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Assessment of Tomato Advanced Lines to Resistance of Late Blight

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A B S T R A C T

Experiment was conducted to screen different advanced lines and genotypes in line × tester mating design against late blight of tomato caused by *Phytophthora infestans*. One hundred genotypes were screened during winter season under field condition and data was recorded on 0 - 5 scale at 30, 60 and 90 days in which eleven genotypes were highly resistant, seventeen genotypes were resistant, nineteen genotypes were moderately resistant, twenty four genotypes were susceptible and twenty nine genotypes were highly susceptible. Forty eight F_1s were screened along with their parents during rainy season, 2014 under field condition. Out of forty eight F_1s, eighteen cross combinations were highly resistant and others were resistant, moderately resistant, susceptible and highly susceptible. The parents namely *Solanum peruvianum* and Pusa Rohini showed highly resistant and other parents were either resistant, moderately resistant, susceptible or highly susceptible in respect of disease reaction.

Introduction

Tomato (*Lycopersicon esculentum* Mill) is an important vegetable of exceptionally high nutritive value and versatile food use (Afroz *et al.*, 2009; Saleem *et al.*, 2009; Noureen *et al.*, 2010). Late blight, caused by the oomycete pathogen *Phytophthora infestans* (Mont.) de Bary, is an economically important disease of tomato (*L. esculentum*) worldwide (Majid *et al.*, 1992; Yan *et al.*, 2002). The causal pathogen from tomato was first described by Payen in France in 1847 (Payen, 1847) and has been found responsible for numerous epidemics since it was first described (Stevenson, 1997). *P. infestans* has a wider host range which includes *L. esculentum*, *S. tuberosum*, *S. sarrachoides*, *S. triflorum*, *S. dulcamara*, *S. sisymbriifolium*, *Nicotiana benthamiana* and plants of the genus *Calibrachoa* (Bectell *et al.*, 2006; Dandurand *et al.*, 2006; Flier *et al.*, 2003; Lebecka, 2008). *P. infestans* can attack leaves, petioles, stems, fruits and seeds of tomato (Irzhansky and Cohen 2006). Late blight disease may be initiated in nursery and adult plants by air-borne sporangia or by oospores harboring the soil and seed (Rubin and Cohen, 2004; Govers, 2005). Disease symptoms may start as water soaked, pale green irregular leaf lesions, which enlarge, turn brown, shrivel and dry

out. Under conditions of moist weather, the underside of the lesions may be covered with a fine white moldy growth composed of sporangiophores and sporangia. On petioles and stems lesions appear at any point as oily, brown areas later turning into black and the whole plant may die. On fruits the disease appears as dark green to brown, greasy, irregular blotches, and fruit become shriveled at later stages. Cool, rainy weather, high relative humidity and heavy dew formation favor the infection, disease progress and sporangia production (Mohan *et al.,* 1996; Stevenson, 1997) which can destroy the unprotected crop within 10 to 14 days (Rubin and Cohen, 2004; Govers, 2005). Disease-management strategies mainly depend on fungicide applications, which are uneconomical and less effective due to increasing resistance of the pathogen against fungicides (Griffith *et al.,* 1992). Identification and utilization of genetic resources resistant to *P. infestans* in tomato is the only way to develop late bight-resistant tomato cultivars following appropriate breeding methods. Although vast genetic diversity exists in well adapted cultivars/germplasm in tomato in India, so far no systematic study on resistance or susceptibility level of existing tomato genetic resources has been conducted. The main objective of the present investigation was to determine the level of resistance in cultivated and wild *Solanaceous* species to identify potential germplasm resistant to late blight disease. Such information would help breeders to develop blight resistant cultivars.

