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Research Article

Prevalence of Southern Leaf Blight of Maize in two major maize producing states of India

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Abstract

Southern corn leaf blight (SCLB) or Maydis leaf blight, caused by *Bipolaris maydis,* is an important disease of maize in the eastern and north-eastern part of India. Hence, to assess the severity and distribution of the disease in two distinct and major maize growing states i.e. Mizoram and West Bengal were selected. A roving survey was conducted under different agro-climatic conditions during the *kharif* season of 2019 and 2020 in three districts of West Bengal and as well as in Mizoram. The survey results revealed that SCLB was more prevalent in the plains of West Bengal in comparison to hilly areas of Mizoram. The mean SCLB incidence varied from 18.87% in Zemabawk, Mizoram to 63.22% in institutional farm, C-block, of BCKV, West Bengal. The mean disease severity ranged from 10.06 % in Muthi, Mizoram to 22.09% in Instructional Farm, Jaguli, BCKV, West Bengal. Both disease incidence and severity were highest at 99 DAS in all the locations surveyed. Successive surveys of SCLB in the maize growing belts across the country need to be conducted to develop a better understanding about the disease prevalence, intensity and severity under different agro-ecological conditions.

Keywords: *Bipolaris maydis,* disease incidence, Maydis blight, roving survey, *Zea mays.*

1. Introduction

Maize (*Zea mays* L.) is an important staple crop worldwide, with a share of 36% (782 million tons) in the global grain production (Solaimalai *et. al*., 2020). Owing to its ability to thrive in a wide range of agro-climatic conditions, it is cultivated across 160 countries with acreage of 201 mha (FAOSTAT, 2022). According to Directorate of Economics and Statistics, Ministry of Agriculture (2020), India ranks fourth in terms of area (4%) and seventh in terms of production (2%) globally. In 1950-1951, India produced 1.73 million metric tonnes of maize which increased upto 27.8 million metric tons in 2018-2019 i.e. an almost 16 fold increase (Basandrai *et. al.,* 2020). Maize production in India exceeded 31 million metric tonnes in the fiscal year 2021 (FAOSTAT, 2022). As per the latest data by Indian Institute of Maize Research, Madhya Pradesh and Karnataka have the most area under maize (15%) among Indian states, followed by Maharashtra (10%), Rajasthan (9%), Uttar Pradesh (8%), and others.

In 2020, maize production of West Bengal was 1.64 million tones (Anon,2020). Maize production of West Bengal increased from 0.71 million tonnes in 2017 to 1.64 million tonnes in 2020 growing at an average annual rate of 35.68% (Debnath *et al.,* 2019). It is Mizoram's second most significant cereal crop after rice, and it is farmed as a single crop or in combination with other crops and trees in a variety of agro environments. As per the report published by department of Agriculture, Mizoram, maize is cultivated in an area of 6,946 ha, with a total production of 12,556 metric tones (Anon,2020a). Although production of maize has grown in India, owing to increased area, productivity has decreased from 2,093 to 1,940 kg/ha over the same time period owing to an increase in the exposure to biotic stresses (Singh *et. al.,* 2019).

The crop is known to be infected by a number of pathogens including fungi, bacteria and viruses (Mubeen *et. al.,* 2017). Among the fungal diseases of maize, Southern corn leaf blight (SCLB), caused by the fungus *Bipolaris maydis*, is a serious foliar disease (Aregbesola *et. al.,* 2020; Debnath *et al.*, 2021). Although the disease has been documented in most maize-growing locations around the world, it is most severe in hot and humid tropical and temperate climates. SCLB has emerged as a major disease in the Indian subcontinent and neighboring areas, resulting in a yield loss of almost 35-40% (Bruns, 2017). The disease is found in warm humid temperate to tropical regions with temperatures ranging from 20^{0}C to 30^{0}C throughout the cropping season (Debnath *et al.*,2019).

For assessing the severity of a disease, survey is an important tool. In the recent years, roving surveys have gained importance as it provides a wholesome picture of the pathogen abundance in a shorter duration (Thapa *et al.*,2022; Das *et al.*,2022). Further, since roving surveys or mobile surveys are conducted on randomly selected spots, it also helps in better allocation of resources with maximum results.

The present investigation, hence, was carried out as a roving survey to develop a comprehensive idea of the incidence of the disease, the disease severity and extent of the disease spread of southern corn leaf blight of maize under different agro climatic zone of West Bengal and Mizoram.

