**Influence of Weather Parameters on Sugarcane Wilt (*Fusarium sacchari*) disease under field Conditions**

**Abstract**

 Sugarcane wilt disease, caused by *Fusarium sacchari*, is a major constraint in sugarcane production, with its incidence strongly influenced by weather parameters. This study aimed to evaluate the role of climatic factors in disease progression under field conditions during the 2023–24 cropping season. Meteorological data, including maximum and minimum temperatures, relative humidity, rainfall and sunshine hours, were collected from Agro Meteorological Advisory Services, RPCAU, Pusa. Disease incidence was recorded fortnightly and statistical analyses, including correlation and multiple linear regression (MLR), were employed to assess the impact of weather factors. Results indicated that disease incidence varied from 0.60% to 26.60% during the study period, with peak incidence (26.60%) recorded in the second fortnight of July 2023. This period was characterized by high relative humidity (84.40% morning, 62.60% evening), elevated minimum temperatures (25.90°C) and substantial rainfall (82.60 mm). Correlation analysis revealed that minimum temperature (r = 0.720) and relative humidity at 14:00 hours (r = 0.560) were significantly associated with disease incidence. The MLR model explained 87.8% (R² = 0.878) of disease variability, highlighting the crucial role of these factors in disease progression. The findings suggest that environmental conditions during the rainy season significantly favour *F. sacchari* infection. Therefore, timely disease monitoring and predictive modelling based on weather trends can enhance disease management strategies in sugarcane cultivation.

**Keywords:** Correlation analysis, Disease incidence Multiple linear regression, Sugarcane wilt, Weather parameters

**Introduction**

 Sugarcane (*Saccharum officinarum* L.) is a vital commercial crop cultivated in tropical and subtropical regions for sugar, ethanol, and bioenergy production. Sugarcane thrives in tropical regions with warm, humid conditions, optimal at 28–32°C. Growth slows below 20°C and ceases above 45°C, while temperatures below 5°C make cultivation unsuitable. The crop requires 75–120 cm of annual rainfall and a growing season of 10–18 months. Ideal relative humidity ranges from 70–85% during growth and 55–75% during ripening, while levels below 50% hinder development (Shukla *et al*., 2017). Globally, it covers approximately 26.34 million hectares, yielding 1,859.39 million tons annually, with Brazil and India being the top producers (FAO, 2022). In India, sugarcane cultivation spans 5.15 million hectares, supporting millions of farmers and contributing significantly to the economy (Ram & Hemaprabha, 2020).

 Despite its economic importance, sugarcane is highly susceptible to various diseases, with over 55 reported in India (Rao *et al*., 2002). Among them, wilt disease, primarily caused by *Fusarium sacchari*, has emerged as a major constraint to production, leading to significant yield losses. In Bihar, the incidence of wilt varies widely, affecting up to 80% of sugarcane fields in some factory zones (Minnatullah *et al*., 2021, 2022). Abiotic factors play a crucial role in the incidence and severity of sugarcane wilt disease by influencing both the host plant and the pathogen. Temperature is a key determinant, as high temperatures above 35°C promote pathogen growth and spore germination, while lower temperatures (<20°C) can slow plant defence responses, making sugarcane more susceptible (Viswanathan & Rao, 2011). Soil moisture also significantly affects wilt severity; drought stress weakens plant vigour and predisposes it to infection, whereas excessive soil moisture creates favourable conditions for fungal survival and spread (Minnatullah *et al*., 2022). Additionally, soil type and pH influence disease dynamics, with heavy, poorly drained soils and extreme pH levels enhancing pathogen persistence (Rao *et al*., 2002). Furthermore, relative humidity plays a role, as high humidity levels promote fungal sporulation and dissemination, while extremely low humidity can stress the plant, making it more vulnerable to infection (Rott *et al*., 2000). These abiotic factors collectively contribute to the initiation, progression, and overall impact of sugarcane wilt disease in affected regions.

**Materials and Methods**

 The monthly meteorological data from June 2023 to February 2024 were collected from the Agro Meteorological Advisory Services, RPCAU, Pusa depicted in table 1. Weather factors such as minimum and maximum temperature (ºC), morning and evening relative humidity (%), rainfall (mm), and bright sunshine hours were correlated with disease incidence. Correlation and regression analysis were conducted on disease incidence and weather parameters. Based on this analysis, the influence of weather parameters on the severity of wilt disease was observed.

