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Screening of QPM & OPV, sweet corn, baby corn and Pop Corn genotypes against Turcicum Leaf Blight disease of maize

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Abstract
Maize (*Zea mays* L.) is one of the most important cereal crops globally, valued for its wide adaptability, high productivity, and diverse end uses. However, its production is significantly constrained by Turcicum Leaf Blight (TLB), a foliar disease caused by *Exserohilum turcicum*, which can lead to yield losses ranging from 25% to 90%. The present study was undertaken to evaluate the resistance response of different maize genotypes, including Quality Protein Maize (QPM), Open-Pollinated Varieties (OPV), Sweet Corn (SC), Baby Corn (BC), and Pop Corn (PC), against TLB under artificially inoculated field conditions during *kharif* 2024 at the Andro Research Farm, College of Agriculture, Central Agricultural University, Imphal, Manipur. Disease severity was assessed using the standard 1-9 rating scale recommended by the Indian Institute of Maize Research (IIMR), Ludhiana. Among the 38 QPM and OPV genotypes evaluated, three genotypes—IQPMH 2405, APC 10, and PFM 12—exhibited resistant reactions, while 35 genotypes showed moderate resistance. Similarly, among 14 SC, BC, and PC genotypes screened, five genotypes—CP SWEET KING, APTSKH1, GOLDEN SWEET SUPER, IBH 11-243, and AP 6005—were moderately resistant, while the remaining entries were moderately susceptible. The study revealed substantial variability in the response of maize genotypes to *E. turcicum*, underscoring the potential of several entries as valuable sources of resistance. These resistant and moderately resistant genotypes can serve as useful parental lines in breeding programs aimed at developing high-yielding, TLB-resistant maize cultivars suitable for the northeastern region and other TLB-prone areas.

Keywords: Maize, *Exserohilum turcicum*, Turcicum Leaf Blight, screening, resistance, genotypes

Introduction

Maize (*Zea mays* L.) is one of the most adaptable, versatile, and economically important cereal crops, cultivated across a wide range of agro-climatic conditions. Often referred to as the “queen of cereals,” maize possesses the highest genetic yield potential among cereal crops. In recent years, besides its primary use for grain production, maize has gained significance as a raw material for various industrial applications. Different types of maize include field corn, quality protein maize (QPM), popcorn, sweet corn, and baby corn. Among these, the speciality corns such as QPM, popcorn, sweet corn, and baby corn are valued for their enhanced nutritional profiles and health benefits. Due to their increasing consumer demand and premium market value, these speciality types are being widely promoted and cultivated across the globe, offering lucrative opportunities for farmers.

However, all these maize types are susceptible to several foliar fungal diseases, among which Turcicum Leaf Blight (TLB), also known as Northern Corn Leaf Blight (NCLB), is of major concern. The disease not only affects grain yield but also reduces the quality of straw, which is an important cattle feed component (Ahangar *et al.*, 2016) [2]. Early onset of epidemics causes premature death of leaves, thereby diminishing their fodder value (Hooda *et al.*, 2017) [13]. TLB is caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs [syn. *Helminthosporium turcicum* (Pass.) Leonard and Suggs; perfect stage: *Setosphaeria turcica* (Luttrell) Leonard and Suggs. The pathogen is identified primarily by its asexual stage (*E. turcicum*), as its sexual stage (*Trichometasphaeria turcica* Luttrell) is rarely observed under natural conditions (Luttrell, 1957) [18]. It exhibits a wide host range and considerable pathogenic variability (Muiru *et al.*, 2010) [23].

The disease was first reported in New Jersey, USA, in 1878, and is now prevalent in the northeastern United States, sub-Saharan Africa, China, Latin America, and India (Adipala *et al.*, 1993; Dingerdissen *et al.*, 1996) [1, 11]. In India, TLB was first documented by Butler in 1907 and is now widespread across several states, including Karnataka, Maharashtra, Andhra Pradesh, Bihar, Uttarakhand, Uttar Pradesh, Odisha, Punjab, West Bengal, Himachal Pradesh, Jammu & Kashmir, Sikkim, and the northeastern states such as Manipur, Meghalaya, Mizoram, Nagaland, Tripura, and Assam (Butler, 1907; Mitra, 1981; Chenhulu and Hora, 1962; Payak and Renfro, 1968; Laxminarayana and Shankar Lingam, 1983; Kaul, 1997) [7, 21, 8, 29, 19, 16].

