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Tomato Yellow Leaf Curl Virus and *Candidatus* Phytoplasma Asteris in *Jasminum Sambac* Plant

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ABSTRACT

This research explores the "Tomato yellow leaf curl virus" (TYLCV) is a virus causing issues in tomatoes worldwide and is most damaging pathogens. Dozens of plants get affected with this virus and harm garden and production field. This study found that infected tomato leaves are tiny and curl upward, and shows signs of marginal yellowing. This research has reviewed the researches done by authors that explored the disease assessment in tomatoes plants. This research has also explored the review how to diagnose the TYLCV and how to manage.

KEYWORDS

Leaf curl Virus, phytoplasma, candidatus, plant, plant virus, Jasminum

Introduction

"Tomato yellow leaf curl virus" (TYLCV) is a tomato-infecting virus (*Solanum lycopersicum*) plants worldwide, causing epidemics. Numerous efforts have been made to identify resistance origins by screening wild tomato species. It is categorised as a member of the genus *Begomovirus* and is a member of the family *Gemini viridae* (Moriones, E. & Navas-Castillo J., 2000). Whitefly transmission and intentional injection with an infectious clone were formerly thought to be the only ways for begomo viruses, including TYLCV, to spread (Stanley, J. et al. 2001). This pathogen causes severe symptoms in tomato plants such as stunting, leaf curling, and yellowing (Papayiannis, L. 2011). The cultivated plants "*pepper* (*Capsicum* species), common bean (*Phaseolus vulgaris*), cucurbit (*Cucumis* species) and eustoma (*Eustoma grandiflora*)"identified as TYLCV (Anfoka, G., Haj Ahmad, F., Abhary, M. & Hussein, A., 2009). TYLCV has been reported in tropical and subtropical areas continuously from the initial report from the "Middle East in 1931" (Czosnek, H. & Laterrot, H., 1997). Since the first epidemic in 2008, TYLCV has been reported continuously throughout Korea (Lee, H. et al., 2010).

The whitefly of sweet potato"*Bemisiatabaci (Genn.)*" is a persistent carrier of TYLCV (Gronenborn, B., 2007).On a global scale, "*B. tabaci*" is a serious invasive pest, with over

175 countries reporting its presence (CABI 2017; *Bemisiatabaci*. In: Invasive Species Compendium). The genus B. tabaci has at least 24 species (De Barro, P. J. et. al. 2011). This virus has been found at retail establishments throughout Florida's southeast, southwest, and north central areas, as well as sent out of state. Affected whiteflies can then disseminate the virus to healthy tomatoes during feeding for 10-12 days. After 10-12 days, this virus must be re-acquired by nibbling on an infected plant. Unlike other tomato viruses that are common in Florida, TYLCV cannot be mechanically transmitted by operations such as plant tying, suckering, or even fruit harvesting. Despite the fact that this virus persists in crops and weeds, the virus's host range in Florida remains unknown (TYLCV, 2021).

Symptoms

The virus that causes the sickness is called the "*tomato yellow leaf curl*" virus and was first found in March 2007 in California and has spread to a limited extent since then. Early infection causes considerable stunting and upright growth in tomato plants. Leaf symptoms, on the other hand, are the most diagnostic.

Tiny, curled leaves with "substantial crumpling and interveinal and marginal yellowing" are symptoms. Internodes on infected plants shorten, giving them a bushy, 'bonsai' or broccoli-like appearance. Infected flowers frequently do not grow and die (abscise).

Disease Assessment

TYLCV is one of the most destructive tomato viruses, decimating tomato crop throughout world. It is a significant issue in a number of Mediterranean countries, including California. As a result, the virus's spread throughout California poses a significant threat to the tomato harvest.

The Central Valley's winter season, which lasts from late November to early February, offers a natural tomato-free period. The virus can infect other plants, but tomatoes are its favorite host. A yearly "tomato-free period" will most likely reduce viral inoculum (and whitefly numbers) during planting time and season returns in late winter or early spring. Additionally, the virus makes curling the leaf in several beans (*Phaseolus vulgaris*) & lisianthus plant (*Eustoma grandiflorum*). This virus can infect a variety of weeds from other families, but the majority of them do not show visible illness symptoms. Bemisia whitefly species spread the virus largely over short distances. The virus spreads across great distances primarily via the transfer of infected plants, most notably tomato transplants. Due to the fact that disease symptoms might take up to three weeks to manifest, infected plants that are symptomless may be relocated inadvertently (Friedmann el al., 1998).

