Journal of Environmental Biology
p-ISSN: 0254-8704 • e-ISSN: 2394-0379 • CODEN: JEBIDP

Original Research Paper
Volume 46 Issue 5 September 2025 pp. 748-754
DOI: http://doi.org/10.22438/jeb/46/5/MRN-5549

J. Environ. Biol., 2025
© Triveni Enterprises, Lucknow (India)
Journal website : www.jeb.co.in ★ E-mail : editor@jeb.co.in

Effect of weather parameters on dieback disease severity of Kinnow mandarin (*Citrus reticulata*) in Haryana, India

P.N. Meena[1*], D. Raghavendra[1], M. Choudhary, S. Singh[1], N. Kumar[2] S.K. Singh[1] and S. Chander[1]

[1]*ICAR- National Research Institute for Integrated Pest Management, New Delhi-110 068, India*
[2]*Department of Agriculture Entomology, Krishi Vigyan Kendra, Sadalpur, Chaudhary Charan Singh Haryana Agricultural University, Hisar-125 052, India*

Received: 13 September 2024 **Revised:** 19 November 2024 **Accepted:** 07 April 2025

***Corresponding Author Email:** pnshera@yahoo.co.in ***ORCiD:** https://orcid.org/0000-0003-3818-8304

Abstract

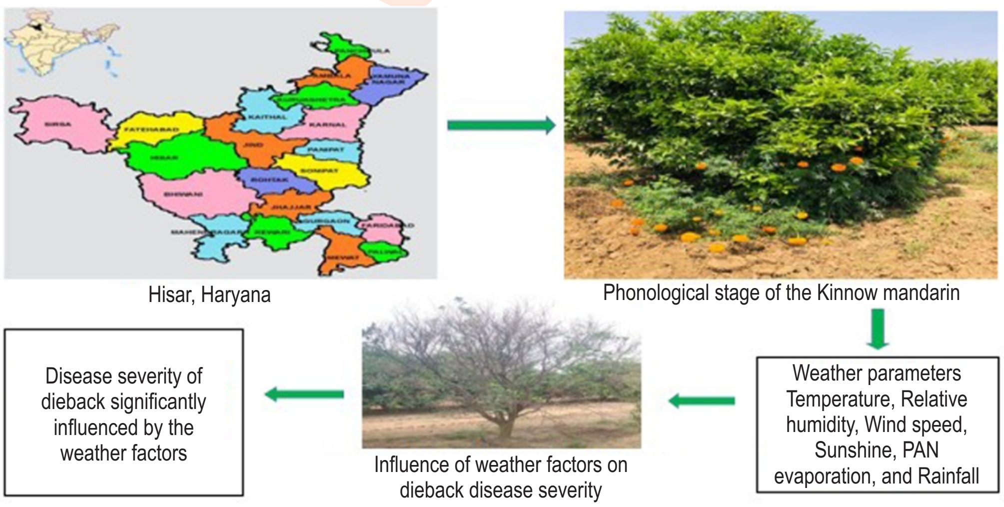
Aim: To assess the dieback disease severity in Kinnow mandarin (*Citrus reticulata* Blanco) and to understand the role of weather variables on dieback.

Methodology: Disease severity was recorded in the fixed orchards of the five randomly selected plants. The scoring was done on the infected twigs and branches per plant. AUDPC was determined based on the data recorded on different days. Correlation was performed to find out the effect of different weather factors on the severity of dieback.

Results: The initial dieback disease symptoms were observed in the 11^{th} SMW, which reached at peak (20.73%) in the 27^{th} SMW. The studies revealed a strong positive correlation between minimum temperature and dieback severity and a moderate positive correlation with the maximum temperature ("r"=0.846, $p<0.01$ & 0.571, $p<0.05$), while the wind speed showed a moderate positive correlation ("r"=0.599, $p<0.01$) with dieback severity. Further, multiple regression predicts dieback severity based on weather conditions, with minimum temperature (X^2) showing a particularly strong influence and explaining 72 percent of disease severity variability.

Interpretation: The information from this study can be utilized to provide protective advisory services to farmers and to develop integrated disease management strategies for the timely management of dieback disease.

