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In vitro Evaluation of Tomato Germplasm and Private Sector Hybrids for Resistance to *Tomato Leaf Curl Virus*

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ABSTRACT

Tomato leaf curl virus (ToLCV) is the most devastating virus infecting tomato crop. ToLCV is transmitted by whitefly (*Bemisia tabaci*) in persistent and circulative manner. For identifying the resistance source against this disease, totally 84 population comprising of 47 segregating population of F_1 generation from cross between resistant parents (DMT2 x COHBT24) and 37 private sector commercial hybrids were screened artificially by using whitefly vector under glasshouse condition. Fifteen-days old tomato seedlings were inoculated with ToLCV by using whitefly (*B. tabaci*) and monitored for appearance of disease symptom at 10, 20 and 30 days after inoculation (DAI). The observations on per cent incidence (PI) and per cent disease index (PDI) were recorded, and Area Under Disease Progress Curve (AUPDC) values were calculated. Among the population screened, no visual symptoms of ToLCV infection were observed in COHBTTF1/11-4, whereas maximum ToLCVD severity (60 PDI) was recorded in COHBTTF1/325-4 at 30 DAI. The total population evaluated were categorized into resistant (8 Nos.), mild infection (36 Nos.), moderate infection (35 Nos.) and susceptible (5 Nos.). The AUDPC value for ToLCVD ranged from 0 (COHBTTF1/11-4) to 1050 (COHBTTF1/325-4). For categorizing the genotypes/hybrids based on resistance reaction, observations (PI and PDI) at a particular point of time, the AUDPC values depicting the resistance reaction over the entire study period will be of additional significance.

Keywords: ToLCV, Whitefly, AUDPC

TOMATO (*Solanum lycopersicum* L.) is an important vegetable crop of solanaceae family grown for its edible fruits in both tropical and subtropical countries of the world. Tomatoes beside being tasty, they are nutritive too and contains mainly vitamin 'A' (42 µg), vitamin 'B1'(0.037 mg), vitamin 'B3'(0.594 mg), nicotinic acid (0.4 mg), vitamin 'C' (14 mg), vitamin 'K' (7.9 µg), lycopene (2573 µg), phosphorus (24 mg), potassium (237 mg) and can provide 18 kcal of energy per 100 g of raw fruit. Tomato has gained importance for its processing potential and also for medicinal value, especially antioxidant property of ascorbic acid and lycopene contents. Tomato cultivation has gained significance since mid-19th century for its ability to adapt varied climatic and growing conditions (outdoor fields, greenhouses and net-houses).

India stands second to China in production of tomato at global level. In India, tomato is being cultivated in an area of about 7,74,000 hectares with an annual production of 18.73 mt and productivity of 20.70 t per ha. The tomato cultivation is mainly concentrated in Madhya Pradesh, Andhra Pradesh, Karnataka, Telangana, Gujarat, Odisha, West Bengal, Bihar and Maharashtra states (Anon., 2017). In Karnataka, tomato is cultivated in an area of 65,545 hectares with an annual production of 2.06 million tonne and productivity is 31.37 tonne per hectare (Anon., 2013). The major tomato growing districts of Karnataka are Bengaluru, Belagavi, Tumakuru, Chikkaballapura, Kolar, Hassan, Haveri and Davanagere.

Tomato is known to be infected by several diseases caused by fungal, bacterial, phytoplasma and viruses. Among the viral diseases reported on tomato, tomato leaf curl virus disease (ToLCVD) caused by *Tomato leaf curl virus* (ToLCV) (family Geminiviridae, genus Begomovirus) is the most destructive one in major tomato growing regions of India and the world. The ToLCV is transmitted by whitefly vector, *Bemisia*

tabaci (Gennadius) (Hemiptera: Aleyrodidae). The genus *Begomo virus* has more than 192 recognized species (Brown *et al.,* 2011) and most of them are transmitted by *B. tabaci* alone (Brown, 2010). The ToLCVD incidence ranged from 17-100 per cent in different tomato growing areas of Karnataka across seasons.

