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Short Communication

Evaluation of medium maturing maize inbred lines for resistance to turcicum leaf blight caused by *Exserohilum turcicum*

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Abstract

Turcicum leaf blight (TLB) caused by fungus *Exserohilum turcicum* is most devastating maize foliar disease in North western Himalayan region of the world. The present investigations were carried out to screen the 70 medium maturing maize inbreds against TLB under artificial epiphytotic conditions.. The per cent disease index ranged from 13.3 - 80.0 and area under disease progressive curve was 300.0 - 1591.7 whereas apparent infection rate varied from 0.020 - 0.070. Based on disease rating scale, per cent disease index, AUDPC and apparent infection rate inbreds CML50, CML119, CML577, 36128, CML44 (OP), CML494, 9402-1, Bajim-08-26, CML112, CML 292, 52303, LM 13, 1336-3, Bajim 06-17, CML563, Bajim 12-6, Bajim 12-6, CML 564, CML 31-1/ CM112, V 6642, CML 112 WH 52323, Bajim 06-8, 30R-77, 52060, P358, 52154, 52200, Bajim 08-27 New Line, CML 33, CML 337, HKI1295, CML141 had lowest values for all pathological traits marked as resistant inbreds, whereas thirteen inbreds were reported moderately resistant. Results suggested that the inbreds found resistant to turcicum leaf blight might be utilized in future breeding program. Alternatively, the said promising inbreds might also be used as parents in hybridization in order to transfer the gene for resistance to existing adapted high yielding cultivars.

Key words: Maize, Turcicum leaf blight (TLB), Resistance.

Maize (*Zea mays* L.) is one of the most versatile crops having the highest genetic yield potential among cereals and wider adaptability under varied agro-climatic conditions rightly earning it the name of 'the queen of cereals'. Maize is cultivated in all agricultural areas around the world and is an economically significant crop for all human population. Predominately, it is crop of tropical and sub-tropical areas but can be cultivated successfully under temperate climatic conditions. In India, maize is the third most important cereal after rice and wheat which provides food, feed, fodder and serves as a source of basic raw material for a number of industrial products *viz*., starch, protein, oil, alcoholic beverages, food sweeteners, cosmetics, bio-fuel, etc. No other cereal can be used in as many ways as maize. Estimated production of maize across the world is around 1038 million metric tones under a cultivated area of about 183 million hectare and productivity of 5.66 tonne per hactare. India is the 7th largest producer of maize with a production of 25.90 million tonnes grown over an area of 9.63 million hectares with a productivity of 25.52 q/ha.

In Himachal Pradesh, maize is mainly grown in *kharif* season under rained conditions. Presently, constraints. Among maize diseases, turcicum leaf blight caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs is the most important and destructive foliar disease. It is cultivated in an area of 293.6 thousand hectares with production of 784.3 thousand tonnes and productivity of 26.72 q/ha. Productivity of maize in India remains low due to number of biotic and abiotic Turcicum leaf blight (TLB) is a major foliar disease of maize in most production areas worldwide (Jakhar *et al*., 2017). It is endemic in the areas of the North Western Himalayan regions and is considered to be very important in terms of its geographical distribution and potential, to cause

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yield losses (Chandrashekara *et al*., 2012). The disease is more prevalent in humid areas with moderate temperatures (Pataky and Ledencan 2006). In India, the disease is prevalent in almost all the maize growing areas. Severe losses in grain yield due to epiphytotics have been reported in several parts of India and these losses vary from 25 to 90 per cent depending upon the severity of the disease (Chenulu and Hora, 1962). It is widely distributed, however, sporadic in nature and its development mostly depends on weather conditions, stage of plant growth and level of resistance in maize cultivars (Perkins and Pedersen, 1987). The pathogen has wide host range and a high pathogenic variability (Muiru *et al*., 2010).The pathogen attacks all parts of the plant but the most conspicuous symptoms/lesions are found on the foliage. Lesions destroy the leaves, resulting in yield losses due to lack of carbohydrate to fill the grains. Heavily infected fields present a scorched or burnt appearance resulting in premature death of leaves (Harlapur *et al*., 2007). TLB causes extensive leaf damage and defoliation during the grain filling period, and yield losses due to necrosis or chlorosis of leaves premature death of the leaves and loss of nutritive value even as fodder (Patil *et al*., 2000) has been reported. TLB varies in incidence and severity from year to year and from one locality to another depending largely on genetic makeup of the plants and prevailing environmental conditions. Resistant cultivars are primarily used to control TLB. Both major genes and partial resistance can be combined for disease control but identifying partial resistance has been prioritized due to practical limitations of *Ht* genes. The disease has attained economic status in Himachal Pradesh. The best and long term, environmentally and economically safe method for control of TLB is planting of resistant varieties. Therefore, the present investigation was carried out to screen available germplasm for resistance.

