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# VIRUS DISEASE INCIDENCE, ALTERNATE HOSTS OF PATHOGENS AND DISEASE RESISTANCE OF TOMATO IN SRI LANKA

I. ARIYARATNE, T. LIYANAGE and M. SAGARIKA
*Horticulture Crops Research and Development Institute, Peradeniya*

## ABSTRACT

**Cucumber mosaic virus (CMV) causes considerable damage to infected tomato plants. Cultivation of resistant varieties is considered the most effective method of minimizing the impact of the virus diseases. A sap transmission experiment revealed that the tomato varieties, T-245, KWR, T-146 and Thilina were susceptible to the CMV isolate collected from Matale District. The diagnostic hosts *Nicotiana* sp. and *Petunia hybrida* expressed CMV symptoms after sap inoculation. Thirteen tomato accessions were evaluated and tomato line, CLN-1507F1 remained symptomless and also gave a negative reaction with ELISA. The tomato samples collected from Yatawatta, Baminiwatta and Gannoruwa were infected and CMV could be detected in common weed *Tribulus terrestris* L. (Nerenchi). An isolate of tomato yellow leaf curl virus (TYLCV) was collected from Matale District. *Bemisia tabaci* was used as a vector to transmit TYLCV to tomato accessions in the screen house. Out of thirty-six tomato accessions, H-24 and SR-7725 remained symptomless under field and screen house conditions. According to the results of the field experiments, tomato line SR-7725 was resistant to TYLCV infection. Accession CLN-2123A gave the lowest disease levels. It was also confirmed the presence of TYLCV in T-245 and Thilina samples collected from Kadugannawa. There is a potential of gene transformation to produce new tomato varieties with virus disease resistance, high yield capacity and good agronomic characters.**

**KEYWORDS**: Tomato virus resistance, alternate hosts.

## INTRODUCTION

Cucumber mosaic virus disease (CMVD) is one of the common viral diseases of many vegetable crops in Sri Lanka. It causes stunting of seedlings, mottling and distortion of leaves and fruits, thus reducing the yield. The CMVD induces systemic mosaic and fern leaf symptom of *Lycopersicon esculentum* (tomato). The disease is of worldwide distribution, economically important and common in temperate region (Gibbs, 1970). Cucumber mosaic virus (CMV) is a RNA-containing virus with a 30nm diameter isomeric particle is transmitted by aphids *Aphis gossypii* and *Myzes persicae* in non-persistent manner (Gibbs, 1970). The virus is readily transmissible mechanically thus is often spread by workers (Gibbs, 1970). There are many minor variants of the virus, but the major variants are "yellow strain of Price" or "strain 6 of Price" (Francki *et.al.*,1979) which produces brilliant yellow mosaic in *Nicotiana* spp. and necrotic lesions in inoculated leaves of *Zinnia elegans*. The "Y strain of Price" causes yellow mosaic in *Nicotiana* but is less intense compared to the yellow strain (Francki *et.al.*,1979). It causes systemic symptoms in *Vigna sinensis*. Spinach strain of

Bhargava (1951) causes necrotic local lesions in *N. tabacum*, systemic green mosaic with distortion and necrosis of veins (Gibbs, 1970).

Jeyanandarajah and Liyanage (1996) and Ariyaratne and Liyanage (1997) have reported CMV infection of tomato in Sri Lanka. The CMV was found to be seed-borne in cowpea (*Vigna unguiculata*), mung bean (*Phaseolus aureus* Roxb.) and winged bean (*Phaseolus lunatus* L.), but not in brinjal (*Solanum melongena*), chilli (*Capsium annuum* L), passion fruit (*Passiflora edulis* Sims.) and tomato (*Lycopersicon esculentum* Mill.).

