



Screening of Parents and Hybrids Resistant to Late Blight and Leaf Curl Virus Diseases in Tomato

Radhe Shyam Kherwa ^a, S. S. Solankey ^{a*}, Shirin Akhtar ^a
and Mahendra Kumar ^b

^a Department of Horticulture (Vegetable & Floriculture), Bihar Agricultural University, Sabour, Bhagalpur– 813 210, Bihar, India.

^b Department of Horticulture, HNBGU, A Central University, Uttarakhand - 246174, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i21670

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/96744>

Original Research Article

Received: 12/12/2022

Accepted: 18/02/2023

Published: 27/02/2023

ABSTRACT

The experimental material included 21 F₁ hybrids (developed by half diallel fashion), 7 parents and standard check were all planted in randomized complete block design with three replications at Bihar Agriculture University, Sabour. Among the parents Pusa Rohini, Arka Vikash and *S. pimpinellifolium* whereas, among the crosses, Pusa Rohini × Arka Vikash, H-86 × Arka Vikash and Arka Vikash × *S. pimpinellifolium* were showed highly resistant for per cent disease incidence and coefficient of infection of late blight and ToLCV. Maximum heterosis over better parent and standard parent in desirable direction were found in Pusa Rohini × Arka Vikash (-48.61, -52.84), (-72.12, -76.42) and Arka Vikash × Arka Abha (-42.02, -50.35), (-61.35, -75.17) for per cent disease incidence and coefficient of infection of late blight. Whereas heterosis for PDI and CI of ToLCV was found in cross combinations namely, Pusa Rohini × *S. pimpinellifolium* (-46.35, -65.08), (-77.50, -88.35) and Arka Vikash × *S. pimpinellifolium* (-60.85, -64.32) (-86.95, -88.27) over better parent and standard parent. The cross identified as best specific combiners Arka Vikash × *S. pimpinellifolium*

*Corresponding author: E-mail: Shashank.hort@gmail.com;

for per cent disease incidence and coefficient of infection of late blight and ToLCV. Among the parents for late blight the per cent disease incidence and coefficient of infection were significantly shown by Arka Vikash and Arka Abha. Against ToLCV (PDI and CI) resistance, parents Pusa Rohini, *S. pimpinellifolium* and Arka Vikash were exhibited significantly negative GCA effect.

Keywords: Heterosis; combining ability; late blight; ToLCV; resistance.

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the second most important vegetable crop in the world and is grown practically throughout India. India is the second top tomato growing country after China contributed about 11 percent of the world tomato production [1]. Worldwide growth and spread of tomato as a vegetable crop is limited by the fact that it is affected by a number of diseases causing substantial yield loss and also affecting the quality of fruits. Besides fungal, bacterial and mycoplasmal infection, it is also affected by large number of viral diseases. In tropics and subtropics, tomatoes are affected with many diseases, which include late blight caused by *Phytophthora infestans* and tomato leaf curl virus disease, a viral disease. They cause huge losses and deterioration to fruit quality, quantity as well as yield [2]. These phyto-pathogens have huge capability to generate new forms of infestation and infection, which can cause much destruction of the crop, leading to crop failure. *Phytophthora infestans* (Mont.) de Bary is not a true fungus, but rather is regarded as a fungus-like organism. This pathogen is currently classified as an Oomycete, which are members of the kingdom Chromista (Stramenopiles or Straminopiles) [2]. Among the diseases, the occurrence of ToLCV and late blight in tomato is a major constraint in cultivation of tomato during summer and rainy season in India. ToLCV is a monopartite, Gemini virus known to be transmitted by the vector white fly, *Bemisia tabaci* Genn. ToLCV is known to infect the crop at all the stages starting from nursery to fruit formation. Saikia and Muniyappa [3] reported cent per cent infection and fruit yield losses up to 90 per cent. Host plant resistance is an important disease control strategy and environmentally safe, with low running costs. Therefore, screening tomato cultivars possessing inbuilt resistance is an appropriate approach for disease management.