2. Materials and Methods

A roving method of survey for southern leaf blight of maize was conducted in different agro-climatic conditions under different maize growing districts of West Bengal, viz., Nadia, Murshidabad and North 24-Parganas and in different districts of Mizoram *viz.*, Mamit, Kolasib & Aizawl (Fig. 1), those are also known for hot spot location for southern leaf blight of maize. For West Bengal conditions, Kaveri variety was assessed while traditional maize lines, viz., Mimpui, Mimban, Puakzo, RCM 75 and RCM 76 were assessed in Mizoram. The location (Global positioning system, GPS reading) was also recorded. Zones and districts were chosen based on differences in production (farming) systems, climatic conditions (relative humidity, maximum and minimum temperatures), altitudes, important transportation corridors and vegetation cover (availability of maize crop) (Ramathani *et al.*, 2011). Observations of disease incidence and severity for southern leaf blight of maize were recorded from the field. Ten maize plant stands were randomly picked in the centre of each indicated area and tested for incidence and severity (Nwanosike *et al.*, 2015).

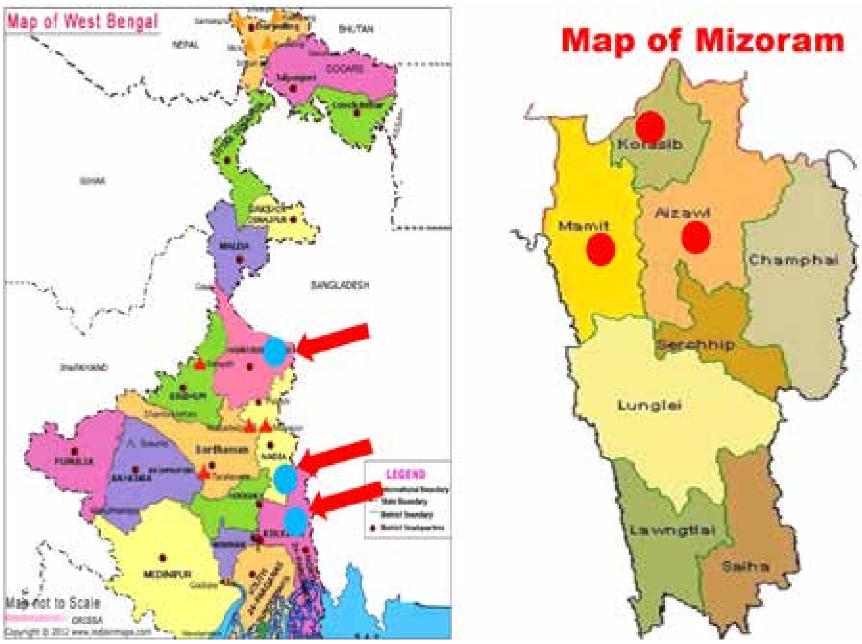

Fig-1: Map of West Bengal and Mizoram showing surveyed areas.

The proportion of plants showing symptoms in the field was used to calculate disease incidence. Disease incidence was recorded at 50, 57, 64, 71, 78, 85, 92 and 99 days after sowing (DAS). The number of plants showing maize leaf spot symptoms within ten randomly selected stands was tallied and expressed as a proportion of the total number of stands per plot using the formula below (Nwanosike *et al.*, 2015).

$$\text{Disease Incidence (\%)} = \frac{\text{No. of infected plants}}{\text{Total no. of plants assessed}} \times 100$$

Disease severity was recorded from 50 days after sowing in 10 plants per square meter in three different spots per plot, avoiding the border areas. The scoring was done at 50, 57, 64, 71, 78, 85, 92 and 99 days after sowing (DAS). It was assessed using the 1-5 standard disease scoring scale (Table 1) recommended by Shekhar and Kumar (2012) and Jakhar *et al.* (2017).