Tomato yellow leaf curl virus (TYLCV) is the most important and common virus disease of tomato in Sri Lanka and it has been reported from all tomato growing areas. *Bemicia tabaci* transmits the virus in a persistent manner (Brown and Nelson, 1988; Harrison, 1985). The symptoms of TYLCV include small yellow curled leaves, inter-venial chlorosis, stunted plants, small-distorted fruits and aborted flowers. The yield losses caused by TYLCV in tomato usually range from 50-75% (Yassin and Nour 1965; Makkouk *et al.*, 1979), but can also reach 100%. High disease incidences in Sri Lanka were found from April to September. The Indian strain of tomato leaf curl virus has been detected in tomato samples sent to the U.S.A. (De Zoysa, 1995). Shivanathan (1982) reported that CMV had been isolated from over 20 species of crops. Tomato curly top virus (CTV) vectored by leafhoppers and tomato spotted
Wilt virus (TSWV) transmitted by *Frankliniella occidentalis* and other thrips are two virus diseases that cause significant crop losses in tomato (Bennett, 1971 and Cho *et. al.* 1987). However, in Sri Lanka, these two viruses have not been confirmed in tomato cultivation.

Genetic resistance is the most practical and economical way of managing virus diseases of tomato (Cho *et al.*, 1989). The present study was carried out to Evaluate tomato accessions for resistance to CMV and TYLCV. The alternate hosts of these viruses were also investigated.

## MATERIALS AND METHODS

### Incidence of tomato virus diseases

A field survey was carried out from 1997 to 2001 for identification of tomato virus diseases and to estimate the virus incidence in major tomato growing areas of Sri Lanka. Infected plant number was counted to calculate the percentage of virus infection. Different tomato varieties cultivated in Kandy, Kegalle, and

Anuradhapura districts were evaluated for virus infections, and the symptoms were recorded. The diseased plants were collected for identification of viruses. Serological analysis, enzyme-linked immunosorbent assay (DAS-ELISA) and host-range studies to confirm the viruses were carried out at the Horticulture Research and Development Institute (HORDI) at Gannoruwa, Sri Lanka (Mid country-Wet zone).

## Tomato yellow leaf curl virus (TYLCV)

### Isolation and maintenance of tomato yellow leaf curl virus (TYLCV)

Whiteflies (*Bemesia tabaci*) were collected from *Solanum melongena* (egg plants) grown at Peradeniya in Kandy district and were reared on *Abutilon* sp. in an insect-proof cage. Tomato plants with typical symptoms of TYLCV (Al-Musa, 1982) were collected from Yatawatte in Matale district and the whiteflies were introduced to infected plants. Healthy plants of tomato and *Nicotiana benthamiana* were placed in the same cage. After appearance of TYLCV symptoms on healthy tomato and *Nicotiana* plants, it was considered that the whiteflies have completed the acquisition of virus. These viruliferous whiteflies were used for virus transmission studies.

### Selection of TYLCV resistance sources under greenhouse conditions

Thirty-four tomato lines and two varieties were planted on 20$^{th}$ January 1999 in 4"X 4" pots filled with sterilized soil. Sixteen plants from each tomato line were exposed to the viruliferous whiteflies on the 21$^{st}$ day after planting in an insect proof screen house. The TYLCV infected plants were counted at 38 days after exposure to the vector.

### Alternate hosts of TYLCV

Fresh leaf samples of *Capsicum annuum*, papaya (*Carica papaya* L.), tobacco (*Nicotiana tabacum*), Mungbean (*Phaseolus aureus* Roxb), and Okra (*Abelmoschus esculentus*) with yellowing and leaf curl symptoms were sent to the Asian Vegetable Research and Development Center (AVRDC), Taiwan for confirmation of TYLCV infection by Nucleic acid hybridization.

## Cucumber mosaic virus

### Testing for sap transmissibility of virus

Young leaves were collected from the infected tomato plants and the virus inocula were prepared by grinding symptomatic leaves in 0.03 M phosphate buffer (Solution A: $Na_2SO_3$ 102.44 g, distilled water 1L and Solution B: $NaH_2PO_4$ 41.39 g, Distilled water 1L.; A and B were mixed until pH 7.0) with carborandom in a mortar and pestle. The extracted plant sap was kept under cool condition (at $4C^0$ using ice) in order to avoid destruction of virus due to high temperatures. When the healthy tomato plants were at 4-leaf stage, they were dusted with carbarandom prior to inoculation. This was done to facilitate the inoculation process. Pestles were useful for application of inocula on leaves of the test plants. Symptoms of inoculated plants were recorded 4 weeks after inoculation (WAI). Enzyme-linked immunosorbent assay (ELISA) was performed to confirm CMV infection.