2. MATERIALS AND METHODS

The experiment was conducted during 2015-17 at Bihar Agriculture College Sabour and the study comprised of genotypes collected from IIVR, Varanasi, ICAR-NBPGR, New Delhi and

ICAR-IIHR, Bengaluru. After screening for disease, quality and yield parameters, seven tomato lines along with one check and 21 F₁ hybrids produced from crossing parental lines in a 7 × 7 half diallel fashion. The parental genotypes and 21 F₁ hybrids were grown in randomized block design with three replications and other agronomic practices were followed as per package of practices given by Fageria et al., [4]. To access the resistant of given strain symptom severity grade designated with numerical value of 0-4 scale were given on the basis of visual observation to quantify the disease severity and calculation were made according to the method described by Kalloo and Banerjee [5]. This calculation used for parents and F₁s screening under natural condition. The present disease incidence and coefficient infection were calculated by the formula-

$$\text{PDI} = \frac{\text{No. of diseased plants}}{\text{No. of total plants}} \times 100$$

$$\text{Coefficient Infection (CI)} = \frac{\text{Percent Disease Incidence (PDI)} \times \text{Response value (RV)}}{100}$$

3. RESULTS AND DISCUSSION

The per cent disease incidence and coefficient of infection of late blight in parents ranged from 36.39 (Arka Vikash) to 69.27 (BSS-488) and 21.85 (Arka Vikash) to 73.19 (Arka Ahuti) (Table 3). Among F₁s populations it ranged from 32.66% (Pusa Rohini × Arka Vikash) to 73.96% (Pusa Rohini × *S. pimpinellifolium*) and 16.33 (Pusa Rohini × Arka Vikash) to 73.96 (Pusa Rohini × *S. pimpinellifolium*), respectively (Table 2). The results were in accordance with the findings of Narayan et al. [6], Solankey et al. [16] Ray et al. [17]. The resistant parents and crosses viz., Arka Vikash and *S. pimpinellifolium* and Pusa Rohini × Arka Vikash, H-86 × Arka Vikash, CLNB × Arka Vikash and Arka Vikash × *S. pimpinellifolium* can be utilized in future breeding programme. Per cent disease incidence and coefficient of infection of ToLCV among parents ranged from 22.58% (*S. pimpinellifolium*) to 60.09% (H-86) and 5.64 (*S. pimpinellifolium*) to 45.07 (H-86)

(Table 3). Whereas among crosses it was varied between 19.25% (Pusa Rohini × *S. pimpinellifolium*) to 70.00% (CLNB × Arka Ahuti) and 4.81 (Pusa Rohini × *S. pimpinellifolium*) to 70.00 (CLNB × Arka Ahuti) (Table 2). The above findings are in agreement with the findings of Chellimi *et al.* [7] and Bhattarai [8]. The parents and crosses viz., Pusa Rohini, Arka Ahuti, *S. pimpinellifolium* and Pusa Rohini × Arka Ahuti, Pusa Rohini × Arka Vikash, Pusa Rohini × *S. pimpinellifolium*, H-86 × Arka Vikash and Arka Vikash × *S. pimpinellifolium* have resistance response for ToLCV.

The cross combination exhibiting negative and significant heterosis in case of (diseases) *i.e.*, PDI and CI of late blight is an indication of low disease incidence it was observed in Pusa Rohini × Arka Vikash (-48.61, -52.84), (-72.12, -76.42) and Arka Vikash × Arka Abha (-42.02, -50.35), (-61.35, -75.17) over better parent and standard parent (Table 4). Sixteen crosses exhibited non- significant (desirable) heterosis over the better parent and standard parent in the needful direction for PDI and CI of late blight. Associated characters were also reported by Arora *et al.* [9]. Sixteen crosses showed desirable heterosis over mid parent and seventeen crosses over standard parent. Whereas maximum desirable heterosis for PDI and CI of ToLCV was found in cross combinations Pusa Rohini × *S.pimpinellifolium* (-46.35, -65.08), (-77.50, -88.35) and Arka Vikash × *S.pimpinellifolium* (-60.85, -64.32) (-86.95, -88.27) over better parent and standard parent (Table 4). Fourteen crosses out of twenty-one exhibited desirable negative heterosis over better parent and standard

parent for PDI and CI of ToLCV Similar reports were also reported by Narayan et al. [6], [10,9,11].

