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Screening of Tomato Genotypes for Early Blight Disease Resistance in Tomato (*Solanum lycopersicum* L.)

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A B S T R A C T

Early blight is the most devastating disease of tomato it is caused by pathogens *i.e. Alternaria solani*. In tropical and subtropical countries it creates hazardous effect. It is also a common problem in United Kingdom, Australia, India, Nepal and United States. It is one of the most common foliar diseases of tomatoes. The disease can occur over a wide range of climatic conditions, but is most prominent in areas with heavy dew, rainfall and high relative humidity. Every year sever disease appears in north India. Early blight disease mostly effects leaf, stem, and rotening of the apical parts of fruit is very serious and damaging symptoms. Entire tomato crop loss occurs during severe occurrence of this disease of tomato. Fourteen genotypes including one check variety of tomatoes were involved in this study for the identification of highly resistant (HR), resistant(R), moderately resistant (MR), moderately susceptible (MS) and susceptible (S) reaction of tomato genotypes under natural field condition. Screening trail was done in multiple replications during two *Rabi* seasons 2016-17 and 2017-18 at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India. Genotype EC-520061 was found highly resistant during both the year 2016-17 and 2017-18. Thus it was proved from our research that the genotype EC-520061 was stable and consists of highly resistant gene against early blight disease of tomato under natural field condition. However, resistant reaction was recorded in two genotypes during *Rabi* 2016-17. But susceptible reaction was proved to be in three genotypes during 2017-18.

Introduction

Tomato native to the Andean region of South America is one of the most common horticultural crops and cultivated throughout the world. It can be grown in a wide range of climates from tropical to temperate; it also can be cultivated under cover conditions when outdoor temperatures are not favorable. Tomato is the world's second most consumed vegetable after potato (Foolad, 2007). The total world production of tomato is 161.7 million metric tons with a value of ~$59 billion. USA tomato production contributes 13.2 million metric tons with a value of $5 billion to the total world production. The India ranks in second position in the total world production of tomato after China (FAOSTAT, 2017). Tomatoes are consumed in several ways: fresh, mixed in other food

items or processed and canned as sauce, ketchup, juice, salsa, paste, soup and pickle. Tomato is the richest source of vitamin A and C and supplies a sufficient amount of the antioxidant lycopene pigment that helps to protect the body against cancer and heart disease (Van Breemen, 2008). Because of its wide use and nutritional values, there is a high demand for both fresh market and processed tomato varieties. Higher production of tomato is therefore required to fulfill the ever-increasing demand. Early blight is the most destructive disease of tomato in India and caused by pathogens *i.e. Alternaria solani*. It is also a common problem in United Kingdom, Australia and United States. Symptoms of early blight appear on all above ground parts of the plant. The disease appears first as spots on leaflet; spots are circular to angular, dark brown to black and range from pin head to 4 mm in diameter. Leaf spots are scattered, brown with conspicuous concentric rings surrounded by chloratic halo on their outer margin due to host specific toxin produced by the pathogen.

The stem lesions are usually restricted elongations and sunken. The fruit symptoms initiate generally at the end of February and radiate between attachment of calyx and fruit are dark brown depressed, firm with distinct concentric rings. Mostly disease appears in vegetative phase of the plant growth before flowering and is more prevalent between flowering to fruit ripening and continue till the crop completely senescent Kumar *et al.*, (2015). It is one of the most common foliar diseases of tomatoes. The disease can occur over a wide range of climatic conditions, but is most prominent in areas with heavy dew, rainfall and high relative humidity. On tomato it causes damping-off of seedlings, later collar rot, leaf spots, stem lesions and fruit rot. Infection of the plants can result in a complete loss of the crop as yields are reduced by destruction of foliage and the fruits are damaged directly by the pathogen and by sun blotch on defoliated plants (Rotem, 1994). Early blight control is based on crop rotation, removal and destruction of crop debris from previous crops, staking, mulching, and timely application of fungicides. (Mary Ann Hansen, 2009).

Materials and Methods

The experimental material for this study consisted of fourteen genotypes of tomato, which were selected based on their *per se* performance for various traits. Screening of early blight for natural infection caused by *Alternaria solani* was conducted to screen fourteen genotypes of tomato with one check variety (DVRT-1) at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India. Varanasi, India**.** Located in the middle Gangetic plain (latitude: $25^0$19’59’’ longitude: $83^0$00’00’’ EN elevation above sea level: 77 m) in the eastern part of the state of Uttar Pradesh. It is located in the Indo-Gangetic Plains of North India. The genotypes were provided by ICAR, Indian Institute of Vegetable Research (IIVR), Varanasi, UP, India**.** The experimental material involved in this experiment was genetically diverse genotypes (EC-620421, EC-620536, EC-620494, EC-620500, EC-620520, EC-620502, EC-552141, EC-538405, EC-570028, EC-273966, EC-520061, EC-520058, Hisar Arun and DVRT-1). During *Rabi* seasons 2015-16, 2016-17 and 2017-18. Twenty plants were selected for each treatment and percent disease index (PDI) was assessed by using 0-5 scale (Pandey *et al.*, 2003) described as in (Table 1).

