RESEARCH ARTICLE

# Exploring Weather Dynamics of Fusarium Wilt Incidence caused by *Fusarium oxysporum* in Chilli (*Capsicum annuum* L.)

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DOI: 10.18811/ijpen.v12i01.11


## Abstract

A field experiment was conducted using the Bullet Lanka variety of chilli to evaluate the influence of meteorological variables and different transplanting dates on the incidence of Fusarium wilt of chilli caused by *Fusarium oxysporum* during the rabi season of 2021-22 at Sriniketan, West Bengal, India. The study employed weather parameters such as the Area Under Disease Progress Curve (AUDPC), apparent infection rate (r), and multiple regression analysis to characterize disease dynamics. A high incidence of the disease was observed at temperatures of 30.72 and 21.58°C, with evening and morning relative humidity (RH) of 68.26 and 72.43%, respectively, and in the absence of rainfall. The AUDPC and apparent infection rate (r) were lowest in the crop transplanted on 15th November 2021, whereas the highest values were recorded in the crop transplanted on 5th November 2021. Correlation analysis revealed that both maximum and minimum temperatures had a positive relationship with percent disease incidence (PDI), while evening and morning RH, as well as rainfall, showed a negative relationship with PDI. Furthermore, the coefficient of determination ($R^2$) obtained from multiple regression analysis indicated that the combined effect of meteorological variables explained 81 to 90% of the variation in disease development across all transplanting dates. The findings highlight the significant role of climatic factors in disease development and provide a basis for developing weather-based prediction models for effective management of Fusarium wilt in chilli.


**Keywords:** Chilli, Fusarium wilt, Infection rate, AUDPC, Disease forecast

**Highlights:**

- Evaluated the impact of various transplanting dates as well as weather conditions on Fusarium wilt incidence in chilli.
- Analyzed disease progression and spread using area under disease progress curve (AUDPC) along with apparent infection rate (r).
- Established an association between disease incidence and environmental variables through correlation analysis.
- Developed multi-linear regression models to predict disease incidence based on weather parameters, aiding in climate-based disease forecasting.

*International Journal of Plant and Environment* (2026); **ISSN:** 2454-1117 (Print), 2455-202X (Online)

## Introduction

Chilli (*Capsicum annuum* L.) is an economically important vegetable and spice crop cultivated widely across tropical, subtropical, and temperate regions. It belongs to the family Solanaceae and is valued for its nutritional and medicinal properties, being rich in vitamins (A, C, and B), minerals, flavonoids, and antioxidants (Shaheen *et al.,* 2021; Chakrabarty *et al.,* 2017). India, often referred to as the "spice bowl of the world", is one of the leading producers, consumers, and exporters of chilli, with a yearly output of 17.62 lakh tonnes, contributing significantly to global production. In West Bengal, chilli cultivation spans 62.39 ha, yielding a total production of 217.65 MT and a mean productivity of 3.49 MT/ha (Sakthivel *et al.,* 2024). Biotic and abiotic stresses profoundly affect chilli production and quality. Under biotic stress conditions, chilli crops are continuously exposed to a wide range of fungal, bacterial, and viral pathogens, with fungi alone responsible for more than 40 diseases (Rangaswami, 2005). Among these, Fusarium wilt is considered one of the most destructive diseases of chilli, caused by the soil-borne fungus *Fusarium oxysporum*.

The disease results in yield losses ranging from 10-80% in India and 10 to 50% worldwide. Although it occurs throughout the year, its incidence in India is markedly higher during November and December compared to other months (Akash *et al.,* 2022; Bai *et al.,* 2018). Typical symptoms include wilting, leaf yellowing, stunted growth, inward and upward leaf rolling, and eventual death of the entire plant. Disease incidence is highest during the flowering and fruiting stages, often leading to partial or complete crop failure (Sakthivel *et al.,* 2024; Wani *et al.,* 2014).

Disease development is governed by the interaction between favorable environmental conditions and the susceptible growth stage of the host plant (Joshi *et al.,* 2018). *Fusarium oxysporum*, a soil-borne pathogen, colonizes the vascular system of plants, thereby disrupting water transport. Environmental factors such as temperature, relative humidity,

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**How to cite this article:** Sakthivel, M., Nath, R., Elangovan, M. (2026). Exploring Weather Dynamics of Fusarium Wilt Incidence caused by *Fusarium oxysporum* in Chilli (*Capsicum annuum* L.). International Journal of Plant and Environment. 12(1), 95-101.
**Submitted:** 21/01/2026 **Accepted:** 24/03/2026 **Published:** 31/05/2026

and rainfall play a critical role in influencing disease incidence. High temperature combined with elevated soil moisture favors wilt development (Sanogo, 2003). In addition, dry atmospheric conditions coupled with excessive soil moisture can further accelerate disease progression.