Table 1: Disease scoring scale for southern corn leaf blight disease of maize

Symptoms	Symptoms Severity Grade	Responsive value	Disease Reaction
No symptoms	0	No lesions	Symptom less
Very slight to Slight infection	1	One, two or few scattered lesions on lower leaves.	Highly resistant
Light infection	2	Light infection, Moderate number of lesion on lower Leaves only	Resistant
Moderate infection	3	Abundant lesion on lower leaves, few on middle leaves	Moderately resistant
Heavy infection	4	Lesions abundant on lower and middle leaves, extending to upper leaves	Susceptible
Very heavy infection	5	Lesion abundant on almost all leaves; plants prematurely dry or killed by the disease.	Highly Susceptible

Severity scores were converted to Percent Disease Index (PDI) using the following formula (Wheeler, 1969; Kumar *et al.*, 2011).

$$\text{PDI (\%)} = \frac{\text{Sum of all individual ratings}}{\text{Total no. of leaves examined} \times \text{Maximum rating}} \times 100$$

The Area Under Disease Progress Curve (AUDPC) was calculated using the standard method as recommended by Campbell and Madden (1990)

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

Where, Y is the AUDPC, X_i is the disease incidence of the *i*th evaluation, and X_{i+1} is the disease incidence of the $i+1$st evaluation, $t_{i+1} - t_i$ is the number of days between two evaluations.

The data recorded for disease incidence and PDI were recorded and the mean value, Standard error of mean and Critical difference was calculated using SPSS by employing SPSS (version 20.0 SPSS Inc., Chicago IL, USA) software package.

3. Results and Discussion

A roving survey was conducted to know the distribution and severity of SCLB of maize under different agro-climatic conditions during *kharif* season of 2019 and 2020 in West Bengal and Mizoram. Under West Bengal conditions, the survey was conducted in seven locations across three districts, while five locations across three districts of Mizoram were surveyed. It was observed that the disease severity level varied (43.51-100% at 99 DAS) from one locality to another especially between plains of West Bengal and hills of Mizoram, due to diversity in agro-ecological conditions and density of inoculum.

During the survey, typical symptoms of southern leaf blight of maize were observed in the form of lesions on the infected plant. The lesions were tan in colour with buff to brown borders. They begin as small, diamond-shaped spots which later transformed to larger, elongated, dark brown, necrotic lesions within the veins as described by Singh and Srivastava (2012), Kaur *et al.* (2014) and Dai *et al.* (2016).

The mean SCLB incidence varied from 18.87% in Zemabawk (Mizoram) to 63.22% at Instructural farm, C-block, Kalyani (West Bengal). Both disease incidence and severity were highest at 99 days after sowing (DAS) in all the locations surveyed.

The pooled data (Table 2) of both the years revealed the minimum disease incidence at 50 DAS while maximum was recorded at 99 DAS in all the locations surveyed. At 50 DAS, maximum disease incidence was recorded at Instructional Farm at Jaguli 2 (9.31%), statistically *at par* with Instructional Farm at C-Block, Kalyani (8.50%), followed by Instructional Farm at Jaguli 1 (6.17%), farmer's field at Char Jadubati P-1 (5.55%), farmer's field at Char Jadubati P - 2 (5.27%), farmer's field at Jalangi (5.02%) and farmer's field at Bodai (4.73%). The minimum disease incidence recorded at 50 DAS was in the farmer's field at Muthi (1.59%), statistically *at par* with farmer's field at Zemabawk (1.75%), followed by farmer's field at Dialdawk-2 (3.72 %), farmer's field at Dialdawk-1 (3.97%) and farmer's field at Meidum (4.67%) and these were statistically significant with Muthi and Zemabawk. As the disease incidence increases with time and age of the crop, the maximum disease incidence (100%) was recorded at 99 DAS in the Instructional Farm at Jaguli 1 and 2, Instructional Farm at C-Block, Kalyani, farmer's field at Char Jadubati P 1&2, farmer's field at Bodai and farmer's field at Jalangi respectively. At 99 DAS, the minimum disease incidence was recorded from farmer's field at Zemabawk (42.33%), statistically *at par* with farmer's field at Muthi (43.51%), followed by farmer's field at Meidum (69.17%), farmer's field at Dialdawk-2 (72.84%) and farmer's field at Dialdawk-1 (78.26%) which were statistically significant with each other as well as with the first two readings.

