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IDENTIFICATION OF TURCICUM LEAF BLIGHT-RESISTANT SOURCES AMONG MAIZE INBREDS AND HYBRIDS THROUGH FIELD SCREENING

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ABSTRACT

Turcicum leaf blight (TLB) caused by *Exserohilum turcicum* (Pass.) is one of the most destructive foliar diseases limiting maize productivity worldwide. The deployment of resistant cultivars remains the most economical and environmentally sustainable strategy for effective disease management. The present study was undertaken to identify resistant sources among diverse maize inbred lines and hybrids under artificial epiphytotic conditions in the field. A total of 65 inbred lines and 50 hybrids were evaluated for TLB response at college of Agriculture, Navile, Shivamogga. Artificial inoculation was performed at 40 days after sowing using a conidial suspension of *E. turcicum*, and disease severity was assessed based on a 1–9 disease rating scale. TLB scores and Percent disease index (PDI) were used to classify the genotypes into resistant (1-3), moderately resistant (4-5), moderately susceptible (6-7) and susceptible (8-9) categories. Out of 65 inbred lines evaluated for TLB response 18 lines were found resistant to TLB (PDI <33.33%), 27 lines moderately resistance (PDI 33.34-55.55%), 14 lines moderately susceptible (PDI 55.56-77.77%) and 6 lines susceptible to TLB (PDI >77.78%). Some inbred lines like MMI-2, GI 2208, VL-111354 and GI2264 showed low disease severity (< 3 score, < 33.33% PDI) with superior grain yield, highlighting their potential as valuable donor parents in resistance breeding programmes. Similarly, among the 50 maize hybrids, 18 were found resistant, 21 moderately resistant, 7 moderately susceptible, and 4 hybrids susceptible to TLB. Hybrids such as GH22629, GH21523, GH21533 and GH21524 showed better resistance coupled with high grain yield, indicating their suitability for commercial cultivation. The variability observed among evaluated germplasm demonstrated the availability of genetic resources for improving TLB-resistant genotypes. The resistant and high-yielding genotypes in the present study constitute valuable breeding material for developing durable TLB-resistant maize cultivars adapted to diverse agro-climatic conditions.

Key words : Maize, *Exserohilum turcicum*, Field screening, Per cent disease index (PDI), Resistant inbreds/ hybrids, Turcicum leaf blight.

Introduction

Maize (*Zea mays* L.; 2n=20) is one of the world's most important cereal crops and serves as a major source of food, feed and industrial raw materials. Owing to its high genetic yield potential, wide adaptability and C₄ photosynthetic efficiency, maize is cultivated across diverse agro-climatic regions and contributes significantly to global food security. Globally, maize is cultivated on approximately 205 million ha with an annual production

exceeding 1.2 billion tonnes. In India, maize occupies approximately 10.74 million ha, with a production of 42.28 million tonnes and an average productivity of 3.54 t ha⁻¹ (FAOSTAT, 2024). Karnataka is one of the leading maize producing states, contributing substantially to national maize production under both rainfed and irrigated ecosystems. Besides its importance as a staple food crop, maize serves as an essential raw material for livestock and poultry feed industries and numerous agro-based

industries involved in the manufacturing of strach, edible oil, ethanol, sweeteners and several pharmaceutical products (Ranum *et al.*, 2014).

Despite its productivity, maize production is severely constrained by several biotic and abiotic stress. Among these, foliar fungal diseases are major causes of economic losses because they reduce the effective photosynthetic area, accelerate leaf senescence and ultimately decrease grain yield and quality (Savary *et al.*, 2019; Zhu *et al.*, 2021). Turcicum leaf blight (TLB), also known as Northern corn leaf blight (NCLB), is caused by the ascomycetes fungus *Exsherolium turcicum* (Pass.) Leonard and Suggs [teleomorph: *Setosphaeria turcica*] is one of the most destructive foliar diseases affecting maize worldwide. The disease is prevalent across temperate, subtropical and tropical maize-growing regions where moderate temperatures (18–27°C), prolonged leaf wetness and high relative humidity favour disease development. Infection may occur throughout the crop growth period; however, severe epidemics generally develop from the pre-tasseling to grain-filling stages under favourable environmental conditions. Under severe epiphytotic condition, grain yield losses ranging from 28 to 91% have been reported depending on susceptibility of cultivar (Jakhar *et al.*, 2021), crop growth stage at infection and prevailing environmental conditions (Perkins and Pedersen, 1987; Harlapur *et al.*, 2008a; Srivastava *et al.*, 2023).