In the northeastern region (NER) of India, maize is predominantly cultivated under rainfed hilly upland and *jhum* (shifting cultivation) systems (Ramkrushna *et al.*, 2022) [30]. It serves as an essential kharif crop, ensuring food security and being used both for direct consumption and as livestock feed. In Manipur, maize is cultivated over an area of approximately 25.53 thousand hectares (Anonymous, 2020) [5]. The pathogen *E. turcicum* can infect maize plants at any growth stage, from seedlings to maturity. Although TLB occurs worldwide, its severity is greater in regions characterized by low temperatures, high humidity, and cloudy weather conditions (Jeevan *et al.*, 2023) [15]. In Manipur, the disease incidence (DI) has been reported to range between 51-71% (Nongmaithem *et al.*, 2022) [28]. Yield losses of up to 70% have been documented (Yeshitila, 2003) [36], with reductions exceeding 50% when infection occurs before flowering (Raymundo *et al.*, 1981; Tefferi *et al.*, 1996) [31, 34]. Severe infection can reduce photosynthetic rates by up to 91% when disease severity exceeds 50% (Pant *et al.*, 2001) [24]. Similarly, yield losses may approach 50% when disease intensity is high two to three weeks after pollination (Shurtleff, 1980; Dey *et al.*, 2017) [27, 10], and under epiphytotic conditions, losses can range from 28% to 91% (Ribeiro *et al.*, 2016) [25].

Although chemical treatments and crop management practices can mitigate TLB, the most sustainable, eco-friendly, and cost-effective strategy for disease management is the deployment of resistant cultivars. Host-plant resistance, achieved through resistance breeding, remains the most practical approach to minimizing yield losses. Therefore, the present investigation was undertaken to screen QPM, open-pollinated varieties (OPVs), sweet corn, baby corn, and popcorn genotypes for resistance against Turcicum Leaf Blight disease of maize under field conditions.

Materials and Methods

Collection of Diseased Samples and Pathogen Isolation

Diseased maize leaf samples exhibiting typical symptoms of Turcicum Leaf Blight (TLB), characterized by elongated necrotic lesions, were collected in paper poly bags from different maize-growing areas of Manipur during the survey and transported to the laboratory for pathogen isolation. The causal pathogen, *Exserohilum turcicum*, was isolated from infected leaf tissues following the standard hyphal tip isolation technique. The obtained pure cultures were maintained on Potato Dextrose Agar (PDA) slants and stored at 5±1 °C in a refrigerator for subsequent laboratory and field investigations.

Isolation of the pathogen

Isolation of the fungus was done through the standard tissue isolation technique. The necrotized leaf lesions, along with the healthy portions, were surface sterilized in 1:1000 sodium hypochlorite solution for 30 sec and again washed thoroughly three times in sterile distilled water to remove the traces of sodium hypochlorite. The sterilized bits were then transferred aseptically to sterile Petri plates that contained PDA media. The inoculated petri dishes were incubated at room temperature (25±1 °C) for periodic observation of fungal growth.

Hyphal tip isolation

For the maintenance of a pure culture of the pathogen, the hyphal tip isolation method was used. From 15 days 15-day-old culture, the spore suspension was diluted in sterilised distilled water to get eight to ten spores per ml. From this, one ml of suspension was uniformly spread on two per cent solidified water agar plates and incubated at 27±1 °C for 12 hr. With a marker pen, a single spore was marked on the backside of the Petri plate with the help of a microscope. After periodically observing under the microscope, the hyphae coming from each cell of the single spore were then traced and marked. With the help of a cork borer, the tip of the hyphae was cut carefully and then transferred to PDA plates and incubated at 27±1 °C for 10 days. Again, the mycelial bits of the fungus from incubated plates were transferred to the petri plates containing PDA and further incubated at 27±1 °C for 10 days. Thus, the pure culture obtained was free from sectoring or saltation. For the identification of *E. turcicum*, spore morphology and colony characteristic studies were done on PDA.

