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Kumari Surbhi
Department of Plant Pathology, College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

KP Singh
Department of Plant Pathology, College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Himani Jeena
Department of Plant Pathology, College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Corresponding Author:
Kumari Surbhi
Department of Plant Pathology, College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Evaluation of soybean genotypes for resistance against bacterial leaf blight under field conditions

Kumari Surbhi, KP Singh and Himani Jeena

Abstract
Soybean is one of the most important oilseed crops cultivated all around the world. Bacterial blight of soybean is a disease of considerable economic importance which renders the crop unproductive and negatively affects the yield. Use of resistant crop varieties is an important component of integrated disease management programs for bacterial blight. The development of bacterial blight depends on prevailing environmental conditions viz., maximum and minimum temperature, relative humidity, rainfall, windstorm and soil moisture. Thus, evaluation of resistant varieties under natural epiphytotic conditions in the field is essential. The present study was conducted with the aim of screening thirty promising soybean genotypes under field conditions for resistance against bacterial blight for five consecutive years (2017-2021). Differential resistance response was observed for the varieties during the five years of study. Thirteen soybean genotypes showing consistency in their resistance response against bacterial blight were identified.

Keywords: Soybean, bacterial blight, resistance, genotype

Introduction

Soybean (*Glycine max* L. Merrill), widely regarded as 'the Golden bean' or 'the Miracle crop' is one of the oldest and most important oilseed crop cultivated throughout the world. The crop is an important source of milk and cheese. It contains 20 per cent edible oil and 40 per cent protein but is considered more of an oilseed crop than a pulse as it contributes to 25 per cent of global edible oil production (Agarwal, 2013) [1]. The crop is a good source of essential fatty acids *viz*., linolenic acid, linoleic acid and oleic acid. India ranks fifth in terms of production of soybean after USA, Brazil, Argentina and China. In India, soybean is grown in an area of 12.50 million ha with an annual production of 11.9 million ton and an average productivity of 0.95 tonn ha^{-1} (USDA, 2022) [2]. A major portion of annual soybean production in India is contributed by the states of Madhya Pradesh and Maharashtra. Despite the cultivation of soybean on such a large scale in the country, the full yield potential of the crop is difficult to attain due to several abiotic and biotic constraints. There are more than three hundred diseases which affect the soybean crop all over the world out of which thirty five diseases have been considered of major economic importance (Sinclair and Backman, 1989; Hartman *et al*., 1999) [3, 4]. The major diseases occurring on soybean in India include anthracnose, pod blight, charcoal rot, target leaf spot, *Alternaria* leaf spot, bacterial blight, bacterial pustules, yellow mosaic and soybean mosaic. Bacterial leaf blight of soybean caused by *Pseudomonas savastanoi* pv *glycinea* is a disease of considerable economic importance. The disease has been reported to cause 5 to 45 per cent reduction in yield of the crop from different soybean cultivating areas in the world (Hartman *et al*., 2015; Bandara *et al*., 2020; Singh, 2021) [5, 6, 7]. The disease appears in the form of small, water-soaked lesions which are angular in shape. Soon, the spots are surrounded by a yellow halo around them. As the tissue starts dying, the spots turn brown to black in color. These dead spots coalesce and form larger patches of dead tissue on the leaf. The bacteria can survive in these dead leaf tissue to the next growing season. The disease is also seed borne in nature. The disease can be managed effectively by following cultural practices, use of disease-free seeds, chemical treatment, bio-control agents and growing resistant varieties (Bastas and Sahin, 2017; Fatmi and Bolkan, 2019) [8, 9]. Development of resistant varieties is an essential component of management program for bacterial blight of soybean as susceptibility to the disease has been reported to vary with variety. Soybean varieties containing the resistance (R) gene *Rpg1b* for bacterial blight provide an effective management of the disease in the field. The varieties need to be evaluated in field conditions for resistance against the disease either in endemic areas or by adopting techniques for increasing disease incidence. As such, considering the importance of field screening of varieties for identification of resistant crop material, the present investigation was taken up to evaluate the resistance response of soybean germplasm under natural epiphytic conditions in the field and finding the best sources of resistance to bacterial blight.