**Table 1. Role of weather parameters on the development of sugarcane wilt disease caused by *Fusarium sacchari***

| **Fortnightly observations** | **Disease incidence** | **Temperature (°C)** | **Relative humidity (%)** | **Rainfall (mm)** | **Bright sunshine (hr)** |
| --- | --- | --- | --- | --- | --- |
| **Maximum** | **Minimum** | **Morning** | **Evening** |
| June-I | 0.88 (5.38) | 40.20 | 23.80 | 71.60 | 34.20 | 0.00 | 9.60 |
| June-II | 1.20 (6.29) | 36.20 | 25.30 | 86.20 | 56.90 | 92.60 | 4.90 |
| July-I | 24.30 (29.53) | 32.60 | 24.90 | 93.20 | 78.50 | 63.60 | 2.20 |
| July-II | 26.60 (31.04) | 35.00 | 25.90 | 84.40 | 62.60 | 82.60 | 7.40 |
| August-I | 22.50 (28.31) | 31.80 | 24.60 | 94.30 | 79.60 | 388.50 | 2.60 |
| August-II | 23.60 (29.07) | 32.50 | 24.70 | 92.50 | 74.80 | 144.40 | 3.60 |
| September-I | 25.50 (30.32) | 33.70 | 24.80 | 92.80 | 75.00 | 99.00 | 4.40 |
| September-II | 22.10 (28.04) | 31.70 | 24.00 | 95.20 | 78.70 | 335.60 | 4.10 |
| October-I | 17.20 (24.50) | 32.40 | 24.40 | 94.20 | 71.10 | 38.40 | 5.80 |
| October-II | 12.90 (21.04) | 31.30 | 19.50 | 94.30 | 56.60 | 1.20 | 8.60 |
| November-I | 6.80 (15.11) | 30.20 | 17.40 | 96.40 | 53.60 | 0.00 | 4.50 |
| November-II | 3.80 (11.24) | 29.30 | 15.10 | 93.20 | 51.60 | 0.00 | 5.80 |
| December-I | 2.60 (9.28) | 25.70 | 13.60 | 96.80 | 58.40 | 4.60 | 3.70 |
| December-II | 1.60 (7.27) | 24.10 | 10.30 | 96.70 | 59.50 | 0.00 | 4.90 |
| January-I | 0.70 (4.80) | 19.00 | 9.80 | 97.90 | 70.60 | 105.60 | 0.80 |
| January-II | 0.60 (4.44) | 16.10 | 8.00 | 97.50 | 76.00 | 70.30 | 0.90 |

**Disease incidence**

Disease incidence (%) = $\frac{Number of affected settlings}{Total number of settlings assessed}$ × 100

**Statistical measures**

 To establish the relationship between weather parameters and the incidence of disease, as well as to develop a forecasting system, the collected data was analyzed using various statistical techniques, which are outlined below:

**Descriptive Statistics**

 Basic statistical measures such as mean, standard deviation, and range were employed to understand the variations in weather factors and their influence on pest and disease incidence.

**Correlation Analysis**

 Correlation analysis was conducted to assess the degree of association between two variables. In this study, Karl Pearson’s correlation coefficient was used to determine the relationship between pest incidence and various weather parameters, including: Minimum temperature, Maximum temperature, Morning relative humidity, Evening relative humidity, Rainfall and Sunshine hours

 The correlation coefficient (R) was computed using the formula:

R = $\frac{COV(XY)}{√V\left(X\right)V(Y)}$

**Significance Testing of Correlation Coefficient**

 To evaluate the statistical significance of the correlation coefficient, a t-test was applied. The null hypothesis was formulated as: H0: 𝜌 = 0 against alternative hypothesis H1: 𝜌≠ 0.

 The test statistic was calculated using:

t = $\frac{r√n-2}{\sqrt{1}-r2}$

Where,

r = Correlation coefficient

n = Number of observations

**Multiple Linear Regression (MLR) Model**

 To establish the fundamental relationship between dependent and independent variables, multiple regression analysis was performed. The following statistical model was used to examine the impact of weather variables on disease incidence:

Y= a +b1x1+ b2x2+ b3x3+ b4x4+ b5x5+b6x6+ei

Where,

Y = Dependent variable (Disease incidence)

a= Pure constant

b1= Regression coefficient for maximum temperature (X1)

b2= Regression coefficient for minimum temperature (X2)

b3=Regression coefficient for RH at 7 hrs. (X3)

b4=Regression coefficient for RH at 14 hrs. (X4)

b5= Regression coefficient for rainfall (X5)

b6=Regression coefficient for sunshine (X6)

ei - Random error

**Coefficient of Determination (R²)**

 The goodness of fit of the regression equation was assessed using the coefficient of determination (R2). This statistic represents the proportion of variation in the dependent variable (Y) that is explained by the independent variables (X2, X3....Xp). It is calculated as:

R2= $\frac{Explained sum of squares }{Total sum of squares}$

 The value of R2 ranges from 0 to 1, indicating the strength of the model in explaining variations in disease incidence.

