Proposed Strategies for Begomovirus Disease Management in Tomato in Trinidad

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Abstract
Geminiviruses represent one of the major groups of phytopathogens of many economically important crops worldwide. In Trinidad, Potato yellow mosaic virus-Trinidad isolate (PYMV-TT) has been implicated as the causal agent of disease epidemics in tomato since the late 1980s. Since its detection there has been an increase both in disease incidence and in geographical distribution among commercial tomato production systems. Current strategies used to control infection have proven to be inadequate at suppressing the disease because such measures are not coordinated, integrated, or regulated. On-going research has identified several epidemic-associated factors which may be involved in PYMV-TT disease spread and persistence. Several management schemes are now recommended as part of a complementary and multi-dimensional system to delay PYMV-TT infection in tomato.

Introduction
Begomovirus disease in tomato has reached epidemic proportions in Trinidad. The primary causal agent is Potato yellow mosaic virus-Trinidad isolate (PYMV-TT), a recently characterized begomovirus first identified in Venezuela in the late 1980s (6). This pathogen has also been identified in other Caribbean countries such as Guadeloupe and Martinique (12,13). In Trinidad, disease incidence varies between 60 and 100% (depending on the geographical location of the farm) and estimated yield losses are as high as 50 to 60%. PYMV-TT infection in tomato (Fig. 1) is manifested by yellow mosaic or mottling of the lamina, interveinal chlorosis, leaf distortion including crinkling, and leaf size reduction with whole plant stunting in severely infected plants. Disease severity may vary according to the time at onset of infection, environmental and agronomic conditions, and cultivar grown (4,15,17).

PYMV-TT (family Geminiviridae, genus Begomovirus) has a ssDNA bipartite genome (designated DNA-A and DNA-B) which are encapsulated by twinned icosahedral particles. The virus is whitefly-transmitted in a semi-persistent manner by its insect vector, the sweet potato whitefly (Bemisia tabaci) to certain dicotyledonous plants (20).
Tomato (*Lycopersicon esculentum* Mill.) is the second most economically important vegetable crop next to potato worldwide (7). The major producers in the Caribbean are the Dominican Republic, Cuba, and Jamaica. Trinidad and Tobago produces approximately 1500 metric tons of tomato mainly for local consumption (7). Tomato production in Trinidad is geared toward supplying primarily local markets. The crop is grown more intensively in the dry season in concentrated pockets of production than in the wet season as some farms experience flooding. The largest commercial holdings are found along the east-west corridor and in southwestern regions of the island. There are no governmental policies to regulate cropping practices.

**Approaches to Disease Management**

**Cultural control.** Begomoviruses as a group have a wide host range which may be explained by the voracious feeding habits of the vector (4). However, single viruses may have a very restricted host range (3). Once conditions are favorable for feeding and ovipositing, whiteflies have a high reproductive rate and can exist in overlapping generations year-round, maintaining disease pressure (18). Interestingly, the dry season seems to encourage the explosive number of whiteflies in some farms (9,19).

The dynamics of the virus/vector complex and the interaction with host plants is as varied as it is complex and may change according to habitat, virus, epidemiology, and crop (4). This presents a challenge to devising control and/or suppressive strategies for disease management. While complementary cultural practices may not totally prevent spread, infection may be delayed and the effects of viral disease may be lessened throughout the crop. For *Tomato yellow leaf curl virus* (TYLCV), another begomovirus, weeds act as a reservoir or “transmission bridge” between cropping and non-cropping seasons (18). Through improved detection techniques it was shown that PYMV-TT has no known dicotyledonous weed hosts inside or outside tomato production systems (15,16). Hence, while rigorous weed control in and around tomato fields may reduce inoculum of other important tomato-infecting viruses such as *Tobacco etch virus* (TEV) and *Tobacco mosaic virus* (TMV), this approach may have minimal impact on controlling PYMV-TT disease spread.

Trap crops are commonly used to restrict vector populations and virus sources to refuge host plants which are usually insusceptible to infection. Certain plants within the Brassicaceae family are susceptible to heavy whitefly infestation. In controlled preliminary transmission tests, it was shown that whiteflies seem to prefer cabbage more than tomato (Rampersad, unpublished data). Planting border rows of cabbage along the perimeter of, or situating cabbage fields next to tomato fields may localize feeding to these crops as shown by studies conducted with TYLCV in Israel (5).

Intercropping may provide a useful approach to controlling geminivirus disease spread (2,8). Planting an insusceptible crop such as cucumber or pumpkin with tomato may delay PYMV-TT infection in tomato. Intercropping systems would affect several factors that may be critical to disease management. In the presence of a variety of host plants, whitefly behavior (feeding, rate of movement between plants) becomes more sporadic (2). Shorter feeding times may lower transmission rates and reduce disease incidence in the affected crop (2). It has also been shown that intercrops may result in a decrease in whitefly populations in *Cassava mosaic virus* (CMV) epidemics (8).