Mass multiplication of the inoculum

Sterilized sorghum grains were used for the mass multiplication of *E. turcicum* (Joshi *et al.*, 1969) [14]. About 40 to 45 g of sorghum grains were dispensed in a 500 ml conical flask, soaked in water for about 3-4 hrs and excess water was drained off. The sorghum grains were autoclaved twice at 15 psi for 1 hour, inoculated with the fungus under aseptic conditions, and incubated at 25-27 °C. Once in 2-3 days, the flasks were shaken for uniform growth of *E. turcicum* on grains. The above impregnated sorghum grains were dried by spreading uniformly on a clean paper sheet in the shade.

Field Screening of Maize Genotypes for TLB

A field experiment was conducted during *kharif* 2024 at the Andro Research Farm, College of Agriculture, Central Agricultural University, Imphal, Manipur (24.763793° N, 94.052882° E; 755.02±2.5 m above mean sea level) to evaluate maize genotypes for resistance to *Exserohilum turcicum*, the causal organism of Turcicum Leaf Blight (TLB). The experiment was laid out in an alpha lattice design with a plot length of 2 m. Each genotype was sown on 29 June 2024, maintaining a spacing of 20 × 60 cm and following the recommended agronomic practices, except for plant protection measures.

Inoculum Preparation and Inoculation Procedure

Pure cultures of *E. turcicum* were maintained on potato dextrose agar (PDA) medium and incubated at 25±1 °C for 20 days to promote sporulation. A spore suspension was prepared by flooding the culture plates with sterile distilled

water and gently scraping the surface to dislodge the conidia. The resulting suspension was filtered through double-layered muslin cloth to remove mycelial fragments.
The spore concentration was adjusted to 3×10^5 spores ml^{-1} using a haemocytometer. The suspension was sprayed uniformly on the maize plants at the three-to four-leaf stage twice at 30 and 40 DAS using a hand-held atomizer during the evening hours to facilitate infection. Immediately after inoculation, a fine water mist was applied to maintain adequate humidity and promote pathogen establishment.

Disease Development and Assessment
Following inoculation, the field was periodically irrigated to maintain moderate humidity conducive to disease development. Disease observations were recorded at regular intervals, and disease severity was assessed using the standard 1-9 rating scale (Table 1) recommended by the Indian Institute of Maize Research (IIMR), Ludhiana (Anonymous, 2014) [14]. Observations began 45 days after sowing when typical Turcicum Leaf Blight (TLB) symptoms were well expressed, and assessments were continued at weekly intervals for six consecutive weeks. Based on the mean disease scores, the genotypes were categorized as follows: The genotypes showing disease scores between 1.0-3.0 were considered as resistant (R), 3.1-5.0 as moderately resistant (MR), 5.1-7.0 as moderately susceptible (MS), 7.1-9.0 as susceptible (S).

Table 1: Disease scoring according to Chung *et al.* (2010) [9]; Mitiku *et al.* (2014) [22]

Rating scale	Degree of infection (% DLA*)	PDI**	Disease Reaction
1.0	Nil to very slight infection (≤10%).	≤ 11.11	Resistant (Score: ≤ 3.0) (PDI: ≤ 33.33)
2.0	Slight infection, a few lesions scattered on two lower leaves (10.1-20%).	22.22	
3.0	Light infection, moderate number of lesions on four lower leaves (20.1-30%).	33.33	
4.0	Light infection, moderate number of lesions scattered on lower leaves, a few lesions scattered on middle leaves below the cob (30.1-40%).	44.44	Moderately Resistant (Score: 3.1-5.0) (PDI: 33.34-55.55)
5.0	Moderate infection, an abundant number of lesions scattered on lower leaves, a moderate number of lesions scattered on middle leaves below the cob (40.1-50%).	55.55	
6.0	Heavy infection, an abundant number of lesions scattered on lower leaves, moderate infection on middle leaves, and a few lesions on two leaves above the cob (50.1-60%).	66.66	Moderately susceptible (Score: 5.1-7.0) (PDI: 55.56-77.77)
7.0	Heavy infection, an abundant number of lesions scattered on lower and middle leaves, and a moderate number of lesions on two to four leaves above the cob (60.1-70%).	77.77	
8.0	Very heavy infection, lesions are abundantly scattered on the lower and middle leaves and spreading up to the flag leaf (70.1-80%).	88.88	Susceptible (Score: > 7.0) (PDI: > 77.77)
9.0	Very heavy infection, lesions abundantly scattered on almost all leaves, plants prematurely dried or killed (>80%).	99.99	