Materials and Methods

In order to find out the resistant source against the late blight of tomato were evaluated under natural conditions. The experiment was conducted at Vegetable Research Farm, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India. Total one hundred tomato genotypes representing cultivars and wild accessions of *Solanum* species were screened under field condition during winter seasons 2012. After screening of one hundred genotypes selected twelve lines and four testers under line × tester mating design. The experimental material comprising of forty eight F_1 hybrids and sixteen parental lines were transplanted in the field in a Randomized Block Design with three replications in next year. In each replication, there were ten plants in a row for each entry. The parents were grown during spring seasons, 2013 in crossing block. After screening the twelve genotypes of tomato namely Arka Vikas, H-86 (Kashi Vishesh), Arka Meghali, LA-3967 (IIHR-2374), LA-3976 (IIHR-2381), LA-3938 (IIHR-2347), LA-3962 (IIHR-2370), H-88-78-5, LA-3952 (IIHR-2361), LA-3948 (IIHR-2357), LA-3930 (IIHR-2339), Pant-T-5 selected as female parents and four genotypes viz., IIHR-2195 (IC-395457), *Solanum peruvianum*, IIHR-2199 (IC-395461), Pusa Rohini were used as male parents for the cross.

The natural screenings were performed during the period when the conditions were favorable for white fly perpetuation that had natural pressure on entire germplasm.

The screening was done at 30, 60 and 90 days after transplanting during each year of experimentation under field conditions after appearance of symptom. The symptom severity was recorded at a 0–5- scale on each genotype following the method described by (Akhtar *et al.,* 2012) with certain modifications.

Disease incidence percentage was calculated as under:

$$\% \text{ Disease incidence} = \frac{\text{No. of infected plants}}{\text{Total No. of plants}} \times 100$$

The resistance against disease was evaluated

by Akhtar *et al.*, 2012.

Results and Discussion

Screening of planting materials

One hundred genotypes were screened during winter season under field condition and data was recorded on 0 - 5 scale at the 30, 60 and 90 days. Result showed that the 11, 17, 19, 24 and 29 genotypes were categorized as highly resistant (PDI 0.01 - 10), resistant (PDI 10.01 - 25), moderately resistant (PDI 25.01 - 40), susceptible (PDI 40.01 - 60) and highly susceptible (PDI > 60.01), respectively (Table 1). These results were in agreement with the findings of Gopal and Singh (2003), Govers (2005), Irzhansky and Cohen (2006), Nowicki *et al.,* (2012), Nowicki *et al.,* (2013), Forbes *et al.,* (2014) and Nowakowska *et al.,* (2014).

Screening of parental lines and hybrids

Forty eight F_1s were screened along with their parents during rainy season, 2014 under field condition. Data presented in Table 2 indicated that the parents namely, *Solanum peruvianum* and Pusa Rohini showed highly resistant and parents *viz*., IC-395457 and IC-395461 showed resistant disease reaction against late blight of tomato. Other parents were either moderately resistant, susceptible or highly susceptible in respect of disease reaction. Table 2 also showed that out of forty eight F_1s, eighteen cross combinations namely, Arka Vikas × IC-395457, LA-3976 × IC-395457, LA-3938 × IC-395457, LA-3962 × IC-395457, LA-3948 × IC-395457, Arka Vikas × *S. peruvianum,* H-86 × *S. peruvianum,* Arka Meghali × *S. peruvianum,* LA-3976 × *S. peruvianum,* LA-3952 × *S. peruvianum,* LA-3930 × *S. peruvianum,* Arka Vikas × IC-395461, LA-3976 × IC-395461, LA-3962 × IC-395461, LA-3930 × IC-395461, LA-3948 × IC-395461, H-86 × Pusa Rohini and LA-3948 × Pusa Rohini were highly resistant whereas nine cross combinations Pant-T-5 × IC-395457, LA-3967 × *S. peruvianum,* LA-3938 × *S. peruvianum,* Pant-T-5 × *S. peruvianum,* H-86 × IC-395461, Arka Meghali × IC-395461, LA-3938 × Pusa Rohini, LA-3962 × Pusa Rohini and H-88-78-5 × Pusa Rohini were resistant.

