminivirus pathogens. Management strategies of plant diseases caused by whitefly-transmitted (WFT) geminivirus pathogens must be based on an understanding of the mechanism underlying successful interactions between the components of these virus-vector-host complexes (Brown, 2000). Studies must also involve gemini-virus diversity, world wide, with respect to viral genotype and phenotype, as these characteristics impact the molecular epidemiology of WFT gemini-viruses and genetic engineering to complement traditional breeding in developing resistance to geminivirus. In addition, research on the *B. tabaci* complex has to be done to understand variability within populations using molecular markers. Collaborative research has so far led to the breeding of resistant varieties, 'Gem Star' to TYLCV along with 'Gem Pride' and 'Gem Pear' (Stevens, 1996). Peto Seed Company and Agricultural scientists at Universities are exploring conventional breeding and biotechnology. This approach would certainly be effective and long term, though benefiting a particular region, location -specific, but environmentally sound.

Chemical control has shown to be more successful if applied in tandem with cultural practices to reduce high populations of *B. tabaci*. The reduced population of the whitefly vector results in significant reduction in viral infection. A systemic insecticide, imidacloprid (Admire® Bayer, AG), applied at time of planting at the rate of 2.4l/ha (2 pints/ac) has proven effective. The pH of the solution should be adjusted to 4.5, with phosphoric acid, at the time of application. During the cropping season 'soft' insecticides, oils and soaps may be applied. These second class insecticides provide growers much shorter harvesting intervals necessary for production of quality vine ripe tomatoes. The late season use of some of the 'soft' insecticides sets the stage for use of biological controls, which also appear to be promising.

In Florida surveys of natural enemies attacking *B. tabaci* have shown 11 species of tiny parasitic wasps and 12 whitefly predators. This effect has led the way to biological control of whitefly in crop-free periods. *Eretmocerus mundus*, an indigenous parasitoid of Spain, is being researched as a possible biological agent to control *B. tabaci* and has shown good promise (Urbaneja et al. 2000).

Other cultural practices such as windbreaks around tomato or other host cultivations are used to trap and/or discourage swarms of the whiteflies; establishment of crop free periods to break the cycle of the whitefly and virus has proven highly successful in the Dominican Republic. Also, adjusting planting dates to avoid whitefly migration periods or use of short season tomato varieties can be complementary. It has also been found essential to produce clean, infected-free transplants by protection in greenhouses. In the field, during crop growth, bright yellow traps or traps to attract and trap flies have also been shown to reduce whitefly infestations.

Non chemical products such as growth regulators and systemic nitro methylene analogs as well as oils (soybean, cottonseed and neem) can effectively reduce both whitefly infestation and the percentage of virus infected plants.

It must be recognized that the use of pesticides can lead swiftly to population resurgence, as they destroy the natural enemies and stimulate the fertility of *B. tabaci*. Alternating the type of insecticide applied can serve to prevent or delay the development of pest resistance to a specific chemical. For example, the insecticides Denitol® and Karate®, can be used in conjunction with soaps such Safer and SJQ21.

The observation in Jamaica should be noted that the chemical Endosulfan (common name) acts as an irritant and repellant as it causes adult whiteflies to move more actively and thereby pick up larger doses of this insecticide (McLaughlin,1998).

In conclusion, the majority of successes so far in managing the WFT geminivirus complex on tomato holds promises for successes in other geminivirus-vector- host complexes, for example, hot and sweet pepper, and cucurbits in the Caribbean.

The need for simulation and modeling to determine the potential impact and conditions under which the proposed Integrated Pest Management (IPM) strategies can be successful is integral to the success in the deployment of such strategies. Finally pest management practices in limiting the most destructive whitefly gemini virus complex on several crops can best be developed through the farmer participatory methodology for improved crop production in the Caribbean.

Pest Significance

Of quarantine significance in the Caribbean

Host Notes

Gemini virus complex affects a wide range of crops – 300 plant species within 63 families (Mc Laughlin,1998), important among these being the Solanaceous crops – tomato, peppers, cucurbits, tobacco, and cotton.