Table 2: Prevalence of Southern leaf blight of maize in West Bengal and Mizoram (Pooled mean of two years)

Location	Latitude and Longitude	Disease Incidence of Different DAS (Pooled mean of two years)							
		50	57	64	71	78	85	92	99
Instructional Farm, Jaguli-1, Nadia District	22°56'56"N 88°32'23"E	6.17 (14.38)	15.84 (23.45)	30.92 (33.78)	54.17 (47.39)	77.00 (61.34)	88.17 (69.88)	100.0 (90.0)	100.0 (90.0)
Instructional Farm, Jaguli-2, Nadia District	22°56.885'N 88°32.410'E	9.31 (17.76)	16.50 (23.97)	31.17 (33.94)	54.50 (47.58)	71.17 (57.52)	84.67 (66.95)	100.0 (90.0)	100.0 (90.0)
Instructional Farm, C-Block, Kalyani, Nadia	22°59'21"N 88°27'22"E	8.50 (16.95)	20.58 (26.98)	43.67 (41.36)	59.67 (50.57)	79.33 (62.96)	94.00 (75.82)	100.0 (90.0)	100.0 (90.0)
Char Jadubati P -1, Nadia District	22°59'25"N 88°24'56"E	5.55 (13.63)	11.83 (20.12)	24.78 (29.85)	43.50 (41.27)	62.17 (52.04)	83.83 (66.29)	100.0 (90.0)	100.0 (90.0)
Char Jadubati P - 2, Nadia District	22°59'25"N 88°24'56"E	5.27 (13.27)	10.75 (19.14)	25.58 (30.38)	46.61 (43.06)	64.00 (53.13)	83.33 (65.91)	100.0 (90.0)	100.0 (90.0)
Bodai, North 24-Parganas District	22°48'18"N 88°29'44"E	4.73 (12.56)	11.25 (19.59)	20.36 (26.82)	38.52 (38.36)	56.33 (48.64)	83.67 (66.16)	100.0 (90.0)	100.0 (90.0)
Jalangi, Murshidabad District	24°07'22"N 88°40'55"E	5.02 (12.95)	11.20 (19.55)	21.18 (27.40)	41.32 (40.00)	60.50 (51.06)	81.33 (64.40)	100.0 (90.0)	100.0 (90.0)
Dialdawk-1, Mamit District, Mizoram	23°50'37"N 92°36'07"E	3.97 (11.50)	10.61 (19.01)	19.71 (26.36)	24.77 (29.85)	36.64 (37.25)	46.80 (43.17)	59.41 (50.43)	78.26 (62.21)
Dialdawk-2, Mamit District, Mizoram	23°49'08.20"N 92°36'03.70"E	3.72 (11.12)	9.05 (17.51)	18.07 (25.16)	24.12 (29.41)	34.03 (35.69)	44.45 (41.81)	56.97 (49.01)	72.84 (58.59)
Muthi, Aizawl District, Mizoram	23°46'21.78"N 92°45'43.02"E	1.59 (7.23)	4.67 (12.48)	8.86 (17.32)	13.97 (21.95)	20.42 (26.86)	27.94 (31.91)	34.82 (36.16)	43.51 (41.27)
Zemabawk, Aizawl District, Mizoram	23°44'23"N 92°44'46"E	1.75 (7.59)	4.83 (12.70)	10.00 (18.43)	14.81 (22.63)	19.50 (26.21)	23.17 (28.77)	34.58 (36.02)	42.33 (40.59)
Meidum, Kolasib District, Mizoram	24°10'40.84"N 92°34'55.33"E	4.67 (12.48)	10.72 (19.11)	20.48 (26.90)	30.79 (33.71)	41.83 (40.30)	52.15 (46.23)	60.50 (51.06)	69.17 (56.27)
S.E. (m)±		0.51	0.50	0.49	0.60	0.94	1.31	0.32	0.32
C.D. at 5%		1.51	1.47	1.45	1.76	2.77	3.86	0.95	0.94