The disease is characterised by the appearance of long, elliptical, cigar-shaped, greyish-green to tan necrotic lesions that initially develop on the lower leaves before progressing upward to the upper canopy. As lesions enlarge and coalesce, extensive blighting of foliage occurs, substantially reducing the plant's photosynthetic capacity. The increasing occurrence of TLB in major maize-growing states of India, including Karnataka, Andhra Pradesh, Maharashtra, Bihar and Himachal Pradesh, highlights the need for developing resistant cultivars suitable for diverse agro-ecological conditions (Payak and Sharma, 1983; Harlapur *et al.*, 2008b; Jakhar *et al.*, 2021).

Resistance to TLB is genetically complex and involves both qualitative and quantitative components. Race-specific resistance is governed by major genes such as Ht1, Ht2, Ht3, HtM, HtN and HtP, whereas durable resistance is predominantly controlled by numerous quantitative trait loci with additive genetic effects. Quantitative resistance generally manifests a prolonged incubation period, reduced lesion number, smaller lesion size and slower disease progression, thereby providing stable resistance across diverse pathogen populations.

However, the continuous evolution of new physiological races of *E. turcicum* frequently overcomes previously effective resistance genes, emphasizing the necessity of identifying novel resistance sources from diverse maize germplasm (Welz and Geiger, 2000; Chung *et al.*, 2010; Hurni *et al.*, 2015).

Maize inbred lines are the primary genetic resources for hybrid development and serve as valuable donors for the introgression of disease resistance genes into elite breeding materials. Likewise, systematic evaluation of commercial and experimental hybrids provides an opportunity to identify high-yielding combinations with durable resistance under field conditions. Field screening under artificial epiphytotic conditions ensures uniform disease pressure, thereby enabling accurate discrimination among resistant and susceptible genotypes and facilitating the identification of promising parental lines and hybrid combinations for resistance breeding (Wani *et al.*, 2017; Varma *et al.*, 2024).

Considering the economic importance of TLB and the continuous emergence of new pathogen races, the present investigation was undertaken to evaluate a diverse set of maize inbred lines and hybrids under artificial epiphytotic conditions in field. The study aimed to identify stable sources of resistance possessing superior agronomic performance that can be effectively utilized as donor parents in resistance breeding programmes and as potential hybrid combinations for the development of high-yielding, disease-resistant maize cultivars adapted to the maize-growing regions of India.

Materials and Methods

Experimental site

The present investigation was conducted during the *Kharif* 2025 season at College of Agriculture, Shivamogga, Karnataka, India (latitude of 13°58'37.19"N, longitude of 75°34'39.48"E and at an altitude of 630 m above mean sea level). The experimental site is situated in the Southern transitional zone (Zone 7) of Karnataka, which experiences climatic conditions favourable for the development of TLB under artificial epiphytotic conditions.

Experimental material

Sixty-five maize inbred lines and fifty hybrids sourced from the University of Agricultural Sciences, Mandya and University of Agricultural Sciences, Dharwad were evaluated for TLB response under artificially inoculated conditions in field.

Experimental design and crop management

Both experiments were laid out in a randomized

complete block design with two replications. Each genotype was planted in two rows of 2 m length, maintaining a spacing of 45 cm between rows and 20 cm between plants. Standard agronomic practices recommended for maize cultivation were followed throughout the crop growth period. Plant protection measures were adopted against insect pests whenever necessary, whereas no fungicides were applied to facilitate natural disease development following artificial inoculation.

Pathogen isolation and artificial inoculation

Exserohilum turcicum was isolated from naturally infected maize leaves exhibiting typical TLB symptoms. Pure cultures were established on potato dextrose agar (PDA) using the tissue bit isolation technique and subsequently multiplied in potato dextrose broth (PDB) (Fig. 1). The conidial suspension was adjusted to 1×10^8 conidia ml^{-1} using a haemocytometer. Artificial inoculation was carried out by spraying the conidial suspension uniformly on maize plants at 40 days after sowing (~6-8 leaf stage) during evening hours. Adequate humidity was maintained after inoculation to promote successful infection and uniform disease development.