Key words: AUDPC, *Citrus reticulata*, Dieback disease, Kinnow mandarin, Weather factors



How to cite: Meena, P.N., D. Raghavendra, M. Choudhary, S. Singh, N. Kumar S.K. Singh and S. Chander: Effect of weather parameters on dieback disease severity of Kinnow mandarin (*Citrus reticulate*) in Haryana, India. *J. Environ. Biol.*, **46,** 748-754 (2025).

Online copy

Introduction

Kinnow mandarin (*Citrus reticulata* Blanco) is one of the most important fruit crops after mango and banana that can be grown in tropical regions of India. It is popularly known for its high juice content, special flavor, and rich source of vitamin C. In North Indian states like Punjab, Haryana, and Rajasthan, the cultivation of other groups of citrus crops is limited due to the occurrence of acidity and puffiness of the fruit. Kinnow mandarin has been growing in larger areas compared to other citrus groups because of its prolific bearing, juice content, sweetness, good quality fruits and high yield. The area under citrus cultivation in India is spread to more than 109.6 million ha with the production of 14.25 million tonnes (DA and FW, 2023-24). Among the Indian states, Haryana covers 25.17 thousand ha area and 359.08 thousand million tonnes of production of citrus fruits, in which Kinnow mandarin occupies more than 90% in both area and production (Meena *et al*., 2025).

Even though many citrus groups of fruits are grown in India but productivity is still low. Numerous biotic (psylla, thrips, whitefly, leaf miner, mite, greening, gummosis, canker, dry root rot, sooty mould, nematode) and abiotic (stem injury, wind scare and stylar end deformities, temperature, rainfall, nutrient imbalance, physiological disorders, and soil related constraints) stresses are responsible for these causes in the tropical region of the country (Meena *et al.,* 2018). Various insect pest infestations and disease incidence are the major constraints reported in India for reducing yield (Sharma, 2008; Savita *et al.,* 2012; Singh *et al.,* 2013; Deka *et al.,* 2018). Dieback is one of the major constraints of citrus and other crops of the citrus group that can affect and limit the quality production of fruits all over the world (Sarker *et al.,* 2017). Kinnow mandarin suffers from various diseases from seedling to fruit harvesting stages. Among them, dieback caused by *Colletotrichum gloeosporioides* is an important disease that is wide spread in the tropical region of India and can reduce 43.80% of fruit yield in orchards when observed as an epidemic (Singh *et al.,* 2008). The major symptoms of this disease can be noticed on twigs, leaves, and on the apical part of the shoot.

The typical symptom of dieback disease includes the complete decline of trees through rotting of rootlets, dropping and blightening of leaves and girdling of the trunk. Dieback is prevalent in orchards throughout the year and major symptoms start from the apical part of the shoots and rapidly spread downwards up to the base of the shoots under favorable climatic conditions and the plant ultimately wilts and dies (Knorr *et al.,* 1957; Wutscher, 1980; Pathania *et al.,* 2021). North Indian states like Haryana, Punjab and Rajasthan are facing the serious problem of dieback in Kinnow mandarin. Sometimes, Kinnow plants die due to disease severity by the holding of fruits on the tree and the farmer encountered massive economic losses (Kassahun *et al.,* 2006). Besides, this disease become a major bottleneck for Kinnow mandarin growers in the north-western part of India during the last five years. Most of the Kinnow varieties grown in the Haryana, Punjab, Rajasthan, and other regions are severely suffering from the dieback disease, which is not only hampering the quality and production of mandarin fruits but also the export value. The significant role of weather factors for severity development and geographical spread of various diseases has been determined by Das *et al.,* (2011). Dolkar *et al.* (2018) reported the effect of weather parameters on plant growth and fruit quality. Besides, Dalal *et al.* (2018) studied the effect of weather parameters on bearing behavior and the correlation of fruit development stages of Kinnow mandarin under semi-arid irrigated conditions. Unfortunately, information on the influence of weather parameters on the perpetuation and development of dieback disease and their management on the basis of weather forecasting in Kinnow mandarin is scanty or not yet studied in depth in arid and semiarid regions of India. All the weather factors play a potent role on the survival, growth, multiplication, spread, and disease severity of the pathogen. Therefore, a thorough understanding of the interaction between dieback severity and weather variables is an urgent necessity for the management strategies. Hence, a three-year consecutive study (2021-2023) was carried out to understand the epidemiology of dieback disease and elucidate the effect of weather factors on disease severity of dieback in Kinnow mandarin for its effective management.