Understanding the influence of weather parameters on disease occurrence is essential for developing reliable prediction models and early warning systems. Therefore, the present study aims to investigate the influence of meteorological parameters and transplanting dates on Fusarium wilt incidence in chilli. The findings are expected to contribute to climate-based disease forecasting and support the timely implementation of effective management strategies by farmers.

## Materials And Methods

### Experimental Site and Details

A field experiment was conducted to assess the effect of major meteorological variables, namely evening and morning relative humidity (%), minimum and maximum temperatures (°C), and rainfall (mm), on the development of Fusarium wilt in chilli. About 25 day-old seedlings of the Bullet Lanka variety were transplanted during the rabi season of 2021-22 at the agricultural farm of Palli-Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, Bolpur, in the Birbhum district of West Bengal. The experimental site is located at 87°37′57″ E longitude and 23°40′06″ N latitude, at an altitude of 58.90 m above mean sea level, within the lateritic belt of West Bengal, characterized by a dry sub-humid, sub-tropical climate. The experiment was laid out in a randomized block design (RBD) comprising three replications for each transplanting date. Individual plots measured 2.5 × 3.0 m in size. The spacing of 60 × 40 cm was adopted as per standard agronomic recommendations for chilli cultivation under the agro-climatic conditions of the region. The crop was transplanted on three different dates - 5$^{th}$, 15$^{th}$, and 25$^{th}$ November 2021. The study was conducted under well-established epiphytotic conditions in a naturally infested field with a documented history of Fusarium wilt, without artificial inoculation, ensuring adequate and uniform disease pressure for evaluating the influence of prevailing environmental factors on disease incidence.

### Disease observation

Disease incidence was recorded weekly on five plants randomly drawn from each plot, beginning at symptom initiation and continuing through crop maturity. Infected plants were identified by diagnosing characteristic symptoms of Fusarium wilt, including leaf yellowing, wilting, vascular browning, and plant death (Reddy *et al.,* 2024). The percent of disease incidence (PDI) was determined according to the formula given below: (Mayee and Datar, 1986)

$$\text{Disease Incidence }\% = \frac{\text{Number of plants infected}}{\text{Total number of plants evaluted}} X\ 100$$

### Calculation of Apparent InfectionRate (r) and Area under Disease Progress Curve (AUDPC)

The disease progression was also quantified by estimating the apparent infection rate (r) and area under the disease progress curve (AUDPC). The r was determined using the formula proposed by Campbell and Madden (1990), while AUDPC was calculated following the method described by Vanderplank (1963).

$$\text{Apparent infection rate (r)} = \frac{2.3}{t_2 - t_1} \log 10 \frac{x_2(1-x_1)}{x_1(1-x_2)}$$

Where, r = the apparent infection rate, $t_1$ = the time of the first measurement, $t_2$ = the time of the second measurement, $X_1$ = the proportion of infection measured at time $t_1$, $X_2$ = the proportion of infection measured at time $t_2$.

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

Where, $Y_i$= Cumulative intensity of disease at i$^{th}$ observation, $t_i$= Time (number of days after transplanting) at i$^{th}$ observations, n = Total no of observations.

### Coefficient of Correlation and Multiple Regression Analysis

The relationship between Fusarium wilt incidence and meteorological variables, namely morning and evening relative humidity, minimum and maximum temperature, and rainfall, was examined for different transplanting dates using Karl Pearson's correlation coefficient. The combined influence of these weather parameters on disease development was statistically analyzed using SPSS software (version 16.0) following the method described by Butt and Royle (1974). Further, multiple regression analysis was carried out to quantify the collective effect of weather variables on disease incidence. The coefficient of determination ($R^2$) was used to assess the cumulative contribution of temperature, relative humidity, and rainfall in predicting disease intensity across all three transplanting dates. The prediction equation proposed by Gupta *et al.,* (2003) was employed for this analysis.

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$$

Where, Y= Percent disease incidence, a= Intercept, $b_1$ to $b_5$= Partial regression coefficients, $X_1$= Temperature (maximum) (°C), $X_2$= Temperature (minimum) (°C), $X_3$= Relative humidity (morning) (%), $X_4$= Relative humidity (evening) (%), $X_5$= Rainfall (mm).

