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Effect of Environmental Factors and Date of Sowing on Disease Development

Hem Chandra Chaudhary [a++], Sunil Zachharia [a#], Mayank [b†*] and Vinay Kumar Choudhary [c‡]

[a] *Department of Plant Pathology, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India.*
[b] *Department of Genetics and Plant Breeding, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh India.*
[c] *Department of Genetics and Plant Breeding, Directorate of Seed, RPCAU, Pusa, Samastipur, Bihar, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Understanding the effect of environmental factors and sowing dates on disease development is crucial for optimizing crop health, improving yield, and devising effective, timely disease management strategies in agriculture. The current investigation, which was conducted During 2021

[++] *Ph.D. Scholar;*
[#] *Associate Professor;*
[†] *M.Sc. Scholar;*
[‡] *Assistant Professor;*
**Corresponding author: E-mail: mmmayankmishra40@gmail.com;*

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in the laboratory of the Department of Plant Pathology, Naini Agricultural Institute, and Sam Higginbottom University of Agriculture Technology and Sciences. To investigate the impact of environment and date of sowing on development of disease Maydis leaf blight of maize. During *Kharif* 2021 and 2022, for all four sowing dates, the disease progression of maydis leaf blight on maize variety CML-186 was monitored at weekly intervals beginning at 45 DAS of crop. It can be concluded that the crop stage showed the highest disease incidence at 45, 80, and 87 DAS; consequently, this stage tends to exhibit the most susceptible reaction during *Kharif* 2021. The crop stage with the highest disease incidence during *Kharif* 2022 was at 45, 52, and 80 DAS; as a result, this stage typically exhibits the most susceptible response. During *Kharif* 2021 and 2022, for all four sowing dates, the AUDPC of maydis leaf blight on maize variety CML-186 was noted at weekly intervals beginning at 45 DAS of crop.

Keywords: Maydis leaf blight; AUPDC; susceptible.

1. INTRODUCTION

The Mexican native maize (also known as maize), which has been dubbed a "miracle crop," is one of the most adaptable new crops in the world and displays varying degrees of flexibility under various agro-climatic conditions (Mangelsdorf, 1974). In the 17^{th} century, the Portuguese introduced maize to India. The word "corn" is derived from the Spanish word "Mahiz". Since maize has a high genetic yield potential, it is referred to as the "queen of cereals." Since maize has a high genetic yield potential, it is referred to as the "queen of cereals." Zea mays, also known as "makka," "bhutta," or "makai," is the botanical name for maize. It belongs to the Poaceae family. The plant is diploid and has 2n=2X=20 chromosomes (Fisk, 1927). The most well-known ancestor of this species is *Zea teosinte*.

Corn is India's third-most significant crop, behind rice and wheat. It is grown on 9.89 million hectares (2020–2021), or 81% of the land, according to preliminary data. At current prices, maize contributes to nearly 9% of India's total food consumption and more than $100 billion of the agricultural sector's gross domestic product (GDP). Additionally, maize generates more than 100 million man-days of employment in the agricultural sector as well as its downstream industrial and agricultural sectors. (Ministry of Agriculture and Farmer Welfare, Government of India, Department of Economic Services, 2020–21). In all of India's states, a total of 9.89 million hectares of maize are grown every day for a variety of purposes, including grain, fodder, green corn cobs, sweet corn, baby corn, and popcorn. It's a crop that has no bias.

Bipolaris maydis (Nisikado & Miyake 1926) Shoemaker is a fungus that causes the disease known as Maydis leaf blight (MLB). This illness, also referred to as Southern Corn Leaf Blight (SCLB), is a significant foliar disease that affects almost all of India's maize-growing regions. Three races of the pathogen have reportedly been identified: race "T," race "O," and race "C." In Texas Male Sterile (TMS) sources, race "T" is particular and causes a highly virulent disease that has the historical significance of causing a significant epidemic of leaf blight in the United States. Munjal and Kapoor (1960) first isolated the infected maize leaf from Malda district of West Bengal and reported the presence of *H. maydis* in maize crop. Harlapur et al. (2000) reported that depending on the weather, MLB disease causes yield losses in cultivators using subtropical or temperate germplasm ranging from 9.7 to 11.7 percent. Similar result was observed by Kumar and saxena (2007). In India's maize-growing states, including Uttar Pradesh, Bihar, Uttarakhand, Punjab, Haryana, Jammu & Kashmir, Himachal Pradesh, Sikkim, Meghalaya, Rajasthan, Delhi, Madhya Pradesh, Gujarat, Maharashtra, Andhra Karnataka, and Tamil Nadu. Sharma and Rai (2005) reported that MLB disease is a problem disease. MLB brought on by *Bipolaris maydis* decreased maize yields by 9.7 to 11.7%, depending on the weather (Bera & Giri, 1979; Harlapur et al., 2000; Sharma et al., 2003, Kumar & Saxena, 2007). However, according to Wang et al. (2001) and Ali et al. (2012), this disease has been linked to yield losses of up to 70%. (2011). Agronomic practises that encourage high humidity and moderate temperatures can have an impact on how severe the maydis leaf blight disease. Therefore, the present research work was framed with objective to conduct survey for the study of maydis leaf blight disease severity in Indo- Gangetic plains of Uttar Pradesh