Materials and Methods

The field experiment was conducted in Soybean Pathology block of N.E. Borlaug Crop Research Center (NEBCRC) of G. B. Pant University of Agriculture And Technology, Pantnagar (Uttarakhand) during the *Kharif* season of five consecutive years *viz.*, 2017-2021. The experiment was carried out in plots of size 4 x 1.2 m^2 with a row to row distance of 60 cm and the plant to plant distance of 10 cm in randomized block design (RBD) with three replications. Thirty soybean genotypes (Table 1) were screened against bacterial blight under natural epiphytotic conditions in the field. Disease severity was recorded at weekly intervals throughout the crop season using the standard (0-9) rating scale as described by Mayee and Datar (1986) [10] (Table 2). The disease scoring was later used to calculate percent disease index using the formula given by Wheeler (1969) [11] as follows:

$$\text{PDI}(\%) = \frac{\text{sum of all ratings}}{\text{number of ratings X maximum grade}} \text{X 100}$$

The mean per cent disease index was transformed into disease reaction as 0%=No infection/immune; 0-10%=Resistance response (R); 10.1-20%=Moderately resistant (MR); 20.1-30%=Moderately susceptible (MS); 30.1-50%= Susceptible (S) and >50%=Highly susceptible (HS). The germplasm were categorized into resistance groups (0-9) accordingly.

Table 1: List of genotypes screened for resistance against bacterial blight in the study

S. No	Genotype	S. No	Genotype	S. No	Genotype
1	PS 1611	11	SL-688	21	NRC-7
2	PS-1540	12	SL 955	22	NRC-128
3	PK 472	13	SL 979	23	NRC 137
4	PK 262	14	SL-1028	24	JS 335
5	BRAGG	15	SL 1068	25	JS 93-05
6	SHILAJEET	16	SL-1074	26	DS-2705
7	VLS 58	17	SL 1123	27	DS 3101
8	VLS 59	18	MACS 58	28	DS- 3105
9	VLS 63	19	MACS-1407	29	DS 3108
10	VLS 89	20	MACS-1460	30	Pb-1

Table 2: Standard rating scale for severity of bacterial blight of soybean

Area of leaf infected (%)	Rating score	Description
0	0	Leaves apparently free from spots
0.01-1.0	1	Very small area of leaf covered with lesions
1.1-10	3	Considerable leaf area covered with spots, no spots on stem
10.1-25	5	One- fourth of leaf area covered with spots, no defoliation of plants; little damage
25.1-50	7	Some leaves dropped, death of a few plants, damage to plant is conspicuous
> 50	9	More than half of the leaf area covered with spots, lesions very common on all plants, defoliation common, death of plants is common