Disease severity was scored on a five-point scale (Pandey *et al.*, 2003) and classification of reaction types.

$$\text{Percent disease index (PDI)} = \frac{\text{Sum of individual ratings x 100}}{\text{Total No. of observation x Maximum rating grade}}$$

Results and Discussion

The diseases caused by fungi *Alternaria solani* cause considerable losses to the tomato. The early blight screening is presented in Table 2. Under field conditions, it leads to leaf and stem blight which causes defoliation of plant resulting in drastic reduction in fruit yield, while fruit infection in the field and after harvest results in rotting of tomato fruits, affecting the marketable quality. Field trail was conducted in natural condition at the Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, UP, India during *Rabi* 2015-2016, 2016-2017 and 2017-2018. The reactions were categorized as highly resistant (HR), resistant(R), moderately resistant (MR), moderately susceptible (MS) and susceptible (S). Significant difference in-between different genotypes were observed on the basis of per cent disease infection (PDI) record which ranged from highly resistant genotype to susceptible check genotype *i.e.* genotype EC-520061 (4.42 %) with the yield of 353.17 q/ha was proved to be highly resistant but the check genotype DVRT-1 (68.31 %) with the yield of 291.67 q/ha was proved to be susceptible during the year 2016-2017. However, during the year 2017-2018 different trained was found the same genotype EC-520061 (3.72 %) with the yield of 354.27 q/ha was found to be highly resistant. Thus it is proved from our experiment that the genotype EC-520061 expressed the stable and highly resistant reaction against early blight disease of tomato in natural field condition during both years 2016-2017 and 2017-2018.

Table.1 Early blight screening under field (Natural) condition

Symptoms	Symptoms severity grade	Percent Disease index(PDI)	Reaction
Free from infection	0	0-5	Highly resistant
One or two necrotic spots on a few lower leaves of plant.	1	5.1-12	Resistant
A few isolated spots on leaves, covering nearly 5%-10% of the surface area of the plant.	2	12.1-25	Moderately Resistant
Many spots coalesced on the leaves covering 25% of the surface area of the plant.	3	25.1-50	Moderately Susceptible
Irregular, blighted leaves and sunken lesions with prominent concentric rings on the stem, petiole, and fruits, covering 40% -50% of the surface area.	4	50.1-75	Susceptible
Whole plant blighted; Leaves and fruits starting to fall; foliar part free of disease.	5	>75.1	Highly Susceptible

Table.2 Per cent disease index, disease reactions and yield of thirteen genotypes for early blight disease resistance in tomato in natural field condition 2016-2017 and 2017-2018

Treatments	2016-17			2017-18		
	PDI (%)	DR	Fruit yield (q/ha)	PDI (%)	DR	Fruit yield (q/ha)
Genotypes						
EC-620421	54.42	S	294.07	48.51	S	**305.00**
EC-620536	48.12	MS	304.67	43.91	MS	**403.00**
EC-620494	45.21	MS	307.00	46.97	MS	**319.67**
EC-620500	24.56	MR	309.00	20.49	MR	**309.67**
EC-620520	32.52	MS	305.13	24.13	MS	**305.33**
EC-620502	37.31	MS	304.47	43.75	MS	**296.67**
EC-552141	10.06	R	334.67	8.76	R	**336.33**
EC-538405	61.44	S	284.71	54.45	S	**293.67**
EC-570028	19.04	MR	322.80	20.97	MR	**323.67**
EC-273966	17.57	MR	334.10	19.87	MR	**333.45**
EC-520061	4.42	HR	353.17	3.72	HR	**354.27**
EC-520058	8.50	R	349.40	7.93	R	**352.28**
Hisar Arun	27.24	MS	403.50	33.09	MS	**406.47**
Check-DVRT-1	68.31	S	291.67	63.43	S	**292.97**
SE(d)	0.861024		4.386539	2.237255		**2.86121**
CV %	3.75414		1.163691	9.00541		**0.759426**
SE. m.±	0.608836		3.101751	1.581978		**2.023181**
CD	**1.712241**		**8.72015**	**4.449027**		**5.687897**

PDI=Per cent disease index,
DR=Disease reaction,
R= Resistant,
MR=Moderately Resistance,
MS=moderately susceptible,
S= Susceptible