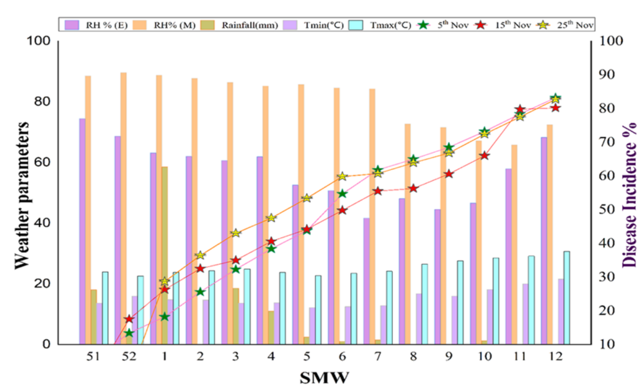


**Fig 1:** Development of Fusarium wilt incidence in relation to weather parameters

## Results and Discussion

### Development of Fusarium wilt Incidence in Chilli

To check the impact of meteorological variables on the development of Fusarium wilt of Chilli, the seedlings were transplanted on three different dates, *viz.,* 5th November, 15th November and 25th November 2021, and the information is depicted in Fig. 1 and Table 1. The disease symptoms began to manifest during the third week of December 2021 and disease incidence was observed up to 24th March 2022. At the onset of the disease in the field, temperature ranged from 22.54 to 30.72°C (max) and 12.14 to 21.58 °C (min). The relative humidity ranged from 65.82 to 89.62% in the morning and 41.60 to 74.43% in the evening, while total rainfall ranged from 0 to 58.5 mm. This indicates that the optimum temperature, moderate humidity and occasional rainfall create advantageous circumstances for the progression of Fusarium wilt.

The present findings indicate that meteorological parameters had a pronounced influence on the development of Fusarium wilt in chilli. The disease incidence increased rapidly over time, it was recorded at its highest in 1st date of transplanting, ranged amid 5.6 to 83.2%. In 2nd and 3rd dates of transplanting the percent disease incidence varied from 0 to 80.2% and 0 to 82.7%, respectively. Amongst three different occasions of transplanting, maximum disease incidence (83.2 %) was observed in 3rd week of March when the highest temperature was between 28 and 30 °C, the minimum temperature was around 21 °C, the RH was between 68 to 72%, and absence of rainfall. These environmental conditions appear to be highly conducive to disease development. The combination of optimum temperature (25–30°C), moderate humidity and occasional rainfall may be responsible for the progression of Fusarium wilt disease. However, disease incidence also declines with increased time of exposure to higher temperatures (Singh, 2018).

The present findings agree with the earlier observations reported by Cook and Baker (1983). They reported that the optimal development of Fusarium is obtained amid 25 to 28°C, while the highest development is normally found at 28°C, inhibited at <17 and >33°C. Similar observations have also been reported in other crops, where temperature plays a critical role in wilt development. Comparable observations have also been documented by Kumar *et al.,* (2012), they observed that the most favorable temperature is 25 to 30°C for the development of Fusarium wilt of pea. Interestingly, Landa *et al.,* (2001) noticed that Fusarium wilt growth was higher at 25°C in comparison to 20°C. According to the data presented in Table 1, the gradual increase in disease incidence across all transplanting dates further suggests that both crop growth stage and prevailing environmental conditions collectively influence disease progression. The higher disease levels observed in early transplanting may be attributed to prolonged exposure to favorable climatic conditions.

### AUDPC and r of Fusarium wilt incidence in Chilli

To quantify the progression of Fusarium wilt in chilli, AUDPC was computed from the PDI recorded at successive time intervals and the results are presented in Table 2. The highest AUDPC (565.6) recorded in the early transplanted crop (5th November,