Among parents for PDI and CI of late blight the varieties, Arka Vikash and Arka Abha (-13.80, -1.41), (-18.05, -4.62) were found good general combiners they exhibited negative and significant GCA effect. Against ToLCV (PDI and CI) resistance, among parents Pusa Rohini, *S. pimpinellifolium* and Arka Vikash (-6.51, -5.47), (-7.67, -5.47), (-4.85, -5.09) were found good general combiner. Hence, these three parents Arka Vikash, Pusa Rohini and *S. pimpinellifolium* may be used extensively in breeding programme aimed at the development of high yielding with quality tomato hybrids along with resistance to late blight and ToLCV diseases (Table 3). Similar findings were also reported by Kulkarni [12], Solankey et al. [13] Ray et al. [14] and Arora et al. [9]. Out of 21 crosses, 6 for PDI and 5 for CI of late blight exhibited significant SCA effects in the desirable direction. The maximum SCA effects in the desirable direction was exhibited by H-86 × Arka Ahuti and Arka Vikash × *S.pimpinellifolium* for PDI (-14.23, -9.86) and CI (-22.34, -13.89) of late blight. Elsayed et al. [15], Solankey et al. [13] Ray et al. [14] were also reported significant SCA effect in desirable direction for late blight. The negative and significant SCA effect was expressed by six crosses for PDI and CI of ToLCV (Table 2). Whereas the maximum significant SCA effect was exhibited by CLNB × Arka Abha and Arka Vikash × *S.pimpinellifolium* for PDI (-24.55, -12.80) and CI of ToLCV (-27.68, -13.21) and this is also concordant with Singh et al. [16], Singh et al. [17] and [9].

Table 1. Disease severity method given by Kalloo and Banerjee [5]

Symptom	Symptom severity grade	Response value	Coefficient of infection	Reaction
Symptom absent	0	0	0-4	Highly resistant
Very mild curling Upton 25% leaves	1	0.25	5-9	Resistant
Curling, puckering of 26-50% leaves	2	0.50	10-19	Moderately resistant
Curling, puckering of 51-75 % leaves	3	0.75	20-39	Moderately susceptible
Severe curling, puckering of >75% of leaves	4	1.00	4-69 70-100	Highly Susceptible

Table 2. Mean, sca effects for late blight and ToLCV incidence, coefficient of infection in tomato