Disease rating scale

Symptoms	Disease rating	Infection %	Reaction
No visible symptoms apparent	0	0	**Immune**
A few minute lesions to about 10% of the total leaf area is blighted and usually confined to the 2 bottom leaves.	1	0.01-10	**Highly resistant**
Leaves on about 25% of the total plant area are infected.	2	10.01-25	**Resistant**
Leaves on about 50% of the total plant area are infected.	3	25.01-40	**Moderately resistant**
Leaves on about 75% of the total plant area are infected.	4	40.01-60	**Susceptible**
Leaves on whole plant are blighted and plant is dead.	**5**	**> 60.01**	**Highly susceptible**

Table.1 Natural screening of one hundred genotypes during winter season, 2012

Disease scale	Reaction	Total number of genotypes	Name of Genotypes
0.01-10	HR	11	**H-24, IC-395461, F-5020, F-6-1, EC-621667, Azad T-5, *S. Peruvianum*,B-9-2, EC-538439, EC-538408, H-28-78-1**
10.01-25	R	17	**Bhaillai-2, B-10-2, Pusa Rohini, IC-395457,Arka Saurabh, CLNB, *S. Cheesmanii*, IIHR-2629,C-19-1, EC-366899, Azad T-6, EC-620421, EC-620439, EC-620438, EC-620404, EC-620444, C-6 T**
25.01-40	MR	19	**H-86, EC-501580, LA-3948, EC-501582, LA-3952, EC-520046, EC-520075,ArkaVikash, F-7012, LA-3930, EC-528374, EC-538380, EC-501577, Pusa Ruby, EC-676781, IIHR-2755, EC-677068, Arka Abha, IIHR-2754**
40.01-60	S	24	**EC-538411, CLN-1621-L, DNT-1, Azad T-2, SEL-18, EC-620500, EC-620377, EC-570422, Rio Grande, EC-538455, Cheku Grande, EC-381263, EC-501575,HATH-8, Hisar Arun, Hisar Lalit, GT-2, H-1-1, Arka Alok, Arka Ahuti, Arka Anannya, Badshah, Tripura Local, Pant T-7**
> 60.01	**HS**	**29**	**EC-521080, EC-528372, ArkaMeghali,IIHR-2619, C-26-1, EC-620520, C-7-1, EC-620568, C-22-2, C-9-2, EC-16788, EC-620541, EC-620564, LA-3967, LA-3976, EC-538156, Pant T-5, EC-538405, H-88-78-5, EC-529080, LA-3962, EC-620419, EC-620478, LA-3938, EC-620505, EC-620442, VRT-2, H-88-78-4, IIHR-837**

Table.2 Natural screening of 16 parents and their 48 F_1's during rainy season, 2013

Disease scale	Reaction	No. of parents	Parents	No. of crosses	Crosses
0.01-10	HR	02	**Pusa Rohini, *Solanum peruvianum***	18	**Arka Vikas× IC-395457, LA-3976 × IC-395457, LA-3938 × IC-395457, LA-3962 × IC-395457, LA-3948 × IC-395457, Arka Vikas× *S. peruvianum*, H-86 × *S. peruvianum*, Arka Meghali× *S. peruvianum*, LA-3976 × *S. peruvianum*, LA-3952 × *S. peruvianum*, LA-3930 × *S. peruvianum*, Arka Vikas× IC-395461, LA-3976 × IC-395461, LA-3962 × IC-395461, LA-3930 × IC-395461, LA-3948 ×IC-395461, H-86 × Pusa Rohini, LA-3948 × Pusa Rohini**
10.01-25	R	02	IC-395461, IC-395457	09	**Pant-T-5 × IC-395457, LA-3967 × *S. peruvianum*, LA-3938 × *S. peruvianum*, Pant-T-5 × *S. peruvianum*, H-86 × IC-395461, Arka Meghali× IC-395461, LA-3938 × Pusa Rohini, LA-3962 × Pusa Rohini, H-88-78-5 ×Pusa Rohini**
25.01-40	MR	02	LA-3938,Pant-T-5,	05	**H-86 × IC-395457, LA-3967 × IC-395457, LA-3952 × IC-395457, LA-3967 ×Pusa Rohini, LA-3930 × Pusa Rohini**
40.01-60	S	02	Arka Vikas, LA 3930,	03	**H-88-78-5 × IC-395457, Arka Vikas× Pusa Rohini, LA-3976 × Pusa Rohini**
> 60.01	**HS**	**08**	**H-86, Arka Meghali, LA-3976, LA-3952, LA-3948, LA-3967, H-88-78-5, LA-3962,**	**13**	**Arka Meghali× IC-395457, LA-3930 × IC-395457, LA-3962 × *S. peruvianum*, H-88-78-5 × *S. peruvianum*, LA-3948 × *S. peruvianum*, LA-3967 × IC-395461, LA-3938 × IC-395461, H-88-78-5 × IC-395461, LA-3952 × IC-395461, Pant-T-5 × IC-395461, Arka Meghali× Pusa Rohini, LA-3952 × Pusa Rohini, Pant-T-5 × Pusa Rohini**