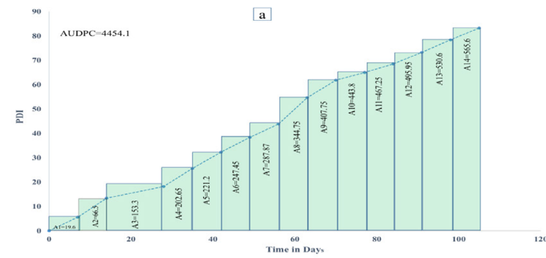


**Fig 2a:** Effect of transplanting on AUDPC in relation to Fusarium wilt incidence in chilli on 5th November 2021

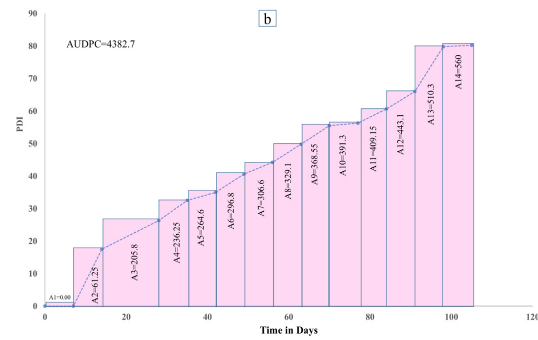


**Fig 2b:** Effect of transplanting on AUDPC in relation to Fusarium wilt incidence in chilli on 15th November 2021

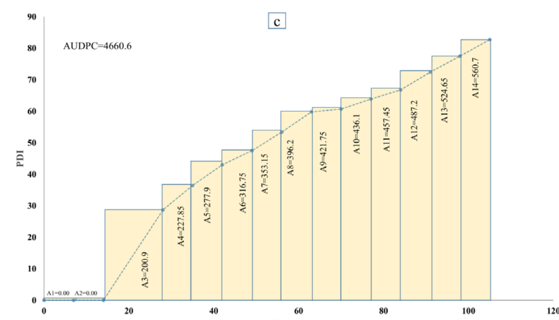


**Fig 2c:** Effect of transplanting on AUDPC in relation to Fusarium wilt incidence in chilli on 25th November 2021

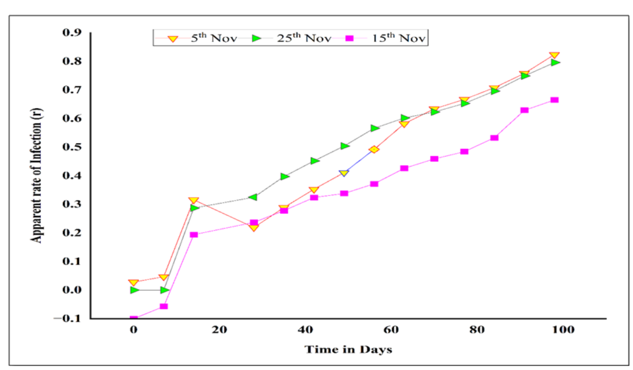


**Fig 3:** Infection rate of Fusarium wilt incidence on different transplanting dates

2021) indicates greater cumulative disease pressure, likely due to longer exposure to favorable environmental conditions. In contrast, comparatively lower AUDPC (560.7 & 560) in later transplanting suggests reduced disease development. The AUDPC value concerning the average of three transplanting dates was maximum (562.1) and minimum (93.9). AUDPC was statistically analyzed based on the disease progression; the result revealed that the AUDPC value (total) was highest on 25$^{th}$ November 2021 (4660.6) (Fig. 2c), while it was lowest in the transplanted-on 5$^{th}$ November 2021 (4454.1) (Fig. 2a) followed by 15$^{th}$ November 2021 (4382.7) (Fig. 2b).

The overall mean AUDPC concerning the average of three transplanting dates was documented as 4499.13 from 51-12 SMW. In the present study, Fusarium wilt AUDPC values were moderately high between 23 December 2021 and 17 February 2022, when temperatures ranged from 22.5–24.88°C (maximum) and 12.14–15.89°C (minimum), relative humidity varied between 84.26–89.62% (morning) and 41.66–74.43% (evening), and rainfall remained between 0 and 58.5 mm (Table 1). A rapid increase in severity of disease and substantially higher AUDPC were documented from 24 February to 24 March 2022, coinciding with a rise in temperature (26.52–30.72°C maximum and 15.92–21.58°C minimum), a decline in relative humidity (65.82–72.73% morning and 44.51–68.26% evening), and minimal rainfall (0–1.2 mm) (Tables 1 and 2). These outcomes underscore the significant impact of weather conditions on disease dynamics and provide useful insights for developing predictive disease-forecasting models.

To quantify the rate of disease progression over time, the apparent infection rate (r) was calculated and depicted in Table 2. Infection rate value (r) ranged from 0.028–0.824, 0.0–0.765, and 0.0 to 0.796 on 1$^{st}$, 2$^{nd}$ and 3$^{rd}$ dates of transplanting, respectively, with a mean of 0.02–0.795 from 51–12 SMW. The observed infection rate was greatest in plants transplanted on 5$^{th}$ November, 2021 (0.824), besides being minimal in crop transplanted on 15$^{th}$ November, 2021 (0.765) (Fig. 3). A higher infection rate observed in early transplanting indicates rapid disease development, emphasizing the importance of transplanting time in disease management.

The temporal increase in both AUDPC and infection rate during the later stages of crop growth corresponded with increasing temperature and declining relative humidity, indicating that these environmental conditions facilitate accelerated disease development. However, despite differences in the rate of disease progression among transplanting dates, the final disease intensity remained comparable across treatments, suggesting that transplanting time primarily influenced the timing of disease development rather than the ultimate disease severity. Overall, AUDPC and infection rate proved to be reliable epidemiological tools for quantifying disease dynamics and identifying critical periods of disease development under varying environmental conditions.

