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Screening of single cross hybrids of maize for resistance to turcicum leaf blight [*Exserohilum turcicum* (Pass.) Leonard and Suggs]

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Abstract
In the present study an attempt has been made to screen the 72 hybrids along with parents to establish their disease performance under artificially inoculated condition against turcicum leaf blight. Disease score and percent disease index were recorded for the 72 hybrids and parents. The study revealed that 19 hybrids possessed a disease score of 0, 33 hybrids scored 1 and 20 scored disease score 2 at the time of tasseling. The range of per cent disease index was 0 to 28.6 per cent. During the season of crop growth there was much incidence of disease, which made possible differentiation of hybrids into different reaction. One hybrid possessed a disease score of 1, 15 hybrids scored 2, with highly resistant and resistant reaction, respectively. Among the crosses, the range of per cent disease index was 22.86 to 68.57 per cent. 34 hybrids showed less than 45 per cent disease index falling under moderately tolerant category and 26 hybrids showed more than 50 per cent disease index falling under susceptible category. Among the male lines RNLB4611, BM1 and BM32 recorded highest per cent disease, while the female lines *viz.*, BM36, BM83 and BM259 found with high per cent disease index were found to be susceptible at 20DAT.

Keywords: Maize, hybrids, genetic studies, turcicum leaf blight, resistance

Introduction
Maize (*Zea mays* L.) is one of the three major cereal crops of worldwide economic importance. It contributes substantially to the total cereal grain production in the world and India, and also occupies an important place in the world and Indian economy and trade as a food, feed and an industrial grain crop. Despite its importance, maize production is limited due to number of factors. Maize diseases are one of the major limiting factors in the production of high grain yield and high quality produce.

Maize is affected by more than 60 diseases. Based on the research efforts for the last few years under the aegis of All India Coordinated Maize Improvement Project, 16 out of 61 diseases adversely affecting this crop have been identified as major ones (Payak and Sharma, 1982) [6]. This means that the maize crop is exposed to a wide range of disease pressures. This results into epidemics with severe consequences on maize production. Thus, development of disease-resistant genotypes is one of the main objectives of corn breeding programs.

Turcicum (TLB) or northern corn leaf blight (NCLB) incited by the ascomycete *Exserohilum turcicum*, has been found to be a ubiquitous foliar disease of maize, which has resulted in maize grain yield losses. TLB, caused by *E. turcicum*, is considered as a serious disease where climatic conditions are cool with relative humidity. 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) [1], Jha (1993) [3]. Observation of near epiphytotic levels of the disease in recent years is an indication that the level of resistance in the commercial varieties is low or the resistance has broken down.

Though, the TLB disease can be managed by chemicals and crop husbandry practices, the most appropriate and economical strategy is through exploitation of host plant resistance, which is not only environmentally friendly but also convenient to adopt at farmer's level. Since the available reports showed that there is limited information on breeding for resistance to this disease, there is a need to identify new sources of resistance through artificial and natural inoculation and to determine the types and levels of resistance possessed by the available breeder's materials and combining them with yield traits is a priority of Indian maize

Breeding programmes. The objectives of this study were to evaluate and to screen the parental lines and resultant hybrids for resistance to turcicum leaf blight.

Materials and Methods

The present investigation was carried out during *kharif* 2012 at botanical garden, Department of Genetics and Plant Breeding, UAS, Dharwad. The materials were carefully selected from 72 inbred lines of maize which were previously evaluated in three consecutive years (2009-2011) for resistance against turcicum leaf blight. Totally 12 lines and 6 testers were selected with varying degrees of TLB resistance (Table 1). The experimental hybrids were generated according to Line x Tester design during *Rabi* 2012. The resultant hybrids and parents were sown in *kharif* 2012 in RCBD with two replications for screening against TLB by following the standard artificial inoculation of turcicum culture. Two rows of each hybrids and parents were sown, spreader rows were planted after every five rows (CM202) to ensure sufficient inoculum load.