Host plant resistance is the most economical and an important approach for plant disease management mainly for its safety to environment. Efforts for development of resistant varieties and hybrids is continuous in both public and private sector institutes. Tomato varieties like Nandi, Sankranti and Vybhav, varieties from UAS, Bengaluru and Arka Rakshak, a triple resistant hybrid from ICAR-IIHR, Bengaluru have been developed and released for commercial cultivation. The continuously evolving variability among the ToLCV strains and its whitefly vector, *B. tabaci* are the main reasons for the frequent breakdown of resistance of the ruling varieties or hybrids. The durability of resistance against ToLCVD is the issue of concern which further necessitates continuous search for resistance and / or development of resistance sources.

The efforts for identification of resistance sources both within the species and also across related species of the genus, and further using them in breeding programmes for development of resistant hybrids is started long back. The evaluation of germplasm and hybrids for their reaction against ToLCV was performed based on the visual symptoms of ToLCVD either by observing under field conditions or after inoculation of virus using vector. The variety Pusa Ruby was breed and cultivars like Hissar Anmol and Hissar Gaurav were identified with relatively less susceptibility to whiteflies and in turn less susceptibility to ToLCV infection under Madhya Pradesh condition.

Similarly, three fresh market tomato lines *viz.,* TLB111, TLB130 and TLB182 (Sankranthi, Nandi and Vybhav) which are resistant to south Indian and Taiwan gemini viruses, and tolerant to bacterial wilt were developed by conventional breeding and screening method by using viruliferous *B. tabaci* from UAS, Bangalore in collaboration with AVRDC Taiwan and Natural Resource Institute (NeRI), United Kingdom. They have been used as source of resistance in further breeding programmes to develop hybrids (Shankarappa *et al.,* 2008). In the present article, it is reported that, the screening of tomato germplasm and private sector hybrids for resistance to the ToLCV. The plants were assayed according to visual symptoms of the leaf curl disease.

Material and Methods

The tomato segregating population from F_1 generation (47 Nos.) which were developed by crosses between parent lines *viz.,* DMT2 x COHBT24 having genetic background of resistance against both ToLCV and its whitefly vector along with private sector commercial hybrids (37 Nos.) were selected. The selected population was evaluated for resistance against ToLCV under glasshouse condition by artificial inoculation using viruliferous whitefly vector.

Establishment and maintenance of *B. tabaci*, whitefly colonies

Whitefly (*B. tabaci*) colonies used in the present study was identified as genetic Subgroup-Asia I (indigenous) which were reared on cotton plants grown in muslin covered wooden cages (45 x 45 x 30 cm) held in an insectary greenhouse at UAS, GKVK, Bengaluru. The colonies were further maintained by introducing fresh cotton plants at regular.

Handling of adult whiteflies

A laboratory aspirator consisting of a glass tube (30 cm length and 0.5 cm diameter) connected to a rubber tube of 40 cm length with a piece of cloth placed at the point of connection to retain the whiteflies within the glass tube while sucking was used for collection and release of whiteflies. The whiteflies present on the lower side of the leaves were collected by turning the leaves slightly upwards using aspirator.

The collected whiteflies were given 24 h of acquisition access period on ToLCV infected tomato source plants, after which they were allowed 24 h inoculation access period on 15 days old tomato test plants @ over 10-15 viruliferous whiteflies per plant.

Maintenance of ToLCV culture

The ToLCV- Ban 4 was obtained from the stock culture which was maintained on tomato plants cv. Arka Vikas. The virus culture was maintained by frequently inoculating to 10-15 days old tomato seedlings cv. Arka Vikas by using viruliferous whiteflies, *B. tabaci* in insect proof glass house and the inoculated plants were maintained in muslin cloth covered cages.

Raising of healthy seedlings

Tomato segregating population derived from ToLCVD resistant and tolerant parental lines along with private sector hybrids were sown in plastic trays containing sterilized coir pith. The F_1 generation of segregating population was derived from the crosses between parents, DMT2 x COHBT24 with know resistance background against ToLCV were selected along with private sector hybrids. The trays were kept in insect proof glasshouse. Ten days after sowing, the seedlings were transplanted into polythene bags of size 13 x 18 cm, filled with sterilized farm yard manure. Seedlings at first true leaf stage were used for screening studies.