## Correlation between Weather Parameters and Fusarium wilt Incidence

To examine the quantitative relationship between Fusarium wilt incidence and major environmental variables, including evening and morning relative humidity, minimum and maximum temperatures, and total rainfall, a correlation coefficient matrix was generated. As presented in Table 3, Correlation analysis revealed that temperature (both maximum and minimum) had a positive association with disease incidence, indicating that

**Table 1:** Influence of weather parameters on the development of Fusarium wilt incidence in chilli

| *Date of observation* | *Standard Meteorological Weeks (SMW)* | *Tmax (˚C)* | *Tmin (˚C)* | *RH % (M)* | *RH % (E)* | *Rainfall (mm)* | *Disease Incidence %* | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | *Dates of Transplanting* | | |
| | | | | | | | *05-11-2021* | *15-11-2021* | *25-11-2021* |
| 23-12-2021 | 51 | 23.93 | 13.64 | 88.53 | 74.43 | 18 | 5.6 | 0.0 | 0.0 |
| 30-12-2021 | 52 | 22.54 | 15.89 | 89.62 | 68.62 | 4.1 | 13.4 | 17.5 | 0.0 |
| 06-01-2022 | 1 | 23.76 | 14.75 | 88.76 | 63.18 | 58.5 | 18.2 | 26.3 | 28.7 |
| 13.01.2022 | 2 | 24.32 | 14.65 | 87.73 | 62.02 | 0 | 25.6 | 32.5 | 36.4 |
| 20-01-2022 | 3 | 24.88 | 13.65 | 86.41 | 60.63 | 18.5 | 32.3 | 35.0 | 43.0 |
| 27-01-2022 | 4 | 23.81 | 13.73 | 85.22 | 61.87 | 11.0 | 38.4 | 40.6 | 47.5 |
| 03-02-2022 | 5 | 22.75 | 12.14 | 85.73 | 52.53 | 2.4 | 43.8 | 44.2 | 53.4 |
| 10-02-2022 | 6 | 23.44 | 12.51 | 84.57 | 50.72 | 1.0 | 54.7 | 49.8 | 59.8 |
| 17-02-2022 | 7 | 24.13 | 12.82 | 84.26 | 41.66 | 1.5 | 61.8 | 55.5 | 60.7 |
| 24-02-2022 | 8 | 26.52 | 16.72 | 72.73 | 48.06 | 0 | 65.0 | 56.3 | 63.9 |
| 03-03-2022 | 9 | 27.55 | 15.92 | 71.57 | 44.51 | 0 | 68.5 | 60.6 | 66.8 |
| 10-03-2022 | 10 | 28.58 | 18.09 | 67.13 | 46.62 | 1.2 | 73.2 | 66.0 | 72.4 |
| 17-03-2022 | 11 | 29.15 | 19.98 | 65.82 | 57.91 | 0 | 78.4 | 79.8 | 77.5 |
| 24-03-2022 | 12 | 30.72 | 21.58 | 72.43 | 68.26 | 0 | 83.2 | 80.2 | 82.7 |

Tmax: Temperature (maximum), Tmin: Temperature (minimum), RH: Relative humidity, M: Morning, E: Evening

**Table 2:** Area under disease progress curve (AUDPC) and infection rate (r) on Fusarium wilt incidence in chilli

| *Date of Observations* | *AUDPC* | | | *Apparent rate of infection (r)* | | |
|---|---|---|---|---|---|---|
| | *Date of Transplanting* | | | *Date of Transplanting* | | |
| | *5-11-2021* | *15-11-2021* | *25-11-2021* | *5-11-2021* | *15-11-2021* | *25-11-2021* |
| 23-12-2021 | 19.6 | 0.00 | 0.00 | 0.028 | 0.000 | 0.000 |
| 30-12-2021 | 66.5 | 61.25 | 0.00 | 0.047 | 0.043 | 0.000 |
| 06-01-2022 | 153.3 | 205.8 | 200.9 | 0.316 | 0.294 | 0.287 |
| 13.01.2022 | 202.65 | 236.25 | 227.85 | 0.219 | 0.337 | 0.325 |
| 20-01-2022 | 221.2 | 264.6 | 277.9 | 0.289 | 0.378 | 0.397 |
| 27-01-2022 | 247.45 | 296.8 | 316.75 | 0.353 | 0.424 | 0.452 |
| 03-02-2022 | 287.7 | 306.6 | 353.15 | 0.411 | 0.438 | 0.504 |
| 10-02-2022 | 344.75 | 329.1 | 396.2 | 0.492 | 0.472 | 0.566 |
| 17-02-2022 | 407.75 | 368.55 | 421.75 | 0.582 | 0.526 | 0.602 |
| 24-02-2022 | 443.8 | 391.3 | 436.1 | 0.634 | 0.559 | 0.623 |
| 03-03-2022 | 467.25 | 409.15 | 457.45 | 0.667 | 0.584 | 0.653 |
| 10-03-2022 | 495.95 | 443.1 | 487.2 | 0.708 | 0.633 | 0.696 |
| 17-03-2022 | 530.6 | 510.3 | 524.65 | 0.758 | 0.729 | 0.749 |
| 24-03-2022 | 565.6 | 560 | 560.7 | 0.824 | 0.765 | 0.796 |

