Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.2838

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (3):** 271-277 (2017)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Evaluation of Tomato and Allied Species for Tomato Leaf Curl Virus (Tolcv) Resistance (*Solanum lycopersicum* L.)

Siddhesh R. Nadkarni[1*], Jayalekshmy V. G.[2], Umamaheshwaran K.[3] and Harikrishnan P. J.[4]

[1, 2, 4,]Department of Plant Breeding and Genetics, College of Agriculture Vellayani

[3]Department of Plant Pathology, College of Agriculture Vellayani, Trivandrum- 695522

*Corresponding Author E-mail: sidd.nadkarni@gmail.com

Received: 12.04.2017 | Revised: 20.04.2017 | Accepted: 22.04.2017

ABSTRACT

Leaf curl disease of tomato caused by tomato leaf curl virus (ToLCV), a gemini virus, is transmitted by whitefly, Bermisia tabaci G. Thirty five tomato genotypes including wild accessions were screened for its resistance/ susceptible reaction against tomato leaf curl disease in field condition during summer cropping season 2015. Among the screened thirty five genotypes, seven genotypes Vaibhav, EC541109 (Solanum pimpinellifolium L.), EC168283 (Solanum pimpinellifolium L.), IIHR2372 (Solanum lycopersicum L.), IIHR1970 (Solanum peruvianum L.), IIHR2200 (Solanum lycopersicum L.) and LA2805 (Solanum lycopersicum var. cerasiforme L.) showed high resistance against ToLCV without producing any symptoms of leaf curl disease. One genotype viz., EC165751 showed resistant reaction and two genotypes viz., Nandi and EC620545 showed moderately resistant reaction to ToLCV, Twelve genotypes showed moderately susceptible reaction, seven genotypes showed susceptible reaction and six genotypes were identified as highly susceptible to ToLCV. Solanum pimpinellifolium L. species is compatible with the cultivated Solanum lycopersicum L. So it can be used successfully as the source of resistance in breeding program. Identified genotypes can be screened for resistance genes using markers and can be used in the molecular breeding programmes for resistance to leaf curl disease in tomato.

Key words: *Tomato; ToLCV, Wild species, Resistance.*

INTRODUCTION

Tomato (*Solanum lycopersicon* L.), belongs to Solanaceae family, it ranks third in priority after Potato and Onion in India. In India, the tomato is grown in 1204,000 ha with a production of 19402,000 mt and productivity of 16.1 mt ha-1 (Indian Horticulture Database, 2014). Tomato leaf curl virus (ToLCV) caused by geminivirus transmitted through whitefly (*Bamisia tabaci* Gennadius) belongs to family Geminiviridae and genus *Begmovirus*. 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[1] and was first reported in India during 1948[27].

Cite this article: Nadkarni, S.R., Jayalekshmy, V.G., Umamaheshwaran, K. and Harikrishnan, P.J., Evaluation of Tomato and Allied Species for Tomato Leaf Curl Virus (Tolcv) Resistance (*Solanum lycopersicum* L.), *Int. J. Pure App. Biosci.* **5(3):** 271-277 (2017). doi: http://dx.doi.org/10.18782/2320-7051.2838

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[17]. The disease induces severe stunting, bushy growth and partial or complete sterility depending on the stage at which infection has taken place. Infected plant bears few or no fruit. The disease is serious throughout India and yield losses may be as high as 100%[11]. Host plant resistance is very effective and non-monetary input of Integrated Pest Management. During the past 20 years, considerable efforts have been made to develop tomato leaf curl virus resistant cultivars. Tomato cultivars however are not completely resistant to ToLCV. Therefore wild *Lycopersicon* species were screened for virus resistance in India by many investigators[15,17,18]. Nevertheless progress in breeding for ToLCV resistance has been slow[3,12] because of the complex genetics of resistance. Identification of resistant genotypes/lines/cultivars and exploration of resistant sources in wild tomato germplasm is very much important for the effective and environmentally safer management of ToLCV. In view of the above, the present investigation was carried out to determine the level of resistance/susceptibility in selected popularly grown tomato varieties along with other wild accessions in open field condition under natural screening.

