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Review article

TURCICUM LEAF BLIGHT OF MAIZE INCITED BY *Exserohilum turcicum*: A REVIEW

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INTRODUCTION

Globally maize (*Zea mays* L.) is the first and most important cereal crop gown under diversity of environments unmatched by any other crop, as expansion of maize to new areas and environment still continues due to its range of plasticity. It is prone to as many as 112 diseases in different parts of the world, caused by fungi, bacteria, viruses and nematodes leading to extensive damage. In India about 61 diseases have been reported to affect the crop. These include seedling blights, stalk rots, foliar diseases, downy mildews and ear rots (Payak*et al.*, 1973 and Payak and Sharma, 1985).Among the fungal diseases turcicum leaf blight caused by *Exserohilum turcicum* (Pass.). Leonard and Suggs. (Synonyms:*Helminthosprium turcicum* (Pass.) Leonard and Suggs) [Perfect stage: *Setosphaeria turcica* (Luttrell) Leonard and Suggs. (Synonym: *Trichometasphaeria turcica* (Luttrell)] is one the important foliar disease causing severe reduction in grain and fodder yield to the tune of 16 -98% (Kachapur and Hegde, 1988). The disease was first described by Passerini (1876) from Italy and by Butler (1907) from India. In India, this disease is prevalent in Andhra Pradesh, Karnataka, Bihar, Himachal Pradesh and Maharashtra. Turcicum leaf blight is potentially an important foliar disease in areas where the temperatures drop at night while the humidity is high. The disease is known to affect maize from seedling stage till harvest. Loss in grain yield will be more if it occurs at flowering, silking and grain filling stages. Lesions produced on the leaves of susceptible plants are normally large (4 -20 cm long and 1-5 cm wide), elliptical in shape and greyish green to tan in color, in conditions of high relative humidity, lesions may be covered with masses of dark conidia of the fungus. The conidia are olive grey and spindle shaped with 1- 9 septations. These conidia spread through air germinate on the surface and penetrate directly. Turcicum blight injures or kills the leaf tissues and thereby reduces the area of green chlorophyll which manufactures food for the plant. If considerable leaf area is killed the vigour and yields are reduced. If much of the green area is killed starch formation is restricted and the kernels are chaffy. The blighted leaves are not suitable for fodder because of the lowered nutrition value. Pant et *al.,* (2001) reported about 91 per cent reduction in the rate of photosynthesis when severity of turcicum leaf blight incidence in maize exceeded 50 per cent.

Symptomatology

The disease starts at first as small elliptical spots on the leaves, greyish green in colour and water soaked lesions. The spots turn greenish with age and get bigger in size, finally attaining a spindle shape. Individual spots are usually ¾ inch wide and 2 to 3 inch long. Spores of the fungus develop abundantly on both sides of the spot. Heavily infected field present a scorched appearance (Chenulu and Hora, 1962). Ullstrup (1966) described the symptoms of the disease in United States. The disease is recognised by long elliptical grayish or tan lesions. When fully expanded, the spots may be 1½× 6 inches in size. These lesions appear first on the lower leaves and as the season progresses, the lesion number increases and all the leaves are covered. The plants look dead and grey.

History and Nomenclature of the Pathogen

Turcicum leaf blight of maize caused by *Helminthosporium turcicum* Pass.was first reported by Passerini (1876) in Perma, Italy. Later on, Pammel *et al*. (1910) and Drechsler (1923) regarded it to be the same as *Trichometasphaeria turcica* Luttrell. Further, Leonard and Suggs (1974) renamed the perfect stage *as Setosphaeria turcica* (Lutrell) Leonard and Suggs and described the conidial stage as *E. turcicum* (Pass.) Leonard and Suggs in which the conidial hilum is strongly protruberant. In India, the disease was first reported by Butler in 1907 from Bihar.

Later it was reported from many parts of the country, viz., Lalmardi, Srinagar (Kaul, 1957), Punjab (Mitra, 1981), Himachal Pradesh (Chenulu and Hora, 1962) and Kashmir valley (Payak and Renfro, 1968). The sexual stage of the fungus, *Trichometasphaeria turcica* Lutrell rarely occurs in nature (Lutrell, 1958). The causal agent of turcicum leaf blight on maize is normaly identified by its imperfect stage *E. turcicum*.

The fungus belongs to division Eumycota, sub-division Deuteromycotina, order Moniliales and family Dematiaceae. The teleomorph *Setosphaeria turcica* belongs to division Eumycota, sub-division Ascomycotina, order Pleosporales and family Pleosporaceae. Conidia of the fungus are olive grey and spindle shaped, measuring 5 x 20 µm with one to nine septa. Presence of protruding hilum is the identifying feature due to which it has been designated as *E. turcicum*.