### Host range studies and alternate hosts of CMV

An inoculum was prepared using symptomatic leaves of the mosaic virus infected tomato plant. Leaf samples were ground with phosphate buffer using a mortar and pestle. *Nicotiana tabacum*, *N. benthamiana*, *N. glutinosa*, *Petunia hybrida*, *Chenopodium amaranticolor*, *C.* quinoa and, *Vigna sinensis* and *Datura stramonium* plants were selected as experimental host range. Four plants from each plant species were planted in 4"x 4" clay pots filled with sterilized soil. Plants were inoculated at 4-leaf stage after dusting carborandom on leaves, using a cotton swab. Distilled water was sprayed on to inoculated leaves in order to wash-off the extra plant sap on the leaves to prevent phototoxic reactions. Symptoms were recorded 4 WAI and ELISA was performed on inoculated plants for confirmation of the virus infection. Common weeds grown in association with tomato were collected from various locations of the country. The ELISA test was performed to confirm CMV infection in selected weeds to identify alternate hosts of the virus.

### Serological confirmation of CMV

A leaf roller grinder was used to extract the plant sap by grinding 0.5 g leaf sample with 1 ml. of sample extraction buffer. A 100 µl plant sap was placed in the antibody coated ELISA-well with 3 replications. Positive control (virus) and negative control (healthy plant sample) were also included in the ELISA plate. The ELISA test was performed according to the protocol to detect CMV

and tomato spotted wilt virus (TSWV) using commercial antibody of Agdia Inc., U.S.A. (Gonsalves, 1986). Final color reaction was recorded and the quantitative measurement of the virus titer was obtained using ELISA Micro Plate Reader with a 405 nm filter. The cut-off values were calculated as follows;

Cut-off value = (ELISA absorbance of negative control x 2) + 0.100

ELISA absorbance values above the cut-off value were considered as positive reaction and lower values considered as negative reaction.

**Evaluation of tomato germplasm for CMV resistance**

Sixteen plants were used from each tomato accession for sap inoculation. Tomato seedlings were planted in 4"x 4" pots filled with sterilized soil. Test plants (at 4-leaf stage) were kept overnight in a dark place prior to inoculation to enhance the success of the sap inoculation. Sap inoculation was done as described previously. The virus symptoms were recorded and symptom-less accessions were tested with ELISA to confirm the absence of CMV.

**Tomato spotted wilt virus (TSWV)**

**Symptomatology, sap transmission and serological confirmation**

Virus-induced symptoms were recorded and ELISA was performed on leaf samples with ring-spot symptoms using commercial antisera of TSWV obtained from Agdia Inc., U.S.A. The infected plant number was recorded for each variety. Sap transmissibility of the virus was confirmed by inoculating healthy plants of the tomato variety "Thilina" as described before. Transmission through graft union is also studied by grafting virus infected tomato scions on healthy tomato rootstocks.

**Tomato curly-top virus (CTV)**

**Symptomatology and graft transmission**

Tomato varietal response for CTV infection and symptoms induced by the virus were recorded. A young scion from virus-infected tomato plant was grafted on healthy tomato plants to study the transmissibility of the virus through graft union. Disease symptoms were recorded 4 weeks after grafting.

## RESULTS AND DISCUSSION

### Incidence of tomato virus diseases

### Incidences of tomato yellow leaf curl virus (TYLCV)

The tomato variety T-146, cultivated for seed production in Katugastota in 1998 was infected with TYLCV (40%). In the year 1999, commercial tomato variety Caribe showed 90% TYLCV infection at Marassana. Even though the virus incidence was high, plant growth and yields were not severely affected. This may be due to the late infection of the virus or due to tolerance of the variety. Early infection may cause severe symptoms and considerable yield reduction (Sastry and Singh, 1973). In the same year, the variety T-245 showed low disease incidence under field conditions at Yatawatta. Tomato varieties "Thilina" and "Marglobe" were susceptible to TYLCV under field conditions. The nucleic acid hybridization with Sri Lankan probe SL14 confirmed the presence of TYLCV in varieties T-245 and Thilina in samples collected from Kadugannawa in 2000 (Personal communication with Dr. S.K. Green, Virologist, Asian Vegetable Research and Development Institute (AVRDC), Taiwan (table 1).