MATERIALS AND METHODS

The experiment was carried out under field conditions at College of Agriculture Vellayani, Thiruvananthapuram, Kerala during summer 2015 for screening of Tomato leaf curl virus resistance (ToLCV). The thirty-five tomato genotypes/ cultivars/ lines were collected from different sources (Table 1). The seedlings were grown in greenhouse and 30 days old seedlings of thirty-five tomato genotypes/ cultivars/ lines/ accessions were transplanted during summer 2015 in randomized block design, with three replications. All the thirty-five tomato genotypes/ cultivars/ lines/ accessions were screened against ToLCV causing leaf curl disease in tomato.

ToLCV incidence and severity

Based on the percent of curling and puckering of leaves, the plants were scored using 0-4 scale as suggested by Banerjee and Kalloo[3] (1987). 0: Symptoms absent; 1: very mild curling (up to 25% leaves); 2: curling and puckering of 26-50 % leaves; 3: curling and puckering of 51-75 % leaves; 4: severe curling and puckering of >75 % leaves.

Based on the disease score, percent disease severity (PDS) was calculated using the following formula:

$$\text{PDS} = \frac{\text{Sum of numerical}}{\text{Total number of plants observed x maximum disease grade}} \text{x } 100$$

Percent disease incidence (PDI) was calculated using the following formula:

$$\text{PDI} = \frac{\text{Number of plants infected}}{\text{Total number of plants observed}} \text{x } 100$$

Based on the coefficient of infection the genotypes were categorized into six groups (Banerjee and Kalloo[3] (1987). 0-4: Highly resistant (HR); 4.1-9: Resistant (R); 9.1-19: Moderately Resistant (MR); 19.1-39: Moderately Susceptible (MS); 39.1-69: Susceptible (S); 69.1-100: Highly Susceptible (HS).

RESULTS AND DISCUSSION

Screening for ToLCV resistance under field conditions: -

Even though several methods have been developed to control ToLCV, such as the use of healthy transplants, chemical and physical control of the vector and crop rotation, breeding for resistance to ToLCV is

considered to be the best method for the management of the diseases[16]. The breeding of tomatoes resistant to ToLCV is reported to be low because of the complicated inheritance of the resistance/ tolerance trait. Depending on the source, resistance has been reported to be controlled by one to five genes that are either recessive or dominant[28]. Therefore, available varieties were screened in open fields so as to find out the source of the resistance in tomato against tomato leaf curl virus disease under field conditions. The severity of disease was determined by using percent disease severity, percent disease incidence and coefficient of infection.

Percent disease severity: -

Percent disease severity result as indicated in Table 1. revealed that tomato genotypes exhibited a wide range of resistance reaction to the tune of 0 to 100 % against ToLCV under field condition during summer season. Among the Thirty-five genotypes, the seven genotypes Vaibhav, EC541109 (*Solanum pimpinellifolium* L.), EC168283 (*Solanum pimpinellifolium* L.), IIHR2372 (*Solanum lycopersicum* L.), IIHR1970 (*Solanum peruvianum* L.), IIHR2200 (*Solanum lycopersicum* L.) and LA2805 (*Solanum lycopersicum var. cerasiforme* L.) recorded disease severity of 0.00 % without any symptoms. One genotype (EC-165751) recorded disease severity of 14.17 %. Ten genotypes recorded disease severity in the range of 50-88.33 %. In seventeen genotypes the disease severity recorded 20 to 50 %. Camara *et al*[5]., screened forty one tomato genotypes for ToLCV under field condition and recorded percent disease severity 0 % to 89.3 %. They observed that eleven genotypes were totally symptom-free and percent disease of incidence up to 100%, severity was generally over 50%. Asian Vegetable Research and Development Center (AVRDC), Shanhua, Taiwan developed these EC series lines and also found percent disease severity depends upon *TY* gene combinations. If any of the *TY* locus is present in germplasm that reduces the Percent disease severity. Lapidot *et al*[12]., working on varieties TY 172 and TY 197, revealed their resistance to ToLCV and their low harvest losses compared to other commercial varieties susceptible to the disease.

