

Tolcv Resistance: A Critical Appraisal And The Way Ahead

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Abstract

Tomato leaf curl virus (ToLCV) is an important and major constraint in the production of tomato worldwide. It belongs to the family Geminiviridae and genus *Begomovirus*. It is transmitted by whitefly (*Bemisia tabaci*). The virus causes stunted growth, deformed leaflets showing inward curling, slightly chlorotic and necrotic patches, interveinal yellowing and vein clearing with reduced fruiting. The disease is serious in India and yield losses may be as high as 90 % (Babu et al., 2018). Host plant resistance is one of the best options to manage the disease economically and environment friendly. The progress on this aspect, till date six resistant genes have been identified and mapped on different chromosomes from the available resources.

Introduction

Tomato is one of the most popular and widely grown vegetable in India and the World. Tomato is botanically called as *Solanum lycopersicum* L. having diploid chromosome number of $2n = 24$ belongs to the family Solanaceae and originated from Peru (South America). It has become an important commercial crop when we talk about the human nutrition.

Tomato is second most important crop, widely adapted to both tropical and subtropical regions. It is grown for its edible fruit, which can be consumed, either raw or cooked or in the form of various processed products like juice, ketchup, sauce, pickle, pastes, puree and powder. It is universally indicated as protective food and esteemed as an important source of minerals, organic acids and vitamins (A and C). India occupies an area of **0.81** million hectares with a production of **20.57** million tones with an average productivity of **25.39** t/ha. Karnataka



is the second leading tomato producing state after Andhra Pradesh in the country and accounts for 10 per cent of total production of tomato in the country. In Karnataka it occupies an area of **0.06** million hectares with a production of **2.37** million tones with an average productivity of **39.50** t/ha (Anon., 2020).

Although vast area is under its cultivation, production is limited by many biotic and abiotic stresses. The abiotic factors like drought, salinity, high temperature, low temperature and water logging condition and the biotic factors like fungi, bacteria and viruses will affecting on tomato and cause severe yield losses. Viral diseases like *Tomato Mosaic Virus*, *Tomato Leaf Curl Virus*, *Ground Nut Bud Necrosis Virus* reported in tomato. Among the different viral diseases, white fly-transmitted gemini viruses (genus: Begomo virus) are the serious tomato production constraints in tropical and subtropical regions of the world and cause severe yield loss up to 90 %.

Tomato Leaf Curl Virus Disease

Tomato crop suffers from large number of fungal, bacterial, nematode, phytoplasma and by many viral diseases. Among the viral diseases reported on tomato, tomato leaf curl virus (ToLCV) (*Geminiviridae*: Sub-group III) is one of the most important and major constraint in the tomato cultivation. Tomato Leaf Curl Virus (ToLCV) is known to be transmitted by the vector whitefly (*Bemisia tabaci*).

The first case of ToLCV was identified in eastern Mediterranean and later it was reported to be a serious problem in the Middle East, African Continents, South-East Asia and Southern Europe and was first reported in India during 1948 (Vasudeva & Samraj, 1948). It was reported that even a single viruliferous white fly can transmit the disease and requires 30 minutes to acquire and transmit the virus in tomato plants.

