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Screening of *Capsicum annuum* L. Germplasm for Resistance against Bacterial Wilt (*Ralstonia solanacearum*) in Mid Hill, Sub-temperate, Humid Region of North Western Himalayas

Munish Sharma[1]* and Akhilesh Sharma[2]

[1]Krishi Vigyan Kendra Mohali, [2]Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Agricultural University, Palampur, 176 062, India

Corresponding author.

Abstract

The present study was carried out at the Experimental Farms of the Department of Vegetable Science and Floriculture, CSKHPKV, Palampur to gather information on Screening of *Capsicum annuum* L. germplasm for resistance against bacterial wilt (*Ralstonia solanacearum*) in mid hill, sub temperate, humid region of north western Himalayas involving 11 lines and three diverse testers. Lines, testers their 33 cross combinations, along with standard check 'CH-1', were evaluated in a Randomized Complete Block Design with three replications during summer-rainy seasons of 2010 and 2011. Data were recorded on ten plants of each genotype for their reaction to bacterial wilt disease. No genotype was found immune towards bacterial wilt disease. In the present investigation, 13 and 11 cross combinations showed 100 per cent plant survival (resistant) during 2010 and 2011, respectively, while, 15 and 18 cross combinations revealed moderately resistant reaction to bacterial wilt disease. The rest of the crosses were moderately susceptible/susceptible during respective years.

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Keywords

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Genotype
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Resistant
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Introduction

Chilli is one of the most important economical and popular vegetable crops grown throughout world for its green fruits as vegetable and red form as spice. Besides, it is used in many processing industries for various products such as pepper sauce, pickled pepper, ground pepper and dried pepper. It belongs to family Solanaceae and originated in Latin American regions of New Mexico, Guatemala and Bulgaria (Saffarod, 1926).

It was first introduced in India from Brazil by the Portuguese towards the end of 15th century and its cultivation became popular in the 17th century. India has immense potential to export different types of chillies around the world. However, the average yield is low due to various constraints such as non-availability of suitable cultivars/hybrids, biotic and abiotic stresses and genetic drift in cultivars. Chilli is important crop throughout world as well as India. India is well known for its rich diversity of spices and many of Indian foods are spicy. Chilli plays leading role in all cuisines. Many chilli varieties and hybrids have been developed but major constraint in its productivity

is occurrence of bacterial diseases. In Himachal Pradesh, bacterial wilt (*Ralstonia solanacearum*) has now assumed serious concern in different areas of Kangra, Kullu, Hamirpur and Mandi districts. The disease manifests at all growth stages with maximum severity at flowering and fruiting stage and results in partial to complete failure of crop. Wilt is a soil borne disease which cannot be managed effectively through chemicals. Wide host range of the pathogen also increased the survival potential of the pathogen. The survival of the pathogen in wild hosts may be one of the reasons for the devastating nature of the disease (Mondal et al., 2014). Consequently, development of resistant cultivar(s) remains the most efficient and eco-friendly approach for the management of this disease. It is, therefore, necessary to screen parents and hybrids of chilli to bacterial wilt disease by growing in bacterial wilt sick plots and identify the immune/resistant genotypes so that they can further be utilized in breeding programmes as a source of resistance to the disease.

Materials and methods

The present investigation was carried out at the Experimental Farms of the Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *Kharif*, 2010 and 2011. The experimental material for the present study comprised of F_1 population of 33 crosses which were developed by crossing 11 lines of chilli, *viz*., 'Jawahar Mirch 283', 'Chilli Sonal', 'PAU Selection Long', 'Arka Lohit' 'LCA 436', 'Pusa Jwala', 'Pusa Sadabahar', 'Kashmir Long', 'Selection 352', 'LCA 443' and 'LCA 206' and with three testers, *viz*., 'Pant C 1', 'Anugraha' and 'Surajmukhi'. Hybrid 'CH-1' was used as a standard check. These genotypes were collected from different sources (Table 1). For screening of these crosses and parents for bacterial wilt disease, a separate experiment was laid out simultaneously at Palampur during both the years in bacterial wilt sick plots by planting ten plants of each entry.

Table 1. List of genotypes along with sources.