Table 1: Characteristic features of the genotypes used in the study (Based on pooled data from 2009-2012 at Dharwad)

Sl. No.	Material	Scoring (Turcicum leaf blight)	Level of resistance
I	**Lines (female)**		
1.	BM259	1.5	Resistant
2.	BM127	2	Resistant
3.	BM136	2	Resistant
4.	BM24	1.5	Resistant
5.	BM423	3.5	Susceptible
6.	BM8	2	Resistant
7.	BM60	2	Resistant
8.	BM51	2	Resistant
9.	BM52	2.5	Resistant (moderate)
10.	BM254	2	Resistant
11.	BM36	2.5	Resistant (moderate)
12.	BM83	4.5	Susceptible
II	**Testers (male)**		
1.	BM59	1.5	Resistant
2.	BM258	2	Resistant
3.	BM32	3	Susceptible (moderate)
4.	RNLB4611	3.5	Susceptible
5.	RNLB4711	4	Susceptible
6.	BM1	4.5	Susceptible

Inoculum collection and preparation: fresh leaves with necrotic lesions were collected from the maize field at MARS, Dharwad. Preparation of turcicum inoculum was done at Department of Plant Pathology, UAS, Dharwad. Cultures were grown on potato dextrose agar (PDA). Two weeks later the culture were placed in each flasks containing autoclaved and sucrose treated sorghum kernels. The flasks were maintained in the lab for 15 days and shaken every other day to distribute the fungus evenly over the kernels. The infested sorghum kernels were then air dried. The same cultures were used as sources of inoculums in the experiment. The culture was inoculated to the maize plants through leaf whorl technique by placing approximately 50 - 60 infested sorghum kernels into the whorl of each plant at 4 to 5 leaf stage. Time of application was just before sunset to allow the dew to initiate spore germination of *E. turcicum* during the night.

Disease severity estimation: Scoring was done using 1 to 5 scale as suggested by Payak and Sharma (1983) [7] on five random plants in each entry at the time of tasseling and at 20 days after tasseling. Score 1 and 2 were considered as highly resistant and resistant respectively and 3 was considered as moderately resistant and, 4 and 5 were considered as susceptible and highly susceptible.

Per cent disease index was calculated using following formula given by Wheeler (1969) [8].

Results and Discussion

Disease ratings taken in the field at the time of tasseling and 20 days after tasseling indicated that susceptible cultivars sustained more disease than intermediate one and the resistant hybrids showed only traces of leaf blight. The weather conditions were conducive for disease development. Field screening studies indicated that there was clear cut differential disease response of inbred lines to turcicum leaf blight due to good infection. The reaction of hybrids is presented in Table 2a and table 2b. The respective PDI values calculated at two stages are also listed in Table 3a and 3b.

Table 2a: Reaction of maize experimental hybrids against *turcicum* leaf blight of maize caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs

Sl. No.	Entries			Score (1-5)		Sl. No.	Entries			Score (1-5)	
				At tasseling	20 DAT					At tasseling	20 DAT
1	BM259	×	BM59	0	3	37	BM60	×	BM59	1	4
2	BM259	×	BM258	0	3	38	BM60	×	BM258	0	3
3	BM259	×	BM32	0	2	39	BM60	×	BM32	2	4
4	BM259	×	RNBL 4611	1	3	40	BM60	×	RNBL 4611	2	4
5	BM259	×	RNBL 4711	0	2	41	BM60	×	RNBL 4711	2	4
6	BM259	×	BM1	1	4	42	BM60	×	BM1	2	4
7	BM127	×	BM59	1	2	43	BM51	×	BM59	0	2
8	BM127	×	BM258	1	4	44	BM51	×	BM258	2	4