A three-part study in China looked at the onset of TYLCD symptoms at different times: eight, ten, and twelve weeks after seeding. In addition, each date was assigned a DSI score between zero and four, where zero indicated no symptoms and four signified severe symptoms such as leaf curling and plant stunting. Intermediate values of 0.5, 1.5, 2.5, and 3.5 were added to better assess disease severity. Only asymptomatic accessions were considered

resistant genotypes (Fulton et al. 1995). As previously stated by Picó et al. (1999a),"TYLCV infection was detected using PCR with the primers TYLCV-Picó-F and TYLCV-Picó-R, respectively.

Researchers from Spain's Institute for Conservation and Improvement of Agrodiversity tested the resistance of various wild tomato varieties to TYLCD (COMAV). These tests were conducted with TYLCV or TYLCSV utilising whitefly-mediated and Agro injection approaches, and accessions were treated with both viruses at the same time. The first geminivirus TYLCSV found in Spain; for that screening began during 1990s.The TYLCSV was the most frequent TYLCV-related Begomovirus in Spain. TYLCSV is a virus that belongs to the TYLCV family (Moriones 1993).

TYLCV-infected tomato plants - Disease Evaluation

A PCR investigation (Kil et al., 2016) determined that the virus was present in the tissues of floral (Petals, stamens, and pistils, respectively) and fruit meat of TYLCV-infected tomatoes. Additionally, it was detected in complete dry seeds with endosperm tissues, surface-sterile seeds, and embryos with endosperm tissues (Fig. 1). As indicated in Materials and Methods, detection rates of TYLCV in diverse tissues were determined to be between 20% and 100%, reflecting a range of theoretically lowest to theoretically largest values (See Fig. 1C and Table 1). Additionally, TYLCV has been observed in genuine leaves (41/45) and cotyledons (22/26) of plants of tomato grown from seeds and derived from TYLCV-infected tomatoes carried by whiteflies (Fig. 1C, Table 1). Floral tissues, dry seeds, embryos, endosperms, and cotyledons have all been found to contain TYLCV, as well as other plant tissues (Fig. 1C). Floral tissue, seeds, and seedling sequences were all identical to TYLCV-infectious clone which was previously identified (NCBI GenBank accession number JN680149). According to Kil et al., (2016), TYLCV was also found in stem, leaf, and root from the samples of immature tomato.

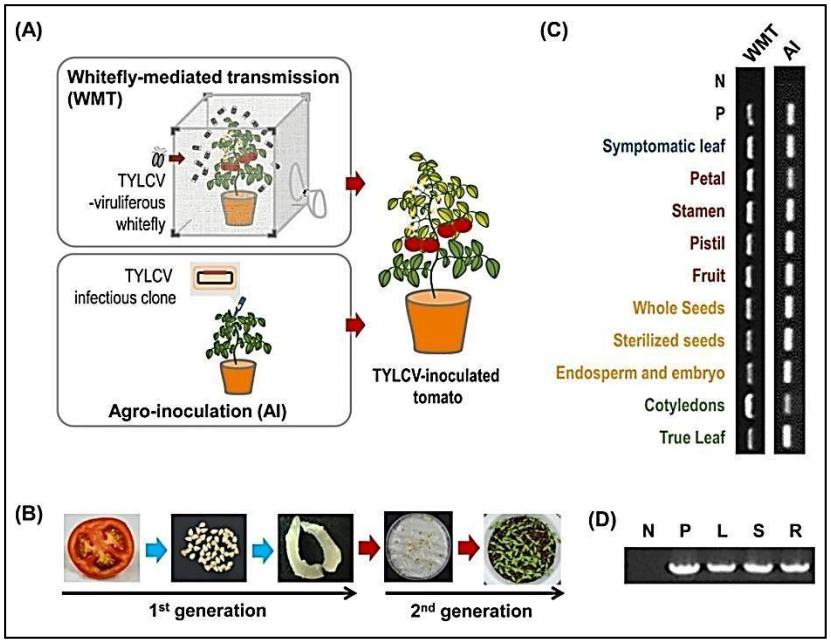

Figure 1. TYLC Detection

Table 1. Rate of TYLC infection

Rate of infection	Petal*	Stamen*	Pistil*	Fruit	Seed*	Embryo and endosperm*	Cotyledon	True leaf
Whitefly-mediated inoculation	5/5 (20 ~ 100%)	5/5 (20 ~ 100%)	5/5 (20 ~ 100%)	6/6 (100%)	6/6 (20 ~ 100%)	12/12 (20 ~ 100%)	22/26 (84.62%)	41/45 (91.11%)
Agro-inoculation	NT	NT	NT	5/5 (100%)	5/5 (20 ~ 100%)	12/12 (20 ~ 100%)	21/26 (80.77%)	55/75 (73.33%)

