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REVIEW

Turcicum leaf blight: A threat to maize cultivation

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Turcicum Leaf Blight disease, caused by *Exserohilum turcicum*, is one of the most destructive diseases of maize, characterized by the blighting of leaves. The disease may cause as much as 90% yield loss. The severity of the disease depends on many factors, like varieties or landraces of crops, growth stages, the virulence of the pathogen, and environmental factors like high humidity, high temperature, and rainfall. In India, this disease is prevalent and is distributed in Karnataka, Maharashtra, Andhra Pradesh, Uttarakhand, Bihar, West Bengal, Manipur, and almost all the maize-growing states. The disease can be effectively managed by adopting integrated management practices that combine cultural, biological, botanical, and chemical components. There are number of genotypes have potential for developing promising varieties with desirable resistance levels in disease-prone areas, aiming to enhance sustainable productivity

Keywords : Leaf blight, *Zea mays*, *Exserohilum turcicum,*

INTRODUCTION

Maize (*Zea mays*) is one of the most important cereals belonging to members of family Poaceae. It is believed to have been domesticated by tribes of Mesoamerica during pre-historic times. Today, it is grown throughout the world from temperate to tropic regions for various forms of food, fodder, starch, dextrose, sugar, alcohol, oil, gluten, paper, soap, dry batteries and toiletries (Reddy, 2008). The cultivation of maize is increasing due to its diverse use.

But, with the introduction of high yielding hybrids and use of chemical fertilizers, there has been a remarkable increase in the area and production, but at the same time, it is prone to several diseases.

Maize (*Zea mays*) is one of the most important cereals belonging to the Poaceae family. Today, it is grown throughout the world, from temperate to tropical regions, for various forms of food, fodder, starch, dextrose, sugar, alcohol, oil, gluten, paper, soap, dry batteries, and toiletries (Reddy, 2008). The cultivation of maize is increasing due to its diverse uses. But, with the introduction of high-yielding hybrids and the use of chemical fertilizers, there has been a remarkable increase in the area and production, but at the same time, it is prone to several diseases.

The different diseases reported in maize are Turcicum leaf blight (*Exserohilum turcicum*), Southern/Maydis leaf blight (*Bipolaris maydis*), Sheath blight (*Rhizoctonia solani*),Fusarium ear rot (*Fusarium graminearum, F. moniliforme*), Aspergillus ear rot (*Aspergillus* spp.), Penicillum ear rot (*Penicillum* spp.), Stenocarpella Stalk rot (*Stenocarpella maydis*), Pythium Stalk rot (*Pythium aphanidermatum*), Common smut (*Ustilago maydis*), Head smut (*Sphacelo-thecareiliana*), Flase Head smut (*Ustilaginoidia virens*), Macrospora leaf stripe (*Diplodiama crospora)*, Phaeospheria (*Phaeospheria maydis*) Curvularia leaf spot (*Curvularia* spp.), Grey leaf spot (*Cercospora zeamaydis),* Common rust (*Puccinia sorghi*), Corn anthracnose

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(*Colletotrichum graminicola*), Spot Blotch (*Bipolaris sorokinia*), etc. Among the foliar diseases affecting maize, Turcicum Leaf Blight (TLB) disease is the most significant.

Distribution, severity, and yield loss

Turcicum Leaf Blight of maize is one of the most destructive diseases of the warm and humid regions of the world. In India, it is distributed in Karnataka, Maharashtra, Andhra Pradesh, Uttarakhand and Bihar (Niwas *et al.* 2022). The geographical condition, especially altitude, and the other meteorological factors determine its severity (Abebe and Singburaudom, 2006); however, its severity ranges from 0 to 66% and causes moderate to severe yield loss (Manu *et al.* 2018). The extent of yield losses depends on many factors, like varieties or landraces of crops, growth stages, the virulence of the pathogen, and environmental factors. The delayed infection causes minimum yield loss, but the establishment of disease in the early stages of crop growth may cause maximum yield loss. Corroborating this finding, it is reported that the yield loss is minimal if the infection occurs 6–8 weeks after silking which may be as high as 28–91% (Swathi *et al.* 2021).

Causal Organism

The pathogen responsible for causing Turcicum leaf blight (TLB) in maize was first reported by Passerini in 1876 from Italy as *Helminthosporium turcicum* Pass. Subsequently, the pathogen was renamed *Setosphaeria turcica* (teleomorphic stage) and *Exserohilum turcicum* (anamorphic stage) by Leonard and Suggs (1974), who described the morphological characters. Furthermore, the morphological characteristics of *Exserohilum turcicum were* studied by several workers throughout the globe. However, there are variations in morphology in different locations (Bankole *et al.* 2023). The pathogen also causes diseases in sorghum (Agrios, 2005).