Cages used for acquisition access period

Whiteflies were collected from the colonies reared in an insect proof cage with the help of an aspirator. Whiteflies were released into a round PVC bottle. It measured 20 cm long and 7.5 cm in diameter at one end and tapering towards the narrow end. The bottom portion was removed with the help of soldering rod and was covered with muslin cloth. Whiteflies were released into the acquisition bottle and the ToLCV infected branch was inserted and closed with a cotton plug. After pre-acquisition fasting of 30 minutes followed by 24 hr acquisition access period, the viruliferous whiteflies were allowed for inoculation access period of 24 hr. on healthy seedlings.

Inoculation of young tomato seedlings

The adult *B. tabaci* collected from stock culture were released into the PVC tubes containing ToLCV infected twig. Totally ten plants were inoculated for each germplasms/entry or hybrid. Healthy tomato seedlings at two-leaf stage were individually covered with plastic / PVC tube (7.5 x 2.5 cm) and 10 to 15 viruliferous adults were released onto each seedling with the help of an aspirator through the hole on the body of the tube and plugged with cotton. Whiteflies were allowed to feed for 24 hr as inoculation access period (IAP). After IAP plastic / PVC tubes were removed and seedlings were kept in glass house for symptom expression. Following inoculation, plants were sprayed with an insecticide (Imidacloprid 17.8 per cent SL @ 05 ml per litre) to kill all the whiteflies and kept in an insect-proof greenhouse for 4 weeks.

Disease severity as per cent disease index (PDI)

The observations on per cent disease index (PDI) of ToLCVD of the segregating population and private sector hybrids was scored by employing the scale described by Muniyappa *et al.* (1991) by visual observation. The observations were recorded at 10, 20 and 30 days after inoculation (DAI) and PDI was calculated as detailed below. The resistance categorization was performed based on final resistance reaction. The disease progress over the study period was calculated and expressed as Area Under Disease Progress Curve (AUDPC) values. The disease severity was scored as detailed below :

Category		Description
1 Resistance (R)	=	No symptoms
2 Mild infection (M)	=	Light yellowing along margins but no curling of leaves. Only few plants were infected.
3 Moderate infection (Mo)	=	Light yellowing along margin, slight curling and stunting
4 Susceptible (S)	=	Very severe curling of leaves, stunting of plants and significant yield loss.

The per cent disease index (PDI) was calculated by using the formula

$$\text{Per cent disease index (PDI)} = \frac{\text{Sum of individual disease ratings}}{\text{Total number of ratings X Maximum scale}} \times 100$$

Calculation of Area Under Disease Progress Curve (AUDPC) values

$$AUDPC = \sum_{i=1}^{n} \left(\left\{ \frac{[Yi + Y(i+1)]}{2} \right\} \right) x\ [t(i+1) - ti]$$

Where,

Yi = Disease severity/incidence at time ti

$t_{(i+1)}$ - t_i = Time (days) between two disease severity/ incidence scores

n = Total number of observations

Results and Discussion

Totally, 84 population comprising of 47 segregating population from F1 generation from cross between resistant parents and 37 private sector commercial hybrids were screened artificially using whitefly vector underglasshouse condition at Department of Plant Pathology, UAS, GKVK, Bengaluru for their reactions to the virus on the basis of development of visible disease symptoms. The results are tabulated (Table 1) and summarized (Table 2).

Among the population screened, no visual symptoms of ToLCV infection were observed in COHBTTF1/11-4, whereas, maximum ToLCVD severity (60 PDI) was recorded in COHBTTF1/325-4 at 30 days after inoculation (DAI) itself. The total population evaluated were categorized into resistant (8 Nos.), mild infection (36 Nos.), moderate infection (35 Nos.) and susceptible (5 Nos.). The AUDPC value for ToLCVD ranged from 0 (COHBTTF1/11-4) to 1050 (COHBTTF1/325-4).