Materials and Methods

The present study was conducted in the permanent orchards of five villages (Daroli 29.27°N and 75.39°E; Kisangarh 24.21°N and 74.51°E; Sadalpur 29.19°N and 75.27°E; KharaBarwala, 29.38°N 75.92°E; and Chuli 29.27°N and 75.47°E) located in the Hisar district of Haryana during 2021 to 2023. Disease severity of dieback was recorded from each demarcated orchard by randomly selecting five plants (four from four corners and one from the center of the orchard). In the orchard, two rows of plants in all directions alongside the boundary were designated for dieback observations. The observations of dieback severity on twigs and branches were recorded randomly in five selected plants from four directions of each plant (north, south, east and west) as per the standard metrological week (SMW) starting from the 11^{th} -52^{nd} SMW. The observations on disease severity were recorded from the upper to lower canopy of the mandarin tree.

The percent severity index (PSI) of dieback was recorded by scoring on twigs and branches of each tree as per a disease rating scale of 0-4 as proposed by Ezeibekwe (2011), where 0=no signs or symptoms, 1=0-25% affected branches, 2=26-50% affected branches, 3=51-75% affected branches and 4=76-100% affected branches. Disease grades were converted into percentage severity index (PSI) by using the formula suggested by Chaube and Singh (1991).The area under the disease progress curve (AUDPC) was assessed by the data recorded on different days for dieback severity using the formula given by Shaner and Finney (1977). To study the dieback disease epidemiology, correlation, and multiple regression among the weather parameters and disease severity were ascertained. Weather parameter data of the corresponding period (2021-2023) on temperature (maximum and minimum), relative humidity (morning and evening), average wind speed km h^{-1}, bright sunshine (hr), PAN evaporation and rainfall (mm) of each SMW were obtained from the Agrometeorological Department, Chaudhary Charan Singh, Haryana, Agricultural University, Hisar. Weather factors significantly affecting the dieback severity were highlighted and established by using correlation and regression analysis. In the statistical study, disease severity of dieback served as dependent variable, while the weather parameters were considered as an independent variable.

Statistical analyses: All the data of disease severity were correlated with weather factors and multiple regression analysis to recognize the responsive variable using R package version 4.3.3 (R core team 2023). All the graphs depicted were also drawn using the R package.

Results and Discussion

The meteorological factors (minimum and maximum temperature, wind speed, and relative humidity) of Haryana were responsible for the development of Kinnow mandarin dieback disease. The weather data revealed that, the average maximum and minimum temperature varied from 44 to 18°C and 30 to 4°C respectively, during the investigation periods. The average mean maximum and minimum temperature from the 11^{th} to 52^{nd} SMW was in the range of 33.30 to 20.09°C. Similarly, the maximum morning and evening relative humidity varied from 100 to 47% and 89 to 15% with an average value of 81.85 to 48.43%. Average wind velocity and bright sunshine from 11^{th} to 52^{nd} SMW varied from 10.8 to 0.9 km hr^{-1} and 10.5 to 0.0 hr^{-1}. Similarly, PAN evaporation and rainfall were found in the range of 10.6 to 0.0 24 hr^{-1} and 111 to 0.0 mm during the observation periods. The initial dieback disease symptoms were observed in the 11^{th} SMW on the upper portion of twigs and branches and continuously persisted till the 52^{nd} SMW in all three years of the cropping season. The peak of dieback severity was observed in 27^{th} SMW but later on, it started declining gradually (Fig. 1). Based on the pooled mean results, it is evident that the maximum dieback severity (20.73%) was recorded in 27^{th} SMW when the prevailing maximum and minimum temperature (43.4 and 30.0°C), morning and evening relative humidity (63 and 35%), average wind velocity and sunshine (6.9 km hr^{-1} and 9.9 hr^{-1}) and PAN evaporation (10.6 24 hr^{-1}) respectively (Table 1).

