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Journal of Food and Nutrition
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ISSN: 2836-2276

REVIEW ARTICLE

Characterization and virulence determination of Northern Corn Leaf Blight of Maize (Zea Mays L.). A Review

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Received Date: 27 May 2023**; Accepted Date:** 10 July 2023**; Published date:** 11 July 2023

Citation: Daniel Abebe. (2023). Characterization and virulence determination of Northern Corn Leaf Blight of Maize (Zea Mays L.). A Review. Journal of Food and Nutrition. 1(1). DOI: 10.58489/2836-2276/010

Abstract

The main intention of this literature survey is to review to characterize the causative agent of northern corn leaf blight disease, caused by Exserohilum turcicum (Leonard and Suggs). Samples were from infected fields were examined for the variability experiments, maize isolates of E. turcicum were used to characterize morphological, pathogenicity and cultural variation respectively. All of the isolates differed in terms of cultural and physical characteristics. The pathogenic variability tested showed that isolates classified as more, less or none aggressive among the isolates tested.

Keywords: *exserohilum turcicum, northern leaf blight, pathogenicity, zea mays*

Introduction

Agriculture is the backbone of sub–Saharan African (SSA) countries, contributing significantly to Gross Domestic Product [1]. In this sector, grains are major product [2] of which Maize (Zea mays L.) is among the most adaptable growing crops is cultivated extensively throughout the world, with a wide range of adaptability under various agro-climatic conditions. Maize is regarded as the "Queen of Cereals" worldwide because it has the most significant genetic yield potential of any cereal. It is grown on about 150 million hectares in around 160 countries with diverse soil, environment, habitats, and management methods, accounting for 36% (782 million tons) of the global grain supply [3].

Several biotic and abiotic stresses impede the attainment of maximum maize yield potential. Prominent among the stresses is the attack caused by the fungus Exserohilum turcicum (Pass.) Leonard & Suggs, which commonly infects maize cultivated in humid mid- and high-altitude regions of the world [4 ,5]. The disease has a worldwide distribution predominantly in areas with 75%–90% relative humidity and 22°C–25°C temperature during the cropping season [6,7]. Northern corn leaf blight (NCLB) the causal agent of Exserohilum turcicum is among the most devastating foliar diseases, causing serious diminishment in grain yield of around 16–98% [8]. The yield loss depending on the growth stage of the crop at which infection occurs, the severity of the outbreak, the resistance of the host plant and the virulence of the pathogen. The disease is more destructive if it appears prior to silk emergence. Disease development during the early growth stages results in the premature death of leaves.

Northern corn leaf blight incidence ranges from 95 to 100% in areas with constant moisture and high humidity and the yield loss can reach up to 70%. Turcicum leaf blight is reported to cause devastating damage on most commercial varieties of maize released in the country [9]. Northern Corn Leaf Blight (NCLB) is an important disease of corn and causes significant economic loss worldwide [10]. Northern corn leaf blight varies in incidence and severity from year to year and from one locality to another depending largely on genetic makeup of the plants and prevailing environmental conditions. It is a multiple cycle disease and new repeated inoculations are needed for disease development making it highly dependent upon sporulation from other lesions [11].

This research will benefit breeding programs developing NCLB disease resistant corn varieties because use of stress resistant/tolerant parental inbred lines increases the chances of developing stress resistant/tolerant maize hybrids and also breeding is most sustainable, environmentally friendly and economically feasible management strategy [12]. Results of our study will facilitate farmers by the extension program; this will also lead to reduction of chemical fungicide usage, maintenance of beneficial microorganisms in the soil and increased yields without increasing planting areas.

E. turcicum is highly versatile to changing environmental conditions and shows high variability across different agro-climatic regions. Therefore, in order to document the changes occurring in populations and individuals, variability studies are important as it indicates different pathotypes and may open up a new avenue for disease management in the future. Variation in pathogen can be generally detected by their cultural and morphological characters. Therefore, a summary is given of this review of the key research that has been conducted on E. turcicum on the cultural, pathogenic variation and morphological characteristics of the pathogen by collecting the fungus from several maize growing areas

Materials and Methods

As a methodology the main source for this systematic literature reviews were different publication journal publication year 1960-2022. To retrieve conference paper, journal articles, literature review and book chapters from these peer reviewed data. Through searching results 31 papers were retrieved and by reading abstract, key work and conclusion parts of these paper were identified that meet the objective of this report. Then, country of origin, year of publication, publisher, journal name, focus areas of the paper, methodology and findings of the paper were considered and analyzed.