Distribution

The whitefly Gemini virus complex can be found throughout the sub tropics and tropics, including Central America and the Caribbean, throughout the Greater Antilles of the Caribbean basin (Puerto Rico, Dominican Republic (DR), Jamaica) and the Lesser Antilles. Barbados and the Eastern Caribbean States including Antigua, Dominica, Grenada, St Kitts & Nevis, St Lucia, St Vincent and the French Antilles (Guadeloupe and Martinique) have reported that the Whitefly-Geminivirus complex has caused US millions of dollars losses in vegetable production (tomato, pepper (hot and sweet), cucurbits (cucumber, watermelon etc.) crucifers and other vegetables (Stevens, 1996).

No State in the United States has yet reported the most virulent of geminiviruses -Tomato yellow leaf curl virus (TYLCV) that is plaguing the Middle East, the Caribbean, and most tomato production areas in the tropical zone. With large populations of the sweetpotato whitefly or the ‘B’ biotype of *Bemisia tabaci* (also known as *B. argentifolii*, the Silverleaf whitefly) established throughout the tropics and subtropics and in greenhouses, it may be just a matter of time before it becomes a major problem in the USA.

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Web Resources -

http://www.whitefly.org/Global-PestEW-GPO1.asp
http://www. Catie.ac.cr/cooperation/mosca.htm
Gemini-viruses.C.online@botanik,unihamburg

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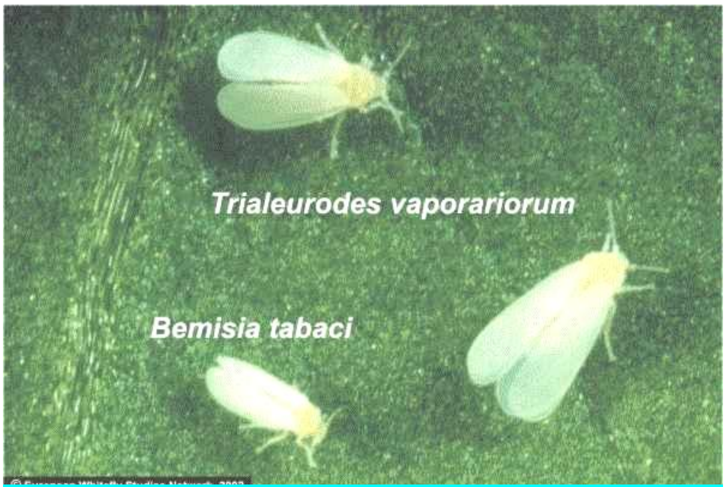

Figure 1: Whiteflies that transmit plant viruses e.g. *B. tabaci*
(Courtesy of EWSN publication, 2002)

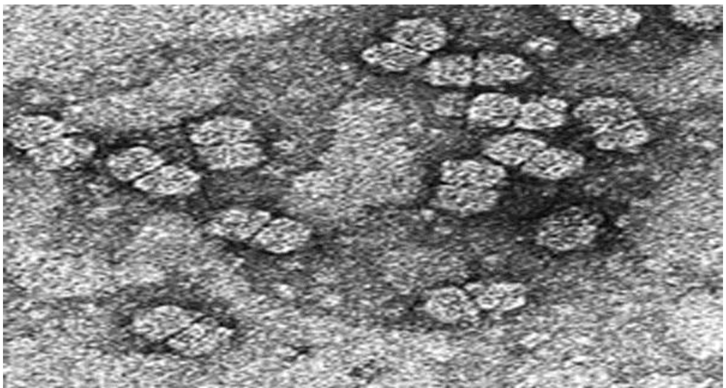

Figure 2: Electron micrograph of Gemini particles
(Courtesy of **Dr** J. Brown University of Arizona)

Figure 3: Tomato yellow leaf curl
(Courtesy of (a) Dr J. K Brown
(b) Dr H Laterrot)