**Results**

 The results of these analysis are organized into two main sections. The first section examines the behaviour of climate factors in relation to wilt disease in sugarcane. The second section focuses on correlation analysis and Multiple Linear Regression (MLR) models developed to forecast wilt disease incidence in sugarcane depicted in table 2 & 3 respectively.

 The data (Table 1, Fig. 1) indicates that disease incidence varied from 0.60% to 26.60% throughout the study period. The highest incidence (26.60%) was observed during the second fortnight of July, followed by 25.50% in the first fortnight of September and 24.30% in the first fortnight of July. Specifically, the peak incidence of 26.60% occurred during the second fortnight of July 2023, when the weather parameters were as follows: maximum temperature of 35.00°C, minimum temperature of 25.90°C, relative humidity of 84.40% in the morning and 62.60% in the afternoon, rainfall of 82.60 mm, and sunshine hours of 7.40. The disease was most prevalent during the rainy season (July to October), with a noticeable decline in incidence following this period. This trend suggests that wilt disease, caused by *Fusarium sacchari*, is strongly influenced by the weather conditions prevalent during the rainy season.

 The correlation analysis of weather factors and disease incidence, as summarized in Table 2, and figure 2, shows that minimum temperature and relative humidity at 14:00 hours are significantly and positively correlated with disease incidence, with correlation coefficients of 0.720 and 0.560, respectively. Conversely, maximum temperature, relative humidity at 07:00 hours, rainfall, and sunshine hours have positive but non-significant correlations, with coefficients of 0.463, 0.064, 0.481, and 0.055, respectively. In addition, multiple linear regression analysis was performed using disease incidence as the dependent variable and climatic factors as independent variables (Table 3). The results indicated that the combined influence of all-weather parameters explained 87.8% of the variation in disease incidence (R² = 0.878). This analysis highlights that minimum temperature and relative humidity at 14:00 hours are particularly important weather factors for the development of the disease.

**Table 2. Correlation matrix of weather parameters on wilt disease of sugarcane**

|  |  |  |
| --- | --- | --- |
| Incidence (y) | Number of observations | Weather data |
| Temperature 0C | Relative Humidity (%) | Rainfall (X5) | Sunshine Hrs (X6) |
| Maximum (X1) | Minimum (X2) | 7.00 Hrs (X3) | 14.00 Hrs (X4) |
| Wilt | 16 | 0.463 | 0.720\*\* | 0.064 | 0.560\* | 0.481 | 0.055 |

\* & \*\* - Significant at 5% & 1% probability

**Table 3. Multiple linear regression (MLR) models for weather parameters on wilt disease incidence in sugarcane**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Incidence (y) | Number of observations | Pure constant (a) | Weather data | R2 | Adjusted R2 |
| Temperature 0C | Relative Humidity (%) | Rainfall (X5) | SunshineHrs (X6) |
| Maximum (X1) | Minimum (X2) | 7.00 Hrs (X3) | 14.00 Hrs (X4) |  |  |
| Wilt | 16 | -97.80 | 0.490 | 0.380 | 0.328 | 0.821 | -0.007 | 2.354 | 0.878 | 0.937 |

**Multiple Linear Regression (MLR) equation**

$$\hat{Y}=-97.80+0.490X\_{1}+0.380X\_{2}+0.328X\_{3}+0.821X\_{4}-0.007X\_{5}+2.354X\_{6}$$

**Figure 1. Fortnight wilt disease incidence on sugarcane during period 2023-24**

**Figure 2. Effect of climatic factors on the incidence of wilt on sugarcane**

**Discussion**

 The current study reveals that disease incidence ranged from 0.60% to 26.60% over the study period. The peak incidence of 26.60% was recorded during the second fortnight of July 2023, coinciding with maximum and minimum temperatures of 35.0°C and 25.90°C, respectively; morning and afternoon relative humidity levels of 84.40% and 62.60%; rainfall of 82.60 mm; and 7.40 sunshine hours. This peak was observed in the rainy season (July to October), after which a significant decline in incidence was noted. This pattern indicates that wilt disease, caused by *Fusarium sacchari*, is highly influenced by the prevailing weather conditions during the rainy season, particularly elevated soil moisture, high relative humidity, and moderate to war temperature. These factors not only favour pathogen survival and sporulation but also enhance infection efficiency and disease progression, ultimately contributing to higher incidence levels in susceptible sugarcane crops..