Percent disease incidence: -

The percent disease incidence was calculated using formula the number of plants infected divided by the total number of plant observed multiplied by 100. The result of percent disease incidence mentioned in Table 1. Out of thirty-five genotypes, seven genotypes were not infected by the virus, it means 0 % percent disease incidence. While in fifteen genotypes, (Palam Pride, Surya, BWR-5, S-7, Manulekshmy, Anagha, Vellayani Vijay, Arka Abha, PKM-1, Arka Alok, Manuprabha, EC-620419, EC-326142, EC-16786 and EC-16465) all the plants were infected, the percent disease incidence observed was 100 %. The Percent disease severity recorded in Anagha variety was 37.50 % and percent disease incidence was 100 % whereas Percent disease severity in Hawaii variety was 54.17 % and percent disease incidence was 90 %. The percent disease incidence and Percent disease severity values could be used to class the genotypes as tolerant or susceptible. Rao *et al*[22]., reported, the percentage of disease incidence in tomato and chillies showed more than 77% in all villages during Hagay season but the severity was observed between 20 and 60%. Maruthi *et al*[13]., screened thirty four tomato genotypes for ToLCV under glasshouse and field conditions and found sixteen Varieties were resistant. Joshi and Choudhury[10], Muniyappa *et al*[15]., and Nateshan *et al*[18]., have also reported the Varieties are resistant to tomato leaf curl virus.

Coefficient of the infection (CI):-

The coefficient of the infection of thirty-five tomato genotypes is mentioned in Table 1. Based on the coefficient of infection, the genotypes were categorized into six groups

Banerjee and Kalloo[3]. Highly resistant reaction was found in seven genotypes, among these seven highly resistant genotypes three genotypes i.e., EC541109 (*Solanum pimpinellifolium* L.) (0%), EC168283 (*Solanum pimpinellifolium* L.) (0%) and IIHR1970 (*Solanum peruvianum* L.) (0%) were wild species and four genotypes i.e., Vaibhav (0%), (0%), IIHR2372 (*Solanum lycopersicum* L.) (0%), IIHR2200 (*Solanum lycopersicum* L.) (0%) and LA2805 (*Solanum lycopersicum var. cerasiforme* L.) (0%) were cultivated species. Anbinder *et al*[2]., (2009) reported that ToLCV resistance derived from *Solanum pimpinellifolium* Hirsute-INRA line is under the control of a single dominant gene other than Ty 1. The fruit size of *Solanum pimpinellifolium* L. is very small and plant is indeterminate in nature but it has resistance against ToLCV. Ilana *et al*[8]., also observed resistance in *Solanum peruvianum* L. is controlled by a previously unknown major QTL, and four additional minor QTLs. The major QTL termed *Ty-5*, maps to chromosome 4 and accounts for 39.7 to 46.6% of the variation in symptom severity. The location of this new gene is between markers TG 153 and CT 83. Along with this gene, QTL was located on chromosome 6 accounting for up to 27.7% of the variation in symptom severity.

Genotype EC-165751 (7.08 %) was found to be Resistant and two genotypes Nandi (12.22 %) and EC-620545 (12.22 %) were found to be Moderately Resistant, whereas twelve genotypes were found to be Moderately Susceptible with Coefficient of the infection ranging from 26.39% to 38.33%, Seven genotypes were observed susceptible with Coefficient of the infection ranging from 41.67% to 57.50% and six genotypes were observed as highly Susceptible with Coefficient of the infection ranging from 71.67% to 88.33% (Table 1). Singh[25], also observed the coefficient of the infection in Kashi Vishesh (8.06 %), Kashi Amrit (8.20 %), Arka Meghali (52.74 %), Arka Alok (52.38 %) and Pusa Ruby (25.33 %). Yadav and Awasthi, 2009 also reported the coefficient of the infection in Arka Meghali (68.34%), Arka Alok (75.00 %) and Pusa Ruby (62.42%). Many researchers reported that wild tomato accessions of *Solanum* species such as H-7998 as resistant sources for ToLCV[3,4]. Sannaulla *et al*[23]., evaluated 29 tomato genotypes for resistance to the virus and found that none of the genotypes showed resistance reaction.

Among the wild species, *Solanum pimpinellifolium* is the most suitable for use in tomato breeding programmes, since there is no hybridization barriers between both species, and fruit size can be recovered in a few backcrosses[6]. In these study also *Solanum pimpinellifolium* L. was found to be highly resistant to local strain of ToLCV of Kerala. Breeding for resistance to ToLCV in tomato was initiated in Israel using the accession LA 121 of *Solanum pimpinellifolium* L. as the source of resistance[20]. *Solanum pimpinellifolium* lines INRA, LA1478, PI407543 and PI407544 with different resistance levels were found[9]. Pilowsky and Cohen[21], also reported *Solanum peruvianum* PI-126935 to be tolerance to ToLCV and this tolerance seemed to be a recessive trait controlled by five genetic factors. Friedmann *et al*[7]., also reported the TYLCV resistance in TY172 was derived from four divergent accessions of *Solanum peruvianum*. The EC series lines which were developed by Asian Vegetable Research Development Centre Taiwan has resistant reaction to ToLCV. The EC genotype which is highly resistant under natural condition can be used as a resistant source for developing resistant/ tolerant varieties/ hybrids against ToLCV. Several other important contributions made on this aspect are also available in the literature[14,19,24,26].