Sr. No.	Genotype	Source
a) Testers		
1.	Pant C 1	University of Agricultural Sciences and Technology, Pantnagar
2.	Anugraha	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur
3.	Surajmukhi	CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur
b) Lines		
1.	Jawahar Mirch 283	Indian Agriculture Research Institute, New Delhi
2.	Chilli Sonal	Punjab Agricultural University, Ludhiana
3.	PAU Selection Long	Punjab Agricultural University, Ludhiana
4.	Arka Lohit	Indian Institute of Horticultural Research, Hessarghatta, Bangaluroo
5.	LCA 436	Regional Agricultural Research Station, Lam, Guntur
6.	Pusa Jwala	Indian Agriculture Research Institute, New Delhi
7.	Pusa Sadabahar	Indian Agriculture Research Institute, New Delhi
8.	Kashmir Long	Shere Kashmir University of Agricultural Sciences and Technology, Srinagar
9.	Selection 352	Indian Agricultural Research Institute, New Delhi
10.	LCA 443	Regional Agricultural Research Station, Lam, Guntur
11.	LCA 206	Regional Agricultural Research Station, Lam, Guntur
c) Standard check		
1.	CH-1	Punjab Agricultural University, Ludhiana

Bacterial wilt incidence (%)

Bacterial wilt disease incidence in chilli was recorded as per Sinha et al. (1990) scale. Mortality (confirmed by ooze test) in each genotype was recorded and expressed in per cent to categorize the genotypes into resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible as per scale:

Rating system for bacterial wilt incidence

Bacterial wilt (%)	Reaction category
0-10	Resistant (R)
11-20	Moderately resistant (MR)
21-30	Moderately susceptible (MS)
31-70	Susceptible (S)
71-100	Highly susceptible (HS)

$$\text{Incidence of bacterial wilt (\%)} = \frac{\text{No. of plants infested}}{\text{Total no. of plants}} \times 100$$

Results and discussion

Chilli is vulnerable to the attack of a number of fungal, bacterial and viral diseases of which bacterial wilt, caused by pathogen *Ralstonia solanacearum*, is most important. The disease is soil borne in nature. The disease occurs in scattered plants or groups of plants in the field. The wilting of plants begins with the youngest leaves during warm or hot weather conditions during the day. The plants may recover, temporarily, in the evening under cooler temperatures. After few days a sudden, permanent wilting occurs. Wilted leaves maintain their green color and do not fall as the disease develops. Roots and lower part of the stem have a browning of the water-conducting portion (i.e. vascular system) of the plant. The affected roots may rot due to infection from secondary bacteria. The diseased roots or stems that are cut and placed in a container of water will show steady, yellowish or gray bacterial ooze coming from the cut end. This bacterial ooze is a key feature in diagnosing this disease. Such oozing is not found with *Fusarium*-infected plants, which die more gradually and have a drier, firmer stem rot than bacterial wilt-infected plants. Bacterial wilt is distinguished from *Phytophthora* blight by the extensive darkening of the external part of the lower stem in the latter case (Ray, 2004). Ooze test is the quick diagnostic test for detection of bacterial wilt. The disadvantage of the test is unable to detect the bacterial streaming by visible in early disease development and the ooze may come for any vascular infection of bacterial pathogen (Manasa et al., 2015).

Soil is the primary source of infection of disease. The bacterium can survive in soil for extended periods without a host plant. The bacterium can also survive in diseased crop debris. The bacteria are released from the roots of the affected plant into the soil and can infect neighboring plants. Many weeds may harbor the bacteria in the roots yet show no symptoms. The bacterium enters pepper tissue through wounds on the roots arising from cultivation, natural wounds at emergence of lateral roots, insect feeding, and nematode feeding. When the diseased plant is removed from the field, the infected root pieces that remain in the soil provide bacteria for infection of new roots. The bacterium disperses through furrow irrigation or surface water, cultivation, transplanting, cutting/wounding, and pruning. Infested soil may be transported with seedlings, farm implements, or shoes of farm workers. Seed transmission in pepper is not considered important. High temperatures (eg. 30-35°C) coupled with high soil moisture favor disease development. High soil moisture increases the survival of *R. solanacearum* in soil, the rate of infection, the disease development after infection, and the number of bacterial cells released from the host into the soil. Bacterial wilt is a major problem in heavy soils and in low-lying areas that can retain soil moisture for long periods. In Himachal Pradesh, the disease becomes a limiting factor for chilli cultivation in humid areas of mid and low hills. The disease assumes serious proportions when the season starts with high rainfall and warm weather conditions and results in complete failure of chilli crop. The identification of high yielding chilli lines combined with bacterial wilt resistance and acceptable quality is the present day need (Ray 2004). The susceptible checks, namely, 'Chilli Sonal' and 'Arka Lohit' succumbed to bacterial wilt disease completely (100% plant mortality) which was confirmed through bacterial ooze test (Table 2). Among the parents PAU Sel Long, LCA 436, Pusa Sadabahar, LCA 443, Pant C1, Anugraha and Surajmukhi were found resistant during both years. Among crosses Jawahar Mirch 283 × Anugraha, PAU Sel Long × Pant C 1, Arka Lohit × Anugraha, LCA 436 × Pant C 1, LCA 436 × Surajmukhi, Pusa Jwala × Anugraha, Pusa Sadabahar × Pant C 1, Sel 352 × Pant C 1, Sel 352 × Anugraha, Sel 352 × Surajmukhi were found to be resistant to bacterial wilt during both the years (Table 2). No parent/hybrid was found to be immune. Among parents, Chilli Sonal, Arka Lohit and Kashmir Long and among hybrids LCA 206 × Anugraha were found susceptible during both years. In the present investigation, 13 and 11 cross combinations showed 100 per cent plant survival (resistant) during 2010 and 2011, respectively, while, 15 and 18 cross combinations revealed moderately resistant reaction to bacterial wilt disease. The rest of the crosses were moderately susceptible/susceptible during respective years as per the scale of Sinha et al. (1990).