Conidia and Conidiophores

The conidia of *Exserohilum turcicum* are septate, curved or straight, ellipsoidal, cylindrical, spindle, and elongated (Abebe and Singburaudom 2006), fusiform, and obclavate, measuring 52.94 μm to 144.12 μm. with a protruding hilum (Anwer *et al.* 2022). As the name indicates, the presence of the protruding hilum is the identifying feature of *Exserohilum turcicum*. The septation in conidia ranges from one to nine septa. Conidiophores are flexuous, geniculate, septate, cylindrical, olivaceous brown, and 47–443 by 46 μm in size. The conidium arises terminally on the conidiophore. The colony color in different growth media appears to be olivaceous brown, blackish brown, whitish black, and grayish (Anwer *et al.* 2022). The variation in colony color may be due to the strains of the pathogen, nutrients, and pH of the media.

Taxonomic Position

The anamorph *Exserohilum turcicum* belongs to

Division	:	Eumycota,
Sub-division	:	Deuteromycotina,
Order	:	Moniliales
Family	:	Dematiaceae.

The teleomorph *Setosphaeria turcica* belongs to

Division	:	Eumycota,
Sub-division	:	Ascomycotina,
Order	:	Pleosporales
Family	:	Pleosporaceae.

Disease Development

After the arrival of the inoculum (conidia) on the host, it will germinate, producing a germ tube. It takes around 12–24 hours of incubation, and the germination is generally bipolar (Ali and Chowdhury, 2014a). Germ tubes grow parallel to the veins of the leaf on which simple or forked appressoria develops, which gives rise to the infection peg (Muiru, 2008). After successful penetration through stomata, the pathogen colonizes intra-cellularly and inter-cellularly, killing cells, excluding the epidermal layer (Ali and Chowdhury, 2014a). The conidiophores come out of the abaxial and adaxial stomata in bunches, and the single conidia arise terminally on the conidiophore (Anwer *et al.* 2022), which appears dark in color. This led to the development of symptoms such as small dark spots on the lower leaves, which coalesce to form larger ones (Ali and Chowdhury, 2014a). During unfavorable conditions, the *Exserohilum turcicum* thrives in undecomposed crop residues after harvest of the crop.

Symptoms

Exserohilum turcicum is a pathogen that affects only leaves (Agrios, 2005). The initial expression of the disease is the development of small, slightly oval, water-soaked spots on lower leaves, which progress upward (Ali and Chowdhury, 2014a). In severe cases, these small sports increase in number and coalesce with each other, resulting in the blighting of the entire leaf (Harlapur *et al.* 2008) and affecting photosynthesis (Swathi *et al.* 2021; Pooja *et. al.* 2023). The length of the lesion varies from 2.0 cm. to 15.5 cm, and the width varies from 0.5 cm to 2.0 cm (Ali and Chowdhury, 2014a).

Meterological factors influencing disease severity

Meterological parameters such as temperature, humidity, rainfall, and wind play a significant role in disease severity and spread (Saeed *et al.* 2023). There is a positive correlation between meteorological parameters relative humidity, rainfall, the number of consecutive rainy days, and the spore production of the pathogen (Indira and Muthusubramanian, 2004). Thus, the Turcicum leaf blight is a disease of warm and humid regions, favored by high humidity and temperature. Maximum disease incidence occurs when temperature ranges about 25–30°C and humidity is 75–90% (Saeed *et al.* 2023).

Besides this, altitude and date of sowing also influence the disease severity; it is reported that the disease was more severe at lower altitudes compared to high altitudes (Abebe and Singburaudom, 2006). Because at lower altitudes, the humidity is generally high, Furthermore, the date of sowing also influences the severity; it has been found that delaying the date of sowing increases the severity (Ali *et al.* 2014). An experiment conducted in Karnataka, India, showed a maximum disease severity of 75.37% in the September crop (Harlarpur *et al.* 2007).

Host Resistance

Continuous efforts to locate the resistant source and utilization in resistant breeding programme are imperative to manage the disease. Host pathogen resistance is an economically feasible, safe, durable, sustainable, and eco-friendly control method for managing plant diseases (Bankole *et. al.* 2022).Several workers throughout the globe worked on the source of resistance in maize against Turcicum leaf blight disease. It is evident that different varieties or landraces of maize differ in response to the disease. Some varieties are susceptible to Turcicum leaf blight disease, while others are tolerant. Among the different traits that contribute to its tolerance to the disease, the structural anatomy of maize leaf may play an important role in resistance and susceptibility to the Turcicum leaf blight disease (Ali and Chowdhury, 2014). Recently, a novel gene (*ZmERF105*) responsible for plant innate immunity has been isolated and characterized (Zang *et. al.* 2020).

Screening of maize landraces leading to the identification of TLB resistant sources holds a great promise in resistance breeding in areas prone to TLB. The determination of genetic basis of these sources and incorporation of their resistant genes into susceptible commercial cultivars is a prerequisite in the development of high yielding TLB resistant maize cultivars (Yousuf *et. al.* 2018). Several workers have identified inbred lines that showed resistance to TLB under artificial epiphytotic conditions (Manu *et. al.* 2017; Bantu *et. al.* 2021; Jakhar *et. al.* 2021; Rajeshwari *et. al.*2022; Bhaskar *et. al.* 2023). TLB resistant inbred lines can be exploited as source of resistance to evolve agronomically desirable, high yielding hybrids with inbuilt TLB resistance. Genotypes identified with low disease severity scores against TLB could be valuable for future breeding programs. These genotypes have potential for developing promising varieties with desirable resistance levels in disease-prone areas, aiming to enhance sustainable productivity.