Table 1: Screening of thirty-five tomato genotypes against tomato leaf curl during summer season 2015-16

Sl. No	Genotype	Source	PDS	PDI	CI	Reaction
1	PALAM PRIDE	CSK HPKV, PALAMPUR	88.33	100.00	88.33	HS
2	SURYA	CSK HPKV, PALAMPUR	75.00	100.00	75.00	HS
3	BWR-5	CSK HPKV, PALAMPUR	71.67	100.00	71.67	HS
4	S-7	CSK HPKV, PALAMPUR	44.17	100.00	44.17	S
5	ARKA VIKAS	IIHR, BENGALURU	35.83	86.67	31.06	MS
6	HAWAII	CSK HPKV, PALAMPUR	54.17	90.00	48.75	S
7	MANULEKSHMY	KAU, KERALA	37.50	100.00	37.50	MS
8	ARKA MEGHALI	IIHR, BENGALURU	30.00	90.00	27.00	MS
9	ANAGHA	KAU, KERALA	37.50	100.00	37.50	MS
10	AKSHAY	KAU, KERALA	33.33	90.00	30.00	MS
11	VELLAYANI VIJAY	KAU, KERALA	42.50	100.00	42.50	S
12	VAIBHAV	UAS, BENGALURU	0.00	0.00	0.00	HR
13	ARKA ABHA	IIHR, BENGALURU	57.50	100.00	57.50	S
14	PKM-1	ASHOK FARM AIDS	51.67	100.00	51.67	S
15	NANDI	UAS, BENGALURU	18.33	66.67	12.22	MR
16	ARKA ALOK	IIHR, BENGALURU	60.00	100.00	60.00	S
17	S-22	SOCCAR SEEDS	31.67	83.33	26.39	MS
18	MANUPRABHA	KAU, KERALA	41.67	100.00	41.67	S
19	EC620419	NBPGR	79.17	100.00	79.17	HS
20	EC362944	NBPGR	31.67	90.00	28.50	MS
21	EC168283 (*Solanum pimpinellifolium* L.)	NBPGR	0.00	0.00	0.00	HR
22	EC620545	NBPGR	18.33	66.67	12.22	MR
23	IC549835	NBPGR	31.67	90.00	28.50	MS
24	EC165751	NBPGR	14.17	50.00	7.08	R
25	EC322634	NBPGR	35.00	96.67	33.83	MS
26	EC326142	NBPGR	80.00	100.00	80.00	HS
27	IIHR2372 (*Solanum lycopersicum* L.)	IIHR, BENGALURU	0.00	0.00	0.00	HR
28	EC16786	NBPGR	85.00	100.00	85.00	HS
29	IIHR1970 (*Solanum peruvianum* L.)	IIHR, BENGALURU	0.00	0.00	0.00	HR
30	EC541109 (*Solanum pimpinellifolium* L.)	NBPGR	0.00	0.00	0.00	HR
31	EC16465	NBPGR	38.33	100.00	38.33	MS
32	IIHR2200 (*Solanum lycopersicum* L.)	IIHR, BENGALURU	0.00	0.00	0.00	HR
33	EC320574-1	NBPGR	35.00	90.00	31.50	MS
34	IC247508	NBPGR	38.33	93.33	35.78	MS
35	LA2805 (*Solanum lycopersicum var. cerasiforme* L.)	UAS, BENGALURU	0.00	0.00	0.00	HR

PDS - Percent disease severity, PDI - Percent disease incidence, CI - Coefficient of the infection HR- Highly Resistant, R-Resistant, MR- Moderately Resistant, MS-Moderately Susceptible, S- Susceptible, HS- Highly Susceptible.