The lines which have shown resistant reaction (8 Nos.) against ToLCV infection *viz.,* COHBTTF1/11-4, COHBTTF1/86-4, COHBTTF1/99-2, COHBTTF1/99-5, COHBTTF1/132-1, COHBTTF1/253-1, COHBTTF1/270-2 and US/2853, whereas COHBTTF1/89-1, COHBTTF1/91-1, COHBTTF1/95-6, COHBTTF1/95-7 and COHBTTF1/325-4 have recorded susceptible reaction (5 Nos.). The AUDPC value for the lines showing resistant, mild infection, moderate infection and susceptible reaction ranged from 0 to 150, 60 to 500, 333.33 to 900 and 650 to 1050, respectively.

The lines COHBTTF1/91-5, COHBTTF1/325-1 and COHBTTF1/86-5 even though grouped under moderate infection category based on final PDI values (after 30 days of inoculation) of 48, 46.7 and 46.7, respectively, while, they have recorded considerable variation in AUDPC values. The line COHBTTF1/91-5 has recorded AUDPC value of 560 as against AUDPC value of 900 for both COHBTTF1/325-1 and COHBTTF1/86-5 lines. Similarly, all the lines under susceptible category COHBTTF1/91-1, COHBTTF1/95-6 and COHBTTF1/95-7 recorded PDI values of 50, but they differed considerably with respect to AUDPC values (650, 650 and 700, respectively) as compared to the lines COHBTTF1/89-1 and COHBTTF1/325-4 under same disease resistance category, which have recorded AUDPC values of 1000 and 1050, respectively. The lines COHBTTF1/91-5 under moderate infection category and COHBTTF1/91-1, COHBTTF1/95-6 and COHBTTF1/95-7 under susceptible category recorded less progress of disease as compared to other lines in the respective resistance category. The less progress of disease at the early stage of the plant growth is a desirable trait if not fully resistant ones are available. Further, screening the plant populations for their resistance reaction against a particular disease based on PDI at singlepoint of growth period is insufficient for categorization of plant population based on resistance reaction.

For the management of plant diseases, identification of resistant sources and utilizing the identified resistant source(s) in further breeding programmes either by conventional and/or molecular assisted approaches is a continuous process. The exploitation of identified resistant source(s) is of highest significance for the management of virus diseases of crop plants in the context of lack of effective curative approaches for post viral infection conditions. Breeding for resistance against ToLCV infection is relatively difficult task due to fact that involvement of complex genetics of the resistance genes. Several previous efforts could not yield fruitful results with

TABLE 1

Evaluation of tomato segregating population and private sector hybrids for resistance to ToLCV by using whitefly, *Bemisia tabaci* vector under glasshouse conditions

