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Estimating the maydis leaf blight disease severity of maize in Southern Karnataka and identifying potential resistant varieties

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Abstract
A roving survey was carried out in maize growing regions of Southern Karnataka (Mandya, Hassan, Mysuru and Chamarajanagar districts) in farmer's field during October 2021 and also 69 maize inbred lines and 19 hybrids were screened under field conditions against *Bipolaris maydis* during *Kharif* 2021. Among the four districts surveyed, Hassan district recorded highest average disease severity of 30.93% Mysuru district recorded lowest average disease severity of 19.72. Among inbreds and hybrids screened eight of them were resistant with mean PDI ranging from 17.78-31.11% and AUDPC ranging from 435.56-700.00. 47 of them were moderately resistant with mean PDI ranging from 35.56-53.33% and AUDPC ranging from 701.00-1190.00. 22 of them were moderately susceptible with mean PDI ranging from 57.78-75.56% and AUDPC ranging from 1191.00-1820.00 and 11 of them were susceptible with mean PDI ranging from 77.78-97.78% and AUDPC ranging from 1821.00-2372.22.

Keywords: Survey, screened, maize, *Bipolaris maydis*, disease severity, PDI, AUDPC

Introduction
Maize (*Zea mays* L.) belonging to the family poaceae is the third most important annual cereal crop after rice and wheat and is also accepted as a staple food source in the entire world. Globally, maize is known as "Queen of cereals" and also "Miracle crop". Bulk of the maize production in India, approximately 47% is used as poultry feed. Of the rest of the produce, 13% is used as livestock feed and food purpose each, 12% for industrial purposes, 14% in starch industry, 7% as processed food, and 6% for export and other purposes (ICAR-IIMR, 2022) [10].

Globally, nearly 1147.7 m t of maize is being produced together by over 170 counties from an area of 193.7 m ha with average productivity of 5.75 t ha^{-1} (FAOSTAT, 2021) [6]. In India, the total production is 28.56 m t from an area of 9.56 m ha with average productivity of 3.07 t ha^{-1}. While, in Karnataka maize is cultivated in an area of 1.29 m ha with a production of 3.73 m t and productivity of 2.89 t ha^{-1} (Anon., 2020) [2].

As many as 112 diseases are known to occur on corn in the corn growing countries. Around 65 diseases have been reported from different regions in India. With respect to production loss due to the diseases, 11 out of 65 diseases are of national importance in the Indian scenario (ICAR-IIMR, 2020) [11].

Among them foliar and fungal diseases, Maydis leaf blight (MLB) caused by *Helminthosporium maydis* (Syn. *Bipolaris maydis* (Nisikado and Miyake), (Telomorph: *Cochliobolus heterostrophus*) is a serious fungal and polycyclic disease, where maize is grown under warm and humid conditions throughout the world (Srivastava, 2017) [14]. The fungus *B. maydis* (Teleomorph: *Cochliobolus heterostrophus*) exists as four different races (race 'T', 'O' 'C' 'S') infecting maize across the world. Race 'T' of *B. maydis* is highly virulent and reported to cause the devastating 'Southern corn leaf blight' epidemic in the USA during the 1970s, resulting in huge losses due to the extremely susceptible response of Texas male sterile maize lines (Singh *et al.*, 2021) [13].

A yield loss of about 12.69 to 42.66 percent is observed in Maydis leaf blight infected plant under favorable environmental conditions (Temperature-22-30 °C, Relative Humidity

72-98% and Rainfall-134-165 mm) depending on the maize cultivars and severity (Gogoi *et al*., 2020) [7].

Since, it is a food crop of economic significance so, by knowing the causes of disease and damaging effects of a disease at particular growth stage of plant will provide basic information to the growers to initiate appropriate management strategies on time to minimize the yield loss. In India, it occurs in wide range of maize growing states (Srivastava, 2017) [14] and various research results shows it to be a potent threat for maize production. And also, Karnataka being the major maize growing region in India and Maydis leaf blight is one of the major diseases in all maize growing regions of Karnataka with varied degree of severity. However, not much work has been carried out scientifically, regarding disease prevelance, severity, symptomotolgy, recognition of natural hotspots, identification of stable resistant sources against *Bipolaris maydis*. In view of above-mentioned facts, the present research has been undertaken to record the severity of Maydis leaf blight of maize in maize growing regions of Southern Karnataka and identification of stable resistant sources.

Materials and Methods

Survey on the disease incidence and severity of Maydis leaf blight of maize in Mandya, Hassan, Mysuru and Chamarajanagara districts

Roving method was followed to record the prevalence and severity of Maydis leaf blight of maize. Percent disease severity was recorded by field key (1-9 scale) on foliage as given by Hooda *et al.* (2018) [9] (Table 1) and these scales were converted to percent disease index (PDI) using the formula given by Wheeler (1969) [15].

$$PDI = \frac{\text{Sum of all disease ratings}}{\text{Total no. of ratings} \times \text{Maximum disease rating}} \times 100$$

Table 1: Standard evaluation system scale for Maydis leaf Blight of Maize.

