International Journal of Plant & Soil Science

Volume 34, Issue 24, Page 407-413, 2022; Article no.IJPSS.95393
ISSN: 2320-7035

Evaluation of Maize Genotypes against Banded Leaf and Sheath Blight Incited by *Rhizoctonia solani* f. sp. *sasakii* Exner (Cantharellales: Ceratobasidiaceae) Under Artificial Epiphytotic Conditions, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i242656

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95393

Original Research Article

Received: 20/10/2022
Accepted: 27/12/2022
Published: 28/12/2022

ABSTRACT

Zea mays L. (Poales) is one of the most important cereal crops belongs to *Poaceae* family with very high potential for yield. Production of maize is hampered by a major constraint and devastating disease banded leaf and sheath blight caused by *Rhizoctonia solani* f. sp. *sasakii*. The experiment

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was conducted to evaluate the maize genotypes under field conditions at CCS Haryana Agricultural University, Regional Research Station, Karnal (India). A set of fifty seven genotypes (hybrids/inbred lines) were screened against banded leaf and sheath blight during *kharif* 2020 and 2021 under artificial epiphytotic conditions. The severity of banded leaf and sheath blight was recorded following 1-9 scale and genotypes evaluated categorized into four groups *viz.,* resistant, moderately resistant, moderately susceptible and susceptible based on their disease reaction. Out of fifty seven genotypes screened against BLSB, eight inbred lines *viz.,* HKI 161, HKI-163, HKI-193-2, HKI-288-2, HKI-295, HKI-488, HKI-1344 and HKI 1352 (58-9-2)-2 found resistant and seventeen maize inbred lines were moderately resistant, whereas two hybrids (HQPM-4 and HKI-1040-7 x HKI 659-3) showed resistant reaction and ten maize hybrids were moderately resistant. Thus, these resistant/ moderately resistant maize genotypes can be further use in maize breeding program to develop durable BLSB resistant varieties.

Keywords: Banded leaf and sheath blight; Rhizoctonia solani f. sp. Sasakii; inbred lines; hybrids.

1. INTRODUCTION

Maize (*Zea mays* L.) is a member of *Poaceae* family, originated in the Mexico, Central America and the most important cereal crops of the tropical and sub-tropical regions of the world agricultural ecosystem. Maize is known as 'Queen of the Cereals' or 'Miracle C 4 crop' because of its genetic makeup conserve highest yield potentiality comparable to the other cereals and gaining popularity as evidenced by its large scale consumption as food, feed, fodder for animals and as source of industrial raw materials *viz*., starch, syrup, dextrose, gelatin, protein, alcoholic beverages, oil, pharmacy, cosmetics, bio-fuel (ethanol), food sweeteners etc. Globally maize area of about 193.7 million hectors is being produced together by over 170 countries with annual production of approximately 1147.7 million MT and average productivity is about 5.75 ton/ha [1]. It occupies an area about 9.89 million hectares having production of 31.65 million tones with average productivity of 3.20 ton/ha in India during 2020-21 [2]. In Haryana, *kharif* maize is cultivated over an area of 6.63 thousand hectares with average production of 20.06 thousand tones achieving productivity of 3.02 ton/ha [2].

Despite its high yield potential, maize is affected by several biotic and abiotic stresses that affect the tropical and subtropical maize yield production. Globally, about one hundred and twelve diseases of maize has been reported form different locations, of these sixty five diseases to occur in India incited by pathogens belonging to fungi, bacteria, viruses and nematodes groups. Out of these, banded leaf and sheath blight disease of maize caused by fungus, *Rhizoctonia solani* f. sp. *sasakii* Exner, (Tel: *Thanatephorus sasakii* (Shirai) Tu and Kimbro) belonging to anastomosis group (AG1-IA) is considered as the major constraint responsible for yield losses. The disease causes severe huge impact on yield in several Asian countries [3]. In India, the disease was first reported from Tarai region of Uttar Pradesh and was recognized as a minor disease [4], later on disease was appeared in the epidemic form in humid and warm foot hill regions of Mandi district in Himachal Pradesh in early 1970 [5].