**Table 3:** Correlation matrix between weather parameters and Fusarium wilt incidence on different dates of transplanting during rabi season, 2021-22

| *Weather variables* | *Correlation coefficient (r)* | | |
|---|---|---|---|
| | *05.11.2021* | *15.11.2021* | *25.11.2021* |
| Temperature (max.) (°C) | 0.792** | 0.791** | 0.723** |
| Temperature (min.) (°C) | 0.589* | 0.630* | 0.575* |
| Relative humidity (mor.) (%) | -0.875** | -0.650** | -0.790** |
| Relative humidity (eve.) (°C) | -0.597* | -0.543* | -0.624* |
| Total rainfall (mm) | -0.523 | -0.493 | -0.447 |

*Significant at p = 0.05 (2-tailed) ** Significant at p=0.01 (2-tailed)

increasing temperature favors the development of Fusarium wilt. In contrast, relative humidity and rainfall showed a negative relationship with disease incidence across all transplanting dates. The correlation with maximum temperature was highly significant ($p$ <0.01), with coefficients of 0.792, 0.791, and 0.723 for the respective transplanting dates.

Similarly, minimum temperature showed a positive and significant correlation ($p$ < 0.05) with percent disease incidence (PDI), with coefficients of 0.589, 0.630, and 0.575. In contrast, both morning and evening relative humidity exhibited a negative association with disease incidence. The correlation with morning relative humidity was highly significant ($p$ <0.01), with coefficients of -0.875, -0.650, and -0.790, whereas evening relative humidity showed a significant negative correlation ($p$ < 0.05), with values of -0.597, -0.543, and -0.624. Rainfall also exhibited a negative but non-significant relationship with disease incidence across all transplanting dates, with correlation coefficients ranging from -0.523 to -0.447. The positive association with temperature indicates that thermal conditions play a crucial role in enhancing pathogen activity and host susceptibility. In contrast, the negative relationship with relative humidity and rainfall suggests that higher moisture levels are less conducive to wilt development under field conditions.

The outcomes of the present investigation corroborate the observations of Gupta *et al.,* (2024), who reported an inverse and significant relationship between evening relative humidity and Fusarium wilt severity in chilli, along with a significant negative association between minimum temperature and disease development. Comparable results were reported by Bhagat et al., (2018) in gladiolus, where relative humidity was found to be negatively and significantly associated with Fusarium wilt incidence, which is also in agreement with Bana et al., (2020). However, the present findings show partial agreement with the study of Chandra *et al.,* (2017), who demonstrated that

**Table 4:** Multiple regression equations for the prediction of Fusarium wilt incidence on different dates of transplanting in relation to weather parameters

| *Date of observation* | *Regression equation* ($Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$) | $R^2$ *Value* | *Adjusted* $R^2$ | $F_{cal}$ |
|---|---|---|---|---|
| 05.11.2021 | $Y = -75.976 + 6.282X_1 + 1.148X_2 + 0.286X_3 - 1.312X_4 - 0.278X_5$ | 0.90 | 0.84 | 15.04 |
| 15.11.2021 | $Y = -106.99 + 5.042X_1 + 3.015X2 - 0.691X_3 - 1.330X_4 - 0.181X_5$ | 0.84 | 0.74 | 8.71 |
| 25.11.2021 | $Y = -153 + 9.730X_1 - 1.393X_2 + 0.719X_3 - 1.399X_4 - 0.125X_5$ | 0.81 | 0.69 | 7.03 |

Where, $X_1$=Maximum temperature, $X_2$=Minimum temperature, $X_3$=Relative humidity (morning), $X_4$=Relative humidity (evening), $X_5$=Total rainfall (mm)

both maximum and minimum temperatures significantly and positively influenced Fusarium wilt incidence, whereas relative humidity during morning and evening hours and rainfall exhibited negative associations with disease occurrence. Thus, correlation analysis provides valuable insights into the individual influence of weather parameters on disease incidence, which is essential for developing predictive models.