 Correlation analysis reveals a significant positive correlation between disease incidence and minimum temperature and relative humidity at 14:00 hours, with correlation coefficients of 0.720 and 0.560, respectively. In contrast, maximum temperature, relative humidity at 07:00 hours, rainfall, and sunshine hours showed positive but non-significant correlations, with coefficients of 0.463, 0.064, 0.481, and 0.055, respectively. Furthermore, multiple linear regression analysis indicates that weather parameters collectively accounted for 87.8% of the variation in disease incidence (R² = 0.878). This analysis underscores the importance of minimum temperature and relative humidity at 14:00 hours as critical factors influencing disease development, highlighting their role in managing and predicting wilt disease. This finding is supported by Irshad *et al*. (2023), who found that wilt incidence in sugarcane was significantly influenced by climate factors, including relative humidity above 85%, temperatures between 26°C and 30°C, and rainfall. Their analysis showed that weather parameters explained 87.8% of the variation in disease incidence (R² = 0.969). Similar findings were reported by Minnatullah *et al*. (2020), Paswan *et al*. (2018) and Mehra and Sahu *et al*. (2015), who also observed that climatic factors such as relative humidity, temperature, and rainfall significantly impact wilt incidence.

**Conclusion**

 The study underscores the critical role of weather parameters in the development of sugarcane wilt disease caused by *Fusarium sacchari*, particularly during the rainy season. The significant associations between minimum temperature, afternoon relative humidity, and disease incidence highlight the need for climate-based predictive modelling. By integrating meteorological data with disease forecasting, it becomes possible to implement proactive and timely management strategies to reduce the impact of wilt disease on sugarcane yields. These findings also stress the importance of monitoring weather trends for early detection and intervention. Future research should focus on refining prediction models to improve accuracy and exploring the development of resistant sugarcane genotypes. Such efforts will be crucial for enhancing sustainable disease management in sugarcane farming, ensuring better crop resilience and productivity under varying climatic conditions. These steps are vital for minimizing the economic losses caused by wilt disease in sugarcane cultivation.

**References**

FAO. (2022). Production: Crops and livestock products. *In FAOSTAT. Rome*. [Cited October 2023].

Irshad, M., Kumar, M., Ray, M., Sattar, A., Paswan, S., & Minnatullah, M. (2023). Effect of meteorological elements on sugarcane wilt in Bihar. *International Journal of Statistics and Applied Mathematics*, SP-**8**(4), 128-133.

Mehra, P., & Sahu, R. K. (2015). Correlation and regression of meteorological factors with sugarcane smut disease caused by *Sporisorium scitaminea* (syn. *Ustilago scitaminea*). *The Bioscan*, **10**(4), 1691-1693.

Minnatullah, Md., Chand, H., Paswan, S., & Singh, S. P. (2020). Influence of weather on Pokkah Boeng disease in sugarcane under North-West Alluvial Plains (Zone I) of Bihar. *Journal of Agrometeorology*, **22**(1), 60-62.

Minnatullah, Md., Singh, P., Singh, S. P., & Aaradhna. (2022). Sugarcane disease scenario, possible reasons for their spread and suitable remedies in Bihar condition. *The Plant Pathologist International*, **11**(6), 655-659.

Minnatullah, Md., Singh, S. P., Singh, A. K., Aaradhna, Kumar, A., & Meena, S. K. (2021). Integrated disease management in sugarcane and estimated cost of components. *Agriblossom,* **02**(03), 42-49.

Paswan, S., Minnatullah, M., Kumar, M., & Sattar, A. (2018). Impact of weather factors on development of red rot disease of sugarcane agro-ecosystem. *International Journal of Current Microbiology and Applied Sciences*, **7**(2), 8-12. <https://doi.org/10.20546/ijcmas.2018.702.002>

Ram, B., & Hemaprabha, G. (2020). The sugarcane variety Co 0238 – A reward to farmers and elixir to India’s sugar sector. *Current Science*, **118**(11).

Rao, G. P., Viswanathan, R., & Singh, S. B. (2002). Current situation of sugarcane diseases in India. In S. B. Singh, G. P. Rao, & S. Eswaramoorthy (Eds.), Sugarcane crop management (pp. 734). *SciTech Publishing* LLC.

Shukla, S. K., Sharma, L., Awasthi, S. K., & Pathak, A. D. (2017). Sugarcane in India: Package of Practices for Different Agro-climatic Zones (AICRP (S) Technical Bulletin No. 1, pp. 1-64).

Viswanathan, R., & Rao, G. P. (2011). Disease scenario and management of major sugarcane diseases in India. *Sugar Tech*, **13**(4), 336-353. <https://doi.org/10.1007/s12355-011-0055-5>