Segregating population/ Private sector hybrids	PDI at days after inoculation (DAI)			AUDPC	Resistance category (Based on PDI at 10 DAI)
	10	20	30		
1	2	3	4	5	6
Segregating population					
COHBTTF1/11-4	0.00	0.00	0.00	0.00	Resistant
COHBTTF1/11—5	10.00	10.00	25.00	325.00	Mild infection
COHBTTF1/13-4	20.00	30.00	35.00	675.00	Moderate infection
COHBTTF1/28-5	4.00	24.00	24.00	400.00	Mild infection
COHBTTF1/31-2	24.00	28.00	40.00	720.00	Moderate infection
COHBTTF1/31-5	10.00	20.00	23.33	416.67	Mild infection
COHBTTF1/33-4	20.00	30.00	40.00	700.00	Moderate infection
COHBTTF1/37-5	30.00	35.00	45.00	875.00	Moderate infection
COHBTTF1/79-4	3.33	10.00	16.67	216.67	Mild infection
COHBTTF1/80-1	0.00	13.33	20.00	233.33	Mild infection
COHBTTF1/80-2	6.67	20.00	26.67	400.00	Mild infection
COHBTTF1/83-1	4.00	8.00	12.00	180.00	Mild infection
COHBTTF1/86-4	0.00	3.33	3.33	50.00	Resistant
COHBTTF1/86-5	23.33	43.33	46.67	900.00	Moderate infection
COHBTTF1/89-1	26.67	46.67	53.33	1000.00	Susceptible
COHBTTF1/89-2	15.00	40.00	45.00	775.00	Moderate infection
COHBTTF1/89-3	8.00	32.00	36.00	580.00	Moderate infection
COHBTTF1/89-5	16.67	36.67	43.33	750.00	Moderate infection
COHBTTF1/91-1	0.00	40.00	50.00	650.00	Susceptible
COHBTTF1/91-5	4.00	28.00	48.00	560.00	Moderate infection
COHBTTF1/91-6	15.00	30.00	45.00	675.00	Moderate infection
COHBTTF1/95-6	10.00	30.00	50.00	650.00	Susceptible
COHBTTF1/95-7	15.00	30.00	50.00	700.00	Susceptible
COHBTTF1/99-2	0.00	4.00	4.00	60.00	Resistant
COHBTTF1/99-5	0.00	4.00	4.00	60.00	Resistant
COHBTTF1/132-1	0.00	0.00	6.67	33.33	Resistant
COHBTTF1/137-5	0.00	13.33	16.67	216.67	Mild infection
COHBTTF1/218-1-1	12.00	24.00	28.00	500.00	Mild infection
COHBTTF1/218-2	0.00	6.67	20.00	166.67	Mild infection
COHBTTF1/218-3	0.00	10.00	10.00	150.00	Mild infection
COHBTTF1/220-1	3.33	6.67	10.00	150.00	Mild infection
COHBTTF1/228-2	10.00	10.00	13.33	266.67	Mild infection

1	2	3	4	5	6
COHBTTF1/228-6	6.67	10.00	13.33	233.33	Mild infection
COHBTTF1/229-1	3.33	10.00	16.67	216.67	Mild infection
COHBTTF1/245-1	10.00	20.00	20.00	400.00	Mild infection
COHBTTF1/253-1	0.00	0.00	5.00	25.00	Resistant
COHBTTF1/270-1	20.00	20.00	20.00	500.00	Mild infection
COHBTTF1/270-2	0.00	6.67	6.67	100.00	Resistant
COHBTTF1/270-5	20.00	20.00	30.00	550.00	Moderate infection
COHBTTF1/283-1	0.00	33.33	40.00	533.33	Moderate infection
COHBTTF1/283-2	20.00	40.00	40.00	800.00	Moderate infection
COHBTTF1/325-1	26.67	40.00	46.67	900.00	Moderate infection
COHBTTF1/325-3	25.00	25.00	40.00	700.00	Moderate infection
COHBTTF1/325-4	25.00	50.00	60.00	1050.00	Susceptible
COHBTTF1/330-1	13.33	23.33	40.00	566.67	Moderate infection
COHBTTF1/330-8	16.00	32.00	36.00	660.00	Moderate infection
COHBTTF1/349-3	13.33	20.00	26.67	466.67	Mild infection
	Private sector commercial hybrids				
US/4545	0.00	0.00	12.00	60.00	Mild infection
US/809	0.00	13.33	13.33	200.00	mild infection
US/2853	0.00	3.33	3.33	50.00	Resistant
US/3383	6.67	36.67	40.00	633.33	Moderate infection
US/04	10.00	10.00	10.00	250.00	Mild infection
US/3330	6.67	23.33	26.67	433.33	Mild infection
US/404	12.00	12.00	12.00	300.00	Mild infection
NS/592	0.00	0.00	23.33	116.67	Mild infection
NS/524	4.00	20.00	40.00	440.00	Moderate infection
NS/505	0.00	28.00	44.00	500.00	Moderate infection
NS/526	13.33	23.33	23.33	483.33	Mild infection
NAINA	12.00	36.00	40.00	680.00	Moderate infection
ABHILASH	0.00	10.00	23.33	216.67	Mild infection
TRISHUL	0.00	13.33	40.00	333.33	Moderate infection
ARUNA	0.00	0.00	23.33	116.67	Mild infection
ALANKAR	0.00	24.00	32.00	400.00	Moderate infection
LAKSHMI	8.00	16.00	36.00	420.00	Moderate infection
AVISHKAR	16.67	20.00	23.33	483.33	Mild infection
SAMPOORNA	13.33	13.33	16.67	350.00	Mild infection
SHAHENSHA	16.67	16.67	36.67	516.67	Moderate infection
APOORVA	10.00	23.33	26.67	466.67	Mild infection