Field screening against Turcicum Leaf Blight (TLB) was carried out at CSKHPKV, Hill Agricultural Research & Extension Centre, Bajaura (Latitude 31^{0} 8' N, Longitude 77^{0}, Elevation 1090 m). A total of 70 medium maturing maize inbreds were planted during 2^{nd} fortnight of June 2019 in a randomized block design (RBD) with two replications. Spreader rows with highly susceptible line (Dhari local, Early Composite) were planted on either side of the screening block. The seeds were sown in well and fine prepared soil with rows and plants spacing of 60 and 20cm, respectively. Recommended agronomic practices and insect pest control measures were followed as per the package of practices of CSKHPKV, Palampur.

Inoculation

Heavily infected leaves collected in the previous year were ground into meal about the coarseness of wheat bran. Inoculation was done by placing a pinch of powdered diseased leaf into the whorls of test plants at 35 DAS and followed by water spray so as to maintain humidity for infection. A second inoculation was made after seven days of first inoculation. The inoculation was done in the evening between 5 and 6 pm.

Recording of disease Data

The disease severity on test entries was scored using 1-9 disease rating scale (Hooda *et al*., 2018). Observations on disease development were taken on 55^{th}, 65^{th}, 75^{th} and 85^{th} DAS. Per cent disease index (PDI), Apparent Infection Rate (r) and Area under disease progress curve (AUDPC) were also calculated.

Per cent disease index (PDI)

The severity scales were converted in to percentage disease index (PDI) for analysis using the following formula given by Wheeler (1969):

$$\text{Percent disease index (PDI)} = \frac{\text{Sum of individual ratings}}{\text{Total number of plants observed} \times \text{maximum grade}} \times 100$$

Area under Disease Progress Curve

The AUDPC values were calculated using the formulae given by Wilcoxson *et al*. (1975).

$$\text{AUDPC} = \sum_{1-0}^{k} \left(\frac{Yi + Yi - 1}{2} \right) \times d$$

Where AUDPC = Area under Disease Progress Curve

Yi = Disease severity at the end of time i

k = Number of successive evaluation of blight severity

d= d is the interval between i and i-1 evaluation of the disease

Apparent rate of infection (r):

Rate of infection was calculated by adopting the formula given by Vanderplank (1963).

$$r = \frac{2.3}{t2 - t1} \log \frac{X2}{X1}$$

Where, r = rate of disease progress or infection rate

$t_2 - t_1$ = time interval

x_1 = Disease at time t_1

x_2 = Disease at time t_2

A total of 70 medium maturing inbreds along with two susceptible checks i.e. Early Composite and Dhari Local were screened against *Exserohilum turcicum* under artificially inoculated field conditions during *kharif* 2019. Data presented in table 1 revealed that among medium maturing inbreds 57 were found resistant and 13 exhibited moderately resistant reaction. Per cent disease Index (PDI) values varied from 13.3 to 33.3. Inbred CML50 showed minimum per cent disease index (13.3) and area under disease progress curve (300). AUDPC values varied from 300.0 (CML 50) to 766.7 (HKI488/HKI295) in resistant inbreds, whereas it varied from 719.7 (HKI1040-7) to 1083.3 (9366-1) in moderately resistant entries. Apparent infection rate (r) varied from 0.020 (52303) to 0.070 (95060-5). Based on disease rating scale, percent disease index, AUDPC and apparent infection rate inbreds CML50, CML119, CML577, 36128, CML44 (OP), CML494, 9402-1, Bajim-08-26, CML112, CML292, 52303, LM13, 1336-3, Bajim06-17, CML563, Bajim 12-6, Bajim12-6, CML564, CML31-1/CM112, V 6642, CML112 WH52323, Bajim 06-8, 30R-77, 52060, P358, 52154, 52200, Bajim 08-27 New Line, CML33, CML337, KI488/HKI295, CML141 had lowest values for all pathological traits marked as resistant inbreds, whereas thirteen inbreds were reported moderately resistant.