Disease scoring

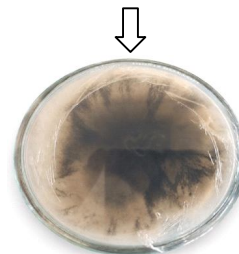
Inbred lines and hybrids were screened for TLB response under artificial inoculated conditions in field. Disease severity was recorded at two different stages viz., flowering (60 days) and dough stage (75 days) (Jakhar *et al.*, 2021) using the 1–9 disease rating

Table 1 : TLB disease 1-9 rating scale.

Rating scale	Degree of infection (% Diseased leaf area)	Disease reaction
1	Nil to very slight infection ($\leq 10\%$).	Resistant (R) (Score: ≤ 3.0) (PDI: ≤ 33.33)
2	Slight infection, a few lesions scattered on two lower leaves (10.1-20%).	
3	Light infection, moderate number of lesions scattered on four lower leaves (20.1-30%).	
4	Light infection, moderate number of lesions scattered on lower leaves, a few lesions scattered on middle leaves below the cob (30.1-40%).	Moderately Resistant (MR) (Score: 3.1–5.0) (PDI: 33.34-55.55)
5	Moderate infection, abundant number of lesions scattered on lower leaves, moderate number of lesions scattered on middle leaves below the cob (40.1-50%).	
6	Heavy infection, 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%)	Moderately Susceptible (MS) (Score: 5.1-7.0) (PDI: 55.56-77.77)
7	Heavy infection, abundant number of lesions scattered on lower and middle leaves and moderate number of lesions on two to four leaves above the cob (60.1-70%).	
8	Very heavy infection, lesions abundant scattered on lower and middle leaves and spreading up to the flag leaf (70.1-80%).	Susceptible (S) (Score: > 7.0) (PDI: > 77.77)
9	Very heavy infection, lesions abundant scattered on almost all the leaves, plants prematurely dried and killed ($> 80\%$).	



a) Isolation *E. turcicum* from infected leaf



b) Pure culture of *E. turcicum* on potato dextrose agar medium



c) Mass multiplication of *E. turcicum* on potato dextrose broth

Fig. 1 : Isolation, culture and mass multiplication of *E. turcicum*.

scale (ICAR-IIMR, Ludhiana) (Table 1). The percent disease index (PDI) scores were determined as below based on TLB scores at two different stages viz., 60 and 75 days after sowing (Jakhar *et al.*, 2021).

$$\text{Percent Disease Index} = \frac{\text{Sum of individual rating}}{\text{No. plants examined} \times \text{Maximum disease grade}} \times 100$$

TLB scores and PDI values were used to classify maize genotypes into four distinct classes: Resistant (≤ 3 , $<33.33\%$), Moderately Resistant (3.1–5.0, 33.4 – 55.5%), Moderately Susceptible (5.1–7.0, 55.6 – 77.7%) and Susceptible (>7.0 , $>77.7\%$) (Fig. 2).

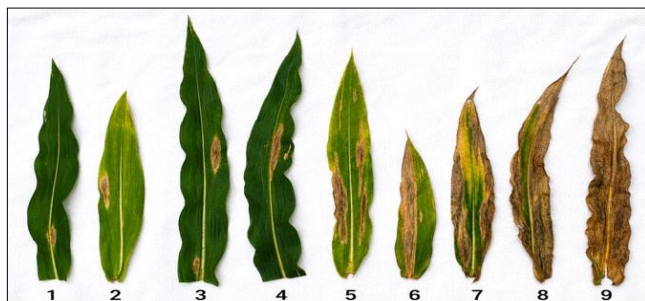


Fig. 2 : TLB Disease severity 1-9 Scale.