(India) and study the effect of environmental factors and date of sowing on disease development.

2. MATERIALS AND METHODS

2.1 Effect of Environmental Factors and Date of Sowing on Disease Development

The experiment, which used a randomised block design (RBD) with the susceptible cultivar CML 186 and four seeding dates, namely July 5th, July 12th, July 19th, and July 26th with three replicates, was conducted during *Kharif* 2021 and 2022 at Central Research Farm, Department of Plant Pathology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj. Every replicate maintained the same 2 x 2 m plot with a spacing of 60 x 25 cm. The entire fertiliser dosage advised for growing the crop was adhered to. To correlate environmental factors related to disease development, the progression of the disease development was tracked at intervals of seven days beginning with the first appearance of the disease in the field. Ten randomly chosen plants from each plot were evaluated for disease intensity using a 1–9 scale developed by Balint-Kurti et al. (2006), Mitiku et al. (2014). The Agro-meteorological observatory Unit, School of Forestry and Environment, SHUATS, Prayagraj provided meteorological data on temperature (maximum and minimum), relative humidity (morning and evening), rainfall (mm), wind speed (km/h), and sunshine (hrs) given in Tables 1 and 2 for *kharif* 2021 and 2022. Calculated average values for the corresponding seven days. The Wheeler, 1969 formula was used to calculate the percentage disease frequency.

$$\text{Disease incidence (\%)} = \frac{\textit{Sum of individual ratings}}{\textit{No.of leaves observed x maximum disease rating}} X\ 100$$

By calculating the percentage of disease intensity and measuring the size of disease spots on the ten randomly chosen plants at intervals of seven days, the progression of the disease was tracked. Using Campbell and Madden (1990) formula, areas under the disease progress curve (AUDPC) were calculated.

$$\text{AUDPC} = \sum_{i=1}^{n-1} \left(\frac{Y_i + Y_{i+1}}{2}\right) (t_{i+1} - t_i)$$

Where, N = nth number of entries, Y_i = disease index at t_i time, Y_{i+1} = disease observation next to ith observation, t_i = time at ith, t_{i+1} = time of next observation.

$$\text{AIR or 'r'} = \frac{2.3}{t_2 - t_1} \text{ Log } \frac{x_2}{x_1}$$

The apparent infection rate (AIR) of MLB disease was calculated as per the formula of Vander plank (1963).

Where, r = apparent rate of infection,

x_1 = PDI at time t_1, x_2 = PDI at time t_2 and t_2-t_1 = time interval between two observations.