**Table 1. Results of the nucleic acid hybridization performed on tomato samples.**

| *Location* | *Tomato line/ variety* | *No. of samples collected* | *No. of samples with symptoms* | *Type of symptom* | *No. of samples positive ** |
|---|---|---|---|---|---|
| Kadugannawa | Avinash 2 | 3 | 3 | y | 0 |
| | CLN-2123A | 3 | 3 | y | 0 |
| | CLN-2116D | 3 | 3 | c, y | 1 |
| | CLN-2026D | 3 | 3 | c, y | 3 |
| | T-245 | 3 | 3 | c, y | 1 |
| | Thilina | 3 | 3 | c, y | 1 |
| | Avinash 2 | 1 | 1 | y | 0 |
| Pallekele | CLN-2123A | 1 | 1 | y | 0 |
| | CLN-2116D | 1 | 1 | c, y | 1 |
| | CLN-2026D | 6 | 6 | y | 1 |
| | T-245 | 1 | 1 | y | 0 |
| | Thilina | 1 | 1 | y | 0 |
| Peradeniya | CLN-2026D | 6 | 6 | v, y | 6 |

**Nucleic acid hybridization with SL probe, c - leaf curl, y – yellowing of leaves*

Leaf samples of AVRDC tomato accession CLN-2116D collected from Pallekele and Kadugannawa, and CLN-2026D collected from Kadugannawa, Pallekele and Peradeniya were infected with TYLCV. Avinash-2 and CLN-2123A

samples collected from Pallekele and Kadugannawa locations gave a negative reaction (table 1).

## Insect transmission of TYLCV

Typical symptoms (Al–Musa, 1982) of TYLCV could be observed on *N. benthamiana* and tomato variety Caribe on the 22nd day of exposure to viruliferous whiteflies. These infected plants were maintained as TYLCV mother plants for future studies. The analysis done at AVRDC, Taiwan confirmed the presence of TYLCV by nucleic acid hybridization.

## Alternate hosts of TYLCV

Out of sixteen fresh leaf samples of chilli, papaya, tobacco, mungbean, and okra collected from Maha Illuppallama and Gannoruwa, mungbean and chilli collected from Maha Illuppallama were positive for Gemini virus (table 2).

**Table 2. Confirmation of TYLCV infection in alternate hosts around tomato cultivations.**

| *Host* | *Locations* | *Type of symptoms* | *PCR results* |
|---|---|---|---|
| *Capsicum annuum* | Mahailluppallama | lc, y | + |
| *Capsicum frutescens* | Gannoruwa | y | - |
| *Carica papaya* | Gannoruwa | m, ld | - |
| *Nicotiana tabacum* | Gannoruwa | y, ld | - |
| *Phaseolus aureus* | Mahailluppallama | y, ld | + |
| *Abelmoschus esculentus* | Mahailluppallama | y | - |

Lc= leaf curl, y= yellowing, m= mosaic, ld = leaf distortion , + = positive reaction for TYLCV, - = negative reaction for TYLCV, (*Personal communication: Dr. S.K. Green, AVRDC, Taiwan).*

Five papaya samples from Gannoruwa and one okra sample from Maha Illuppallama gave a negative reaction. *Nicotiana tabacum*, and *Capsicum*, collected from Gannoruwa were also negative for Gemini virus (table 2).

## Resistant sources for TYLCV

Table 3 displays the results of the TYLCV insect-transmission experiment carried out under insect-proof screen house conditions. Tomato lines H-24, SR-7725, CLN-2123DC1F1-111-17-21-2-12 and FL-699SP+ were symptom-less. Tomato lines ATY-10 and ATY-13 were weak plants and did not survive until the end of the experiment. All the other tomato lines showed TYLCV symptoms. In the second experiment, ATY-10 and ATY-13 showed clear symptoms of TYLCV. One out of sixteen plants of FL-699SP+ showed inter-venial chlorosis. The H-24

and SR-7725 remained symptom less after the second exposure to viruliferous whiteflies and also after planting in the field.