Inherent resistance or tolerance of crop plants to infection by the pathogen is safe, most economical and eco-friendly disease management strategy. The genetic nature of resistance has been determined to be quantitative and hence can be exploited for the development of resistant cultivar (Kumar *et al*., 2011). Wende *et al*. (2013) identified two inbreds 136-a and Gibe-1-186-2-2-1 as TLB resistant whereas CM-111, CM-501, CM-121, KDMI-12 and CM- 118 were moderately resistant. Inbreds CM-203, CM-115, CM-117, CM-128, CM-600 and KDMI-10 were found highly susceptible. Bindhu *et al*. (2014) evaluated 128 inbred lines against turcicum blight of maize under artificial epiphytotic conditions. Nineteen inbreds were found resistant whereas 57 were moderately resistant followed by 35 moderately susceptible and 9 were found highly susceptible. Panda *et al*. (2017) screened single cross hybrids and inbred lines of maize for turcicum leaf blight resistance. Ajithkumar *et al*. (2018) evaluated 26 inbred lines for TLB disease of maize. Ten lines namely CAH-1533, CAH-1505, CAH-158, CAH-1437, H-15002, E-5, CAH-1526, CAH- 1454, CAH-1532 and CAH-1545 showed resistant reaction. Per cent disease Index (PDI) and AUDPC values gave clear cut indication of resistance and susceptibility among the inbreds evaluated in the present investigations. Harlapur *et al*. (2008) also reported that AUDPC values differed considerably for genotypes. The highest AUDPC value was observed in CM-202 (1488.20) followed by GS-2 (1218.70) and PEMH-2 (1216.95), while the lowest AUDPC values were noticed in Allrounder (499.10).The apparent infection rate (*r*) values varied among resistant and susceptible genotypes and did not revealed a particular trend. The observations in the present study are in agreement with the work of Mallikarjuna (1998) who reported significantly maximum '*r*' value for CM- 202 (0.482). The lowest '*r*' value was observed in NAC-6004 (0.009). Harlapur *et al*. (2008) reported lowest '*r*' in Hi-Shell, Allrounder, Cargill 900M, IB-8501, PRO 4642, C-111, NK-6240, DMH-2 and NAC-6004, which ranged between 0.019 and 0.032, whereas in other genotypes, '*r*' value ranged between 0.033 and 0.049.

Sources of resistance identified in the present investigation can be utilized in future breeding programme for maize improvement in respect of high yield with disease resistance. In addition, outcome of the present study will provide base materials to study genetics of maize disease and the material can further be used for mapping of resistance genes and probable mobilization of such genes for fine tuning of otherwise best inbred lines through marker assisted selection.

Conflicts of interest: The authors declare that there is no conflict of interest among them in this paper.

Table 1. Evaluation of medium maturing maize germplasm against Turcicum leaf blight

S.No.	Inbred	PDI	Disease Score	Reaction Type	AUDPC	Infection Rate
1	CML50	13.3	1.2	R	300.0	0.040
2	CML119	15.6	1.4	R	311.1	0.040
3	CML577	15.6	1.4	R	322.2	0.040
4	36128	15.6	1.4	R	322.2	0.040
5	CML44 (OP)	15.6	1.4	R	347.2	0.035
6	CML494	15.6	1.4	R	366.7	0.040
7	CML575	16.7	1.5	R	316.7	0.045
8	9166-1	17.8	1.6	R	322.2	0.050