Rating scale	Description (Degree of infection)
1.	Nil to very slight infection (10%)
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, few lesions scattered on middle leaves below the cob (30.1%-40%)
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 few lesions on two leaves above the cob (50.1%-60%)
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%)
9.	Very heavy infection, lesions abundant scattered on almost all, plants prematurely dried and killed (>80%)

Screening of the maize inbred lines and hybrids against *Bipolaris maydis*

Field layout

Screening of the maize inbred lines and hybrids against Maydis leaf blight was carried out during *Kharif* 2021 in C Block of ZARS, V. C. Farm, Mandya. Infector row technique was followed to identify the disease resistant sources in the present study. 69 maize inbreds and 19 hybrids (Table 3) were screened under field conditions**,** where these lines were planted with a spacing of 60×30 cm and replicated twice**.** Disease severity was recorded using the (1-9) scale (Table 1).

Mass multiplication of inoculum and artificial inoculation

Mass multiplication and artificial inoculation of *Bipolaris maydis* was carried out by multiplying the pathogen in Petri plates containing PDA, a technique given by Hooda *et al.* (2018) [9], where about 20 Petri dishes of 14 days old culture of *B. maydis* were macerated in water in a blender for 15-30 seconds, strained through a layer of cheese or muslin cloth and made up to four-five litres of suspension. This stock suspension was taken to the field and diluted in a compressed air sprayer (which should not have been used for fungicidal or insecticidal spray) at the rate of one litre in about 12 litres of water containing 10^6 cfu/ml. Inoculations was made twice per week for three weeks beginning when plants were 30-45 cm high and percent disease severity was recorded after 10 days of disease appearance and was scored using the (1-9) scale (Table 1).

Severity of Maydis leaf blight on inbred and hybrid lines

Percent disease severity was recorded by using field key 1-9 scale (Table 1), these scales were converted to percent disease index (PDI) by using the formula given by Wheeler (1969) [15] and computed for area under disease progress curve (AUDPC) based on severity of inbreds and hybrids, based on the disease reaction was divided into different categories.

Area under disease progress curve (AUDPC):

The "Area Under Disease Progress Curve" was calculated using the formula suggested by Campbell and Madden, 1990.

$$AUDPC = \sum_{i=1}^{n-1} [\{(X_i + X_{(i+1)}) / 2\} \times (t_{(i+1)} - t_i)]$$

X_i = disease index expressed as a proportion at the i^{th} observation.

t_i = time (days after transplanting) at the i^{th} observation

X_{i+1} = disease index expressed as a proportion at the $i+1^{th}$ observation.

t_{i+1} = time (days after transplanting) at the $i+1^{th}$ observation

n = total number of observations.

Results and Discussion

Survey

The disease was recognized through the peculiar symptom of small diamond shaped to elongated rectangular lesions of 2-6 cm length which is straw colored. The blighted areas being present more in mature leaves along the margin and midrib. Similar symptoms were observed by Akonda *et al.* (2015) [1] in a survey carried out in Bangladesh during January 2007 to March 2008.

The disease severity in the areas surveyed ranged from 19.72 to 30.93 percent. It was also observed that the disease prevailed throughout the growth stages of the maize from knee high stage to dough stage in the farmer's field and also percent disease severity varied in both local and hybrid varieties of maize. Among the four districts surveyed, Hassan district recorded highest average disease severity of 30.93 percent followed by Chamarajanagara district with 28.89 percent and Mysuru district recorded lowest average disease severity of 19.72 percent followed by Mandya district with 22.84 percent (Table 2).

In the taluks of four districts, Channaraypatna taluk of Hassan district recorded highest average percent disease severity of 42.23 percent followed by Chamarajanagara and Belur taluk being on par with 28.89% of Chamarajanagara and Hassan district respectively and Hassan taluk (28.15%) of Hassan district. The lowest average disease severity was recorded in Mandya taluk of Mandya district of 18.89% followed by Nanjungud taluk (19.44%) of Mysuru district.

The variation in disease severity was observed among the districts surveyed and it ranged from 19.72 to 30.93 percent. Likewise, the average disease severity varied from one taluk to another taluk, ranging from 18.89 to 42.23 percent. In villages of four districts the percent disease severity varied from 13.33 to 51.11 percent.

The highest disease severity was recorded at silking stage of the crop in hybrid variety with percent disease severity of 51.11% and the lowest disease severity was recorded at knee high stage in hybrid variety with percent disease severity of 13.33%.

Similarly, Harlapur and Utpal (2013) [8] reported that during *Kharif* 2011, Maydis leaf blight caused by *Bipolaris maydis* in North Karnataka, the percent disease severity ranged from 56.26 to 33.88 percent and during Rabi 2011 it ranged from 50.26 to 27.88 percent in Ranebennur and Kushtagi districts.

Likewise, In a Survey conducted during 1995-1996, 1996-1997 and 1997-1998 to obtain information on maize diseases in north Karnataka, India. Harlapur *et al.* (2000) [5] reported that, 53.5% incidence of turcicum leaf blight and 16.5% incidence of Maydis leaf blight during *Kharif* season.