Figures in parenthesis are angular transformed values

Note: -DAS: Days After Sowing; AUDPC: Area Under Disease Progress Curve

The pooled data (Table 3) of both the years revealed the minimum disease severity at 50 DAS while maximum was recorded at 99 DAS in all the locations surveyed. At 50 DAS, maximum disease severity was recorded from Instructional Farm at Jaguli-1 (5.02 %) statistically *at par* with Instructional Farm at Jaguli-2 (4.99 %). These were followed by farmer’s field at Meidum (3.06 %), Instructional Farm at C-Block, Kalyani (2.93%), farmer’s field at Char Jadubati P-1 (2.70%), farmer’s field at Char Jadubati P-2 (2.63%), and these were statistically significant with the disease severity from Jaguli 1 and 2 The minimum disease severity at 50 DAS was recorded from farmer’s field at Muthi (1.40 %) which was statistically *at par* with farmer’s field at Zemabawk (1.50 %), farmer’s field at Jalangi (1.63 %), farmer’s field at Dialdawk-2 (1.70 %) and farmer’s field at Bodai (1.75%). The severity at farmer’s field at Dialdawk-1 (2.55%) was statistically significant with Muthi and Zemabawk. The highest disease severity was recorded at 99 DAS in all the locations surveyed (Table 3). At 99 DAS, the maximum disease severity was recorded from farmer’s field at Bodai (45.46 %) which is statistically *at par* with farmer’s field at Jalangi (45.18 %). These were followed by disease severity in farmer’s field at Char Jadubati P-1 (44.60 %), farmer’s field at Char Jadubati P-2 (43.66 %), Instructional Farm at C-Block, Kalyani (40.79%), Instructional Farm at Jaguli-1 (38.64%), Instructional Farm at Jaguli-2 (38.10%), and these were statistically significant with Bodai. The minimum disease severity at 99 DAS was reported from farmer’s field at Muthi (20.51 %) followed by farmer’s field at Zemabawk (22.40 %), farmer’s field at Dialdawk-1 (29.43 %) and farmer’s field at Meidum (31.78 %) which were statistically significant with each other.

Table 3: Disease Severity at Different DAS (Pooled mean of two years)

Location	Latitude and Longitude	Disease Severity at Different DAS (Pooled mean of two years)								
		50	**57**	**64**	**71**	**78**	**85**	**92**	**99**	**AUDPC**
Instructional Farm, Jaguli-1, Nadia District	22°56’56”N 88°32’23”E	5.02 (12.94)	9.41 (17.87)	13.37 (21.45)	18.66 (25.59)	23.55 (29.03)	28.13 (32.03)	33.74 (35.51)	38.64 (38.43)	1040.84
Instructional Farm, Jaguli-2, Nadia District	22°56.885’N 88°32.410’E	4.99 (12.90)	8.76 (17.22)	15.33 (23.05)	21.19 (27.41)	25.17 (30.11)	29.49 (32.89)	33.70 (35.49)	38.10 (38.12)	1086.28
Instructional Farm, C-Block, Kalyani, Nadia	22°59’21”N 88°27’22”E	2.93 (9.85)	6.36 (14.61)	10.15 (18.57)	15.18 (22.93)	22.02 (27.98)	29.34 (32.79)	35.49 (36.56)	40.79 (39.69)	982.66
Char Jadubati P -1, Nadia District	22°59’25”N 88°24’56”E	2.70 (9.46)	5.48 (13.53)	8.96 (17.42)	13.25 (21.34)	17.24 (24.53)	24.67 (29.78)	35.55 (36.60)	44.60 (41.90)	901.49
Char Jadubati P - 2, Nadia District	22°59’25”N 88°24’56”E	2.63 (9.33)	6.10 (14.30)	9.26 (17.72)	13.68 (21.71)	17.91 (25.04)	25.61 (30.40)	35.14 (36.36)	43.66 (41.36)	915.94
Bodai, North 24-Parganas District	22°48’18”N 88°29’44”E	1.75 (7.59)	4.23 (11.87)	8.49 (16.94)	16.17 (23.71)	25.79 (30.52)	34.19 (35.78)	40.82 (39.71)	45.46 (42.39)	1073.02
Jalangi, Murshidabad District	24°07’22”N 88°40’55”E	1.63 (7.33)	4.80 (12.65)	8.89 (17.35)	16.00 (23.58)	26.57 (31.03)	34.14 (35.76)	41.63 (40.18)	45.18 (42.23)	1087.96
Dialdawk-1, Mamit District, Mizoram	23°50’37”N 92°36’07”E	2.55 (9.19)	5.90 (14.06)	9.76 (18.20)	14.22 (22.15)	18.45 (25.44)	22.37 (28.22)	26.30 (30.85)	29.43 (32.85)	790.85
Dialdawk-2, Mamit District, Mizoram	23°49’08.20”N 92°36’03.70”E	1.70 (7.48)	5.27 (13.27)	9.54 (17.99)	14.54 (22.41)	19.65 (26.31)	23.82 (29.21)	28.18 (32.06)	32.23 (34.59)	825.69
Muthi, Aizawl District, Mizoram	23°46’21.78”N 92°45’43.02”E	1.40 (6.80)	2.94 (9.87)	5.32 (13.33)	7.98 (16.41)	10.81 (19.19)	14.04 (22.01)	17.46 (24.70)	20.51 (26.93)	486.48
Zemabawk, Aizawl District, Mizoram	23°44’23”N 92°44’46”E	1.50 (7.04)	4.93 (12.83)	8.67 (17.12)	11.57 (19.89)	14.55 (22.43)	17.58 (24.79)	20.50 (26.92)	22.40 (28.25)	628.31
Meidum, Kolasib District, Mizoram	24°10’40.84”N 92°34’55.33”E	3.06 (10.07)	6.28 (14.52)	10.75 (19.14)	18.66 (23.51)	20.59 (26.99)	24.80 (29.86)	28.60 (32.33)	31.78 (34.31)	870.43
S.E.(m)±		0.35	0.33	0.25	0.27	0.26	0.23	0.26	0.28	12.84
C.D. at 5%		1.02	0.97	0.75	0.79	0.76	0.69	0.75	0.82	37.91