9	BM127	×	BM32	2	4	45	BM51	×	BM32	0	2
10	BM127	×	RNBL 4611	2	5	46	BM51	×	RNBL 4611	1	3
11	BM127	×	RNBL 4711	1	3	47	BM51	×	RNBL 4711	1	3
12	BM127	×	BM1	1	3	48	BM51	×	BM1	1	3
13	BM136	×	BM59	1	3	49	BM52	×	BM59	1	4
14	BM136	×	BM258	1	3	50	BM52	×	BM258	0	2
15	BM136	×	BM32	1	3	51	BM52	×	BM32	2	4
16	BM136	×	RNBL 4611	2	4	52	BM52	×	RNBL 4611	0	4
17	BM136	×	RNBL 4711	2	4	53	BM52	×	RNBL 4711	2	4
18	BM136	×	BM1	1	4	54	BM52	×	BM1	2	5
19	BM24	×	BM59	1	3	55	BM254	×	BM59	1	3
20	BM24	×	BM258	1	2	56	BM254	×	BM258	0	2
21	BM24	×	BM32	0	3	57	BM254	×	BM32	0	2
22	BM24	×	RNBL 4611	1	3	58	BM254	×	RNBL 4611	1	3
23	BM24	×	RNBL 4711	1	3	59	BM254	×	RNBL 4711	2	4
24	BM24	×	BM1	1	2	60	BM254	×	BM1	1	3
25	BM423	×	BM59	0	2	61	BM36	×	BM59	1	3
26	BM423	×	BM258	1	3	62	BM36	×	BM258	1	3
27	BM423	×	BM32	1	3	63	BM36	×	BM32	1	3
28	BM423	×	RNBL 4611	0	2	64	BM36	×	RNBL 4611	2	4
29	BM423	×	RNBL 4711	1	3	65	BM36	×	RNBL 4711	2	4
30	BM423	×	BM1	1	3	66	BM36	×	BM1	2	4
31	BM8	×	BM59	1	2	67	BM83	×	BM59	0	2
32	BM8	×	BM258	1	3	68	BM83	×	BM258	2	4
33	BM8	×	BM32	0	1	69	BM83	×	BM32	2	4
34	BM8	×	RNBL 4611	0	3	70	BM83	×	RNBL 4611	2	4
35	BM8	×	RNBL 4711	0	3	71	BM83	×	RNBL 4711	1	4
36	BM8	×	BM1	0	2	72	BM83	×	BM1	2	5

Table 2b: Reaction of maize experimental parents against *turcicum* leaf blight of maize

Sl. No.	Entries	Score (1-5)	
		At tasseling	20 DAT
1	BM259	0	3
2	BM127	1	3
3	BM136	0	2
4	BM24	0	2
5	BM423	0	2
6	BM8	0	1
7	BM60	0	1
8	BM51	1	3
9	BM52	1	3
10	BM254	0	1
11	BM36	1	4
12	BM83	2	4
13	BM59	0	2
14	BM258	0	3
15	BM32	1	3
16	RNBL4611	1	4
17	RNBL 4711	0	2
18	BM1	2	4

Table 3a: Per cent disease index for experimental hybrids against *turcicum* leaf blight of maize

Sl. No.	Entries			PDI		Sl. No.	Entries			PDI	
				At tasseling	20 DAT					At tasseling	20 DAT
1	BM259	×	BM59	0	37.14	37	BM60	×	BM59	14.29	51.43
2	BM259	×	BM258	0	37.14	38	BM60	×	BM258	0	37.14
3	BM259	×	BM32	0	22.86	39	BM60	×	BM32	28.57	51.43
4	BM259	×	RNBL 4611	14.3	37.14	40	BM60	×	RNBL 4611	28.57	51.43
5	BM259	×	RNBL 4711	0	22.86	41	BM60	×	RNBL 4711	28.57	51.43
6	BM259	×	BM1	14.3	51.43	42	BM60	×	BM1	28.57	51.43
7	BM127	×	BM59	7.1	22.86	43	BM51	×	BM59	0	34.29
8	BM127	×	BM258	14.3	51.43	44	BM51	×	BM258	21.43	62.86
9	BM127	×	BM32	28.6	51.43	45	BM51	×	BM32	0	34.29
10	BM127	×	RNBL 4611	28.6	65.71	46	BM51	×	RNBL 4611	14.29	48.57
11	BM127	×	RNBL 4711	14.3	37.14	47	BM51	×	RNBL 4711	14.29	48.57