Crop rotation may be used to control disease spread by naturally breaking the life cycles of insect vectors, disease, and weeds. It may be also employed to establish host-free periods. Enforced host-free periods have been shown to effectively reduce disease incidence in TYLCV-infected tomato in the Dominican Republic (18). Introducing a host-free period may delay infection in tomato until the later stages of crop development because: (i) whitefly population would be reduced once a non-preferred host is used as an alternate crop; (ii) a reduction in vector numbers would result in lower rates of virus transmission; (iii) initial vector numbers would be lowered until tomato becomes established (early to mid-flowering stage) which may cause a delay onset of infection and minimize yield losses.

Sequential plantings should be carefully monitored so that new tomato fields are not cultivated in close proximity to heavily infested but still productive fields and to harvested fields. In agroecosystems in which the tomato crop (old, abandoned, or harvested fields and pre-existing fields) is the inoculum source,
synchronized plantings may be important to disease management (14,18). Sufficient time should be allowed between plantings to minimize initial infestation by the vector, and so, to delay onset of infection. This may be difficult to implement in Trinidad since: (i) tomato farms are in concentrated areas of production; (ii) the crop is grown year-round; and (iii) tomato is usually cultivated as staggered plantings within holdings and among large acreages that lie within close proximity.

The source and use of crop transplants are also important in reducing or delaying infection. Early infection of susceptible seedlings should be monitored prior to transplanting. In Trinidad, the majority or large farms purchase seedlings to be transplanted to the field from local growers. Nurseries should produce seedlings for commercial distribution in insect-proof environment or under net cover to minimize infestation by the vector, and subsequent virus transmission prior to transplanting (1,12). Upon transplanting, the seedlings should be chemically treated to deter whitefly feeding.

Roguing, or immediate removal of infected individual plants, may assist in delaying virus spread once the infected material is immediately destroyed and not left to compost near adjacent, developing fields. Plants heavily infested with whiteflies may need to be bagged, and tied off prior to uprooting and discarding to eliminate dispersal of whiteflies to other plants (19).

Dry weather conditions seem to favor infection, perhaps due to the degree of water stress experienced by the plants, which may make them more susceptible to disease. Sufficient irrigation may reduce water stress. While flash irrigation may be useful in dispelling whiteflies from leaves, many farmers cannot afford such systems.

The use of row covers and reflective or repellent mulches may help to delay infection in cases of moderate vector numbers and infection rates (4). The efficacy of these measures may be optimal in newly developing fields to prevent early onset of infection. Mulches should be applied simultaneously with or immediately after transplanting.

Post-harvest practices are important in controlling disease spread since whiteflies continue to develop on infected plants after the crop has been abandoned (12). Harvested plants should be sprayed and destroyed immediately after the last harvest.

**Chemical control.** Apart from damage caused by viral infection by PYMV-TT, vector infestation can result in feeding damage, disruptions in plant physiology, honeydew secretions which serve as a substrate for secondary fungal infestations, and irregular fruit ripening which reduces the value of the produce (10). Focused cultural methods of disease suppression should be supplemented with regulated chemical use. The difficulty experienced with reducing vector numbers using chemical sprays is explained by the behavior (feeding, ovipositing, and mating) of the adult, nympha, and larval forms of the whitefly. Nymphs and older larvae are found in the lower regions of the plant canopy and insecticide sprays (including natural or synthetic soaps, oils, and detergents) may not adequately access these areas. Systemic insecticides may have a select advantage by reducing vector numbers irrespective of developmental stage as all regions of the plant are accessed. Systemic insecticides only work to reduce disease if applied before onset of infection. Neonicotinoids (imidacloprid) and non-neurotoxic insect growth regulators (buprofezin and pyriproxyfen) have been used to control *Bemisia tabaci* in agronomic and horticultural production systems (11). However, intensive and unregulated use of insecticides has resulted in insecticide resistance or reduced susceptibility of the vector (11) and may suggest that the efficacy of chemical control may be temporary. Also, frequent insecticide use may disrupt the ecology of other pathogens. Chemical use should be monitored and the manufacturers’ instructions or guidelines should be strongly followed.

**Biological control.** Biopesticides may offer a solution to disease control through introduction of predators and parasitoids of the vector (19). This measure needs to be monitored by an advisory governing body whose function is to routinely regulate importation and usage, and to provide ecological impact assessments of such production systems.

**Use of resistant cultivars.** Studies on development of resistant lines have been carried out but the level of resistance afforded to these lines is not well indicated (17). Ideally, broad spectrum resistance or acceptable levels of
tolerance would control begomovirus disease epidemics in tomato where other methods of disease management are inefficient or difficult to implement. To date, there are no commercially available tomato hybrids that are resistant to PYMV.

**Conclusion**

While several workable approaches exist for the management of begomovirus disease in tomato, it is the focused implementation of integrated strategies aimed at delaying or suppressing onset of infection that would be the most beneficial. A complementary system of disease control that is preventative and coordinated should be exercised. Such a system should also be initiated by improved seed, planting material, and transplant treatments and progress throughout the development of the crop with timely and adequate irrigation during the dry season, regulated insecticide use, and consistent cultural cropping practices. With suppressive therapies, the virus/vector complex should be treated as a single infectious entity, and mechanisms to reduce vector numbers will subsequently reduce inoculum and infection. It is understood that absolute control is difficult to achieve; however, compensatory measures have proven to be effective in begomovirus disease management.

**Literature Cited**


**Electronic Resources for Further Information**