### Multiple regression analysis for the prediction of Fusarium wilt incidence in Chilli

To predict Fusarium wilt incidence in the Bullet Lanka variety across three transplanting dates, the multiple regression equations were developed and are presented in Table 4. The combined influence of meteorological variables on disease development was quantified using the coefficient of determination ($R^2$), which ranged from 81 to 90% across the three transplanting dates. The results indicated that weather parameters accounted for 90, 84, and 81% of the variability in percent disease incidence for crops transplanted on 5$^{th}$ ($R^2$=0.90, $F_{cal}$=15.04), 15$^{th}$ ($R^2$=0.84, $F_{cal}$=8.71), and 25$^{th}$ ($R^2$=0.81, $F_{cal}$=7.03) November 2021, respectively.

Among the transplanting dates, the model corresponding to 5th November exhibited the highest predictive accuracy, indicating a strong dependence of disease incidence on prevailing weather conditions. The regression coefficients further showed that maximum temperature, minimum temperature, and morning relative humidity contributed positively to disease development, with unit increases resulting in corresponding increases of 6.282, 1.148, and 0.286 in disease incidence, respectively. Collectively, these meteorological variables contributed to up to 90% ($R^2$=0.90) variation in disease incidence. These findings are consistent with those of Nagaraju *et al*. (2025), who reported that the coefficient of determination ($R^2$) effectively captures the combined influence of multiple weather variables on Fusarium wilt development, accounting for 82 to 90% of the observed variation.

## Conclusion

The present study clearly demonstrates that weather variables play a crucial role in the development and progression of Fusarium wilt in chilli. The timing of transplanting significantly influences disease incidence, with the highest wilt severity observed during the third week of March. This peak coincided with specific environmental conditions, particularly temperatures ranging from 25 to 30°C, moderate relative humidity, and minimal rainfall. Furthermore, the area under the disease progress curve (AUDPC) and the apparent infection rate (r) provided valuable insights into disease build-up and temporal spread, highlighting the importance of early detection and timely disease management strategies. In addition, the multiple regression model successfully predicted disease incidence using weather parameters, offering a dependable framework for forecasting potential outbreaks. These findings contribute to the development of climate-based predictive models that can support early warning systems and guide farmers in implementing timely disease management strategies. Future research should emphasize integrating weather-based forecasting tools with sustainable control measures to enhance chilli production and reduce disease impact.

## Acknowledgments

The authors are truly thankful to the Department of Plant Pathology, Palli-Siksha Bhavana (PSB), Visva-Bharati, for granting the invaluable chance to participate in research, offering their unwavering support and providing the necessary facilities for the research.

## Contribution of Authors

All the authors provided crucial feedback and contributed to shaping the research, analysis and manuscript. Madhaiyan Sakthivel wrote the manuscript with support and comments from Dr. Ranjan Nath, conceptualization and supervision, while Marimuthu Elangovan assisted in editing and revising the manuscript.

## Conflict of Interest

According to the authors, there is no conflict of interest.

## References

Akash, Z., Rajput, N. A., Atiq, M., & Malik, A. U. (2022). Assessment of synthetic fungicides against wilt of chili caused by *Fusarium oxysporum* f. sp. *capsici*. Pakistan *Journal of Agricultural Sciences, 59*(3), 485-492.

Bai, A. T., Ruth, C., Gopal, K., Arunodhayam, K., Priya, B. T., & Ramakrishna, M. (2018). Survey and identification of Fusarium wilt disease in chili (*Capsicum annuum* L.). *International Journal of Current Microbiology and Applied Sciences, 7*(6), 1073-1078. https://doi.org/10.20546/ijcmas.2018.706.127

Bana, J. K., Choudhary, J. S., Ghoghari, P. D., Sharma, H., Kumar, S., & Patil, S. J. (2020). Influence of weather parameters on powdery mildew of mango inflorescence in humid tropics of South Gujarat. *Journal of Agrometeorology, 22*(4), 488-493. https://doi.org/10.54386/jam.v22i4.473

Bhagat, S. S., & Gupta, S. T. (2018). Study on isolation, purification and identification of gladiolus disease. *International Journal of Chemical Studies, 6*, 1554-1558.

Butt, D. J., & Royle, D. J. (1974). Multiple regression analysis in the epidemiology of plant diseases. In: Kranz, J. (Ed.) Epidemics of plant diseases. Ecological studies (analysis and synthesis). Springer, Heidelberg, pp. 78-144. https://doi.org/10.1007/978-3-642-96220-2_4

Campbell, C. L., & Madden, L.V. (1990). Introduction to plant disease epidemiology. John Wiley & Son, New York, p.193.