Results and Discussion

Response of maize inbred lines for TLB

Out of 65 inbred lines screened, 18 lines (27.69%) were resistant (R), 27 lines (41.54%) moderately resistant (MR), 14 lines moderately susceptible (MS), and six lines (9.23%) as susceptible (S) to TLB based on disease rating and PDI values (Table 2). These findings demonstrate that a large proportion (69.23%) of the evaluated inbred lines exhibited either resistant or moderately resistant reactions, suggesting that the germplasm set contained valuable resistant sources for maize improvement programmes. The resistant inbred lines were MMI-2, MMI-3, MMI-12, MMI-13, MMI-15, MMI-16, MMI-17, MMI-19, MMI-25, MMI-35, MMI-43, VL-111354, VL-18959, GI 2208, GI 2250, GI 2258, GI 2264 and VL 2051, which recorded PDI values

below the resistance threshold. These genotypes exhibited limited lesion development and lower disease severity under artificial inoculation, indicating the presence of effective resistance mechanisms against *E. turcicum*. Such resistant inbred lines can serve as valuable donor parents for the introgression of TLB resistance into elite breeding populations. In contrast, six inbred lines categorized as susceptible viz., MMI-7, MMI-42, GI 2210, GI 2240, GI 2251 and CM 202 consistently recorded high disease severity (PDI $> 77.77\%$). The susceptible check CM 202 exhibited high disease severity, confirming adequate disease pressure and the reliability of the artificial inoculation technique adopted in the present study.

The present findings demonstrated substantial genetic variability for TLB resistance among maize germplasm. Genetic variability for TLB resistance in maize germplasm has been reported by various researchers by screening under artificial conditions in field (Kumar *et al.*, 2011; Chandrashekar *et al.*, 2014; Gulzar *et al.*, 2018; Hailu *et al.*, 2018). Similarly, stable sources of resistance were also identified by testing across diverse locations (Kumar *et al.*, 2018 and Jakar *et al.*, 2021). Hence, systematic field screening under artificial inoculation is an effective approach for identifying stable sources of resistance that can be utilized in resistance breeding programs.

Response of maize hybrids for TLB

Fifty maize hybrids were evaluated for TLB response under artificial inoculation using the 1–9 disease rating scale. The disease response was quantified by calculating the PDI values and the hybrids were classified into four categories, namely resistant (R), moderately resistant (MR), moderately susceptible (MS) and susceptible (S). Wide range of variation for disease response was observed among the evaluated hybrids, indicating

Table 2 : Response of maize inbred lines to TLB disease.

S. no.	Reaction category	PDI	Number of inbreds	Inbred lines
1	Resistant (R) (Score: ≤ 3.0)	≤ 33.33	18	MMI-2, MMI-3, MMI-12, MMI-13, MMI-15, MMI-16, MMI-17, MMI-19, MMI-25, MMI-35, MMI-43, VL-111354, VL-18959, GI 2208, GI 2250, GI 2258, GI 2264, VL 2051
2	Moderately Resistant (MR) (Score: 3.1–5.0)	33.34 to 55.55	27	MMI-1, MMI-4, MMI-6, MMI-9, MMI-20, MMI-21, MMI-24, MMI-27, MMI-37, VL-18960, VL-18966, VL-108727, VL-21933, VL-21919, VL-143906, VL-187123, GI 2123, GI 2213, GI 2247, GI 2249, GI 2255, GI 2256, GI 2259, GI 2261, GI 2265, GI 2266, GI 2267
3	Moderately Susceptible (MS) (Score: 5.1–7.0)	55.56 to 77.77	14	MMI-5, MMI-8, MMI-11, MMI-14, MMI-26, MMI-31, MMI-38, MMI-41, MMI-44, GI 2212, GI 2229, GI 2248, GI 2275, GI 2276
4	Susceptible (S) (Score: >7.0)	>77.77	6	MMI-7, MMI-42, GI 2210, GI 2240, GI 2251, CM 202

Table 3 : Response of maize hybrids to TLB disease.