TYLCV disease occurrence and spread

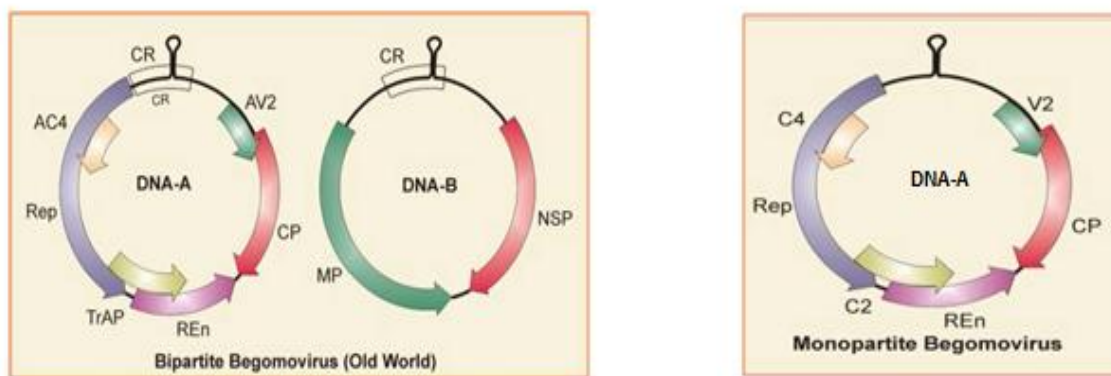
The virus is distributed in major parts of the world like Africa, America, part of Europe and Asia. The disease is still spreading to the new areas, with recent outbreaks reported in California and Hawaii in USA, China, Trinidad and Tobago.

In India it was reported in most of the states like New Delhi, Punjab, Uttar Pradesh, Bihar Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Kerala and Tamil Nādu. In the Indian subcontinent it is known by different names like *Tomato leaf curl New Delhi virus*, *Tomato leaf curl Bangalore virus*, *Tomato leaf curl Karnataka virus* and *Tomato leaf curl Patna virus* etc. based on their locality.

Virus Genome

The viruses causing ToLCV are gemini viruses (genus *Begomo virus* and family Gemini viridae) transmitted by the whitefly (*Bemisia tabaci*). The ToLCV genome is composed of a single (monopartite) circular single-stranded DNA molecule of about 2800 nucleotides. In the past, there has been some confusion regarding the taxonomy of ToLCV. Several begomo viruses, inducing similar symptoms in tomato, were all named as ToLCV. Further analyses of these viruses showed that the *Tomato Yellow Leaf Curl Disease* (ToLCD) is induced by a heterogeneous complex of begomo viruses. Most of the isolates have a monopartite genome and recently a ToLCV isolate containing a DNA- β satellite has been identified.

Genome organization of Begomo viruses (Each component is ~2.7kb)



All the genera of geminiviridae have monopartite ssDNA as their genome except for begomo virus, which may have monopartite or bipartite ssDNA. Viruses with bipartite genome have DNA-A and DNA-B as their genetic components, each with DNA-A harboring genes for replication, packaging, vector transmission and viral suppressors.

Virus	Mono/Bipartite
<i>Indian tomato leaf curl virus</i>	Bipartite
<i>Tomato leaf curl virus</i>	Bipartite
<i>Tomato leaf curl Gujarat virus</i>	Bipartite
<i>Tomato leaf curl New Delhi virus</i>	Bipartite
<i>Tomato leaf curl Karnataka virus</i>	Monopartite
<i>Tomato leaf curl Patna virus</i>	Bipartite

Symptoms of ToLCV disease



Stunted growth



Interveinal chlorosis

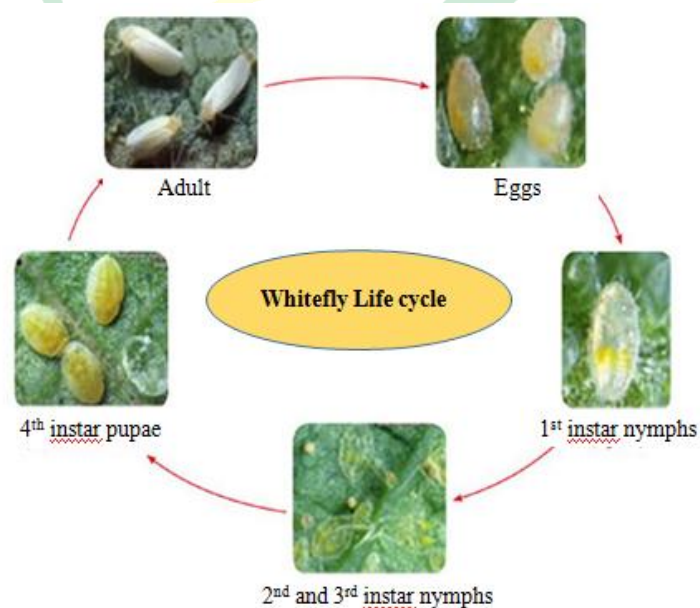


Upward curling of leaves

Tomato is susceptible to TYLCV infection at all stages of plant growth. The disease symptoms become apparent several weeks post-virus infection. The disease symptoms include stunting of plant growth, reduction in leaf size, upward cupping of leaves, yellowing of the leaf margins, flower drop and reduced fruit set and fruit yield.