12	BM127	×	BM1	14.3	37.14	48	BM51	×	BM1	14.29	48.57
13	BM136	×	BM59	14.3	37.14	49	BM52	×	BM59	14.29	62.86
14	BM136	×	BM258	14.3	37.14	50	BM52	×	BM258	0	34.29
15	BM136	×	BM32	7.1	37.14	51	BM52	×	BM32	28.57	62.86
16	BM136	×	RNBL 4611	21.4	51.43	52	BM52	×	RNBL 4611	0	62.86
17	BM136	×	RNBL 4711	28.6	51.43	53	BM52	×	RNBL 4711	28.57	62.86
18	BM136	×	BM1	14.3	51.43	54	BM52	×	BM1	28.57	68.57
19	BM24	×	BM59	14.3	37.14	55	BM254	×	BM59	7.14	48.57
20	BM24	×	BM258	7.1	22.86	56	BM254	×	BM258	0	34.29
21	BM24	×	BM32	0	37.14	57	BM254	×	BM32	0	34.29
22	BM24	×	RNBL 4611	14.3	37.14	58	BM254	×	RNBL 4611	14.29	48.57
23	BM24	×	RNBL 4711	14.3	37.14	59	BM254	×	RNBL 4711	28.57	62.86
24	BM24	×	BM1	7.1	22.86	60	BM254	×	BM1	14.29	48.57
25	BM423	×	BM59	0	22.86	61	BM36	×	BM59	14.29	48.57
26	BM423	×	BM258	14.3	37.14	62	BM36	×	BM258	14.29	48.57
27	BM423	×	BM32	14.3	37.14	63	BM36	×	BM32	14.29	48.57
28	BM423	×	RNBL 4611	0	22.86	64	BM36	×	RNBL 4611	28.57	62.86
29	BM423	×	RNBL 4711	14.3	37.14	65	BM36	×	RNBL 4711	21.43	62.86
30	BM423	×	BM1	14.3	37.14	66	BM36	×	BM1	28.57	62.86
31	BM8	×	BM59	7.1	22.86	67	BM83	×	BM59	0	22.86
32	BM8	×	BM258	14.3	37.14	68	BM83	×	BM258	21.43	51.43
33	BM8	×	BM32	0	20	69	BM83	×	BM32	28.57	51.43
34	BM8	×	RNBL 4611	0	37.14	70	BM83	×	RNBL 4611	28.57	51.43
35	BM8	×	RNBL 4711	0	37.14	71	BM83	×	RNBL 4711	14.29	51.43
36	BM8	×	BM1	0	22.86	72	BM83	×	BM1	21.43	65.71

Table 3b: Per cent disease index for parents against *turcicum* leaf blight of maize caused by *Exserohilum turcicum*

Sl. No.	Entries	PDI	
		At tasseling	20 DAT
1	BM259	0.0	37.14
2	BM127	14.3	37.14
3	BM136	0.0	22.86
4	BM24	0.0	22.86
5	BM423	0.0	22.86
6	BM8	0.0	8.57
7	BM60	0.0	8.57
8	BM51	14.3	37.14
9	BM52	14.3	37.14
10	BM254	0.0	8.57
11	BM36	14.3	51.43
12	BM83	28.6	51.43
13	BM59	0.0	22.86
14	BM258	0.0	37.14
15	BM32	14.3	37.14
16	RNBL4611	14.3	51.43
17	RNBL 4711	0.0	22.86
18	BM1	28.6	51.43

Screening at the time of tasseling

The disease score at the time of tasseling ranged from 0 to 2. Out of 72 hybrids, nineteen hybrids possessed a disease score of 0, thirty three hydrids scored 1 and twenty scored disease score 2 at the time of tasseling.

Per cent disease index was found to be range between 0 per cent and 28.6 per cent for females and from 0 per cent to 28.6 per cent in males. Among the crosses, the range of per cent disease index was between 0 per cent to 28.6 per cent.