Table 2. Bacterial wilt incidence (%) in chilli at Palampur.

S. No.	Genotypes/crosses	2010	2011
1	Jawahar Mirch 283	MR	MR
2	Chilli Sonal	S	S
3	PAU Sel Long	R	R
4	Arka Lohit	S	S
5	LCA 436	R	R
6	Pusa Jwala	MS	S
7	Pusa Sadabahar	R	R
8	Kashmir Long	S	S
9	Sel 352	MR	R
10	LCA 443	R	R
11	LCA 206	MR	S
12	Pant C 1	R	R
13	Anugraha	R	R
14	Surajmukhi	R	R
15	CH-1	R	R
16	Jawahar Mirch 283 × Pant C 1	MR	MR
17	Jawahar Mirch 283 × Anugraha	R	R
18	Jawahar Mirch 283 × Surajmukhi	R	MR
19	Chilli Sonal × Pant C 1	MR	MR
20	Chilli Sonal × Anugraha	MR	MR
21	Chilli Sonal × Surajmukhi	MR	MR
22	PAU Sel Long × Pant C 1	R	R
23	PAU Sel Long × Anugraha	R	MR
24	PAU Sel Long × Surajmukhi	MR	R
25	Arka Lohit × Pant C 1	MR	MR
26	Arka Lohit × Anugraha	R	R
27	Arka Lohit × Surajmukhi	MS	MS
28	LCA 436 × Pant C 1	R	R
29	LCA 436 × Anugraha	MR	MR
30	LCA 436 × Surajmukhi	R	R
31	Pusa Jwala × Pant C 1	MS	MS
32	Pusa Jwala × Anugraha	R	R
33	Pusa Jwala × Surajmukhi	MR	MR
34	Pusa Sadabahar × Pant C 1	R	R
35	Pusa Sadabahar × Anugraha	MS	MS
36	Pusa Sadabahar × Surajmukhi	MS	MR
37	Kashmir Long × Pant C 1	MR	MR
38	Kashmir Long × Anugraha	MR	MR
39	Kashmir Long × Surajmukhi	MR	MR
40	Sel 352 × Pant C 1	R	R
41	Sel 352 × Anugraha	R	R
42	Sel 352 × Surajmukhi	R	R
43	LCA 443 × Pant C 1	MR	MR
44	LCA 443 × Anugraha	MR	MR
45	LCA 443 × Surajmukhi	R	MR
46	LCA 206 × Pant C 1	MR	MR
47	LCA 206 × Anugraha	S	S
48	LCA 206 × Surajmukhi	MR	MR

Among the 14 parents, seven were found resistant during 2010 and 8 parents during 2011. The results are similar to report of Singh and Gopalakrishnan (1998). Tiwari et al. (2012) screened twenty genotypes along with two checks of tomato and observed that genotypes Cherry Jaspur had high resistant reaction (HR); genotypes *viz.*, ATL-01-19, Pant T-10 and CO-3 recorded moderately resistance in field condition against bacterial wilt. In study of Padalkar et al. (2012) who studied twenty six chilli genotypes, it was found that Jayanti was susceptible to wilt disease while Jwala was moderately resistant whereas in the study of Pawaskar et al. (2014) who screened thirty three varieties/ genotypes of chilli, no variety was immune to bacterial wilt incited by *Ralstonia solanac*earum, eleven varieties found moderately resistant while nine were susceptible and two were highly susceptible. Rest others were moderately susceptible. It can be concluded that parents which are resistant to bacterial wilt disease can be utilized in further breeding programmes and crosses/hybrids *viz.*, Jawahar Mirch 283 × Anugraha, PAU Sel Long × Pant C 1, Arka Lohit × Anugraha, LCA 436 × Pant C 1, LCA 436 × Surajmukhi, Pusa Jwala × Anugraha, Pusa Sadabahar × Pant C 1, Sel 352 × Pant C 1, Sel 352 × Anugraha, Sel 352 × Surajmukhi can be exploited further by enriching them with yield and quality traits by various breeding tools.

Conflict of interest statement

Authors declare that they have no conflict of interest.

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