Figures in parenthesis are angular transformed values
Note: -DAS: Days After Sowing; AUDPC: Area Under Disease Progress Curve

The pooled maximum area under disease progress curve (AUDPC) was recorded from farmer's field at Jalangi (1087.96) statistically *at par* with Instructional Farm at Jaguli-2 (1086.28), farmer's field at Bodai (1073.02). This is followed by AUDPC in Instructional Farm at Jaguli-1 (1040.84), Instructional Farm at C-Block, Kalyani (982.66), farmer's field at Char Jadubati P-2 (915.94) and farmer's field at Char Jadubati P-1 (901.49). The minimum AUDPC was recorded from farmer's field at Muthi (486.48), followed by farmer's field at Zemabawk (628.31), farmer's field at Dialdawk-1 (790.85), farmer's field at Dialdawk-2 (825.69) and farmer's field at Meidum (870.43) and all of these were statistically significant with each other.

The survey results showed that the disease was more prevalent in the plains of West Bengal *viz,*. Nadia, Murshidabad and North 24-Parganas districts in comparison to hilly are as of Mizoram. The variations in disease incidence and disease severity from location to location may be attributed to the varying climatic factors, different hybrids cultivated, differences in pathogen inoculum density in the field, non-adoption of disease management practices, etc. which affected the growth and development of the disease. The results of this investigation coincided with the findings of Nongmaithem *et al.* (2022) who observed a low incidence of maydis leaf blight (10-20%) in the state of Manipur. During the survey of the fields, it was also observed that most of the fields practiced monocropping with maize as the sole crop, which might lead to an increase in disease inoculum resulting in higher disease incidence (Surendhar *et al.,* 2021).

The findings of the present survey are in accordance with the findings of Debnath *et al.* (2019), who reported SCLB in Murshidabad and Nadia districts of West Bengal. Surveys and surveillance by Harlapur *et al.* (2000) in north Karnataka revealed a moderate intensity of SCLB in the surveyed districts.

Similar trend was also reported by Hulagappa *et al.* (2013), who surveyed the severity of maydis leaf blight of maize in northern Karnataka during Kharif, 2011. They recorded maximum disease severity in Ranebennur (56.26%) while least severity was noticed in Kushtagi (33.88%), indicating the status of the disease in the area.

Conclusion

The plain zones of West Bengal as well as the north eastern states are prone to leaf blight of maize. This roving survey was conducted in three districts of West Bengal and three districts of Mizoram. Among the areas surveyed, the disease incidence as well as severity was found to be lower in the districts of Mizoram as compared to those of West Bengal. Successive surveys of SCLB in the maize growing belts across the country need to be conducted to develop a better understanding of the disease prevalence, intensity and severity under different agro-ecological conditions. This would also help the breeder to recommend zone specific varieties for the sake of the farmers to avoid excessive loss due the disease.

Conflict of interest:

All the authors declare that they do not have any conflict of interest.

Author contribution

All the authors have equally contributed for this review article. SM made the concept of the article, VL, SC and SD wrote according to the concept. SM finally edited and corresponded to the journal

Ethical statement

Not applicable with this article.

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