The banded leaf and sheath blight is known as highly destructive disease in Himachal Pradesh, Assam, Meghalaya, Uttar Pradesh, Bihar, Nagaland, Jammu Kashmir, Haryana, Uttarakhand, Punjab, Sikkam, Madhya Pradesh, Delhi, Rajasthan, Orissa, Andhra Pradesh and West Bengal (India) [6], [7], [8]. The magnitude of grain yield losses may vary between 11-40 per cent with 71 percent disease index in India, up to 100 per cent at the ear rot phase in Indonesia and 44-66 per cent in Myanmar depending upon prevailing agro climatic conditions [9], [8], [10]. In India, losses in terms of grain yield may estimate to the range of 11-40 per cent, even to 100 per cent especially in Haryana due to continue rains in the months of July and August [11]. In this study, we investigated the reaction of maize genotypes against banded leaf and sheath blight disease incited by soil-borne fungal pathogen *R. solani* f. sp. *sasakii.*

2. MATERIALS AND METHODS

2.1 Experimental Setup and Field Preparation

In the present investigation, fifty seven maize genotypes (Hybrids/inbred lines) were screened against banded leaf and sheath blight (BLSB) at research area of Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Karnal during *kharif* seasons 2020 and 2021 under artificial epiphytotic

conditions. These conditions were created through inoculations of fungal coated barley grains inserted between second and third sheath of maize during evening hours. Two lines of each genotype consist of 3 m length with a row to row and plant to plant spacing of 75 cm and 20 cm, respectively were sown during both the *kharif* seasons. Experiments were laid out in randomized complete block design with three replications and all the recommended packages and practices of CCS Haryana Agricultural University, Hisar were followed [12].

2.2 Preparation of Mass Culture of *R. solani* f. sp. *sasakii*

Barley grains were soaked in water for 24 hours and dispensed 40 g seeds in 250 ml Erlenmeyer flask after removing excess of water and autoclaved at 121.6°C at 15 lbs for 20 minutes. Each flask was inoculated with 5 mm mycelium disc of *R. solani* isolates, derived from the actively growing cultures on the potato dextrose agar (PDA) plates and incubated at 25 ±2°C in biochemical oxygen demand (BOD) incubator for ten days. The fully grown fungal mycelium on barley grains were dispensed out from flask on a paper for drying at 15°C. The impregnated grains were utilized for inoculation and stored in paper bags or in the flasks for later use [13]. The barley grains are widely use for preparation of mass culture of *R. solani,* provides appropriate nutrients to pathogen for increasing inoculums density.

2.3 Artificial Inoculation Method

Inoculation on 30-35 days old maize plants was performed during evening hours and the moist conditions prevailed either due to rain or through irrigation. The grain inoculums were inserted between the leaf sheath and stalk at lower second or third internodes level of plant [13].

2.4 Observations Recorded

The observations were recorded using 1-9 scale (Table 1) [14] and categorized them into different disease reaction on the basis of average disease score as follows (Table 1).

3. RESULTS AND DISCUSSION

3.1 Screening of Maize Genotypes (hybrids/inbred lines) against Banded Leaf and Sheath Blight

Host plant resistance is considered as one of the outstanding ways for managing the diseases to a sustainable agriculture with cost effective and eco-friendly approach. All the genotypes (hybrids/inbred lines) were showed greater extent of variations in disease reaction during both the *kharif* seasons 2020 and 2021. Data indicated that all the genotypes showed resistant to susceptible reaction against banded leaf and sheath blight of maize. During *kharif* 2020 and 2021 the mean of disease score of banded leaf and sheath blight of maize varied from 2.2 to 8.4 (Table 2).