Similar result was also reported by Singh *et al.*, (2011), they observed highly resistant reaction against the early blight disease in the genotypes EC-520057, EC-520058, EC-520059, EC-520061, EC-508765, EC-538394, H-88-78-1 and EC-501583. "USDA researcher R. E. Webb" in "1967", 'identified field resistance in tomato breeding genotype 67B833' (Barksdale, 1971; Barksdale and Stoner, 1973; USDA, 2007). Barksdale (1969) did screening of many breeding 'lines and accessions of *S. lycopersicum*' and found a resistant accession (PI138630) that was successfully utilized for 'early blight resistant breeding programme'. Thus, the 'development and release of resistant breeding lines71B2 and (C1943) (Barksdale and Stoner, 1977) become possible. "C-1943" was used as a 'source of early blight resistance' in developing breeding lines NC-63EB, NC-870, NCEBR-2, NCEBR-3 and NCEBR-4 (Gardner, 1988) Respectively, however '71B2 was also used as a source of resistance' in developing tomato breeding lines NCEBR-5 and NCEBR-6 (Gardner, 2000). However, during 2016-2017 two genotypes showed resistant reaction *i.e.* EC-552141 (10.06 %) yielding 334.67 q/ha and

EC-520058 (8.50 %) yielding 349.40 q/ha. While, during 2017-2018 again same two genotypes showed resistant reactions namely EC-552141 (8.76 %) yielding 336.33 q/ha and EC-520058 (7.93 %) yielding 352.28 q/ha. Thus these two genotypes were observed stable for resistant reaction in both the year in natural condition. These findings are similar with the report of Kanjilal *et al.,* (2000) in West Bengal. Alsafadi *et al.,* (2012) was recorded disease level based on a 1-9 scale. Results showed that cultivars Bosfer and Daher aljabal had a high level of resistance to early blight disease. During 2016-2017 genotypes which showed moderately resistant reaction are EC-620500 (24.56 %) yielding 309 q/ha, EC-570028 (19.04 %) yielding 322.80 q/ha, EC-273966 (17.57 %) yielding 334.10 q/ha. While, during 2017-2018 genotypes which showed moderately resistant reaction are EC-620500 (20.49 %) yielding 309.67 q/ha, EC-570028 (20.97 %) yielding 323.67 q/ha and EC-273966 (19.87 %) yielding 333.45 q/ha. Similar findings were also reported by Upadhyay *et al.,* (2009) they found that EC-165690, EC- 163681, EC-136711, EC -163683, LE- 16, LE -35, LE 54, LE 85, LE-172 and LE-189 were moderately resistant (PDI 25.1-40 %). were supported by our study and reported for disease severity and host resistance of the plants. Five genotypes showed moderately susceptible reactions during 2016-2017 with their PDI values namely EC-620536 (48.12 %) yielding 304.67 q/ha, EC-620494 (45.21 %) yielding 307 q/ha, EC-620520 (32.52 %) yielding 305.13 q/ha, EC-620502 (37.31 %) yielding 304.47 q/ha and Hisar Arun (27.24 %) yielding 403.50 q/ha. Whereas, five genotypes showed moderately susceptible reaction during 2017-2018. They are EC-620536 (43.91 %) yielding 403.00 q/ha, EC-620494 (46.97 %) yielding 319.67 q/ha, EC-620520 (24.13 %) yielding 305.33 q/ha, EC-620502 (43.75 %) yielding 296.67 q/ha and Hisar Arun (33.09 %) yielding 406.47 q/ha. Three genotypes showed susceptible reaction during 2016-2017 with their PDI values namely EC-620421 (54.42 %) yielding 294.07 q/ha, EC-538405 (61.44 %) yielding 284.71 q/ha and DVRT-1 (68.31 %) 291.67 q/ha. While, three genotypes showed susceptible reaction during 2017-2018 *i.e.* EC-620421 (48.51 %) yielding 305.00 q/ha, EC-538405 (54.45 %) yielding 293.67 q/ha and DVRT-1 (63.43 %) 292.97 q/ha. Thus we had observed similar trends in both years for resistant and susceptible in genotypes. Similar results were observed by Kanjilal *et al.,* (2000). Yield losses up to 79 % due to early blight damage were reported from Canada, India, USA, and Nigeria (Datar and Mayee 1981); Sherf and MacNab1986; Kalloo and Banerjee (1993); Gwary and Nahunnaro 1998; and Vloutoglou (1999). Similar reports were also provided by Singh, A. K. and Singh, K. P. 2000, Singh *et al.,* 2007, Singh *et al.,* 2008, Kumar *et al.,* 2017.

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