Integrated Disease Management (IPM)

IPM is an approach to managing plant disease by combining biological, cultural, physical, and chemical components to minimize economic, health, and environmental risks (CAST 2003). Numerous workers have worked on the various components of IPM to establish its efficiency, which can be incorporated into an integrated management strategy. Several bacterial and fungal bioagents, singly or in combination with other components, have been used, and it has been found that the bacterial bioagent *Bacillus* spp. (Sartori *et al.* 2017), namely *Bacillus subtilis* (Harlapur *et al.* 2007), *Bacillus lentimorbus, Bacillus agaradhaerens,* and other endophytic bacterial strains like *Ewingella americana* and *Xanthomonas axonopodis,* are effective against *E. turcicum* (Shiomi *et al.* 2015).

The fungal bio-agents used to manage the plant pathogens involve various mechanisms like parasitism, antagonism, competition for nutrients, the production of compounds harmful to the pathogens, etc. (El-Baky and Amara, 2021). Among the fungal bioagents, *Trichoderma* spp. is the most common fungus that has been evaluated against Turcicum leaf blight. Among the *Trichoderma* spp., *T. viridae* (Bindhu *et al.* 2019; Subedi *et al.* 2019), *T. harzianum* (Rani *et al.* 2022), *T. asperellum* (Ma *et al.* 2023; Limdoltham and *et al.* 2023), *T. hamatum* and *T. harzianum* (Limdolthamand *et al.* 2023) are potential candidates as biological components in IPM.

Many studies in the literature report that plant extracts and their essential oils suppress fungal infections in plants (El-Baky and Amara, 2021). There are numerous plants that have the potential to be used as bio-pesticides (Dikshit *et al.* 2014). Many researchers have tried to evaluate the efficiency of diverse plant extracts against *E. turcicum.* plants like *Azadirchata indica, Polyalthia longifolia and Ocimum sanctum*, neem seed kernel extracts (Harlapur *et al.* 2007; Vishwanath *et al.* 2018; Subedi *et al.* 2019), and neem oil (Wani *et al.* 2017), *Magnolia cylindrical* (Dong Hui *et al.* 2009), *Rauwolfia serpentina* (Malik *et al.* 2018), *Lantana camera* (Vishwanath *et al.,* 2018; Subedi *et al.* 2019), and *Allium sativum (* Manu *et al.* 2017a; Subedi *et al.* 2019). *Acorus calamus, Artimisia indica, Xanthoxylum armatum* (Subedi *et al.* 2019), and *Datura stramonium* (Rani *et al.* 2022) have shown their effectiveness against the pathogen.

The application of fungicides is the most effective means to manage plant disease. Different fungicides have been evaluated against TLB of maize by several workers, and these fungicides have shown antifungal activity in varying degrees as per their mode of action. Amongst the fungicides, triazole fungicides, namely, propiconazole, difenocon-azole, tebuconazole, and hexacon-azole, have been tested. (Malik *et al.* 2018; Bindhu *et. al.* 2019; Limdolthamand *et. al.* 2023). Fungicides like Tebuconazole effectively suppress the disease if they are applied in combination with other fungicides like Trifloxystrobin, bio-agents, and cultural management practices (Bindhu *et. al.,* 2019). In the same way, propiconazole 0.1% has been reported as the most effective fungicide against Turcicum leaf blight by many workers (Ali *et. al.* 2015; Wani *et al.* 2017; Malik *et al.* 2018; Rani *et. al.* 2022). Beside triazole fungicides, benzimidazole groups of fungicides like Carbendazim 12WP (Subedi *et al.* 2019), dithiocarbamate like Mancozeb (Singh *et. al.* 2015; Malik *et. al.* 2018; Wani *et al.* 2017; Vishwanath *et al.* 2018), and strobilurins are effective and can be considered as key components while formulating an integrated management strategy.

CONCLUSION

Turcicum Leaf Blight disease, caused by *Exserohilum turcicum,* is one of the most destructive diseases of maize, causing as much as 90% yield loss. The disease is prevalent in warm and humid regions throughout the world. In India, this disease is prevalent and is distributed in Karnataka, Maharashtra, Andhra Pradesh, Uttarakhand, Bihar, West Bengal, Manipur, and almost all the maize-growing states. Meteorological and geological parameters like maximum relative humidity, rainfall, and altitude play an important role in disease severity. The disease can be effectively managed by adopting integrated management practices that combine cultural, biological, botanical, and chemical components.There are number of genotypes have potential for developing promising varieties with desirable resistance levels in disease-prone areas, aiming to enhance sustainable productivity

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