1	2	3	4	5	6
GARVA	0.00	16.67	16.67	250.00	Mild infection
ANJU	6.67	6.67	10.00	183.33	Mild infection
CHIRAYU	8.00	16.00	40.00	440.00	Moderate infection
SATYAM	10.00	26.67	26.67	500.00	Mild infection
RASSAM	0.00	25.00	30.00	400.00	Moderate infection
HYB 3252	20.00	40.00	40.00	800.00	Moderate infection
INDUS 1030	5.00	20.00	35.00	425.00	Moderate infection
INDAM 535	0.00	10.00	26.67	233.33	Mild infection
INDAM 1004	20.00	30.00	30.00	650.00	Moderate infection
NIRUPAM	20.00	36.00	36.00	740.00	Moderate infection
JKTH 811	16.67	20.00	36.67	550.00	Moderate infection
MAHI 701	0.00	6.67	10.00	116.67	Mild infection
NOVO81	3.33	33.33	33.33	533.33	Moderate infection
HEEM SHIKHAR	16.67	33.33	36.67	683.33	Moderate infection
CHANDINI	12.00	20.00	32.00	480.00	Moderate infection
SUPER GANESHA	0.00	24.00	24.00	360.00	Mild infection

DAI- Days After Inoculation
AUDPC- Area Under Disease Progress Curve

some exceptions like development and release of tomato lines *viz.,* TLB111, TLB130 and TLB182 for fresh fruit market by Muniyappa *et al.,* (2002) from UAS Bengaluru and Arka Rakshak from IIHR, Bengaluru during 2006 with multiple disease resistance traits.

In spite of the challenges, breeding for disease resistance is being exploited for its potential property of safety to environment besides directly reducing the cost involved for plant protection. In the present study, the successful management of ToLCVD by breeding lines which have shown considerable resistance to ToLCV infection like DMT2 x COHBT24 were used as parent to develop the F_1 generation and the segregating population from F_1 generation along with the commercially available private sector hybrids were subjected for rigorous screening in glasshouse using viruliferous whitefly vector. Many earlier workers followed the crossing of ToLCV resistant parents of tomato to develop either resistant F_1's or lines (Singh, 2014 and Ray *et al.,* 2017).

The present study was performed by using ToLCV Ban 4 isolate of virus and Asia I (indigenous) type of whitefly population as both are most prevalent in this region. The segregating population *viz.,* COHBTTF1/11-4, COHBTTF1/86-4, COHBTTF1/99-2, COHBTTF1/99-5, COHBTTF1/132-1 and COHBTTF1/253-1have recorded resistant reaction against ToLCVD. Hence, these can be further evaluated for horticulture traits in multi-location trials / farm trials in large areas and can be used either for further breeding programmes or directly released for cultivation purpose after thorough screening.

In COHBTTF1/91-5 under moderate infection category, and COHBTTF1/91-1, COHBTTF1/95-6 and COHBTTF1/95-7 under susceptible category were observed to have significantly slow progression of ToLCVD, especially during early stage of the crop growthin comparison to other lines in the respective resistance category by taking infection late.