At the time of tasseling, since there was little incidence of the disease, out of 12 lines, five lines *viz.* BM83, BM127, BM51, BM52 and BM36 showed per cent disease indexes of 28.6, 14.3, 14.3, 14.3 and 14.3, respectively. Remaining seven lines recorded zero disease incidences at the time of tasseling. Among testers, 3 testers *viz.*, BM1, BM32 and RNBL4611 showed per cent disease indexes of 28.6, 14.3 and 14.3, respectively. Remaining three testers recorded zero disease indexes at the time of tasseling.

Among the crosses, disease indexes ranged from 0 per cent to 28.6 per cent, among which 12 crosses showed highest per cent disease index of 28.

Screening at 20 days after tasseling: During the season of crop growth there was much incidence of disease, which made possible differentiation of hybrids into different reaction groups. The disease score at twenty days after tasseling ranged from 1 to 5. Out of 72 hybrids, one hybrid possessed a disease score of 1, fifteen hybrids scored 2, which were found to be highly resistant and resistant, respectively. Twenty nine scored disease score 3 indicating that they were moderately resistant to the disease. Twenty four crosses registered susceptible, which possessed a disease score of 4. Only three crosses recorded disease score 5, which were found to be highly susceptible to the disease.

Per cent disease indexes were found to be range between 8.5 per cent and 51.42 per cent for females and from 22.85 per

cent to 51.42 per cent in males. Among the crosses, the range of per cent disease index was 22.86 per cent to 68.57 per cent. The male lines RNLB4611, BM1, BM32 and BM258 found with highest per cent disease indexes of 51.42, 51.42, 37.14 and 37.14 per cent respectively. While the female lines *viz.*, BM36, BM83, BM259, BM127, BM51 and BM52 found with per cent disease indexes 51.4, 51.4, 37.14, 37.14, 37.14 and 37.14 per cent respectively. The crosses have shown differential response to disease incidence ranging from 22.86 per cent to 68.57 per cent. Thirty four hybrids showed less than 45 per cent disease index falling under moderately tolerant category and twenty six hybrids showed more than 50 per cent disease index falling under susceptible category. This suggests that the disease development was highly satisfactory and the categorization of materials into different classes is appropriate.

The investigation revealed that, among the male lines BM59 and RNBL4711 were found with disease score 2 and less per cent disease, while the female lines *viz.*, BM136, BM24, BM423, BM8, BM60 and BM254 found with disease score of 1 to 2 and less per cent disease index were found to be resistant parents for TLB at 20 days after tasseling. Among hybrids BM8 x BM32 found to be highly resistant since it recorded the disease score 1 and recorded lowest per cent disease index of 20.00%. This revealed that the cross is highly resistant cross among the hybrids.

Whereas, among the male lines RNLB4611, BM1, BM32 and BM258 found with highest per cent disease, while the female lines *viz.*, BM36, BM83, BM259, BM127, BM51 and BM52 found with high per cent disease index and were found to be susceptible for TLB at 20 days after tasseling. Among hybrids BM52 x BM1 found to be highly susceptible since it recorded the disease score 5 and recorded highest per cent disease index of 68.57%. This revealed that the cross is highly susceptible and poor yielding cross among the hybrids.

In the present investigation, the loss in Ear weight was up to 68% and the loss in grain yield was up to 72%. Among hybrids BM52 x BM1 evidenced highest percentage of loss both in Ear weight (68%) and grain yield (72%), due to turcicum leaf blight. TLB appears in sizeable form in Karnataka resulting in grain yield reduction by 28 to 91 per cent in case of TLB (Pandurangegowda *et al.*, (1993) [5], Kachapur, (1988) [4] and Harlapur *et al.*, (2000) [2]).

Thus, it can be emphasized from the results that the identified highly resistant and resistant lines hold excellent promise for resistance against *E. turcicum* causing TLB and can be used for developing hybrids and composites in future programme of breeding for disease resistance.

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