**Table 3. Symptoms, disease reaction and percentage of TYLCV infection of AVRDC tomato lines evaluated under screen house at HORDI, Gannoruwa.**

| *Tomato line** | *% of TYLCV infection* | *Symptoms* | *Disease reaction* |
|---|---|---|---|
| ATY-1 | 50 | | MR |
| ATY-5 | 66.66 | (c), (y) | MS |
| ATY-6 | 50 | c, y | MR |
| ATY-7 | - | NS | - |
| ATY-10 | 22.22 | (y) | R |
| ATY-11 | - | NS | - |
| ATY-13 | 75 | c | S |
| ATY-14 | 77.78 | (c), (y) | S |
| ATY-15 | 100 | c | S |
| ATY-16 | 57.14 | y | MS |
| ATY-17 | 75 | c, y | MS |
| ATY-18 | 93.33 | c | S |
| ATY-19 | 75 | c | S |
| ATY-21 | 80 | (c), (y) | S |
| ATY-22 | 16.66 | c | R |
| ATY-23 | 100 | c | S |
| Ty –52 (BL-982) | 100 | c | S |
| FL-505 (BL-1172) | 100 | c, y | S |
| FL-619 (BL-1170) | 83.33 | c, y | S |
| FL-776 (BL-1169) | 77.77 | c, y | S |
| FL-805 (BL-1171) | 93.7 | c | S |
| FL-744-6-9 (BL-163) | 43.75 | c | MR |
| FL-736 (BL-1165) | 56.25 | c | MS |
| FL-699SP (BL-1166) | 40.00 | c | MR |
| FL-699SP+ (BL-1167) | 0 | NS | HR |
| CLN-5915-93D4-1-0-3 | 100 | c, y | S |
| CLN-2116DC1F1-180-50-15-8 | 100 | c, y | S |
| CLN-2114DC1F1-2-29-7-2 | 100 | c, y | S |
| CLN-2123DC1F1-111-17-21-2-12 | 0 | NS | HR |
| CLN-2026D | 100 | c | S |
| Avinash | 50 | c | MR |
| SR-7725 | 0 | NS | HR |
| H-24 | 0 | NS | HR |
| Fiona F1 | 31.25 | c | MR |
| Caribe | 100 | c, y | S |
| T-245 | 70 | c, (y) | MS |

** No. of plants sown – 16; % of disease incidence -38 days after exposure to viruliferous Whiteflies, Y= yellowing; c= curling; st=- stunting; NS= no symptoms; (c)= mild curling symptoms; (y)= Mild yellowing symptom; (st)= slightly stun; D= death of the plants; Caribe = Commercial variety; T-245 = local variety; Leaf curl rating: HR=highly resistant-0% infection, R = resistant-1-25% infection; MR = moderately resistant-26-50% infection; MS = moderately susceptible-50-75% infection; S =susceptible-75-100% infection.*

## Screening of tomato accessions for TYLCV resistance under field conditions

In 1999, an experiment at Pallekele was successful and all tomato accessions except SR-7725 showed symptoms of TYLCV. Avinash-2 and CLN-2026D had 16% and 15% of TYLCV infection. The other lines CLN-2123D and T-245 showed 10% and 7% TYLCV infections respectively (table 4). In 2000, Avinash-2 and CLN-2026D had 22% and 21% infection, respectively. T-245 and CLN-2123A showed 9% and 2% infection. Tomato line CLN-2116D did not show symptoms of TYLCV (table 4). The results of the experiment done at Kadugannawa showed that Avinash-2 was highly susceptible to Early-blight infection. Both CLN-2026D and T-245 had 24% infection of TYLCV. Thirteen per cent and 11% infections were observed in Avinash-2 and CLN-2123A, respectively. Tomato line CLN-2126D showed 21% infection with TYLCV (table 4).

**Table 4. Results of the experiments conducted during years 1999 and 2000 at pallekele and Kadugannawa to select resistance for TYLCV under Field Conditions.**

| *Location/Year* | *Tomato line/ variety* | *% of TYLCV infected plant-54 DAP* | *Type of symptom* |
|---|---|---|---|
| Pallekelle, 1999 | Avinash-2 | 16 | c |
| | SR-7725 | 0 | ns |
| | CLN-2026D | 15 | c, y, St. |
| | CLN-2123D | 10 | c, y |
| | T-245 | 7 | c, (y) |
| Pallekelle, 2000 | Avinash-2 | 22 | c |
| | CLN-2123A | 2 | (y) |
| | CLN-2116D | 0 | ns |
| | CLN-2026D | 21 | (y), c |
| | T-245 | 9 | (y), c |
| Kadugannawa, 2000 | Avinash-2 | 13 | c |
| | CLN-2123A | 11 | y |
| | CLN-2116D | 21 | y, c, st |
| | CLN-2026D | 24 | y, c |
| | T-245 | 24 | (y), c |