The results showed that, the maximum AUDPC (145) was noticed in 28^{th} SMW followed by 29^{th} SMW (143.2) and 30^{th} SMW (140.6) respectively. The highest disease severity was noticed on leaves, twigs and new branches initiated on the tree. *Colletotrichum* spp. causing dieback disease in numerous agriculture plant hosts on leaves, twigs and branches in tropical and subtropical regions (Klotz, 1961; Agrios, 2005; Peres, 2008). Similarly, Hyde *et al.* (2009) and Cannon *et al.* (2012) reported that, *Colletotrichum* including many plant pathogens causes huge loss in many major crops worldwide. Earlier workers Dean *et al.* (2012) and Ramos *et al.* (2016) have reported that a number of host plants attacked by *Colletotrichum* species and infect all the plant tissues. Similarly, investigations carried out in California, Italy and Tunisia have emphasized that Botryosphaeriaceae is the most devastating fungus that causes dieback and vascular necrosis in citrus trees (Hartman *et al.,* 1999). The highest disease severity was also observed from the 28^{th} SMW to 30^{th} SMW due to conducive weather conditions. The values of AUDPC showed the potent role of meteorological factors and phenological stages of Kinnow mandarin for disease infection,

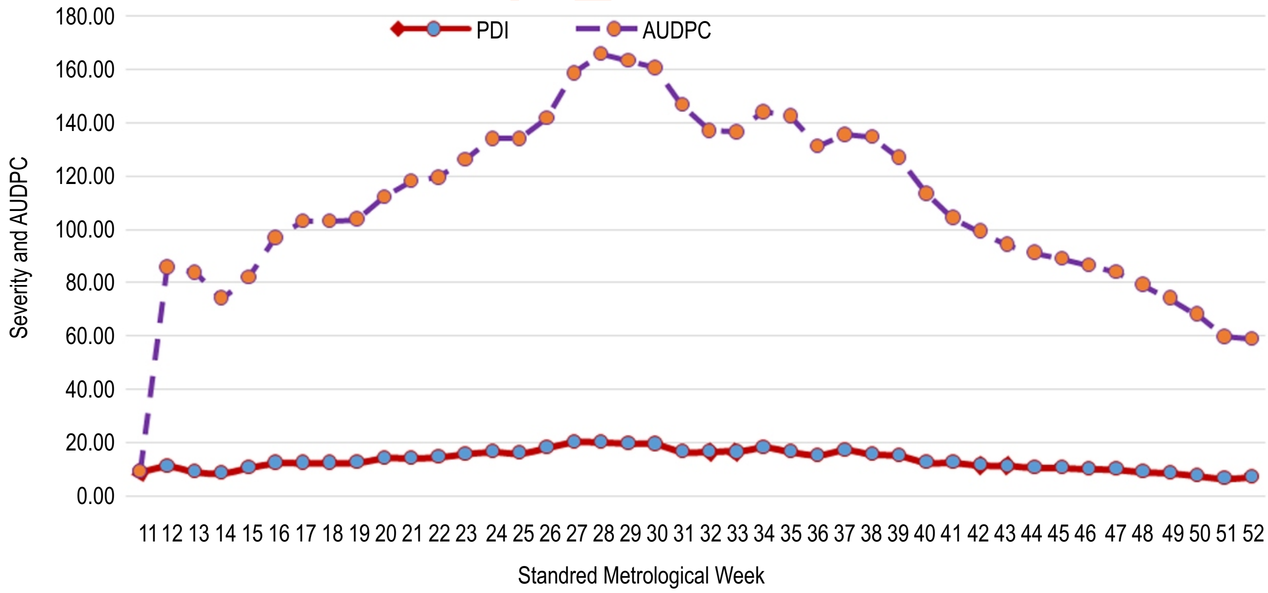


Fig.1: Area under disease progress curve (AUDPC) for severity of dieback during 2021-23.