S. no.	Reaction category	PDI (%)	Number of hybrids	Hybrids
1	Resistant(R) (Score: ≤ 3.0)	≤ 33.33	18	MAH-201, MAH-202, MAH-203, MAH-205, MAH-207, MAH-208, MAH-210, MAH-214, MAH-228, GH 21523, GH 21524, GH 21533, GH 21555, GH 22504, GH 22515, GH 22517, GH 22543, GH 22631
2	Moderately Resistance (MR) (Score: 3.1–5.0)	33.34 to 55.55	21	MAH-204, MAH-206, MAH-209, MAH-211, MAH-213, MAH-222, MAH-223, MAH-224, MAH-225, MAH-226, MAH-227, MAH-229, MAH-230, GH 20561, GH 21547, GH 21568, GH 22562, GH 22568, GH 22594, GH 22602, GH 22629
3	Moderately Susceptible (MS) (Score: 5.1-7.0)	55.56 to 77.77	7	MAH-215, MAH-218, MAH-220, MAH-221, GH 22582, GH 22583, GH 150125
4	Susceptible (S) (Score: >7.0)	>77.77	4	MAH-212, MAH-216, MAH-217, MAH-219

considerable genetic diversity for TLB resistance. Among the 50 hybrids, 18 were resistant (36%), 21 moderately resistant (42%), 7 moderately susceptible (14.00%) and 4 susceptible (8.00%) to TLB disease (Table 3). The resistant hybrids were MAH-201, MAH-202, MAH-203, MAH-205, MAH-207, MAH-208, MAH-210, MAH-214, MAH-228, GH 21523, GH 21524, GH 21533, GH 21555, GH 22504, GH 22515, GH 22517, GH 22543 and GH 22631, which recorded PDI values below 33.33%. These hybrids exhibited lower disease severity and minimal lesion development following artificial inoculation, indicating resistance against *E. turcicum*. The expression of resistance in these hybrids suggests that favourable resistance alleles inherited from their parental lines contributed to reduced disease development under field conditions.

The moderately resistant group comprised 21 hybrids, which showed intermediate disease severity (PDI 33.34 to 55.55%). Although, these hybrids developed more lesions than the resistant group, disease progression remained moderate, indicating partial or quantitative resistance. Such hybrids may also serve as valuable breeding materials because quantitative resistance is generally considered more stable across diverse environments and pathogen populations. Only seven hybrids exhibited moderately susceptible reactions (PDI 55.56-77.77%), while four hybrids (MAH-212, MAH-216, MAH-217 and MAH-219) were categorized as susceptible (PDI $> 77.77\%$). These susceptible hybrids developed extensive leaf blight under artificial disease pressure, confirming their vulnerability to TLB infection.

The results of the present investigation are in agreement with earlier reports that documented considerable variability in TLB resistance among maize hybrids. Varma *et al.* (2024) reported distinct differences

in disease reaction among maize genotypes and emphasized the importance of resistant cultivars for sustainable disease management. Similarly, Wani *et al.* (2017) identified resistant maize hybrids under artificial disease screening, highlighting the effectiveness of systematic field evaluation in identifying superior genetic materials for resistance breeding. The consistency of the present findings with previous studies confirms that field screening under artificial epiphytotic conditions remains a reliable approach for identifying stable and durable sources of resistance. The present study demonstrated substantial genetic variation for TLB resistance among the evaluated maize hybrids. The resistant hybrids identified here in constitute promising candidates for commercial cultivation in disease-prone regions due to their durable resistance to TLB through extensive testing over multiple locations in the agro-ecologies.

Conclusion

The present study demonstrated substantial genetic variability for TLB resistance among the evaluated maize inbred lines and hybrids under artificial epiphytotic conditions. Out of 65 inbred lines screened, 18 were identified as resistant, while among the 50 hybrids evaluated, 18 exhibited resistant reactions to *Exserohilum turcicum*. Several resistant genotypes also maintained superior grain yield, indicating that effective TLB resistance can be successfully combined with desirable agronomic performance. Among the inbred lines, VL 2051, MMI-2, GI 2208, VL-111354 and MMI-15 were identified as promising sources of resistance coupled with high grain yield and may serve as valuable donor parents for resistance breeding programmes. Likewise, the hybrids GH 22629, GH 22517, GH 21523, GH 21533 and GH 21524 exhibited excellent resistance together with superior productivity, making them promising candidates

for multi-location evaluation and potential commercial cultivation. The findings of the present study provide valuable genetic resources for the development of high-yielding maize cultivars with durable resistance to TLB. Further validation of these resistant genotypes across diverse environments and their utilization in hybrid development and resistance breeding programmes will contribute to sustainable maize production in TLB-endemic regions.

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