Table.3 Disease incidence for late blight of tomato in parents

S. No.	Genotypes	Severity Grade	Per cent of disease infection	Coefficient of infection	Reaction
1	2	3	5	6	7
1.	Arka Vikas	3	67.16	50.37	S
2.	H-86	4	97.75	97.75	HS
3.	Arka Meghali	4	76.63	76.63	HS
4.	LA-3967	4	85.31	85.31	HS
5.	LA-3976	4	79.32	79.32	HS
6.	LA-3938	3	65.65	49.24	MR
7.	LA-3962	4	77.07	77.07	HS
8.	H-88-78-5	4	78.33	78.33	HS
9.	LA-3952	4	76.24	76.24	HS
10.	LA-3930	3	74.92	56.19	S
11.	LA-3948	4	94.15	94.15	HS
12.	Pant-T-5	3	66.51	49.88	MR
13.	**IC-395457**	1	13.82	3.46	R
14.	*S. peruvianum*	1	1.38	0.35	HR
15.	**IC-395461**	1	19.75	4.94	R
16.	**Pusa Rohini**	1	2.42	0.61	HR

Table.4 Disease incidence for late blight of tomato in crosses

S. No.	Genotypes	Severity Grade	Per cent disease infection	Coefficient of infection	Reaction
	2	3	5	6	7
1.	**Arka Vikas× IC-395457**	1	22.47	5.62	HR
2.	H-86 × IC-395457	2	48.89	24.45	MR
3.	Arka Meghali × IC-395457	3	55.51	41.63	HS
4.	LA-3967 × IC-395457	2	44.45	22.23	MR
5.	LA-3976 × IC-395457	1	16.98	4.25	HR
6.	LA-3938 × IC-395457	1	12.86	3.22	HR
7.	LA-3962 × IC-395457	1	30.22	7.56	HR
8.	H-88-78-5 × IC-395457	3	52.29	39.22	S
9.	LA-3952 × IC-395457	2	40.06	20.03	MR
10.	LA-3930 × IC-395457	3	55.88	41.91	HS
11.	LA-3948 × IC-395457	1	24.39	6.10	HR
12.	Pant-T-5 × IC-395457	2	33.86	16.93	R
13.	Arka Vikas × *S. peruvianum*	1	16.31	4.08	HR
14.	H-86 × *S. peruvianum*	1	1.79	0.45	HR