Cultural Studies

Robert (1960) identified two races of *Helminthosporium turcicum* on ten American strains of corn and noticed cultural changes in two races as they grew on artificial media and concluded that *H. turcicum*, *H. carbonum* and *H. sativum* consist of two or more parasiticraces. Robert (1960) and Rodriquez (1961) reported physiologic specialization in maize and sorghum isolates tested in their respective hosts. They also observed morphological and cultural variations of the isolates. Misra and Singh (1963) studied the effect of temperature and humidity on the development of a maize isolate of *H. turcicum* and found that the optimum temperatures for spore germination, growth of the fungus in culture,and for infection and development of disease were 20-30°C, 25-30°C, and 30°C, respectively.

Bergquist and Masias (1974) reported the optimum growthrate of sorghum and maize isolates of the fungus at 28^0C while abundant sporulation was observed at 24^0C.

Pedersen and Brandenburg (1986) reported that isolates from Delaware, Florida, Pennsylvania and West Virginia had significantly larger radial growth on lactose-casein hydrolysate agar after 10 days at 20 ^{0}C temperature than isolates from lowa, Illinois, and Indiana. Conversly, isolates from Champaigan and Iroquois and La Grange County in Indiana had significantly larger radial growth diameters at 28 than at 20^0C temperature.

In a study Daniel Abebe and Narong Singburaudom (2006) reported variation in the cultural characters of 28 isolates and they showed variation in colony growth, colony color and pigmentation.

Harlapur *et al.*(2007)observed the growth of 16isolates and reported that growth in five isolates, viz., Et1, Et4, Et5, Et9 and Et11 was considered as profuse and fast growing. Excellent growth was obtained in Et2 and Et15 isolates. Growth of isolates Et6 and Et12 was rated as good. Moderate growth was observed in Et7, Et10, Et14 and Et16 isolates. But, poor growth was observed in Et3, Et8 and Et13 isolates. Maximum radial growth was observed in the isolate Et1 with colony diameter of 87.33 mm followed by Et4, Et9 and Et15 (86.33 mm each). Minimum colony diameter of 52.00 mm was seen in Et13 after 12 days of incubation. Maximum dry mycelial weight of 315.34 mg was observed in Et9 followed by Et11 (314.67 mg) and Et4 (308.00 mg).

Isolates from different agro-ecological zones showed variation in morphology, pigmentation, growth rate and sporulation rate in different media Muiru *et al.*(2008). The different light regimes had significant effect on the growth rate and sporulation of *E. turcicum* isolates. The type of media and incubation temperatures had a significant effect on the growth rate of different isolates. The optimum temperature was 25^0C and only one isolate had minimal growth below 10^0C and no growth was observed in all the isolates at 40^0C.

The germination of conidia of *E. turcicum* [*Setosphaeria turcica*], causing turcicum leaf blight of maize, was tested out at various incubation periods starting from 4 to 36 h at an interval of 4 h. The maximum conidial germination (94.20%) was observed after 36 h of incubation, while the least germination (7.67%) was noticed after 4 h. More than 50% germination was observed after 16 h of incubation. However, there was no significant increase in the germination of conidia from 28 to 36 h of incubation Harlapur and Kulakarni (2009).

Gowda *et al.* (2010) studied the cultural and morphological variation of the 13 isolates of maize Turcicum leaf blight (TLB) caused by *E. turcicum*. The cultural variability was carried out on five solid media namely Czapek's medium, glucose peptone medium, maize leaf extract medium, potato dextrose agar medium and Richard's medium. Observation on variation in mycelia weight, sporulation and morphological characters were recorded. The isolates from Almora, Bajaura and Nagenahalli were observed to exhibit fastest growth as compared to other isolates. The Coimbatore and Udaipur isolates were grouped in slowest growing category. The Nagenahalli, Hyderabad, Coimbatore and Almora isolates exhibited light brown to bright brown color colony with compact growth, while the Udaipur, Jorhat and Jashipur isolates exhibited olive green color. In general, most of the isolates showed better in respect of sporulation and mycelial weight.

Morphological Studies

Variation in morphological characters of seventy isolates of *Exserohilum turcicum* was studied by Daniel Abebe and Narong Sing buraudom (2006) and reported that the conidia shapes were curved, spindle and elongated. The size of the conidia averaged 93.97 µm in length and 13.11 µm in width. The number of septa was found to range from 2 to 7.
Harlapur *et al.* (2007) studied morphological and cultural characters of 16 isolates of *E. turcicum* and observed variation in colony character, colony diameter, mycelial dry weight, spore germination. Bunker *et al.* (2011) studied morphological and cultural variability in five isolates of *Bipolaris maydis* from Rajasthan,Haryana and Uttarakhand and observed variation in mean length and width of conidia in isolates and it ranged from 55.02 to 81.80 µm and 12.45 to 16.70 µm, respectively.