Cultural characteristics

Colony colour

Pure isolates collected from North Thailand grown on PDA plates for 10 Days initially produced grayish white colonies subsequently changed to greenish, and the color of PDA changed to dark green [10]. The colony color 45 isolated collected 5 district in Bihar, India varied from olivacous brown to whitish black color [13]. In a study [14] reported from Ethiopia variation in the cultural characters of 28 isolates and they showed variation in colony color. The researcher conducted by [15] in their study, isolate G001 had regular margin, was grey in colour with brownish pigmentation and had profuse growth. Isolate K005 was light and grey with regular margin and had black pigmentation. Isolate M004 was light grey with circular margin and had golden brown pigmentation and showed profuse growth. Isolate G002 was dark grey in colour with irregular margin with greenish pigmentation and showed profuse growth. Isolate T002 was greyish in colour, had brownish to blackish pigmentation with irregular margin while the growth was sparse. The authors in study paper [16] confirmed nine colonies isolate which grow on PDA ranged from white to gray to dark brown, with light tan. [17] studied the cultural 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 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.

Colony growth

Cultural characteristics revealed that, there was variation in conidial growth rate among isolates. The fungus isolates could be divided into two groups, slow and fast growth rate. conidial growth rate was investigated by culturing conidia of 28 isolates on PDA and lengths of conidia were measured under microscope at 9 and 13 days after culturing [14]. [18] 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 0C temperature than isolates from Iowa, Illinois, and Indiana. Conversely, isolates from Champaigan and Iroquois and La Grange County in Indiana had significantly larger radial growth diameters at 28 than at 20^{0}C temperature. [19] observed the growth of 16 isolates 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. [20] stated the colony colour of fungus was recorded 14 days after incubation on PDA medium the colony colour varied from grey to black colour. Based on the colony colour all the nine isolates were grouped in 8 categories i.e., dark Grey, light greenish, white to grey, yellow, blackish, creamy white, white to black and black. The KEt5 (Kannad), KhEt8 (Khultabad) and SoEt9 (Soegaon) showed Black colony colour where isolate AEt1 shown Dark greyish to black colony colour. The isolates SEt2 from Sillod showed yellow colony colour and GEt3 from Gangapur showed light greenish colony colour which was distinctly different from all other isolates. The isolates PEt4 (Paithan) showed white to grey colony colour while creamy white colony colour was observed in the isolates VEt6 from Vaijapur. PhEt7 from Phulambari showed white to black colony colour

Morphological characteristics

Conidial Shape

The conidial shapes observed in this study were curved, spindle or elongated with characteristic protruding hilum on one end which agreed with findings by [8,14,19]. [15] reported that E. turcicum isolates from different location in Tharaka Nithi County the conidia observed in this study were straight to slightly curved and spindle shaped. The study by [21] investigated all the eight isolates of E. turcicum were grown on PDA and after ten days of incubation the morphological characters were studied and almost all the isolates showed variation in the morphological characters such as the size of conidia, and septations

Number of septa

The proposed study by [21] Conidia of maximum number of isolates were having the septa of 4-5 (Et1, Et3, Et4 and Et6) and 5-6 (Et2, Et5 and Et 6) with protruding hilum. It is interesting to note that the isolate Et8 from Raichur local had maximum of 4-7 septa. Interestingly, an isolate Et16 and Et28 from Hadagali and Kanakagiri respectively having 3 to 15 septa, followed by 3-10 septa in Tupparagadde (Et27) isolate. These results are in similar with findings of [19] who observed variation in morphologic and cultural characters of 16 isolates of E. turcicum. The number of septate of conidia study by [15] ranged from 3-7 septate and conidia had protruding hilum at one end. Researchers study result [14] reported the number of septa was found to range from 2 to 7.