15.	Arka Meghali × *S. peruvianum*	1	15.13	3.78	HR
16.	LA-3967 × *S. peruvianum*	2	27.08	13.54	R
17.	LA-3976 × *S. peruvianum*	1	23.66	5.92	HR
18.	LA-3938 × *S. peruvianum*	2	32.18	16.09	R
19.	LA-3962 × *S. peruvianum*	3	64.21	48.16	HS
20.	H-88-78-5 × *S. peruvianum*	3	59.40	44.55	HS
21.	LA-3952 × *S. peruvianum*	1	5.31	1.33	HR
22.	LA-3930 × *S. peruvianum*	1	6.15	1.54	HR
23.	LA-3948 × *S. peruvianum*	3	64.35	48.26	HS
24.	Pant-T-5 × *S. peruvianum*	2	32.81	16.41	R
25.	**Arka Vikas× IC-395461**	1	23.82	5.96	HR
26.	H-86 × IC-395461	2	25.57	12.79	R
27.	Arka Meghali × IC-395461	2	31.12	15.56	R
28.	LA-3967 × IC-395461	3	69.12	51.84	HS
29.	LA-3976 × IC-395461	1	17.43	4.36	HR
30.	LA-3938 × IC-395461	3	60.26	45.20	HS
31.	LA-3962 × IC-395461	1	19.61	4.90	HR
32.	H-88-78-5 × IC-395461	3	56.33	42.25	HS
33.	LA-3952 × IC-395461	3	55.66	41.75	HS
34.	LA-3930 × IC-395461	1	19.13	4.78	HR
35.	LA-3948 ×IC-395461	1	13.45	3.36	HR
36.	Pant-T-5 × IC-395461	3	55.60	41.70	HS
37.	Arka Vikas × Pusa Rohini	3	51.35	38.51	S
38.	H-86 × Pusa Rohini	1	13.11	3.28	HR
39.	Arka Meghali × Pusa Rohini	3	55.73	41.80	HS
40.	LA-3967 ×Pusa Rohini	2	43.02	21.51	MR
41.	LA-3976 × Pusa Rohini	3	53.31	39.98	S
42.	LA-3938 × Pusa Rohini	2	34.70	17.35	R
43.	LA-3962 × Pusa Rohini	2	35.45	17.73	R
44.	H-88-78-5 ×Pusa Rohini	2	29.10	14.55	R
45.	LA-3952 × Pusa Rohini	3	53.78	40.34	HS
46.	LA-3930 × Pusa Rohini	2	46.69	23.35	MR
47.	LA-3948 × Pusa Rohini	1	1.28	0.32	HR
48.	Pant-T-5 × Pusa Rohini	3	57.60	43.20	HS

Five cross combinations were moderately resistant viz., H-86 × IC-395457, LA-3967 × IC-395457, LA-3952 × IC-395457, LA-3967 × Pusa Rohini and LA-3930 × Pusa Rohini whereas, some susceptible H-88-78-5 × IC-395457, Arka Vikas × Pusa Rohini, LA-3976 × Pusa Rohini and highly susceptible Arka Meghali × IC-395457, LA-3930 × IC-395457, LA-3962 × *S. peruvianum*, H-88-78-5 × *S. peruvianum*, LA-3948 × *S. peruvianum*, LA-3967 × IC-395461, LA-3938 × IC-395461, H-88-78-5 × IC-395461, LA-3952 × IC-395461, Pant-T-5 × IC-395461, Arka Meghali × Pusa Rohini, LA-3952 × Pusa Rohini and Pant-T-5 × Pusa Rohini.

The coefficient of infection of late blight of tomato was recorded in the range of 0.35 %

(*S. peruvianum*) to 97.75 % (H-86) in parental lines (Table 3) and 0.32 % (LA-3948 × Pusa Rohini) to 51.84 % (LA-3967 × IC-395461) in crosses (Table 4). Among the parents *S. peruvianum,* Pusa Rohini, IC-395457 and IC-395461 were highly resistant due to low coefficient of infection. However, among the crosses Arka Vikas × IC-395457, LA-3976 × IC-395457, LA-3938 × IC-395457, LA-3962 × IC-395457, LA-3948 × IC-395457, Arka Vikas × *S. peruvianum,* H-86 × *S. peruvianum,* Arka Meghali × *S. peruvianum,* LA-3976 × *S. peruvianum,* LA-3952 × *S. peruvianum,* LA-3930 × *S. peruvianum,* Arka Vikas × IC-395461, LA-3976 × IC-395461, LA-3962 × IC-395461, LA-3930 × IC-395461, LA-3948 × IC-395461, H-86 × Pusa Rohini and LA-3948 × Pusa Rohini were very low coefficient of infection.

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