A total of forty four state inbred lines of maize were screened against banded leaf and sheath blight (BLSB). Out of which eight maize inbred lines namely HKI 161, HKI-163, HKI-193-2, HKI-288-2, HKI-295, HKI-488, HKI-1344 and HKI 1352 (58-9-2)-2 were found resistant (disease score $\leq$ 3.0) to banded leaf and sheath blight disease and seventeen maize inbred lines *viz.,* MBR-139, HKI-164-7-6, HKI-191-2-5, HKI-193-1, HKI-323, HKI-335, HKI-488-1RG, HKI-536C, HKI-1105, HKI-1128, HKI-1332, HKI-1345, HKI-1354-7, HKIL-287, HKI-1042-NP 19-ER-1 and PC-1 ER-4 were moderately resistant (disease score 3.1-5.0). Eighteen maize inbred lines (HKI-488T-3, HKI-536YN, BC- 570 ER-1, HKI-1011, HKI-1015-6, HKI-1025, HKI-1040-4, HKI-1105-ER-5, HKI-1348-8-2, HKI-1352, HKI-1651 (14-3-1), HKI-1657, HKI-1659, HKI-1664, NP-80ER-2, PC-3 ER-1, PC4-6 and PC 1221-4) were moderately susceptible (disease score 5.1-7.0) whereas, one inbred line PC 1473-5 exhibited susceptible reaction (disease score $\geq$7.0) against BLSB (Table 3).

Table 1. Banded leaf and sheath blight disease rating scale in maize (India)

Rating scale	Disease reaction	PDI (%)
1.0-3.0	Resistant (R)	0.00-33.33
4.0-5.0	Moderately resistant (MR)	44.44-55.55
6.0-7.0	Moderately susceptible (MS)	66.66-77.77
8.0-9.0	Susceptible (S)	88.88-99.99

PDI- Per cent disease intensity, Source- Hooda et al. (14)

Table 2. Disease rating and disease reaction of maize genotypes against banded leaf and sheath blight under field conditions during *kharif* 2020 and 2021

Sr. No	Inbred lines	Disease score		Avg. rating score	Disease reaction	Sr. No	Inbred lines	Disease score		Avg. rating score	Disease reaction
		2020	2021					2020	2021		
1	HKI-161	2.8	2.6	2.7	R	31	HKI-536C	3.6	3.8	3.7	MR
2	HKI-163	2.5	2.4	2.5	R	32	HKI-536YN	5.6	6.2	5.9	MS
3	HKI-193-1	4.6	4.9	4.8	MR	33	HKI-1015-6	6.4	6.7	6.6	MS
4	HKI-193-2	2.6	2.5	2.6	R	34	HKI-1040-4	5.6	5.9	5.8	MS
5	HKI-488-1RG	3.9	4.6	4.3	MR	35	HKI-1105-ER-5	6.8	6.5	6.7	MS
6	HKI-1025	5.4	6.5	6.0	MS	36	HKI-1332	4.2	4.7	4.5	MR
7	HKI-1128	4.8	4.6	4.7	MR	37	HKI-1348-8-2	5.3	6.4	5.9	MS
8	HKI-1344	2.4	2.7	2.6	R	38	HKI 1352 (58-9-2)-2	2.8	2.6	2.7	R
9	HKI-191-2-5	4.2	4.4	4.3	MR	39	HKI-1659	6.4	6.9	6.7	MS
10	HKI-288-2	2.3	3.6	3.0	R	40	PC-1 ER-4	3.8	4.6	4.2	MR
11	HKI-323	3.5	4.5	4.0	MR	41	PC-3 ER-1	5.4	6.8	6.1	MS
12	HKI-335	4.6	4.8	4.7	MR	42	PC 1221-4	6.5	5.8	6.2	MS
13	HKI-488	2.7	2.4	2.6	R	43	HKI-1011	6.8	6.4	6.6	MS
14	BC-570ER-1	6.3	6.9	6.6	MS	44	PC 4-6	5.9	6.4	6.2	MS
15	HKI-1105	3.5	3.8	3.7	MR	**Sr. No**	**Hybrids**	**Disease score**		**Avg. rating score**	**Disease reaction**
								2020	**2021**		
16	HKI-1345	4.1	4.5	4.3	MR	1	HQPM-1	3.6	3.9	3.8	MR
17	HKI-1352	6.4	6.8	6.6	MS	2	HQPM-4	2.4	2.2	2.3	R
18	HKI-1354-2	4.8	4.6	4.7	MR	3	HM-8	3.5	3.8	3.7	MR
19	HKI-1354-7	3.5	4.2	3.9	MR	4	HM-11	4.1	4.5	4.3	MR
20	HKI-1651 (14-3-1)	5.9	6.8	6.4	MS	5	HKI 288-2x HKI 323	4.8	4.6	4.7	MR
21	HKI-1657	6.4	6.6	6.5	MS	6	HKI 193-2x L-287	4.5	4.8	4.7	MR
22	HKI-1664	6.6	5.9	6.3	MS	7	HKI 288-2x LM-17	5.6	6.2	5.9	MS
23	HKIL-287	4.2	4.6	4.4	MR	8	HKI 327 T x L-287	3.7	4.2	4.0	MR
24	HKI-1042-NP 19-ER-1	3.8	3.4	3.6	MR	9	HKI-1105-6 x LM-17	4.5	5.3	4.9	MR
25	NP-80ER-2	6.7	6.4	6.6	MS	10	HKI-1040-7 x HKI 659-3	2.4	2.7	2.6	R
26	PC 1473-5	7.6	8.4	8.0	S	11	HKI-1354-7 x HKI-1344	4.3	4.5	4.4	MR