*DLA-Diseased leaf area; **Percent disease index (PDI)

Results and Discussion
For the disease screening of QPM & OPV maize genotypes, thirty-eight genotypes were evaluated; three genotypes, *viz.*, IQPMH 2405, APC 10 and PFM 12, were found to be resistant. Thirty five genotype *viz.*, APH 9, FBH 105, FBH 106, FBH 127, FBH 202, FMH 99, IMH 10-K24wx1, IMH 10-K24wx2, IMH 10-K24wx3, IQPMH 2401, IQPMH 2402, IQPMH 2403, IQPMH 2404, IQPMH 2406, IQPMH 2407, IQPMH 2408, IQPMH 2409, APH 7, APH 8, FBH 101, FLPH 45, FMH 24, ADC 9, APC 11, APC 12, BU 1, CAU-LMC-3, DOP 351, DOP 352, JC 1520, JC 1526, KDM 36, SKMC 5, PFM 14 and ADC 4 were found to be moderately resistant for TLB (Table 2).
For the disease screening of SC, BC & PC maize genotypes, fourteen genotypes were evaluated. Five genotypes, *viz.*, CP SWEET KING, APTSKH1, GOLDEN SWEET SUPER, IBH 11-243 and AP 6005, showed moderately resistant reaction. Nine genotypes, *viz.*, FSCH 290, FSCH 218, FSCH 131, IBH 11-245, IBH 11-246, IBH 11-223, JH 32484, AP 6012 and AP 8203 were found to be moderately susceptible to TLB (Table 3).
The present findings are in accordance with studies of Kachapur *et al.* (2014) [17] which reported that among the fifty new germplasm lines screening against TLB, they found that GPM-378, GPM-408, GPM-496, GPM-524 and GPM-537 showed resistant reaction and GPM-375, GPM-440, GPM-540 and GPM-569 showed susceptible reaction against TLB.
Mir *et al.* (2015) [20] reported that among the screening of 10 inbred lines, three were found to be moderately resistant, five lines were found to be moderately susceptible, and two were found to be susceptible to TLB.
Similarly, Ahanger *et al.* (2016) [37] reported that field trial against sixty isolates of maize against *E. turcicum* under artificially inoculated field conditions, twenty-six genotypes were found to be resistant and moderately resistant. Later, screening of these twenty-six genotypes against twelve isolates of *E. turcicum* under artificially epiphytotic conditions revealed that eight genotypes were found to be resistant and eight as moderately resistant.
Shikari and Zafar (2009) [26] also reported that inbred NAI-147 and composite Girija have shown resistance against Turcicum leaf blight.
Yousuf *et al.* (2018) [37] also reported that among the seventy landraces, forty-three lines were reported as resistant, eighteen were found to be moderately resistant, five as moderately susceptible and Tral 3 was found to have the highest per cent disease index (PDI) as 78.91 per cent and was rated to be susceptible.

Table 2: Disease screening of Quality protein Maize (QPM) & open-pollinated variety (OPV) maize genotypes.