Host range and pathogenic variability

E. turcicum is a common pathogen of sorghum, teosinte, *Paspalum*, and *Zea* in nature. In addition, *Triticum, Hordeum, Avena, Saccharum,*and *Oryza* are susceptible to *Eturcicum* whenartificially inoculated. Numerous workers have examined the host range of isolates of *E. turcicum* from maize, sorghum, and Johnson grass. There is a strong tendency for isolates from one species to infect that same species. Isolates from nature that were homokaryons were pathogenic to them on species, whereas species that were heterokaryons were capable of attacking two ormore species (Bergquist and Masias 1974).
Robert (1960) evaluated the reaction of eight inbred lines of corn to 27 single- conidial isolates of *E.turcicum* by rating infection on a scale from 1 to 11 , the reaction of 24 isolates collected from corn ranged from 1.1 to 7.1, thus displaying a wide range of aggressiveness. Robert also observed significant in bred isolate interaction, which she attributed to genetic differences among the isolates. In a subsequent study, Robert and Sprague (1960) observed slight differences in aggressiveness among isolates from the inbred lines K64 and CI.64. Isolates from K64 tended to be more adapted on K64 than on CI 64, and vice versa, although not all isolates conformed to this pattern. Thus, there appeared to be some physiological specialization among isolates for the partial resistance of K 64 and C.I64 , in addition to differences among isolates in generalized aggressiveness. Similar phenomena were observed in other pathosystems. Similarly, Nelson *et al*, (1970) observed that size of lesions on a susceptible inbred,R4,ranged from approximately 1.5 to 11.5 cm^2 for 69 different isolates of *E. turicum* .The number of lesions on the inbred C128A was slightly correlated with lesion size, indicating that aggressiveness of isolates could be expressed through various components of the infection cycle . Like Robert and Sprague, Nelson *et al*. (1970) also found an association between physiological specialization and aggressiveness.
Ayala-Escobar*et al.* (1997) reported the existence of special forms of *S. turcica* in maize in the Bajio region of Mexico causing damage to sorghum. Field isolates (140) of *S. turcica* were obtained and inoculated to seedlings of maize, sorghum and Johnson grass (*Sorghum halepense*). On the basis of pathogenicity, 3 special forms were distinguished. *Setosphaeria turcica* f.sp.*sorghi*, specific for sorghum and Johnson grass; *S. turcica* f.sp. *zea*, specific for maize; and *S. turcica* f.sp. *complexa* in sorghum and maize or sorghum and Johnson grass. No isolate was pathogenic to all 3 hosts. The response of 2 popcorn (Pirapoca and Composto Indigena) and 2 common maize (Iw and F-352) cultivars was evaluated to isolates of *E. turcicum* [*Setosphaeria turcica*] under greenhouse conditions (Fernandes *et al.*2002). Plants at the 4- to 5-true leaf stage were inoculated with 0.5 ml conidial suspension (5x103 conidia ml^{-1}) of *E. turcicum*. It was, characterized by monogenic resistance, showed varying response to the various isolates. F-352, characterized by polygenic resistance, and Composto Indigena exhibited high levels of resistance to all the isolates. Daniel Abebe and Narong Singburaudom (2006) studied the pathogenicity of seventy isolates of *E. turcicum* and among that twenty representative isolates were selected and evaluated for pathognicity on 11 seedlings of maize varieties. A significant difference in disease reaction was found among tested isolates, varieties and isolates and varieties interaction. Lesion size varied from 0.69 to 2.91cm.The most virulent isolate, GOR, was found to cause disease on five varieties. Lesion size that was classified as resistance, was 0.69 to1.12cm^2. Susceptible lesion size was between 1.17-2.91cm^2.
Bunker and Kusum Mathur (2010) collected eight isolates of sorghum leaf blight pathogen *E. turcicum* (Pass.) Leonard and Suggs from Rajasthan, Gujarat, Maharashtra and Andhra Pradesh during 2004-05 and reported the Pathogenic variability in pot-grown plants by inoculating them of on a set of 14 differential lines comprising 12 sorghum (*Sorghum bicolor* L. Moench) germplasm accessions and 2 maize (*Zea mays* L.) cultivars. Based on the disease severity and disease reaction the 8 isolates were distinguished into 5 pathotypes. Four isolates from Rajasthan were grouped into 3 different pathotypes and 2 from Maharashtra into 2 separate pathotypes, while the others from Gujarat, Maharashtra and Andhra Pradesh into a single pathotype. The isolate from Andhra Pradesh was the most virulent, followed by that in Rajasthan.