TABLE 2

Summary of evaluation of tomato segregating population and private sector hybrids based on resistance to ToLCV using *B. tabaci,* whitefly vector screened under glasshouse condition

Resistance category (AUDPC)	Total number	Segregating population / Private sector hybrids		
Resistant (0-100.00)	8	COHBTTF1/11-4	COHBTTF1/86-4	
		COHBTTF1/99-2	COHBTTF1/99-5	
		COHBTTF1/132-1	COHBTTF1/253-1	
		COHBTTF1/270-2	US/2853	
Mild infection(60-500)	36	COHBTTF1/11-5	COHBTTF1/28-5	
		COHBTTF1/31-5	COHBTTF1/79-4	
		COHBTTF1/80-1	COHBTTF1/80-2	
		COHBTTF1/83-1	COHBTTF1/137-5	
		COHBTTF1/218-1-1	COHBTTF1/218-2	
		COHBTTF1/218-3	COHBTTF1/220-1	
		COHBTTF1/228-2	COHBTTF1/228-6	
		COHBTTF1/229-1	COHBTTF1/245-1	
		COHBTTF1/270-1	COHBTTF1/349-3	
		US/04	US/404	US/809
		US/3330	US/4545	NS/526
		SAMPOORNA	NS/592	APOORVA
		SUPER GANESHA	AVISHKAR	ANJU
		SATYAM	ARUN	ABHILASH
		GARVA	INDAM 535	MAHI 701
Moderate infection (333.33-900)	35	COHBTTF1/13-4	COHBTTF1/31-2	
		COHBTTF1/33-4	COHBTTF1/37-5	
		COHBTTF1/86-5	COHBTTF1/89-2	
		COHBTTF1/89-3	COHBTTF1/89-5	
		COHBTTF1/91-5	COHBTTF1/91-6	
		COHBTTF1/270-5	COHBTTF1/283-1	
		COHBTTF1/283-2	COHBTTF1/325-1	
		COHBTTF1/325-3	COHBTTF1/330-1	
		COHBTTF1/330-8		
		US/3383	NS/505	NS/524
		INDUS 1030	HYB 3252	NOVO81
		INDAM 1004	JKTH 811	TRISHUL
		SHAHENSHA	ALANKAR	RASSAM
		LAKSHMI	CHIRAYU	CHANDINI
		HEEM SHIKHAR	NAINA	NIRUPAM
Susceptible(650-1050)	5	COHBTTF1/89-1	COHBTTF1/91-1	
		COHBTTF1/95-6	COHBTTF1/95-7	
		COHBTTF1/325-4		

It has been reported that the extent of yield loss due to ToLCV under field condition is directly proportional to earliness of initiation of virus infection. More specifically, upto 45 days after transplanting (DAT) is more critical time for infection of ToLCV in relation to its effect of ToLCVD on yield. Avinash-2 and US-1008 have been recorded as moderately resistant based on visual scoring (Singh, 2014).

The delay in initiation of infection of ToLCV under field condition will considerably reduce the final impact of the disease on reduction in fruit yield. Hence, the rate of progress of disease as AUDPC values arrived based on either Per cent Incidence (PI) or Per cent Disease Index (PDI) is a significant criteria which needs to be considered along with quantifying the disease at particular stage of the crop growth as PI or PDI for resistance categorization of tomato varieties / hybrids against ToLCVD.

Segregating population from F_1 generation obtained from cross between resistant parents DMT2 x COHBT24 (47 nos.) and 37 private sector commercial hybrids were screened artificially under glasshouse using whitefly vector (genetic subgroup Asia I) and ToLCV Ban4 virus under glasshouse and found eight segregating populations / public sector hybrids *viz.,* COHBTTF1/11-4, COHBTTF1/86-4, COHBTTF1/99-2, COHBTTF1/99-5, COHBTTF1/132-1, COHBTTF1/253-1, COHBTTF1/270-2 and US/2853 as resistant to ToLCVD. Further, COHBTTF1/91-5 under moderate infection category, and COHBTTF1/91-1, COHBTTF1/95-6 and COHBTTF1/95-7 under susceptible category observed for having significantly slow progression of ToLCVD as evident by lesser AUDPC values, especially in early stage of crop growth, a property crucial in the event of non-availability of completely resistant population in reducing the impact of ToLCVD incidence on yield.

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