Natural whitefly infection and agro inoculation were used to explore wild tomato accessions in China and the Netherlands (Yan et al., 2018). Virus symptoms were not found in plants *S. arcanum* accession LA2172, *S. chilense* LA0458, *S. corneliomulleri* CGN14358, or any of the 11 tested *S. peruvianum*" accessions (CGN15530, CGN15532, LA0372, LA1977, LA4125, or PI 126928, etc.). Plants of the *S. cheesmaniae* accession LA1409, six *S. habrochaites accessions* (CGN15790, CGN15791, CGN15792, CGN15879, CGN24035, and PI 134417), and the *S. pimpinellifolium accession* LA1584 all showed severe symptoms, according to the study (Yan et al. 2018).

Another study employed non-virulent whiteflies to spread TYLCV from seedlings to healthy plants (Kil et. al., 2016). A transmission study was also carried out with a infected donor tomato plant that was developed from TYLCV-infected seeds (Fig. 2A). After eight weeks of co-cultivation in an insect-rearing tent, three healthy tomato plants were infected, which was transmitted by immature viruliferous whiteflies from a donor plant. On three receiver plants, PCR and Southern blot hybridization were used to validate this disease manifestation (Fig. 2E) (Fig. 3A, B). Southern blot demonstrated that, TYLCV replicated viral DNA in eight weeks after co-cultivation (Fig. 3B). Through sequencing analysis, it was

determined that all of the plants were infected with the TVLCV (Fig. 3C). Whiteflies that are not virulent transmit TYLCV from a donor tomato plant to healthy recipient tomato plants that were grown from the seeds of TYLCV-infected plants (Fig. 4).