Chakrabarty, S., Islam, A. M., & Islam, A. A. (2017). Nutritional benefits and pharmaceutical potentialities of chili: A review. *Fundamental and Applied Agriculture, 2*(2), 227-232. https://f2ffoundation.org/faa/index.php/home/article/view/74

Chandra, P., Sharma, O. P., Vennila, S., Singh, N., & Yadav, S. K. (2017). Climatic relationship of Pigeon pea Fusarium wilt in hot arid ecoregion of Banaskantha, Gujarat. *Annals of Plant Protection Sciences, 25*(2), 443-445.

Cook, R. J., & Baker, K. F. (1983). The nature and practice of biological control of plant pathogens (p. 539). American Phytopathological Society, St. Paul, MN, USA.

Gupta, P., Sangwan, P., Singh, M., Malik, V. K., & Sapna. (2024). Effect of weather parameters on disease severity and progression of Fusarium wilt in chili (*Capsicum anuum* L.). *International Journal of Environment and Climate Change, 14*(8), 182-188. https://doi.org/10.9734/ijecc/2024/v14i84340

Gupta, R., Awasthi, R. P., & Kolte, S. J. (2003). Influence of sowing dates and weather factors on development of Alternaria blight on rapeseed-mustard. *Indian Phytopathology, 56*(4), 398-402. https://epubs.icar.org.in/index.php/IPPJ/article/view/18435

Joshi, D., Pushpendra, K. S., Adhikari, S., & Rani, S. (2018). Screening of soybean germplasm for important disease prevalent in North India. *International Journal of Chemical Studies, 6*(2), 2731-2733.

Kumar, S., Singh, J., Biswas, S. K., Prem, N. P., & Dabas, M. R. (2012). Effect of culture media, temperature, pH and host range on the growth of *Fusarium oxysporum* f. sp. *pisi*. *Journal of Mycopathological Research, 50*(1), 73-76.

Landa, B. B., Navas-Cortes, J. A., Hervas, A., & Jiménez-Díaz, R. M. (2001). Influence of temperature and inoculum density of *Fusarium oxysporum* f. sp. *ciceris* on suppression of Fusarium wilt of chickpea by rhizosphere bacteria. *Phytopathology, 91*(8), 807-816. https://doi.org/10.1094/PHYTO.2001.91.8.807

Mayee, C. D., & Datar, V. V. (1986). Phytopathometry. Technical Bulletin, Marathwada Agricultural University, Parbhani, pp.125.

Nagaraju, D., Kharbade, S.B., Hasabnis, S. N., Jadhav, J. D., Shaikh, A. A., & Balasubramanian, R. (2025). Assessment of weather parameters on percent disease incidence and forewarning models of Fusarium wilt in pigeon pea as influenced by different sowing windows. Indian *Journal of Agricultural Research, 59*(4), 649-653.

Rangaswami G. (2005). Diseases of Crop Plants in India. New Delhi: Prentice Hall of India Pvt. Ltd., p. 520.

Reddy, N. S., Rajamohan, K., Lakshmidevi, P., & Vigneshwaran, K. (2024). Regional survey, isolation, and morphotypes diversity of Fusarium wilt pathogen in chili from Andhra Pradesh and Tamil Nadu. *International Journal of Advanced Biochemistry Research, 8*(9), 1382-1387. https://doi.org/10.33545/26174693.2024.v8.i9Sq.2359

Sakthivel, M., Ranjan Nath, S. S., Elangovan, M., & Sathish, K. (2024). Survey on the incidence of Fusarium wilt of chili in the agro-ecological condition of red and lateritic zone of West Bengal. *International Journal of Research in Agronomy, 7*(11), 526-529. https://doi.org/10.33545/2618060X.2024.v7.i11g.2054

Sanogo S. (2003). Chile pepper and the threat of wilt diseases. Online Plant Health Progress. https://doi.org/10.1094/PHP-2003-0430-01-RV

Shaheen, N., Khan, U. M., Azhar, M. T., Tan, D. K., Atif, R. M., Israr, M., Yang, S.H., Chung, G., & Rana, I. A. (2021). Genetics and genomics of Fusarium wilt of chilies: *A review. Agronomy, 11*(11), 2162. https://doi.org/10.3390/agronomy11112162

Singh, R. S. (2018). Plant diseases (10th edition). Scientific International (Pvt.) Ltd, New Delhi. pp.536.

Vanderplank, J. E. (1963). Plant Disease: Epidemic and Control. Academic press, New York, p.3.

Wani, S. A., Mohiddin, F.A., Hamid, B., Rizvi, K. A., Bhat, K. A., Hamid, A., Alam, A., Baba, Z. A., Pedder, S. A., & Bhat, M. A. (2014). Incidence of Fusarium wilt of chili (*Capsicum annum* L.) in Kashmir valley and its management by *Trichoderma* spp. *Mycopath, 12*(1), 1-8.