Crosses	Per cent late blight incidence		Late blight coefficient of infection		Per cent ToLCV incidence		ToLCV coefficient of infection	
	Mean	SCA effects	Mean	SCA effects	ToLCV (%)	SCA effects	Mean	SCA effects
Pusa RohinixH-86	50.89	-6.09*	38.17	-12.36*	35.74	-2.29	17.87	-3.74
Pusa RohinixCLNB	55.36	-3.90	41.52	-9.73*	59.33	11.53**	44.50	9.57**
Pusa RohinixArka Ahuti	55.74	-5.82*	46.82	-7.36	31.13	-7.14**	15.57	-8.30*
Pusa RohinixArka Vikash	32.67	-10.41**	16.34	-14.06**	27.71	-3.45	11.83	-3.95
Pusa RohinixArka Abha	61.12	5.66*	56.52	12.69*	36.65	-0.12	21.92	0.70
Pusa Rohinix <i>S. pimpinellifolium</i>	73.97	10.98**	73.97	16.42**	19.25	-11.29**	4.82	-10.67**
H-86xCLNB	53.94	-3.52	45.48	-4.90	56.82	0.49	42.61	-0.72
H-86xArka Ahuti	45.63	-14.13**	30.97	-22.34**	36.00	-10.79**	21.48	-10.80**
H-86xArka Vikash	41.78	0.50	31.34	1.81	24.10	-15.58**	12.05	-12.13**
H-86xArka Abha	46.93	-6.74*	35.20	-7.76	42.95	-2.34	25.63	-4.00
H-86x <i>S.pimpinellifolium</i>	71.52	10.32**	71.52	14.84**	42.50	3.43	25.19	1.29
CLNBxArka Ahuti	61.21	-0.83	51.43	-2.60	70.00	13.43**	70.00	24.41**
CLNBxArka Vikash	38.18	-5.37	21.40	-8.84	51.17	1.72	38.38	0.88
CLNBxArka Abha	52.94	-3.01	39.70	-3.98	30.51	-24.55**	15.26	-27.68**
CLNBx <i>S. pimpinellifolium</i>	68.06	4.59	68.06	10.67*	59.42	10.58**	54.81	17.60**
Arka AhutixArka Vikash	58.34	12.48**	48.87	15.69**	37.69	-2.23	18.84	-7.60*
Arka AhutixArka Abha	55.03	-3.22	41.27	-5.34	44.17	-1.36	29.84	-2.04
Arka Ahutix <i>S. pimpinellifolium</i>	59.56	-6.21*	49.80	-10.52	51.37	12.06**	38.52	12.37**
Arka VikashxArka Abha	34.40	-5.37	17.20	-5.63	37.28	-1.14	22.20	-1.59
Arka Vikashx <i>S. pimpinellifolium</i>	37.43	-9.86**	22.65	-13.89**	19.40	-12.80**	4.85	-13.21**
Arka Abhax <i>S. pimpinellifolium</i>	58.01	-1.67	43.51	-6.46	53.83	16.02**	40.37	16.87**
C.V.	9.03		18.50		10.54		19.49	
S.E.	2.89		4.95		2.61		3.26	
C.D. 5%	8.19		14.02		7.40		9.24	

Table 3. Mean, GCA effects for late blight and ToLCV incidence, coefficient of infection in tomato

Genotypes	Per cent late blight incidence		Late blight coefficient of infection		Per cent ToLCV incidence		ToLCV coefficient of infection	
	Mean	GCA effects	Mean	GCA effects	Mean	GCA effects	Mean	GCA effects
Pusa Rohini	63.57	1.91*	58.61	2.95	35.89	-6.51**	21.41	-7.67**
H-86	65.02	0.11	65.02	2.08	60.09	2.02*	45.07	0.74
CLNB	65.75	2.38*	60.79	2.80	59.50	11.79**	44.63	14.06**
Arka Ahuti	73.19	4.68**	73.19	5.73**	45.05	2.26**	30.51	3.00**
Arka Vikash	36.39	-13.80**	21.85	-18.05**	49.55	-4.85**	37.16	-5.09**
Arka Abha	59.33	-1.41	44.50	-4.62**	50.79	0.76	38.09	0.34
<i>S. pimpinellifolium</i>	63.13	6.12**	58.15	9.10**	22.59	-5.47**	5.65	-5.38**
BSS-488	69.27	1.91*	69.27	2.95	55.13	-6.51**	41.35	-7.67**
C.V.	9.03		18.50		10.54		19.49	
S.E.	2.89		4.95		2.61		3.26	
C.D. 5%	8.19		14.02		7.40		9.24	

Table 4. Heterosis (%) over better parent and standard parent for late blight and ToLCV incidence, coefficient of infection in tomato