Conidial length

Variation in morphological characters of seventy isolates of Exserohilum turcicum was studied by [14] reported that the conidia size averaged 93.97 µm in length and 13.11 µm in width. [22] studied morphological and cultural variability in five isolates of Bipolaris maydis from Rajasthan, Haryana and Uttara hand 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. The size of the conidia averaged 73.79 µm in length and 22.42 µm in width. Among the isolates, conidia size was maximum in isolate PhEt7 (97.96× 26.52µm) and minimum in isolate AEt14 (49.62×15.55 µm) [20].

Pathogenic variation

The pathogenic reaction of different isolates was categorized as per the scale proposed by [23] and the results revealed significant variation in virulence among E. turcicum isolates on the test genotypes. All the isolates produced disease on the test host genotypes in a moderate to severe form and none of the test genotypes were free from the diseases [24]. [14] studied the pathogenicity of seventy isolates of E. turcicum and among that twenty representative isolates were selected and evaluated for pathogenicity 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 to1.12cm2. Susceptible lesion size was between 1.172.91cm2. [25] 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.

[26] evaluated E. turcicum virulence factors and resistance responses of three sets of maize inbred lines (four differentials, eight isogenic and 22 commercial inbreeds) to three isolates of this pathogen under greenhouse conditions. Based upon virulence or a virulence 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 MRIZP1435 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. [27] reported all isogenic lines not containing the Ht gene were susceptible to both races

0 and 1. The pathogenic variability tested on Thai Super Sweet (TSS) corn variety, showed that isolates ET001 and ET003 were more aggressive while isolate ET005 was less aggressive among the isolates tested.

[28] demonstrated that strains from various geographical regions were distinctive in parasitic action while strains of the same area indicated less variability. [29] stated that, E. turcicum isolates showed differences in virulence level and in isolates B3, B5 and G7, the lesions combine to form huge chlorotic and necrotic lesions, while in isolates Sorte 2, S62 and G5, the lesions remained as little chlorotic specks limited in the regions secured by the drop of the spore suspension. The period of incubation extended from two to six days for the most aggressive and the least aggressive strains respectively, and the normal period of incubation was 3.8 days for most of the isolates [29]. [30] assessed the response of eight in bred lines of corn, to twenty-seven single-conidial strains of E. turcicum by rating disease on a scale from one to 11, the response of 27 strains to corn ranged from 1.1 cm2 to 7.1 cm2, along these lines showing an extensive variability of aggressiveness. Slight variability in virulence level among isolates from the inbred lines CI.64 and K64 indicated that, there are some physiological specializations among isolates for the halfway resistance of C. I64 and K 64, in relation to differences among isolates in term of aggressiveness [30]. [31] stated that size of lesions on a susceptible line, R4, ranged from 1.5 to 11.5 cm2 for 69 diverse isolates of E. turicum. The quantity of lesions on the in bred line C128A, was marginally corresponded with the size of the lesion, demonstrating that aggressive level of isolates is expressed through different parts of the infection cycle. Similar to Robert and Sprague [30,31] found the relationship between physiological specialization and aggressiveness of E. turcicum pathogen.

Conclusions

In this literature review research conducted on pathogenic, cultural and morphological variability among Exserohilum turcicum isolates has been reported. Most often, researchers investigated the variation pathogenicity and characteristics of cultural and morphological among maize isolates collected from different maize growing areas. The literature review data was collected from 31 retrieved research papers. This study characterized E. turcicum isolates associated with maize crop that is grown indifferent region. The results obtained from the current review proved that the E. turcicum pathogen is the causative agent of turcicum leaf blight of maize in different maize growing county. The E. turcicum isolates studied were culturally and morphologically different. The variations were observed in cultural characteristics such as colour, pigmentation, growth and pattern. Morphologically, conidia lengths were significantly different their width were significantly different. The variations observed were attributed to the prevailing varied weather conditions in isolated collected places. The current study recommendation is that molecular characterization should be done for race determination of E. turcicum isolates since they registered variation both on cultural and morphological aspects.

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