*ns= no symptoms y = yellowing c = curling st = stunting (y) = mild yellowing symptoms, DAP=Days after planting*

## Incidences of Cucumber mosaic virus

The infected plants showed stunted growth, narrow leaves with mosaic symptoms, and produced distorted fruits and low yield. In 1997, CMV incidence calculated for tomato variety T-245 at 3 locations were 7% at Marassana, 64% at

Manikhinna and 4% at Mawanella. The tomato variety KWR had low disease level compared to T-245 at Manikhinna and Mawanella (1% and 13%, respectively), but at Marassana, KWR had 10% infection of CMV. DAS-ELISA was performed on tomato samples collected from several locations. Tomato samples collected from Yatawatta and Gannoruwa were positive for CMV infection and all the other samples collected from other locations gave negative results for virus infection.

**Host range studies and alternate hosts of the virus**

Cucumber mosaic virus symptoms appeared on some of the tested host range plants and ELISA confirmed the presence of the virus. The local tomato cultivars were susceptible to the virus infection (table 5). Cucumber mosaic virus symptoms appeared on some of the tested host range plants and ELISA confirmed the presence of the virus. The local tomato cultivars were susceptible to the virus infection (table 5).

**Table 5. Symptoms caused by CMV isolated from tomato.**

| *Host* | *Variety* | *Symptoms* |
|---|---|---|
| *Lycopersicon esculentum* | T-245 | Mosaic |
| | KWR | Mosaic |
| | T-146 | No symptoms |
| | Caribe | Narrow leaves |
| | Thilina | Narrow leaves |
| *Nicotiana tabacum* | White burly | Mosaic |
| *N. benthamiana* | | Mosaic |
| *N. glutimosa* | | Mosaic |
| *Solanum melongena* | SM-164 | No symptoms |
| | BW-11 | No symptoms |
| *Capsicum annum* | GLT | Mosaic, stunting |
| | CA-8 | Leaf mottle |
| *Datura stramonium* | S-361 | No symptoms |
| | S-351 | No symptoms |
| | S-352 | No symptoms |
| *Petunia hybrida* | | Color-break of flowers |
| *Chenopodium amaranticolor* | | Local lesions |
| *C. quinoa* | | Local lesions |
| *Vigna sinensis* | | Local lesions |

**Evaluation of tomato accessions for resistance against CMV**

The screening results of the tomato accessions of HORDI and Plant Genetic Resources Center (PGRC), Sri Lanka against CMV are given in table 6 and 7, respectively. All tested tomato accessions of HORDI and PGRC were susceptible to CMV infection and ELISA confirmed the presence of the virus.

Tomato accession HF-7 showed the lowest disease level (10%) and all the other lines were highly susceptible to the CMV infection.

**Table 6. Symptoms caused by CMV isolate from after inoculation onto tomato accessions of HORDI Sri Lanka.**

| *Tomato line/variety* | *No. of infected plants/Total plants* | *Type of symptoms* | *ELISA results* |
|---|---|---|---|
| AC-01449 | 63 | m | + |
| BT-15-1 (VS) | 44 | m | + |
| BT-15-1 (VS1) 2 | 38 | m | + |
| BT-15-1 (VS) 3 | 63 | m | + |
| BT-15-1 (VS1) 6 | 81 | m | + |
| 4253 | 38 | m | + |
| 140 | 56 | m | + |
| ID-1 | 44 | mm | + |
| ID-2 | 38 | mm | + |
| ID-3 | 54 | mm | + |
| ID-4 | 49 | mm | + |
| ID-6 | 38 | m | + |
| ID-8 | 64 | m | + |
| ID-9 | 42 | m | + |
| ID-10 | 56 | mm | + |
| HF-1 | 70 | mm | + |
| HF-2 | 100 | mm | + |
| HF-3 | 100 | m | + |
| HF-4 | 40 | m | + |
| HF-5 | 100 | mm | + |
| HF-6 | 100 | m | + |
| HF-7 | 10 | mm | + |
| HF-8 | 100 | m | + |
| HF-9 | 100 | m | + |
| HF-10 | 70 | mm | + |
| Superma | 60 | mottle+fernleaf | + |
| Caribe (commercial) | 90 | sm | + |
| T-245 | 40 | mm | + |