Crosses	Per cent late blight incidence		Late blight coefficient of infection		Per cent ToLCV incidence		ToLCV coefficient of infection	
	BPH (%)	SPH (%)	BPH (%)	SPH (%)	BPH (%)	SPH (%)	BPH (%)	SPH (%)
Pusa RohinixH-86	-21.73**	-26.54**	-41.29**	-44.90**	-40.53**	-35.18**	-60.35**	-56.78**
Pusa RohinixCLNB	-15.80*	-20.08**	-31.70**	-40.06**	-0.29	7.61	-0.28	7.62
Pusa RohinixArka Ahuti	-23.85**	-19.54**	-36.03**	-32.41**	-30.89**	-43.54**	-48.97**	-62.35**
Pusa RohinixArka Vikash	-48.61**	-52.84**	-72.12**	-76.42**	-44.08**	-49.75**	-68.17**	-71.39**
Pusa RohinixArka Abha	-3.85	-11.76	-3.56	-18.41	-27.84**	-33.53**	-42.46**	-46.99**
Pusa Rohinix <i>S. pimpinellifolium</i>	16.35*	6.78	26.21*	6.78	-46.35**	-65.08**	-77.50**	-88.35**
H-86xCLNB	-17.97**	-22.14**	-30.05**	-34.34**	-5.45	3.05	-5.46	3.06
H-86xArka Ahuti	-37.65**	-34.13**	-57.69**	-55.30**	-40.09**	-34.70**	-52.35**	-48.06**
H-86xArka Vikash	-35.75**	-39.69**	-51.80**	-54.76**	-59.90**	-56.29**	-73.26**	-70.85**
H-86xArka Abha	-27.82**	-32.25**	-45.87**	-49.19**	-28.53**	-22.10**	-43.14**	-38.02**
H-86x <i>S.pimpinellifolium</i>	9.99	3.24	9.99	3.24	-29.27**	-22.91**	-44.11**	-39.08**
CLNBxArka Ahuti	-16.37**	-11.64	-29.74**	-25.76*	17.65**	26.96**	56.86**	69.29**
CLNBxArka Vikash	-41.93**	-44.88**	-64.79**	-69.10**	-13.99*	-7.18	-14.00	-7.18
CLNBxArka Abha	-19.49**	-23.58**	-34.69**	-42.69**	-48.72**	-44.66**	-65.81**	-63.10**
CLNBx <i>S.pimpinellifolium</i>	3.52	-1.75	11.96	-1.75	-0.13	7.78	22.82*	32.55**
Arka AhutixArka Vikash	-20.30**	-15.79*	-33.23**	-29.45**	-23.94**	-31.64**	-49.30**	-54.43**
Arka AhutixArka Abha	-24.82**	-20.57**	-43.61**	-40.42**	-13.02	-19.88**	-21.67	-27.84*
Arka Ahutix <i>S. pimpinellifolium</i>	-18.62**	-14.02*	-31.96**	-28.11**	14.03	-6.83	26.25	-6.84
Arka VikashxArka Abha	-42.02**	-50.35**	-61.35**	-75.17**	-26.59**	-32.38**	-41.72**	-46.31**
Arka Vikashx <i>S. pimpinellifolium</i>	-40.71**	-45.97**	-61.05**	-67.30**	-60.85**	-64.82**	-86.95**	-88.27**
Arka Abhax <i>S. pimpinellifolium</i>	-8.11	-16.26**	-25.18	-37.19**	5.99	-2.37	5.99	-2.36

4. CONCLUSION

It could be concluded from the present study that among the parents Pusa Rohini, Arka Vikash and *S. pimpinellifolium* whereas, among the crosses, Pusa Rohini × Arka Vikash, H-86 × Arka Vikash and Arka Vikash × *S. pimpinellifolium* were showed highly resistance response for per cent disease incidence and coefficient of infection of late blight and ToLCV. Similarly, for heterosis over better parent and standard parent the crosses, Pusa Rohini × Arka Vikash and Arka Vikash × Arka Abha found superior for per cent disease incidence and coefficient of infection of late blight. Whereas heterosis for PDI and CI of ToLCV was found in cross combinations namely, Pusa Rohini × *S. pimpinellifolium* and Arka Vikash × *S. pimpinellifolium* over better parent and standard parent. Whereas, the cross Arka Vikash × *S. pimpinellifolium* identified as best specific combiners for per cent disease incidence and coefficient of infection of late blight and ToLCV. Among the parents Arka Vikash and Arka Abha for late blight and against ToLCV (PDI and CI) resistance, Pusa Rohini, *S. pimpinellifolium* and Arka Vikash were exhibited significantly negative GCA effect.