Results and Discussion

The field screening experiments conducted during 2017 to 2021 revealed a differential resistance response of soybean genotypes against bacterial blight. During 2017, the maximum temperature ranged from 30 to 38 °C, minimum temperature (18-26 °C), relative humidity (66 to 96%) and maximum rainfall recorded during the season was 206.8 mm. The disease pressure recorded during the year was low and most of the genotypes exhibited a resistant or moderately resistant response to bacterial blight. Three genotypes *viz.*, PS 1611, SL-688 and NRC-128 were found to be free from symptoms of the disease while seventeen other genotypes were found to be resistant (Table 3). Only two genotypes (JS 335 and JS 93-05) were found to be susceptible and moderately susceptible to the disease respectively. During 2018, a further less disease pressure was recorded. The maximum and minimum temperature during the *Kharif* season of 2018 ranged from 29 to 37 °C and 14 to 26.6 °C, respectively, relative humidity ranged from 70 to 95% and maximum rainfall recorded during the season was 218 mm (in the month of August when the disease starts to develop in the field). During *Kharif* 2018, four genotypes (PS-1611, SL-688, SL-955, MACS-1460) were found to be completely free from infection of bacterial blight while sixteen other genotypes were found to be resistant. Eight genotypes were found to be moderately resistant while, only Shilajeet and JS 93-05 were found to be moderately susceptible and susceptible. No genotype was found to be highly susceptible during 2018.
During the year 2019, maximum number of genotypes i.e. nineteen out of thirty, were found to exhibit a resistance response to the disease. The maximum and minimum temperature during the year ranged from 31 to 39 °C and 16 to 26 °C respectively, relative humidity varied from 69 to 94% and maximum rainfall recorded during the season was 174.6 mm. Only one genotype (PS 1611) was found to be free from infection of bacterial blight during *Kharif* season 2019. Six genotypes (Bragg, VLS-63, SL-1068, SL-1074, NRC 137 and DS-2705) were found to be moderately resistant to the disease, three genotypes (Shilajeet, JS 335 and DS-3101) were moderately susceptible and one was susceptible. During 2020, maximum and minimum temperature ranged from 31 to 34 °C and 17 to 26 °C respectively, relative humidity ranged from 87 to 93% and maximum rainfall recorded was 182 mm. The disease pressure during the year 2020 was recorded to be slightly higher as compared to other years during the study. None of the genotypes under study were found to be completely free from infection of bacterial blight while only eleven genotypes were found to be resistant. Fifteen genotypes were found to exhibit a moderately resistant response to the disease during 2020 while thee (VLS 63, JS 335 and JS 93-05) were found to be moderately susceptible (Table 3 and 4). During the year 2021, a lower disease pressure was recorded as compared of the previous year. The maximum and minimum temperature during the year ranged from 29 to 36 °C and 20.6 to 26 °C, relative humidity ranged from 78 to 91% and maximum rainfall received was 168.6 mm. No genotype was found to be completely free from bacterial blight during 2021. Sixteen varieties exhibited a resistant response to the disease while ten were found to be moderately resistant. Moderately susceptible and susceptible disease response was found in two genotypes in each category. The disease response of the thirty genotypes was found to be more or less similar in different environmental

conditions prevailing during the five years of study. The varieties which consistently showed resistant response to bacterial blight during all the years of study include PS 1611, PS-1540, PK 472, VLS 58, SL-688, SL 955, SL 979, SL-1028, SL-1074, SL-1123, MACS 58, NRC-7 and NRC-128.

Warm and humid weather favors the development of bacterial blight. Occurrence of rain with windstorms enables the spread of bacterial inoculum in the crop canopy and lead to severe outbreaks. The progress of disease ceases in hot and dry weather conditions (Faske, 2014) [12]. Epidemiology of bacterial blight disease is directly influenced by changes in pattern of rainfall, soil moisture, prevailing temperature, soil fertility and relative humidity, which predispose the plants to pathogen attack. These factors are responsible for growth and susceptibility of the host plant, reproductive capacity of the pathogen, survival, spread and interaction of the pathogen with the host (Hailu, 2015) [13]. As such the genotypes developed for utilization in disease management and breeding programs need to be evaluated under field conditions for their consistency in resistance response to the pathogen. Several workers have emphasized the importance of field screening of soybean genotypes for disease resistance against major pathogens of the crop and have recommended many useful soybean varieties for field use (Shrirao *et al.*, 2009; Madhavi *et al*., 2011; Sajeesh *et al.*, 2014; Joshi *et al.*, 2018; Surbhi *et al*., 2021) [15, 17, 14, 16, 18]. In a similar study for screening of soybean varieties against bacterial pustule has been conducted by Zinsou *et al*. (2016) [19], five varieties were found to be moderately sensitive and seven were found moderately resistant. Suryadi *et al*., (2012) [20] conducted a field screening of hundred soybean accessions, forty eight accessions were found to be resistant and eight moderately resistant to bacterial blight.

