Development and Evaluation of Hybrids Resistant to Late Blight and Leaf Curl Virus Diseases in Tomato

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Abstract: The experimental material included 21 F_1 hybrids (developed by half diallel fashion), 7 parents and standard check were all planted in randomized complete block design with three replications. 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 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* 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.

Key words: Heterosis, Combining Ability, Late Blight, ToLCV

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1. Introduction

Tomato (*Solanum lycopersicum* L. Mill) 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 (Anonymous, 2011). 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 (Nelson SC 2008). 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). (Nelson S 2008). 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 (1989) 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 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 F_1 hybrids produced from crossing parental lines in a 7 × 7 half diallel fashion. The parental genotypes and 21 F_1 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*., (2003). 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 calculation were made according to the method described by Kalloo and Banerjee (1987). This calculation used for parents and F_1s screening under natural condition. The present disease incidence and coefficient infection were calculated by the formula-

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

Coefficient Infection (CI) = Percent Disease Incidence (PDI) x Response value (RV)

3. Result 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). Among F_1s 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. The results were in accordance with the findings of Narayan *et al*. 2018. 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). 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) The above findings are in agreement with the findings of Chellimi *et al*. (1994) and Bhattarai (1998). The resistant parents and crosses *viz*., Pusa Rohini, Arka Ahuti and *S. pimpinellifolium* and Pusa Rohini × Arka Ahuti, Pusa Rohini × Arka Vikash, Pusa Rohini × *S.pimpinellifolium*, H-86 × Arka Vikash and Arka Vikash × *S.pimpinellifolium*.

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. 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*. 2022. 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. 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. 2018, Sowjanya and Sridevi 2020, Arora *et al*. 2022 and Sundharaiya *et al*. 2018.

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. Similar findings were also reported by Kulkarni 1999 and Arora *et al*. 2022. 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*. 2016 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. 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*. 2011, Singh *et al*. 2014 and Arora *et al*. 2022.

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Table: 1 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 Rohini×H-86	50.89	-6.09*	38.17	-12.36*	35.74	-2.29	17.87	-3.74
Pusa Rohini×CLNB	55.36	-3.90	41.52	-9.73*	59.33	11.53**	44.50	9.57**
Pusa Rohini×Arka Ahuti	55.74	-5.82*	46.82	-7.36	31.13	-7.14**	15.57	-8.30*
Pusa Rohini×ArkaVikash	32.67	-10.41**	16.34	-14.06**	27.71	-3.45	11.83	-3.95
Pusa Rohini×Arka Abha	61.12	5.66*	56.52	12.69*	36.65	-0.12	21.92	0.70
PusaRohini×*S.pimpinellifolium*	73.97	10.98**	73.97	16.42**	19.25	-11.29**	4.82	-10.67**
H-86×CLNB	53.94	-3.52	45.48	-4.90	56.82	0.49	42.61	-0.72
H-86×Arka Ahuti	45.63	-14.13**	30.97	-22.34**	36.00	-10.79**	21.48	-10.80**
H-86×Arka Vikash	41.78	0.50	31.34	1.81	24.10	-15.58**	12.05	-12.13**
H-86×Arka Abha	46.93	-6.74*	35.20	-7.76	42.95	-2.34	25.63	-4.00
H-86×*S.pimpinellifolium*	71.52	10.32**	71.52	14.84**	42.50	3.43	25.19	1.29
CLNB×Arka Ahuti	61.21	-0.83	51.43	-2.60	70.00	13.43**	70.00	24.41**
CLNB×ArkaVikash	38.18	-5.37	21.40	-8.84	51.17	1.72	38.38	0.88
CLNB×Arka Abha	52.94	-3.01	39.70	-3.98	30.51	-24.55**	15.26	-27.68**
CLNB×*S.pimpinellifolium*	68.06	4.59	68.06	10.67*	59.42	10.58**	54.81	17.60**
Arka Ahuti×ArkaVikash	58.34	12.48**	48.87	15.69**	37.69	-2.23	18.84	-7.60*
Arka Ahuti×Arka Abha	55.03	-3.22	41.27	-5.34	44.17	-1.36	29.84	-2.04
ArkaAhuti×*S.pimpinellifolium*	59.56	-6.21*	49.80	-10.52	51.37	12.06**	38.52	12.37**
Arka Vikash×Arka Abha	34.40	-5.37	17.20	-5.63	37.28	-1.14	22.20	-1.59
ArkaVikash×*S.pimpinellifolium*	37.43	-9.86**	22.65	-13.89**	19.40	-12.80**	4.85	-13.21**
ArkaAbha×*S.pimpinellifolium*	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: 2 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	SCA effects	Mean	SCA effects	Mean	SCA effects	Mean	SCA 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
S.pimpinellifolium	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:3 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 o infection		Per cent ToLCV incidence		ToLCV coefficient of infection	
	BPH (%)	SPH (%)	BPH (%)	SPH (%)	BPH (%)	SPH (%)	BPH (%)	SPH (%)
Pusa Rohini×H-86	-21.73**	-26.54**	-41.29**	-44.90**	-40.53**	-35.18**	-60.35**	-56.78**
Pusa Rohini×CLNB	-15.80*	-20.08**	-31.70**	-40.06**	-0.29	7.61	-0.28	7.62
Pusa Rohini×Arka	-23.8	-19.5	-36.0	-32.4	-30.8	-43.5	-48.9	-62.3