3. RESULTS AND DISCUSSION

3.1 Progression of MLB INCIDENCE in Maize Variety CML-186 under Different Dates of Sowing

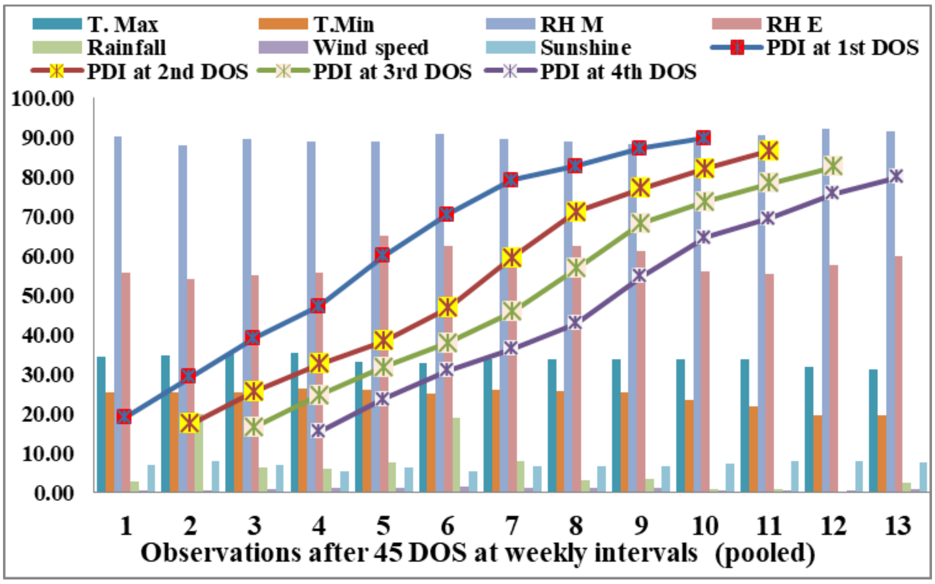
The progression of MLB disease incidence in maize variety CML-186 is depicted in Table 1 and Graph 1 pooled analysis (*Kharif*-2021 & 2022) respectively.

During *Kharif* 2021 and 2022, epidemiological studies on the maize variety CML-186 that were sown on four different dates—the first week of July (05 July), the second week of July (12 July), the third week of July (19 July), and the last week of July (26 July)—showed that the maydis leaf blight disease first manifested itself 45 days after sowing the crop (45 DAS) in all cases. The CML-186 maize variety was examined for disease incidence (*Kharif* 2021 & 2022) at intervals of seven days or at weekly intervals, 45 days following crop sowing. The initial planting slot date was found to have the highest disease incidence. Between 19 August and 21 October, the disease intensity at the first date of sowing ranged from 19.11 to 89.94%. Disease intensity ranged from 17.43 to 86.67 percent between 26 August and 28 October in the second date of sowing. Disease intensity ranged from 16.58 to 82.66 percent between 09 September and 04 November in the third date of sowing slot. The disease incidence was lower in the fourth date of sowing slot, ranging from 15.50 to 79.85 percent between September 9 and November 11. The first and second dates of sowing, according to the results, showed increased disease intensity. Under artificial epiphytotic conditions at Kalyani, West Bengal, during *Kharif* 1995–98, Pal, and Kaiser (2001) found that planting in July favours the disease incidence, while planting early in May or June, or planting late in August, reduces the disease incidence. These findings also showed that in the maize variety sowed at various times during *Kharif* 2021 and 2022, the disease development happened when the plant had reached age of 45 days in July or August. Southern leaf blight of maize was found to be most contagious in 65-day-old plants, and the months of July to October were the most conducive to the disease's development. According to Bhandari et al. (2017), all maize genotypes showed signs of southern leaf blight 63 to 79 days after sowing (Agriculture Statistics at a glance 2021, Agrios 2005).

The progression of disease incidence was assessed during pooled data (*Kharif* 2021 & 2022) at intervals of seven days and associated with the meteorological variables beginning with the disease's onset. In the maize variety sown for the first date of sowing slot, the disease intensity increased from 33 to 42 metrological weeks. The maximum temporal progression of the disease intensity was noted when maximum temperatures ranged between 32.91 and 35.30°C, minimum temperatures ranged between 25.04 and 26.33°C, relative humidity ranged between 88.14 and 90.86% in the morning and 54.14-64.93% in the evening, rainfall ranged between 2.64 and 19.78 mm, sunshine hours ranged between 5.31 and 7.94 hrs/day, and wind speeds ranged between 0.53 and 1.33 (Km/h) during 33 to 39 meteorological weeks. However, due to a decline in temperature, relative humidity, and rainfall during the 40 to 42 meteorological weeks, the disease's temporal course slowed down. In the maize variety sown for the second date of sowing slot, the disease intensity increased from 34 to 43 metrological weeks. The maximum temporal progression of the disease intensity was observed between 34 and 41 meteorological weeks, when the maximum temperature ranged between 32.91 and 35.30°C, the minimum 25.04 to 26.33°C, relative humidity morning 88.14-90.86% and evening 54.14-64.93%, rainfall 2.94-19.78 mm, sunshine 5.31 to 7.94 hours per day, and wind speed 1.25 to 1.33 (Km/h). However, due to a decline in temperature, relative humidity, and rainfall over the course of 42 to 43 meteorological weeks, the disease's temporal progression slowed. In the maize variety sown on the third date of sowing slot, the disease intensity increased from 35 to 44 metrological weeks. The maximum temporal progression of the disease intensity was observed between 34 and 41 meteorological weeks when the maximum temperature ranged between 32.91 and 35.30°C, the minimum 25.04 to 26.33°C, relative humidity morning 88.21-90.86% and evening 55.14-64.93%, rainfall 2.94-18.80 mm, sunshine 5.31 to 7.05 hours per day, and wind speed 0.86-1.33 (Km/h). However, due to a decline in temperature, relative humidity, and rainfall over the course of 42 to 44 meteorological weeks, the disease's temporal progression slowed. In the maize variety sown on the fourth date of sowing slot, the disease intensity increased from 36 to 45 metrological weeks. The highest temporal progression of the disease intensity was observed between 36 and 42 meteorological weeks, when the maximum temperature ranged between 32.91 and 35.30°C, the minimum 23.54 to 26.33°C, with relative humidity morning 88.21-90.86% and evening 55.64-64.93%, rainfall 0.79-18.80 mm, sunshine 5.31 to 7.41 hours per day, and wind speed 0.63 to 1.33 (Km/h). However, due to a decline in temperature, relative humidity, and rainfall over the course of 43 to 45 meteorological weeks, the disease's temporal progression slowed. The phrase "favourable conditions" refers to the presence of water on the leaf surface and an environment that is between 60 and 80^{0}F (Singh and Srivastava, 2012). This is significant in areas with a warm, humid climate where the temperature ranges between 20 and 30°C (Bhandari et al.,2017, FAOSTAT 2021).