Table 3: Disease response of different genotypes based on mean per cent disease index during 2017-21

S. No	Genotype	2017	2018	2019	2020	2021
1	PS 1611	0 (AR)	0 (AR)	0 (AR)	1 (R)	1 (R)
2	PS-1540	1 (R)	1 (R)	1 (R)	1 (R)	1 (R)
3	PK 472	1 (R)	1 (R)	1 (R)	1 (R)	1 (R)
4	PK 262	1 (R)	1 (R)	1 (R)	3 (MR)	1 (R)
5	BRAGG	1 (R)	1 (R)	3 (MR)	3 (MR)	1 (R)
6	SHILAJEET	3 (MR)	5 (MS)	5 (MS)	9 (HS)	7 (S)
7	VLS 58	1 (R)	1 (R)	1 (R)	1 (R)	1 (R)
8	VLS 59	3 (MR)	3 (MR)	1 (R)	3 (MR)	3 (MR)
9	VLS 63	5 (MS)	3 (MR)	3 (MR)	5 (MS)	5 (MS)
10	VLS 89	1 (R)	1 (R)	1 (R)	3 (MR)	3 (MR)
11	SL-688	0 (AR)	0 (AR)	1 (R)	3 (MR)	1 (R)
12	SL 955	1 (R)	0 (AR)	1 (R)	1 (R)	3 (MR)
13	SL 979	1 (R)	3 (MR)	1 (R)	1 (R)	1 (R)
14	SL-1028	1 (R)	1 (R)	1 (R)	3 (MR)	1 (R)
15	SL 1068	3 (MR)	1 (R)	3 (MR)	1 (R)	3 (MR)
16	SL-1074	1 (R)	1 (R)	3 (MR)	1 (R)	1 (R)
17	SL 1123	1 (R)	1 (R)	1 (R)	3 (MR)	1 (R)
18	MACS 58	1 (R)	1 (R)	1 (R)	3 (MR)	1 (R)
19	MACS-1407	1 (R)	1 (R)	1 (R)	3 (MR)	3 (MR)
20	MACS-1460	1 (R)	0 (AR)	1 (R)	3 (MR)	3 (MR)
21	NRC-7	3 (MR)	1 (R)	1 (R)	1 (R)	1 (R)
22	NRC-128	0 (AR)	1 (R)	1 (R)	3 (MR)	1 (R)
23	NRC 137	1 (R)	1 (R)	3 (MR)	3 (MR)	3 (MR)
24	JS 335	7 (S)	3 (MR)	5 (MS)	5 (MS)	3 (MR)
25	JS 93-05	9 (HS)	7 (S)	7 (S)	5 (MS)	5 (MS)
26	DS-2705	3 (MR)	3 (MR)	3 (MR)	1 (R)	3 (MR)
27	DS 3101	1 (R)	3 (MR)	5 (MS)	3 (MR)	7 (S)
28	DS- 3105	3 (MR)	1 (R)	1 (R)	3 (MR)	1 (R)
29	DS 3108	5 (MS)	3 (MR)	1 (R)	1 (R)	3 (MR)
30	Pb-1	1 (R)	3 (MR)	1 (R)	3 (MR)	1 (R)

Table 4: Year wise distribution of soybean genotypes in various infection categories for resistance to bacterial blight

Resistance group	2017	2018	2019	2020	2021
AR	3	4	1	-	-
R	17	16	19	11	16
MR	6	8	6	15	10
MS	2	1	3	3	2
S	1	1	1	-	2
HS	1	-	-	1	-

Conclusion

The use of resistant varieties is an important component of integrated disease management practices. Besides being environmentally safe as compared to the chemical means of disease management, the selection and use of resistant varieties saves cost of cultivation, time and energy of the farmers. Thus, screening and identification of resistant sources for bacterial blight of soybean is essential for managing the disease effectively in hotspot areas. The genotypes identified with resistant reaction in the present study could be recommended for use in breeding programs and farmer fields.

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