Ahuti	5**	4**	3**	1**	9**	4**	7**	5**
Pusa Rohini×ArkaVikash	-48.61**	-52.84**	-72.12**	-76.42**	-44.08**	-49.75**	-68.17**	-71.39**
Pusa Rohini×Arka Abha	-3.85	-11.76	-3.56	-18.41	-27.84**	-33.53**	-42.46**	-46.99**
PusaRohini×*S.pimpinellifolium*	16.35*	6.78	26.21*	6.78	-46.35**	-65.08**	-77.50**	-88.35**
H-86×CLNB	-17.97**	-22.14**	-30.05**	-34.34**	-5.45	3.05	-5.46	3.06
H-86×Arka Ahuti	-37.65**	-34.13**	-57.69**	-55.30**	-40.09**	-34.70**	-52.35**	-48.06**
H-86×Arka Vikash	-35.75**	-39.69**	-51.80**	-54.76**	-59.90**	-56.29**	-73.26**	-70.85**
H-86×Arka Abha	-27.82**	-32.25**	-45.87**	-49.19**	-28.53**	-22.10**	-43.14**	-38.02**
H-86×*S.pimpinellifolium*	9.99	3.24	9.99	3.24	-29.27**	-22.91**	-44.11**	-39.08**
CLNB×Arka Ahuti	-16.37**	-11.64	-29.74**	-25.76*	17.65**	26.96**	56.86**	69.29**
CLNB×ArkaVikash	-41.93**	-44.88**	-64.79**	-69.10**	-13.99*	-7.18	-14.00	-7.18
CLNB×Arka Abha	19.49**	23.58**	34.69**	42.69**	48.72**	44.66**	65.81**	63.10**
CLNB×*S.pimpinellifolium*	3.52	-1.75	11.96	-1.75	-0.13	7.78	22.82*	32.55**
Arka Ahuti×ArkaVikash	-20.30**	-15.79*	-33.23**	-29.45**	-23.94**	-31.64**	-49.30**	-54.43**
Arka Ahuti×Arka Abha	-24.82**	-20.57**	-43.61**	-40.42**	-13.02	-19.88**	-21.67	-27.84*
ArkaAhuti×*S.pimpinellifolium*	-18.62**	-14.02*	-31.96**	-28.11**	14.03	-6.83	26.25	-6.84
Arka Vikash×Arka Abha	-42.02**	-50.35**	-61.35**	-75.17**	-26.59**	-32.38**	-41.72**	-46.31**
ArkaVikash×*S.pimpinellifolium*	-40.71**	-45.97**	-61.05**	-67.30**	-60.85**	-64.82**	-86.95**	-88.27**
ArkaAbha×*S.pimpinellifolium*	-8.11	-16.26**	-25.18	-37.19**	5.99	-2.37	5.99	-2.36