9	CML282	17.8	1.6	R	344.4	0.050
10	52212	17.8	1.6	R	377.8	0.050
11	9402-1	17.8	1.6	R	408.3	0.025
12	Bajim-08-26	17.8	1.6	R	419.4	0.025
13	CML112	17.8	1.6	R	427.8	0.030
14	CML292	17.8	1.6	R	438.9	0.030
15	52303	17.8	1.6	R	466.7	0.020
16	9243	18.9	1.7	R	338.9	0.050
17	LM13	18.9	1.7	R	400.0	0.035
18	9402-1	20.0	1.8	R	344.4	0.050
19	299	20.0	1.8	R	344.4	0.050
20	605	20.0	1.8	R	400.0	0.050
21	1336-3	20.0	1.8	R	472.2	0.040
22	Bajim06-10/CIMMYT13	21.1	1.9	R	397.2	0.045
23	Bajim06-17	21.1	1.9	R	488.9	0.040
24	CML563	21.1	1.9	R	505.6	0.030
25	Bajim06-10/CIMMYT13	22.2	2	R	388.9	0.050
26	BML-7	22.2	2	R	400.0	0.050
27	52040	22.2	2	R	411.1	0.050
28	LM15	22.2	2	R	450.0	0.040
29	Bajim 06-6	23.3	2.1	R	494.4	0.055
30	52553	23.3	2.1	R	527.8	0.030
31	Bajim 12-6	23.3	2.1	R	569.4	0.035
32	52319	24.4	2.2	R	444.4	0.060
33	Bajim12-6	24.4	2.2	R	516.7	0.040
34	CML564	24.4	2.2	R	575.0	0.035
35	CML31-1/CM112	24.4	2.2	R	575.0	0.035
36	V 6642	24.4	2.2	R	577.8	0.030
37	CML112 WH	24.4	2.2	R	588.9	0.030
38	52323	24.4	2.2	R	588.9	0.030
39	Bajim 06-8	24.4	2.2	R	622.2	0.030
40	30R-77	25.6	2.3	R	591.7	0.040
41	72218-1	25.6	2.3	R	611.1	0.045
42	Bajim06-9	26.7	2.4	R	530.6	0.045
43	CML565	26.7	2.4	R	550.0	0.050
44	BML2036-3	26.7	2.4	R	552.8	0.045
45	CML422	26.7	2.4	R	561.1	0.050
46	52060	26.7	2.4	R	613.9	0.035
47	IML12195	27.8	2.5	R	633.3	0.050
48	Bajim08-27	27.8	2.5	R	641.7	0.055
49	P358	28.9	2.6	R	655.6	0.040
50	52154	28.9	2.6	R	666.7	0.040
51	40401	30.0	2.7	R	680.6	0.045
52	52200	31.1	2.8	R	700.0	0.040
53	Bajim 08-27 New Line	31.1	2.8	R	711.1	0.040
54	CML33	31.1	2.8	R	761.1	0.030
55	CML337	32.2	2.9	R	672.2	0.040
56	HKI488/HKI295	32.2	2.9	R	766.7	0.035
57	CML141	33.3	3.0	R	744.4	0.040
58	HKI1040-7	35.6	3.2	MR	719.7	0.055
59	CML144	35.6	3.2	MR	833.3	0.030
60	Bajim06-11	36.7	3.3	MR	758.3	0.055
61	CML422	36.7	3.3	MR	980.6	0.025
62	CML336	37.8	3.4	MR	911.1	0.030
63	CML417	40.0	3.6	MR	833.3	0.070

64	40030	40.0	3.6	MR	875.0	0.055
65	CML420	42.2	3.8	MR	875.0	0.055
66	BML16	44.4	4	MR	938.9	0.060
67	40218	44.4	4	MR	1002.8	0.050
68	High Shell	46.7	4.2	MR	983.3	0.060
69	95060-5	48.9	4.4	MR	1038.9	0.070
70	9366-1	50.0	4.5	MR	1083.3	0.060
Check	EC	72.2	6.5	MS	1580.6	0.060
Check	Dhari Local	80.0	7.2	S	1591.7	0.055
	CD	1.6	0.1	-	-	-
	CV	2.9	2.9	-	-	-

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