Sr. No	Inbred lines	Disease score		Avg. rating score	Disease reaction	Sr. No	Inbred lines	Disease score		Avg. rating score	Disease reaction
		2020	2021					2020	2021		
27	MBR-139	4.3	4.8	4.6	MR	12	HKI-1105 x IMR 307	3.8	4.1	4.0	MR
28	HKI-164-7-6	3.9	4.5	4.2	MR	13	HKI-184 x HKI-1105	4.1	4.6	4.4	MR
29	HKI-295	2.4	2.6	2.5	R						
30	HKI-488T-3	6.8	6.4	6.6	MS						

Table 3. Screening of inbred lines against banded leaf and sheath blight (*R. solani* f. sp. *sasakii*) under field conditions during *kharif* 2020 and 2021

Disease score	Disease reaction	No. of inbreds	Inbreds
< 3.0	Resistant	8	HKI 161, HKI-163, HKI-193-2, HKI-288-2, HKI-295, HKI-488, HKI-1344, HKI 1352 (58-9-2)-2
3.1-5.0	Moderately Resistant	17	MBR-139, HKI-164-7-6, HKI-191-2-5, HKI-193-1, HKI-323, HKI-335, HKI-488-1RG,HKI-536C,HKI-1105,HKI-1128, HKI-1332, HKI-1345, HKI-1354-7, HKIL-287, HKI-1042-NP 19-ER-1, PC-1 ER-4
5.1-7.0	Moderately Susceptible	18	HKI-488T-3, HKI-536YN, BC- 570 ER-1, HKI-1011, HKI-1015-6, HKI-1025, HKI-1040-4,HKI-1105-ER-5, HKI-1348-8-2, HKI-1352, HKI-1651 (14-3-1), HKI-1657, HKI-1659, HKI-1664, NP-80ER-2, PC-3 ER-1, PC4-6, PC 1221-4
7.1-9.0	Susceptible	1	PC 1473-5

Table 4. Screening of hybrids against banded leaf and sheath blight (*R. solani* f. sp. *sasakii*) under field conditions during *kharif* 2021 and 2021