Sl. No.	Genotype	TLB (1-9)	Reaction
QPM			
1	APH 9	3.2	MR
2	FBH 105	3.3	MR
3	FBH 106	3.3	MR
4	FBH 127	4.3	MR
5	FBH 202	4.0	MR
6	FMH 99	4.6	MR
7	IMH 10-K24wx1	4.3	MR
8	IMH 10-K24wx2	3.6	MR
9	IMH 10-K24wx3	3.8	MR
10	IQPMH 2401	3.9	MR
11	IQPMH 2402	3.1	MR
12	IQPMH 2403	3.7	MR
13	IQPMH 2404	3.5	MR
14	IQPMH 2405	3.0	R
15	IQPMH 2406	3.4	MR
16	IQPMH 2407	3.6	MR
17	IQPMH 2408	3.4	MR
18	IQPMH 2409	4.2	MR
19	APH 7	3.2	MR
20	APH 8	4.3	MR
21	FBH 101	4.6	MR
22	FLPH 45	4.0	MR
23	FMH 24	3.8	MR
24	ADC 9	3.6	MR
25	APC 11	3.7	MR
26	APC 12	3.2	MR
27	BU 1	4.2	MR
28	CAU-LMC-3	3.6	MR
29	DOP 351	3.5	MR
30	DOP 352	4.0	MR
31	JC 1520	4.5	MR
32	JC 1526	3.6	MR
33	KDM 36	4.3	MR
34	SKMC 5	3.8	MR
OPV			
35	APC 10	3.0	R
36	PFM 12	2.3	R
37	PFM 14	3.2	MR
38	ADC 4	3.7	MR
Checks			
C1	APH 1	4.0	MR
C2	Bajaura Makka	5.2	MR
C3	BIO 9544	3.5	MR
C4	CMVL 55	4.0	MR
C5	Dhari Local	6.1	MS
C6	Hemant	4.3	MR
C7	HQPM 5	4.7	MR
C8	LG 34.05	3.8	MR
C9	LQMH 1	4.3	MR
C10	RCRMH4-1	4.1	MR
C11	VAMH 12014	3.6	MR
C12	Vijay	4.6	MR
C13	VLMH 57	4.4	MR
C14	VMH 51	3.9	MR
	CV (%)	12.8	
	F (Prob)	0.0	
	CD (5%)	1.0	
	CD (1%)	1.4	

Table 3: Disease screening of Sweet corn (SC), Baby corn (BC) & and Popcorn (PC) maize genotypes

Sl. No.	Genotype	TLB (1-9)	Reaction
SC			
1	FSCH 290	5.6	MS
2	CP SWEET KING	4.2	MR
3	FSCH 218	6.0	MS
4	APTSKH1	5.0	MR
5	GOLDEN SWEET SUPER	4.9	MR
6	FSCH 131	5.9	MS
BC			
7	IBH 11-243	4.2	MR
8	IBH 11-245	7.0	MS
9	IBH 11-246	5.5	MS
10	IBH 11-223	5.1	MS
11	JH 32484	5.7	MS
PC			
12	AP 6005	4.6	MR
13	AP 6012	5.2	MS
14	AP 8203	5.8	MS
Checks			
C1	AH 7043	5.9	MS
C2	ASKH 1	4.8	MR
C3	ASKH 4	4.7	MR
C4	BPCH 6	4.9	MR
C5	CMVL BC 2	5.9	MS
C6	CMVL SC 1	4.1	MR
C7	Dhari Local	4.5	MR
C8	DMRHB 1305	5.2	MS
C9	DMRHP 1402	6.1	MS
C10	LPCH 3	5.2	MS
C11	Misthi	4.3	MR
C12	RCRMH4-1	4.5	MR
C13	VAMH 12014	5.6	MS
	CV (%)	22.9	
	F (Prob)	0.8	
	CD (5%)	2.4	
	CD (1%)	3.3	

Conclusion

The present investigation demonstrated considerable variability among maize genotypes in their response to *Exserohilum turcicum*, the causal agent of Turcicum Leaf Blight (TLB). Several short-and medium-duration hybrids exhibited resistance or moderate resistance, highlighting their potential as valuable genetic resources for resistance breeding. Identification of such resistant sources is crucial for developing durable and sustainable TLB resistance, particularly in regions prone to frequent disease outbreaks.

The incorporation of resistance genes from these sources into susceptible but agronomically superior cultivars can greatly enhance yield stability and resilience. Furthermore, the use of these resistant genotypes in population improvement and hybrid development programs will significantly enhance maize germplasm and lead to the development of high-yielding, TLB-resistant maize cultivars for sustainable maize production.

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