3.2 Correlation between MLB Disease Incidence in Relation to Weather Parameters in Different Dates of Sowing

As per Table 2, The correlation coefficients for the maize variety CML-186 with the date of sowing and with weather parameters were obtained using a pooled study (*Kharif* 2021 & 2021). The findings showed that the morning and evening maximum and minimum temperatures, relative humidity (%) For the first day of sowing (05 July) slot, there was no statistically significant correlation between rainfall, wind speed, and sunshine, and percentage disease incidence (progression of Maydis leaf blight). Results for the second date of sowing (12 July) slot showed that rainfall was negatively and significantly correlated to the percentage of disease incidence (progression of Maydis leaf blight), whereas maximum and minimum temperatures, relative humidity (%) in the morning and evening, wind speed, and sunshine were not significantly correlated with the percentage of disease incidence (Progression of Maydis leaf blight). Results for the third date of sowing (19 July) slot showed that sunshine was significantly and positively correlated with percent disease incidence, whereas minimum temperature and wind speed were significantly and negatively correlated (Progression of Maydis leaf blight). The relationship between the maximum temperature, relative humidity (%) in the morning and evening, and rainfall was not statistically significant (Progression of Maydis leaf blight). Results for the fourth date of sowing (26 July) slot showed that Maximum temperature, Minimum temperature, rainfall, and wind speed were all negatively and significantly correlated with Percent Disease Incidence (Progression of Maydis leaf blight), while Sunshine was positively and significantly correlated with Percent Disease Incidence. Relative humidity (%) at morning and evening, however, was not significantly correlated with percent disease incidence (Progression of Maydis leaf blight). Therefore, during *Kharif* 2021 and 2022, the maximum and minimum temperatures, rainfall, wind speed, and sunshine all have a substantial impact on the development of the maydis leaf blight in maize. In maize, maximum, and minimum temperatures, rainfall, and wind speed all have an inverse relationship with disease progression, whereas sunshine has a direct relationship. In other words, if temperature and rainfall are high on their own, disease progression is low; however, if temperature and rainfall are low on their own, and sunshine is high, this will result in an increase in humidity, which will then result in disease progression. It can also be deduced that while weather variables had a largely insignificant impact on disease incidence, weather had a nearly neutral impact on the incidence of diseases. Further references from the literature suggested that the oligogenic character of the recessive gene in the host may have contributed to the host's sensitivity to the maydis leaf blight disease and its resistance symptoms. In other words, under the disease triangle concept of host-pathogen-environment interaction for disease incidence, environmental effect became negligible as disease susceptible interaction was controlled primarily by oligogenic genes and Oligogenic genes do not have effect of environment on expression of its character. This oligogenic nature favoured plant variety to be susceptible independent of weather parameters. Only the host and pathogen interacted. From the Flor Hypothesis, it can be deduced that the pathogen's increased virulence was due to its counteracting virulent gene present against resistant gene of plant variety that lead to weak host reaction for resistance against virulent race of pathogen (*B. maydis*) thus, host to develop the disease (Flor, 1971; Robinson, 1971 and Singh, 2015). Temperature, relative humidity, and rainfall all have significant roles in the development of the maydis leaf blight disease in maize (Kaur et al., 2014, Nislkado 1926, Robinson 1971, Singh 2015).