Hence, the parents viz., Pusa Rohini, Arka Vikash and *S. pimpinellifolium* as well as hybrids viz., Pusa Rohini × Arka Vikash and Arka Vikash × Arka Abha may be used for future breeding programme for development of late blight and ToLCV resistance/ tolerance varieties/ hybrids in tomato.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. National Horticulture Board, Department of Agriculture and cooperation, Government of India; 2011. Available:www.nhb.gov.in
2. Nelson Scot C. Late blight of tomato (*Phytophthora infestans*). Plant Disease. 2008;45.
3. Saikia AK, Muniyappa V. Epidemiology and control of tomato leaf curl virus in Southern India. Trop. Agric. (Trinidad). 1989;66:350-364.
4. Fageria MS, Chaudhury BR, Dhaka RS. Vegetable crops production technology. 2003;25–40.
5. Kallou G, Banerjee MK. Transfer of tomato leaf curl virus resistance from *Lycopersicon hirsutum f. glabrum* to *L. esculentum*. Plant Breed. 1989;105:156–159.
6. Narayan RPJ, Mallesh SB, Patil MG, Dhotre M. Heterosis and combining ability for tomato leaf curl virus (ToLCV) and bacterial wilt disease in tomato (*Solanum lycopersicum* L.) Electronic Journal of Plant Breeding. 2018;9(1): 73-81
7. Arora H, Jindal SK, Sharma A, Gill R, Chawla R. Development and evaluation of hybrids resistant to late blight and leaf curl virus diseases in tomato. Genetika. 2022;54(2):801-816.
8. Sowjanya BA, Sridevi O. Combining ability and heterosis studies in tomato (*Solanum lycopersicum* L.) under ToLCV disease stress condition. International Journal of Chemical Studies. 2020;8(3): 2134-2141.
9. Sundharaiya K, Karuthamani M, Sathish G. Estimate of heterosis and per se performance of tomato f_1 hybrids for leaf curl virus resistance. Int. J. Curr. Microbiol. App. Sci. 2018;6: 189-196.
10. Kulkarni GP. Heterosis, combining ability and reaction to tomato leaf curl virus in tomato. M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad. 1999;1-107.
11. Elsayed AY, Elsaid EM, Elsherbiny EA. The performance of late blight gene ph-3 in tomato under the effect of local populations from *phytophthora infestans*. J. Plant Production, Mansoura Univ. 2016;7(3):361-371.
12. Chellemi DO, Dankers HA, Olson SM, Hodge WC, Scoot JW. Evaluating bacterial wilt resistant genotypes using a regional approach. J. American Soc. Hort. Sci. 1994;119(2):325-329.
13. Solankey SS, Akhtar S, Neha P, Ray PK Singh RG. Reaction of tomato genotypes for resistance to late blight (*Phytophthora infestans* Mont. de Bary) disease. Indian J. Agril. Sci. 2017;87(10):1358-1364.
14. Ray PK, Verma RB, Solankey SS, Chaudhary A. Assessment of Tomato Advanced Lines to Resistance of Late Blight. Intel. J. Current Microbiol. and Applied Sci. 2018;7(1):2622-2629.

15. Bhattarai SP, Panthee DR. Identification of the parents for production of bacterial wilt resistant tomato lines. *Himachal J. Agric. Res.* 1998;23:40-44.
16. Singh RK, Rai N, Singh M, Singh AK, Kumar P, Singh R, Singh SN. Molecular diversity in tomato genotypes and their exploitation of heterosis against tomato leaf curl virus (ToLCV) and yield traits. Abstract in National Symposium on Vegetable Biodiversity, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, India. 2011; 47–48.
17. Singh RK, Rai N, Singh M, Singh SN, Srivastava K. Genetic analysis to identify good combiners for ToLCV resistance and yield components in tomato using interspecific hybridization. *J. Genet.* 2014; 93(3):623–629.

© 2023 Kherwa et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<https://www.sdiarticle5.com/review-history/96744>