CONCLUSION

Goal of this research was to identify germplasm lines which have resistance to local Kerala strain of tomato leaf curl virus (ToLCV). In this study, we have identified that genotypes Vaibhav, EC541109 (*Solanum pimpinellifolium* L.), EC168283 (*Solanum pimpinellifolium* L.), IIHR2372 (*Solanum lycopersicum* L.), IIHR1970 (*Solanum peruvianum* L.), IIHR2200 (*Solanum lycopersicum* L.) and LA2805 (*Solanum lycopersicum var. cerasiforme* L.) were highly resistant to tomato leaf curl virus under natural field screening. The wild species *Solanum pimpinellifolium* L. can be successfully used as donor for resistance as it is reported to be compatible with *Solanum lycopersicum* L. and *Solanum lycopersicum var. cerasiforme* L. can also be used as it is found to be compatible with *Solanum lycopersicum* L. and can produce viable seeds. These genotypes can be screened for identification of specific resistance gene genotypically with molecular markers. Identified resistance gene donors can be used for pyramiding the reported ToLCV genes i.e., Ty 1, Ty 2, Ty 3a and Ty 3b so that durable resistance can be imparted to the varieties.

REFERENCES

1. Abhary, M., Patil, B.L. and Fauquet, C.M., Molecular biodiversity, taxonomy, and nomenclature of tomato yellow leaf curl-like viruses. In: Czosnek H (Ed.) Tomato Yellow Leaf Curl Virus Disease:Management, Molecular Biology, Breeding for Resistance, *Springer*, Dordrecht, the Netherlands, pp, 85–118 (2007).
2. Anbinder, I., Reuveni, M., Azari, R., Paran, I., Nahon, S., Shlomo, H., Chen, L., Lapidot, M. and Levin I., Molecular dissection of *Tomato leaf curl virus* resistance in tomato line TY172 derived from *Solanum peruvianum*. *Theoretical and Applied Genetics*, **119:** 519-530 (2009).
3. Banerjee, M.K. and Kalloo, G., Sources and inheritance of resistance to leaf curl virus in *Lycopersicon*. *Theory of Applied Genetics*, **73:** 707-710 (1987).
4. Banerjee, M.K. and Kalloo, G., Nature of resistance to tomato leaf curl virus (TLCV) in two species *of Lycopersicon*. *H. A. U. J. of Res*., **20:** 225-228 (1990).
5. Camara, M., Mbaye, A.A., Noba, K., Samb, P.I., Diao, S. and Cilas, C., Field screening of tomato genotypes for resistance to Tomato yellow leaf curl virus (TYLCV) disease in Senegal. *Crop Protection*. **44:** 59-65 (2013).
6. Esquinas, A.J. and Nuez, F., Situación taxonómica, domesticación y difusión del tomate, in: Nuez F(Ed), El Cultivo del Tomate. Ediciones Mundi Prensa, Madrid, pp: 14-42 (1995).
7. Friedmann, M., Lapidot, M. and Cohen, S., A novel source of resistance to tomato yellow leaf curl virus exhibiting a symp tomless reaction to viral infection. *J. Am. Soc. Hortic. Sci*., **123:** 1004- 1006 (1998).
8. Ilana, A., Moshe, R., Raviv, A., Ilan, P., Sahadia, N., Haviva, S., Lea, C., Moshe, L. and Ilan, L., Molecular dissection of Tomato leaf curl virus resistance in tomato line TY172 derived from *Solanum peruvianum. Theor. Appl. Genet*., **119:** 519-530 (2009).
9. Ji, Y.F., Schuster, D.J. and Scott, J.W., *Ty-3*, a begomovirus resistance locus near the tomato yellow leaf curl virus resistance locus *Ty-1* on chromosome 6 of tomato. *Mol. Breed*., **20:** 271- 284 (2007).
10. Joshi, G.C. and Choudhury, B., Screening *Lycopersicon* and *Solanum* species for *Lycopersicon* species and hybrids to tomato leaf curl geminivirus. In: Gerling D, Mayer RT (eds) *Bemisia* 1995: Taxonomy, Biology, Damage, Control and Management Intercept Ltd., Andover, UK, pp 369-377(1981).
11. Kalloo, G., Disease resistance in vegetable crops. Vegetable Breeding Vol. 2, Ch. 1, CRC Press Inc., Florida, USA, Pp 1-94 (1988).
12. Lapidot, M., Friedmann, M., Lachmann, O., Yehezkwel, A., Nahon, S., Cohen, S. and Pilowsky, M., Comparison of resistance level to tomato yellow leaf curl

virus among commercial cultivars and breeding lines. *Plant Disease*, **81:** 1425-1428 (1997).