mm- mild mosaic, m- mosaic, ld- leaf distortion, sl- small leaves, sm – severe mosaic
Seed source -HORDI - Mrs. R. Pieris, RO, Horticultural Crop Research & Development Institute,
ELISA – Enzyme-linked Immunosorbent Assay. - ELISA negative, + ELISA positive

Of 8 AVRDC tomato lines, 5 lines showed clear CMV symptoms (table 8). Tomato lines CLN-1507F1, VL-262-6-12-1-1 and CLN-1494 F1 were symptom less after the 1$^{st}$ and 2$^{nd}$ inoculations. According to the results of DAS-ELISA performed on symptomless tomato lines, CLN-1507F1 gave a negative reaction. Even though VL-262-6-12-1-1 and CLN-1494 F1 were symptom-less, they were positive for CMV infection.

**Table 7. Symptoms caused by CMV isolate from after inoculation onto tomato accessions of PGRC Sri Lanka**

| *Tomato line/variety* | *Seed source* | *% of infection* | *Type of symptoms* | *ELISA results* |
|---|---|---|---|---|
| AC-01449 | PGRC | 63 | ,m | + |
| AC-02898 | ,, | 100 | mm | + |
| AC-02139 | ,, | 63 | ld, mm | + |
| AC-00272 | ,, | 56 | m , sl | + |
| AC-00139 | ,, | 63 | m | + |
| AC-0166 | ,, | 81 | m | + |
| AC-01038 | ,, | 38 | m | + |
| AC-01925 | ,, | 75 | m | + |
| AC-07581 | ,, | 75 | mm+sl | + |
| AC-0757 | ,, | 50 | mm | + |
| AC-05895 | ,, | 51 | mm | + |
| AC-01668 | ,, | 44 | mm | + |
| AC-07967 | ,, | 38 | mm | + |
| Caribe | Commercial | 90 | sm | + |
| T-245 | Sri Lanka | 40 | mm | + |

mm- mild mosaic, m- mosaic, ld- leaf distortion, sl- small leaves; Seed source - PGRC – Plant Genetic Resource Center, Sri Lanka; ELISA – Enzyme-linked Immunosorbent Assay. - ELISA negative, + ELISA positive

**Table 8. CMV resistance in AVRDC tomato accessions and local tomato varieties.**

| *Tomato line/variety* | *Seed source* | *%. of infected* | *Type of symptoms* | *ELISA results* |
|---|---|---|---|---|
| CLN-1499F1 | AVRDC | 12.5 | Def. | NT |
| CLN-1507F1 | ,, | 0 | NS | - |
| CLN-1501B1F1 | ,, | 57 | m | NT |
| VL-262-6-12-1-1 | ,, | 0 | NS | + |
| CLN-1499B1F1 | ,, | 92 | Def. | NT |
| CLN-1494F1 | ,, | 0 | NS | + |
| | | | | NT |
| CLN-1507B1F1 | ,, | 23 | m, Dist. | NT |
| CLN-1494B1F1 | ,, | 43 | m | + |
| Thilina | Sri Lanka | 56 | m | + |
| T-146 | ,, | 75 | Dist. m | + |
| T-245 | ,, | 75 | m | + |
| KWR | ,, | 38 | m | + |
| Caribe | Commercial | 75 | m, Dist | NT |

m = mosaic, def = leaf deformation, Dist = distortion, NS = no symptoms, NT = not tested

In the survey conducted to estimate the incidences of CMV in tomato-cultivated areas, high incidence of CMV was recorded in Gannoruwa and

Yatawatta area (table 9). This may be due to continuous cultivation of the same crop in the surveyed area.