Disease score	Disease reaction	No. of hybrids	Hybrids
< 3.0	Resistant	2	HQPM-4, HKI-1040-7 x HKI 659-3
3.1-5.0	Moderately Resistant	10	HQPM-1, HM-8, HM-11, HKI288-2x HKI 323, HKI 193-2x L-287, HKI 327 Tx L-287, HKI-1105-6x LM-17, HKI-1354-7x HKI-1344, HKI-1105 x IMR 307, HKI-184 x HKI-1105
5.1-7.0	Moderately Susceptible	1	HKI 288-2x LM-17
7.1-9.0	Susceptible	0	NIL

Similarly, thirteen maize hybrids were screened against banded leaf and sheath blight (BLSB) during *kharif* 2020 and 2021. Among them, two hybrids *viz.,* HQPM-4 and HKI-1040-7 x HKI 659-3 were found resistant (disease score ≤ 3.0) to banded leaf and sheath blight disease and ten maize hybrids *viz.,* HQPM-1, HM-8, HM-11, HKI288-2x HKI 323, HKI 193-2x L-287, HKI 327 Tx L-287, HKI-1105-6x LM-17, HKI-1354-7x HKI-1344, HKI-1105 x IMR 307 and HKI-184 x HKI-1105 were moderately resistant (disease score 3.1-5.0). One maize hybrid (HKI 288-2x LM-17) showed moderately susceptible reaction against BLSB whereas, none of maize hybrid exhibited susceptible reaction (Table 4). The variable response of the genotypes for *R. solani* f. sp*. sasakii* has also been observed by earlier researches. However, there have been limited reports on genetics of resistance to banded leaf and sheath blight in maize [15]. The developments of resistant hybrids through classical plant breeding have been slow because unavailability of banded leaf and sheath blight resistance source [16, 17]. Lal [18] screened one hundred inbred lines and sixty hybrids of maize against banded leaf and sheath blight during *kharif* 2011, out of which eighteen inbred and fourteen hybrids were resistant. Malik et al. [19] also evaluated thirty inbred lines and seven hybrids during *kharif* 2013-14. Out of thirty, only four inbreed lines (HKI-488WG, HKI-C-141, HKI-1040-5 and HKI-1347-4LT) were resistant, whereas (HKI-139, HKI-1352, HKI- 1378, HKI-150, HKI-766RG, HKI-MBR-139, HKI-323 and HKI-325-17A) were found moderately resistant. In case of hybrids, HM 11 was resistant whereas HQPM 1, HQPM 7, HM 6 and HKI 1040-7 x HKI 1128 were found moderately resistant. Similarly, Madhavi et al. [20] also screened twenty two maize genotypes out of which one inbred line PFSR9-2 was resistant against BLSB, whereas PFSR6-1, PFSR6-2 and PFSR18 were moderately resistant. In case of hybrids, one hybrid DHM 117 showed resistant reaction while DKC9145, DKC9133 and KMH3110 were found moderately resistant. Thakur et al. [21] and Meena et al. [22] also corresponds the variable pathological response in maize inbred lines and hybrid against BLSB pathogen under artificial epiphytotic conditions.

4. CONCLUSION

This study emphasized the identification of resistance source among maize genotypes (hybrids /inbred lines) against banded leaf and sheath blight disease. This study revealed eight inbred lines *viz.,* HKI 161, HKI-163, HKI-193-2, HKI-288-2, HKI-295, HKI-488, HKI-1344 and HKI 1352 (58-9-2)-2 and two hybrids (HQPM-4 and HKI-1040-7 x HKI 659-3) of maize found resistant against banded leaf and sheath blight can be further utilize for developing resistant maize varieties and help to develop management strategies for the control of banded leaf and sheath blight. These resistant /moderately resistant genotypes of maize could be used for identifying durable resistance, quantitative trait loci analysis/as donor parents in breeding programs.

ACKNOWLEDGEMENT

All the sort of assistance rendered by CCS Haryana Agricultural University, Regional Research Station, Karnal for the above study is gratefully acknowledge.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/95393