13. Maruthi, M.N., Czosnek, H., Vidavski, F., Tarba, S.Y., Milo, J., Leviatov S., Venkatesh, H.M., Padmaja, A.S., Kulkarni, R.S. and Muniyappa, V., Comparison of resistance to Tomato leaf curl virus (India) and Tomato yellow leaf curl virus (Israel) among *Lycopersicon* wild species, breeding lines and hybrids. *European Journal of Plant Pathology*, **109:** 1–11 (2003).
14. Mohanta, L., Thangaraju, D., Mohanasundaram, M. and Jayaraj, S., Outbreak of greenhouse whitefly *Trialyrodesvaporariorum* Westwood in the Nilgiris. *Madras Agricultural Journal*, **75:** 368-370 (1988).
15. Muniyappa, V., Jalikop, S.H., Saikia, A.K., Chennarayappa, S.G., Ishwarabhat, A. and Ramappa, H.K., Reaction to *Lycopersicon* cultivars and wild accessions to tomato leaf curl virus. *Euphytica*, **56:** 37-41 (1991).
16. Nakhla, M.K., and Maxwell, D.P., Epidemiology and management of tomato yellow leaf curl virus. Pages 565- 583 in: Plant Virus Disease Control. A. Hadidi, R. K. Khetarpal, and H. Koganezawa, eds. *The American Phytopathological Society*, St. Paul, MN (1998).
17. Nariani, T.K. and Vasudeva. R.S., Reaction of *Lycopersicon* species to tomato leaf curl virus. *Indian Phytopathology*, **16:** 238-239 (1963).
18. Nateshan, H.M., Muniyappa, V., Jalikop, S.H. and Ramappa, H.K., Resistance to to leaf curl virus. *Vegetable Science*, **8:** 45–50 (1996).
19. Pico, B., Diez, M.J. and Nuez, F., Evaluation of white fly medicated inoculation technique to screen *Lycopersicon esculentum* and wild relatives for resistance to tomato leaf curl virus. *Euphytica*, **101:** 259-271 (1998).
20. Pilowsky, M. and Cohen, S., Inheritance of resistance to tomato, yellow leaf curl virus in tomatoes. *Phytopathol*., **64:** 632-635 (1974).
21. Pilowsky, M. and Cohen, S., Tolerance to tomato yellow leaf curl virus derived from Lycopersicon peruvianum. *Plant Dis*., **74:** 248-250 (1990).
22. Rao, S., Danish, S., Keflemariam, S., Tesfagergish, H., Tesfamariam, R. and Habtemariam, T., Pathological Survey on Disease Incidence and Severity of Major Diseases on Tomato and Chilli Crops Grown in Sub Zoba Hamelmalo, Eritrea. *IJRSAS*. **2(1):** 20-31 (2016).
23. Sannaulla, S., Ramappa, H.K., Shankarappa, K.S. and Rangaswamy, K.T., Effect of fern leaf diseased caused by cucumber mosaic virus on growth and yield of tomato and screening of tomato genotypes for resistance to viral diseases. *Crop. Res*., **34:** 118-121 (2007).
24. Singh, A.K., Rai, G.K., Singh, M., Singh, S.K. and Singh, S., Inheritance of resistance to tomato leaf curl virus in tomato (*Lycopersicon esculentum* Mill.). *Vegetable Science*, **35:** 194–196 (2008).
25. Singh, K., Evaluation of tomato genotypes and its reaction against ToLCV causing leaf curl disease in tomato (*Solanum lycopersicon* L.). *Journal of Experimental Biology and Agricultural Sciences*, **2:** 120-125 (2014).
26. Singh, K., Singh, D.K. and Raju, S.V.S., Evaluation of tomato germplasms/cultivars for its comparative level of resistance against tomato fruit borer (*Helicoverpa armigera* Hubner). *Pestology*, **25:** 17-20 (2011).
27. Vasudeva, R.S. and Samraj, J., A leaf curl disease of tomato. *Phytopathology* 38: 364-369 (1948).
28. Zakai, Y., Navot, N., Zeidan, M., Kedar, N., Rabinowitch, H.D., Czosnek, H. and Zamir, D., Screening Lycopersicon accessions for resistance to tomato yellow leaf curl virus: presence of viral DNA and symptom development. *Plant Disease*, **75:** 279–281 (1990).