**Table 9. Results of the survey conducted for CMV of tomato.**

| *Survey dates* | *Locations* | *No. Of samples collected* | *Type of symptoms* | *No. Of positive ELISA Samples* |
|---|---|---|---|---|
| 09-06-1997 | Naranwita | 03 | Def, m | 0 |
| | Yatawatta | 02 | (m) | 01 |
| | Rikillagaskada | 01 | (m) | 0 |
| 23-06-1997 | Yatawatta | 01 | m | 01 |
| 01-10-1997 | Yatawatta | 02 | m | 02 |
| | Baminiwatta | 02 | m | 01 |
| 29-12-1997 | Baminiwatta | 01 | m | 0 |
| | Gannoruwa | 03 | NS | 02 |
| 06-03-1998 | Gannoruwa | 04 | (m) | 03 |
| 06-05-1998 | Gannoruwa | 02 | (m) | 0 |
| | Matale | 01 | (m) | 0 |
| 18-11-1998 | Gannoruwa | 03 | (m) | 0 |

m = mosaic (m) = mild mosaic def = leaf deformation NS = no symptoms

## Alternate hosts of CMV:

Table 10 shows the first record of CMV infection in common weeds of Sri Lanka.

**Table 10. Confirmation of CMV infection in alternate weed hosts.**

| *Host* | *Locations* | *Type of symptoms* | *ELISA results* |
|---|---|---|---|
| *Commmelina benghalensis* | Thibbotumulla | m+ld | + |
| **Colocasia esculenta* (L.) | „ | sm +ld | + |
| **Ageratum conyzoides* L. | „ | m | + |
| **Syzygium jambos*(L.) | „ | ltc | + |
| **Acacta caesia* | „ | ld | + |
| **Isachne globosa* | „ | y | + |
| **Euphobia heterophylla* | „ | m | + |
| **Ocimum sanctum* L. | Wagolla | ltc | + |
| *Ocimum sanctum* L | Thibbotumulla | ltc +mm | + |

Sm = severe mosaic, m = mosaic mm = mild mosaic ld = leaf deformation, ltc= leaf tip curling, y = yellowing, NS = no symptoms *First record in Sri Lanka

Presence of CMV in several weed hosts in major tomato growing areas can spread the disease to the adjoining tomato cultivations. Identification of locally available alternate hosts of CMV is very important in management of virus disease.

**Tomato spotted wilt virus (TSWV)**

In 2003, an epidemiological out break of viral disease was reported from Matale District, and samples were collected for virus identification. Clear ring-spot symptoms appeared on the leaves and fruits of infected plants in variety Thilina. The ELISA test confirmed the infection and this is the first confirmation of TSWV infection in tomato. The virus could be sap and graft transmitted to healthy tomato plants. About 85% of variety Thilina and 52% of varietyT-245 cultivated in Matale district for seed production were affected by the TSWV infection. Due to high probability of seed transmission, affected crops are not suitable for seed extraction.

**Table 11. Percentage of TCTV infection observed in tomato varieties.**

| *Tomato variety* | *Locations* | *Type of symptoms* | *% of TCTV infected plants* |
|---|---|---|---|
| T-245 | Gannoruwa | pv | 12 |
| Thilina | Gannoruwa | pv | 8 |
| Ravi | Maha-Illuppallama | pv | 9 |
| Caribe | Marassana | pv | 10 |

First record in Sri Lanka. Pv – purple veins, y – yellowing, db – drooping of branches; s – stunting of plant

Tomato variety T-245 showed highly susceptibility for TCTV disease. Symptoms could be observed in commercial tomato variety Caribe and local variety Thilina. The TCTV transmission was confirmed by grafting. Infected plants showed purple veins near the leaf margins, drooping of the branches and they produced unmarketable small fruits with rough corky patches.

## CONCLUSIONS

All local tomato lines were susceptible to TYLCV and CMV infections. Tomato line H-24 can be used to transfer genes responsible for resistance for TYLCV. Genetic resistance should be incorporated into new tomato varieties in the tomato-breeding programme of Sri Lanka. The AVRDC tomato line SR-7725 showed resistance under greenhouse conditions to leaf curl virus, while CMV resistance was observed in AVRDC tomato line CLN-1507F1. These tomato accessions could be used in the breeding programmes to develop resistant varieties. Local tomato variety Thilina is highly susceptible and other local tomato varieties were moderately susceptible to TSWV infection. The tomato variety T-245 is susceptible to CTV infection but other local varieties showed moderately susceptible reaction.

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