Levic *et al.* (2008) evaluated *E. turcicum* virulence factors and resistance responses of three sets of maize inbred lines (fourdifferentials, eight isogenic and 22 commercial inbreeds) to three isolatesof this pathogen under greenhouse conditions. Based upon virulence or avirulence of three isolates of *E. turcicum* on differential maize inbred lines, it was found out that the isolateMRIZP-1747 could be classified as race 0, whereas isolates MRIZP-1416and MRIZP-1435 could be classified as race 1. These are the first results that confirm the presence of race 1 of *E. turcicum* in Serbia. Not including differential lines, 22 and six lines were resistant to race 0 and race 1, respectively, while eight and five lines were resistant and susceptible to both races, respectively. All isogenic lines not containing the *Ht* genewere susceptible to both races 0 and 1.

Muiru*et al*. (2010) evaluated aggressiveness of 89 *E. turcicum* isolates comprising 59 Kenyan, 26 German and 7 Austrian isolates in green house condition and reported that isolates from the three countries showed a great variation in aggressiveness with incubation periods ranging from 2 to 6 days, lesion size ranging from 1.81 $mm^2$to 57.04 mm^2,rate of lesion expansionranging from 0.29mm2/day to 21.67 $mm^2 day^{-1}$ and audpc ranging from31.3 mm^2 to 133.9 mm^2. Twelve races namely 0, 1, 2, 3, N, 12, 13, 13N, 3N, 123, 23, 23N were identified from the three countries. Race 2 was the most common and had 27 % frequency of occurrence followed by race 0 and 1 which had frequency occurrence of 22 % and 12 % respectively.

Pathogenic variability and disease resistance to leaf blight in sorghum through a collaborative Sorghum Leaf Blight Virulence Nursery (SLBVN). The SLBVN consisting of 20 diverse sorghum lines were tested at three locations in India for 1-3 seasons (2007-09). Leaf blight severity recorded at the soft-dough stage of the crop varied significantly among lines, years and locations, indicating potential differences in virulence of *E. turcicum* populations at different locations (Kusum Mathur*et al*. 2011).

E.turcicum has a wide host range and under natural conditions it infects sorghum, teosinte, kodo millet, andmaize, but in specific inoculations it attacks wheat, barley, oats, sugarcane, and rice (Shaw 1921, Mitra 1923, and Misra 1979). This is important in the epidemiology ofthe disease. It indicates the possibility that the initialinoculum could come from any of these hosts if the fungus lacks host specificity.

Isolates of ***E.*** *turcicum* that infected sorghum weredifferent from those which infected maize (Shaw 1921) anddiffered culturally and pathogenically although they weresimilar in morphology (Mitra 1923). Lefebvre and Helen (1945) reported that isolates from sorghum failed to infectmaize, while isolates from maize infected sorghum. Bhowmikand Prasada (1970) reported that isolates of the fungus frommaize and sudan grass infected both of these hosts andJohnson grass but not sorghum. Isolates from sorghum werepathogenic to all of the four hosts tested.Misra and Mishra (1971a) made a comparative study offour sorghum isolates of the fungus from four widely separatedlocalities in India. They observed that there was adifference among the isolates in their physiological characters,pathogenicity, viability and colony growth at different temperatures.

Masias and Bergquist (1974) reported that isolates ofthe fungus which are pathogenic to only maize, sorghum orsudan grass were homokaryons. Isolates which were pathogenic to both sorghum and maize were heterokaryons. Hamid and Aragaki(1975) worked on 47 isolates of *Setosphaeria turcica* from sorghum and Johnson grass and observed that 18 isolates werevirulent only to the host species from which each was isolated. The remaining 29 isolates were virulent to at leastone other host.Arjunan *et al*.(1976) reported that sorghum isolates of the fungus infected *Eleusine coracana, Pennisetum typhoides, Setaria italica,*and *Panicum maximum*.

Misra (1979) reported that *E.turcicum* can infectmaize, several millet speciessuch as *Setaria italica. Eleusine coracana, and Paspalurn scrobiculatum,* sudan grass,Johnson grass, and teosinte. Shankerlingam and Balasubramanian (1984) reported that a sorghum isolate of the fungus infected maize. Sisterna (1985) tested the pathogenicity of isolates of *E.turcicum* from maize and sorghum on a range of cereals in a greenhouse, and found that only sorghum andmaize were infected with similar symptoms.

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