Screening

Among the 69 maize inbred lines and 19 hybrids screened under field conditions against *Bipolaris maydis* during *Kharif* 2021 they were categorized into four kinds *i.e.*, resistant (PDI: ≤33.33), moderately resistant (PDI: 33.34-55.55), susceptible (PDI: 55.56-77.77) and highly susceptible (PDI ≥77.77) based on disease reaction (Percent Disease Index-PDI).

The MLB symptoms first appeared on 11 inbreds such as MAI 317, MAI 755, MAI 763, MAI 769, NAI 158, NAI 179, VL 108867, VL 1016247, KL 153120, KL 171521, MAI E2-14 at 40 DAS with mean PDI of 50.71 percent and mean Area Under Disease Progress Curve (AUDPC) of 177.47. The disease appeared lately in GK 3207 hybrid and in MAI E2-78, VL 055063, VL 102756, FSR 23, FSR 26, NAI 217, MAI 764 inbreds with mean PDI of 10.37 percent and mean AUDPC of 40.83 at 61 DAS. The progression in disease was observed with the increase in the age of the crop. The disease appeared in almost all inbreds and hybrids within 47 to 54 DAS and showed varied severity depending on disease reaction (Table 3.).

Among inbreds and hybrids screened eight of them were resistant with mean PDI ranging from 17.78-31.11 percent and AUDPC ranging from 435.56-700.00. 47 of them were moderately resistant with mean PDI ranging from 35.56-53.33 percent and AUDPC ranging from 701.00-1190.00. 22 of them were moderately susceptible with mean PDI ranging from 57.78-75.56 percent and AUDPC ranging from 1191.00-1820.00 and 11 of them were susceptible with mean PDI ranging from 77.78-97.78 percent and AUDPC ranging from 1821.00-2372.22.

Among 69 inbred lines screened, the inbred MAI 764 showed lowest mean PDI of 17.78 percent (AUDPC-435.56) which was significantly resistant among all the inbreds followed by FSR 23 with 22.22 percent mean PDI (AUDPC-513.33) and MAI 317 showed highest mean PDI of 97.78 percent (AUDPC-2302.22) followed by KL171521 with 95.56 percent mean PDI (AUDPC-2372.22).

Among 19 hybrids screened, the hybrid GK 3207 showed least mean PDI value of 31.11 percent (AUDPC-575.56) which was significantly resistant among all the hybrids followed by CP 508 with 37.78 percent mean PDI (AUDPC-770.00) and SUN 909 showed highest mean PDI of 73.33 percent (AUDPC-1485.56) followed by GK 3018 with 66.67 percent mean PDI (AUDPC-1322.22) (Table 4.).

It was observed that among inbreds and hybrids screened MAI 764 was resistant against the pathogen with least mean PDI of 17.78 percent and AUDPC of 435.56 and MAI 317 was susceptible against the pathogen with highest mean PDI of 97.78 percent and AUDPC of 2302.22. However, both inbreds and hybrids were found resistant which could be further used in breeding program to develop resistant sources against Maydis leaf blight disease.

Omprakash *et al.* (2016) [12] reported significant variation among the inbreds for AUDPC values. They found that in 53 maize inbreds screened during 2013 and 2014 in two environments at BHU, Varanasi and Mandya, Karnataka, AUDPC value ranged from 600-950 in resistant, 951-1350 in partially resistant, 1351-1650 in partial susceptible, 1651-2000 in Susceptible and 2001-2350 in highly susceptible.

Similarly, Bhandari *et al.* (2017) [3] observed that the MLB disease symptom appeared first in yellow popcorn at 63.67 DAS and lately on RML-32/RML-17 at 79.00 DAS with the least score in field. Symptoms appeared in all maize genotypes within 63.67 to 79 DAS.

From the present study it could be concluded that maize grown in Mandya, Hassan, Mysuru and Chamarajanagar districts of Karnataka were found infected with Maydis leaf blight with varying percent disease severity ranging from 19.72 to 30.93 percent. The disease prevailed throughout the growth stages of the maize from knee high stage to dough stage in the farmer's field. Among the four districts surveyed, Hassan district recorded highest average disease severity of 30.93% Mysuru district recorded lowest average disease severity of 19.72%. And also, from the screening

which were carried out during *Kharif* 2021, eight were resistant, 47 were moderately resistant, 22 were moderately susceptible and 11 were susceptible. Hence, the identified resistant sources can be used in breeding programme to develop resistant varieties.

The disease being great threat to further yield production, and farmers mainly depend fungicide application for the management which causes environmental pollution, destructs the beneficial microorgansims and also affects the applicator *via*., toxicity. Hence, the survey and screening results provides an insights into the regions where disease is prevailing and an alternative strategy in management of disease by using resistant varieties which acts as a sustainable method.

Future Prospect

The insights of the study helps in developing resistant varities, which acts as a major contribution to farmers distress in management of the disease and also further the cultural, morphological and molecular characterisation of the *Bipolaris maydis* can be carried out to further benefit the research and development in disease management.

Conflict of interest

The authors declare no competing interests

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