Graph 1. Progression of maydis leaf blight disease incidence in relation to weather parameters in different date of sowing during *Kharif* -2021 and 2022 (Pooled)

Table 1. Progression of maydis leaf blight disease incidence in relation to weather parameters in different date of sowing during *Kharif* 2021 and 2022 (Pooled)

Date of observations	Std. Met. Week	Percentage of disease Incidence at different date of sowing				Weather Parameters						
						Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	Wind Speed (Km/hrs.)	Sunshine (hrs.)
		05 July	12 July	19 July	26 July	Max.	Min.	Morning	Evening			
19 Aug.	33	19.11	-	-	-	34.55	25.46	90.36	55.64	2.64	0.60	6.84
26 Aug.	34	29.34	17.42	-	-	34.65	25.28	88.14	54.14	19.78	0.53	7.94
02 Aug.	35	39.24	25.68	16.58	-	35.00	25.29	89.50	55.14	6.20	0.86	7.05
09 Sept.	36	47.20	32.63	24.61	15.50	35.30	26.33	89.07	55.64	6.13	1.27	5.31
16 Sep.	37	60.00	38.40	31.79	23.67	33.06	25.91	89.07	64.93	7.60	1.28	6.30
23 Sep.	38	70.45	46.80	37.92	30.89	32.91	25.04	90.86	62.43	18.80	1.33	5.41
30 Sep.	39	79.26	59.49	45.71	36.40	33.89	25.93	89.50	60.57	7.93	1.20	6.61
07 Oct.	40	82.70	71.08	56.79	42.85	33.77	25.66	89.00	62.36	2.94	1.10	6.49
14 Oct.	41	87.23	77.06	68.22	54.76	33.77	25.49	88.21	61.36	3.54	1.17	6.79
21 Oct.	42	89.94	82.07	73.76	64.60	33.77	23.54	88.79	56.14	0.79	0.63	7.41
28 Oct.	43	-	86.67	78.33	69.49	33.64	21.87	90.50	55.36	0.76	0.64	8.06
04 Nov.	44	-	-	82.66	75.86	31.80	19.40	92.14	57.71	0.00	0.58	8.05
11 Nov.	45	-	-	-	79.95	31.10	19.43	91.53	59.84	2.40	0.86	7.64

Table 2. Correlation matrix for progression of MLB disease in relation to weather parameters in different date of sowing during *Kharif* 2021 and 2022 (Pooled)

Date of sowing	Weather Parameters						
	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	Wind Speed (Km/hrs.)	Sunshine (hrs.)
	Max.	Min.	Morning	Evening			
05 July	-0.619^{NS}	-0.285^{NS}	-0.206^{NS}	0.598^{NS}	-0.279^{NS}	0.466^{NS}	-0.156^{NS}
12 July	-0.488^{NS}	-0.587^{NS}	0.151^{NS}	0.185^{NS}	-0.688*	-0.098^{NS}	0.251^{NS}
19 July	-0.583^{NS}	-0.736*	0.282^{NS}	-0.121^{NS}	-0.619^{NS}	-0.647*	0.722*
26 July	-0.646*	-0.881**	0.515^{NS}	-0.381^{NS}	-0.659*	-0.868**	0.925**

**Significance at 5%, **Significance at 1%*

4. CONCLUSION

The disease progression of maydis leaf blight on maize variety CML-186 was recorded at weekly intervals starting at 45 DAS of crop during *Kharif* 2021 and 2022 for all four sowing dates. It can be concluded that at 45, 80 and 87 DAS the stage of crop showed maximum disease incidence, therefore this stage tends to show most susceptible reaction during *Kharif* 2021. During *Kharif* 2022, 45, 52 and 80 DAS stage of crop showed maximum disease incidence, therefore this stage tends to show most susceptible reaction. The AUDPC of maydis leaf blight on maize variety CML-186 was recorded at weekly intervals starting at 45 DAS of crop during *Kharif* 2021 and 2022 for all four sowing dates.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

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1. ChatGPT, Version 2 (as of 2024).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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