ToLCV vector (*Bemisia tabaci*)

Complex *B. tabaci*, the whitefly vector of begomoviruses, belongs to order homoptera and family Aleyrodidae. It is a sibling species group comprised of genetic and phenotypic variants. More than 35 biotypes or cryptic species and numerous haplotypes have been differentiated by DNA markers. *B. tabaci* bio-type differences include host range, insecticide-resistance, virus transmission efficiency and the ability to cause plant disorders.



The most predominant and damaging biotypes worldwide are the B and Q, recently termed the Middle East Asia Minor 1 (MEAM1) and the Mediterranean (MED) species. It is having different host ranges of other solanaceous crops like brinjal, capsicum, tobacco and potato, legumes.

The whitefly has a complex lifecycle. It undergoes five distinct stages of development. Eggs are laid on undersides of leaves, and are at first pale yellow in colour and then turn to gray colour. The first nymphal stage is hardly visible even with a hand lens. The crawlers move around for several hours, then settle down and remain immobile. In second nymphal stage, they are oval and flattened like small scale insects. In 3rd nymphal stage the legs and antennae are greatly reduced and flattened like small scale insects. The winged adult emerge from last nymphal stage, sometimes called pupa for convenience purposes.

Management

- Use of healthy transplants
- Crop rotation with non-solanaceous vegetables
- Use reflective mulches.
- Use resistant cultivars in tomato when whitefly populations are expected to be high (ArkaAbha, ArkaRakshak, Arka Samrat, Arka Vikas)
- Spray NSKE @ 4%
- Spray systemic insecticides like imidacloprid

Source of resistance

- Land races and cultivars are the good starters
- Lines with established genomic resources **Ex:-** LA 1777, LA 716 and LA 1589
- Wild species are reservoirs of viral resistance genes.

Table 1. List of *ToLCV* resistant genes and source

Gene	Source	Genetics
<i>Ty-1</i>	<i>S. chilense</i> LA 1969	Partial dominant
<i>Ty-2</i>	<i>S. habrochaites</i> H24	Dominant
<i>Ty-3</i>	<i>S. chilense</i> LA 2279 <i>S. chilense</i> LA 1932	Partial dominant
<i>Ty-4</i>	<i>S. chilense</i> LA 1932	Partial dominant
<i>ty-5</i>	<i>S. peruvianum</i> TY 172	Recessive

Ty-6	<i>S. chilense</i> LA 2279	Partial dominant
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Breeding approaches for ToLCV resistance

- ✿ Screening techniques
- ✿ Development of resistant hybrids for ToLCV along with good horticultural traits
- ✿ Identification and mapping of resistance genes
- ✿ Marker assisted selection for ToLCV resistance genes
- ✿ Gene pyramiding
- ✿ Biotechnological approaches

Conclusion

The effectiveness of the resistance breeding programme for tomato leaf curl virus disease depends upon the source of resistance and efficient screening techniques. Future research must be focused on tackling such recombinants by identification of new resistant sources, MAS and pyramiding of *Ty-1*, *Ty-2*, *Ty-3* along with major and minor QTL's like *Ty-4*, *ty-5* and *Ty-6* could provide stable resistance. Transgenic plants to produce antibodies against antigen, use of peptide aptamers and CRISPR-associated protein 9 would be an effective tool for controlling ToLCV infection and also the future breeding programmes must be focus on the development of resistant lines for ToLCV.

References

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