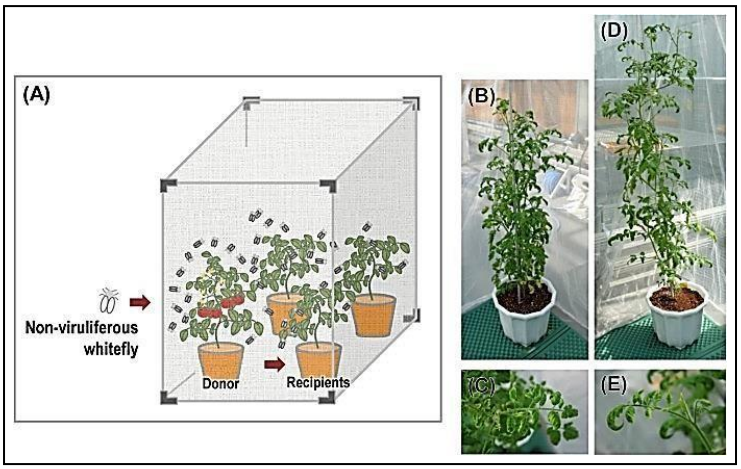

Figure 2. TYLCV-infected seeds

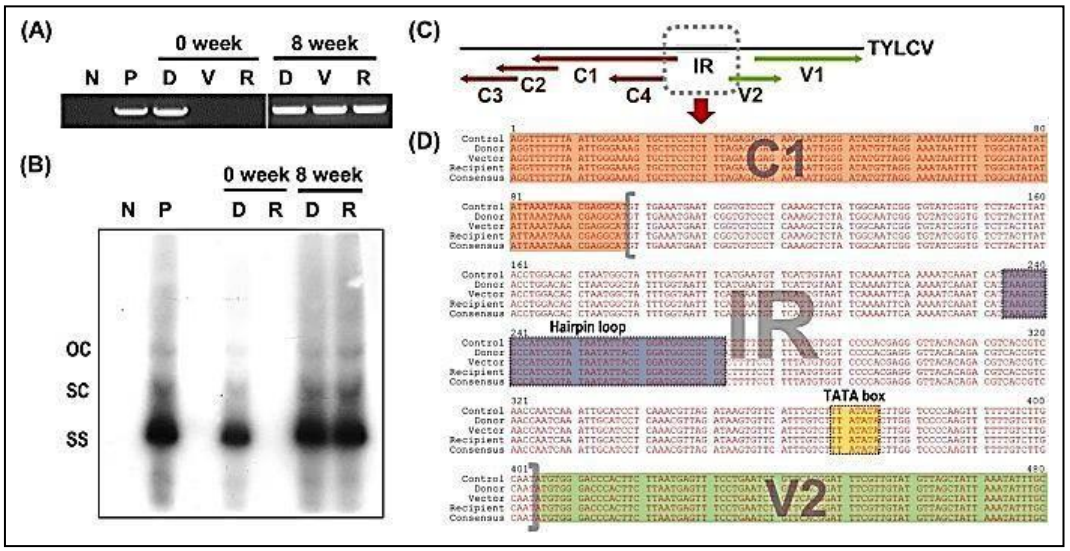

Figure 3. TYLCV replicated viral DNA after 8 weeks

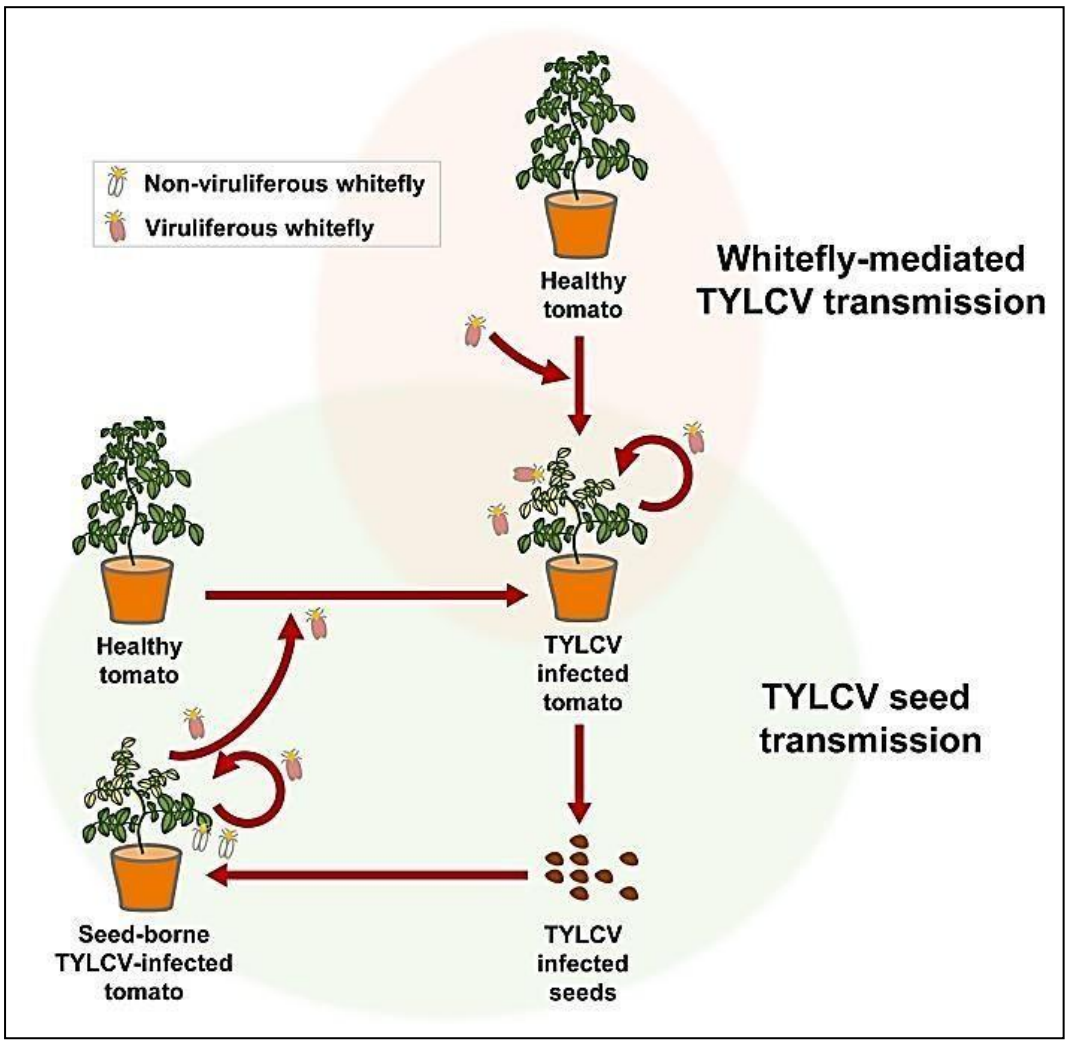

Figure 4. TYLCV-infected plants' seeds

Tomato is one of the most common crop grown across the world (Lapidot, M. et al., 2010). Tomatoes are abundantly grown in Korea, and consumption has gradually increased. However, tomato-infecting viruses conceded significant economic loss in Korea (Kil et al., 2015). TYLCV, which initially appeared in 2008, harmed tomato crop and has been documented repeatedly across the country (Kil et al., 2014). Sequence analysis suggests Korean TYLCV isolates evolved from two Japanese TYLCV isolates (Lister R. and Murant, A., 1967). In Korea, where non-viruliferous whiteflies have rapidly proliferated TYLCV since 2005, seedlings or viruliferous whiteflies may operate as an initial inoculum (Lee et al., 2010). Some viruses have seeds as their initial viral source (*Sastry 2013*). To yet, no evidence has been found that TYLCV is spread by seeds or mechanical inoculation, but solely through the insect vector Bemisiatabaci (Ali and Kobayashi 2010).

Diagnose and Manage TYLC in Tomato

TYLCV is extremely adaptable due to virus recombination, mutations, satellite additions, and external whitefly infection (Hosseinzadeh et al., 2014). TYLC is a virus that can be detected and handled in other crops and weeds.

Diagnose of TYLC

TYLCV caused marginal yellowing of leaves, upward or downward leaf cupping, leaf shrinking, and plant stunting. TYLCV can be found in one to all garden plants acquired from a store. Early symptoms include marginal leaf yellowing and minor cupping of the most recent leaf or leaves. Plant aging generates symptoms such as stunting and flower and fruit abortion. Reduced leaf size, leaf cupping, bloom loss, and plant stunting all become more noticeable as plants age ("*TYLCV, 2021*").Definitions of TYLCV based exclusively on marginal leaf yellowing or minor leaf cupping may contain errors. When tomatoes exhibit isolated symptoms, they may be caused by one of the following factors:

- Leaf yellowing: Deficiency in magnesium in older leaves may coax marginal yellowing, whereas overall leaflet yellowing may be due to a nitrogen deficiency. Iron deficiency in very alkaline soils, as well as luteovirus, tomato yellow, can cause young leaves to yellow on the margins.

- Leaf curl (upward): Physiological curling of leaf is most likely to blame for lower leaf curl, which is caused by a severe disruption in the plant's water transport system, particularly at fruit bearing age.

- Reduced leaflet size: Viruses such as "*tobacco mosaic, cucumber mosaic and pseudo curly top*" as well as virus combinations caninduce reduced leaf size.
- Stunting: Plant vitality can be harmed by Pseudo curly top geminivirus and virus combos, resulting in a stunted plant.
- Flower drop: Adverse climatic circumstances or small soil moisture imbalances can cause loss of the initial bloom cluster.

Management of TYLC

TYLCV management is a multi-step method that is outlined below.

Plants exhibiting symptoms should be placed with stem in tied black plastic bag at the soil level. Before discarding the plant, cut it close to bag and make it dry for 1-2 days on the soil surface. To prevent the virus from spreading to other tomatoes, infection-carrying whiteflies are captured and eliminated from the garden.

- If whiteflies are absent on the lower leaf surface of the symptomatic plants, they can be disposed off or buried.
- If whiteflies appear, insecticides such as azadirachtin (Neem), pyrethrin, or insecticidal soap should be sprayed.

Conclusion

Sweet potato whiteflies influence the transmission of TYLCV in tomato to other healthy tomato plants. Thirty non-virulent Bemisiatabaci (Q biotype) were placed in an insect rearing tent alongside three TYLCV-positive recipient plants and one TYLCV-positive donor plant (TYLCV-free tomato plants, Seogwang). Silver leaft whitefly was found to have physically transported tomato yellow leaf curl virus (a geminivirus family Geminiviridae) from plant to plant. Infected plants have little leaves that curl upward, are yellowish in colour, and are short in height.

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