Table 1: Weather data recorded during observations of Kinnow mandarin dieback occurrence during 2021–2023 crop seasons

Average mean of weather parameters (2021-2023)																	
SMW	**T_{max} (°C)**	**T_{min} (°C)**	**Rhm (%)**	**Rhe (%)**	**AWS (Km/h)**	**SS (h)**	**PAN Evap**	**Rainfall (mm)**	**SMW**	**T_{max} (°C)**	**T_{mini} (°C)**	**Rhm (%)**	**Rhe (%)**	**AWS (Km/h)**	**SS (h)**	**PAN Evap**	**Rainfall (mm)**
11	32	15.7	78	50	6.4	7.3	2.3	1.2	32	34.4	26.5	89	51	5.4	6.2	4.0	0
12	32.4	14.7	93	23	3.3	4.9	3.6	0	33	37.0	26.0	75	56	8.4	9.5	6.5	0
13	27	11.7	93	38	3.2	5.4	3.8	0	34	38.0	29.0	76	79	5.8	9.3	7.7	0
14	33.4	10.5	58	22	5.1	9.2	6.8	0	35	37.4	25.0	80	51	5.4	8.1	7.8	0
15	34	12	47	15	3.6	9.4	6.8	0	36	33.4	22.5	100	83	4.4	1.7	2.9	72.2
16	39	20	47	20	5.2	8.6	8.1	0	37	33.0	26.7	92	73	7.2	4.8	2.9	0
17	34.4	20.5	65	46	10.8	9.8	8	0	38	34.0	24.7	92	67	7	8.4	3.8	0
18	42.6	23.9	48	28	6.6	7.6	7.3	0.5	39	30.4	22.7	100	82	2.2	2.2	0.0	111.0
19	38.4	20.7	68	45	7.1	6.2	5.5	5.2	40	33.0	26.5	98	60	3.5	8.6	2.8	0
20	33	20	83	34	7.4	5.8	5.6	0	41	33.4	22.8	95	42	4.1	7.8	4.1	0
21	36.8	20	94	59	8.5	10	6.8	14.4	42	32.2	17.0	84	35	1.3	8.2	3.4	0
22	41.4	24.2	71	27	5.2	10.5	9.6	0	43	33.0	16.5	85	39	1.1	8.6	4.9	0
23	35.4	26.3	72	25	4.2	6.4	9.2	0	44	28.4	13.0	93	29	1.3	8.0	2.6	0
24	44.0	26.5	70	28	3.4	5.7	6.3	0	45	27.4	12.0	89	38	1.0	1.4	1.2	0.0
25	35.0	25.1	82	48	6.1	4.1	4.5	0	46	27.4	11.0	95	42	0.6	0.0	1.0	0.0
26	40.4	26.4	65	23	3.1	6.2	9.1	0	47	25.8	7.5	83	27	1.4	7.3	1.9	0.0
27	43.4	30.0	63	35	6.9	9.9	10.6	0	48	27.0	8.5	95	31	3.1	6.9	1.4	0.0
28	41.8	29.5	66	39	6.1	9.9	10.1	0	49	18.0	8.0	100	58	1.5	0.0	1.3	0.0
29	33.4	28.0	89	56	6.2	3.9	3.3	0	50	23.4	7.0	100	39	0.9	7.1	1.6	0.0
30	34.0	27.4	92	74	7.3	5.2	3.9	0	51	18.4	4.0	100	82	1.8	0.0	1.4	0.0
31	28.4	24.5	100	89	3.4	0.3	0.0	80.5	52	22.0	8.0	88	54	5.1	6.1	1.0	0.0

SMW-Standred Metrological Week; Tmax- Maximum Temperature; Tmin- Minimum Temperature; Rhm- Morning Relative Humidity; Rhe - Evening Relative Humidity; AWS-Average Wind Speed; SS- Sun shine; PAN evaporation and Rainfall

Table 2: Correlation between dieback severity with weather parameters during 2021-23

Weather parameters	**Correlation coefficient ®**
Maximum Temperature	0.571*
Minimum Temperature,	0.846**
Morning relative humidity,	-0.189^{NS}*
Evening relative humidity	0.237^{NS}
Wind speed	0.599*
Sun shine	0.104^{NS}
PAN evaporation	0.438^{NS}
Rainfall	0.220^{NS}

**Significant at 0.01 level, * Significant at 0.05 level, NS=Non-significant

multiplication and further development. The results revealed a strong positive correlation between minimum temperature and dieback severity and a moderate positive correlation with maximum temperature ("r"=0.846, p<0.01 & 0.571, p<0.05). Wind speed also showed a moderate positive correlation ("r"=0.599, p<0.01) suggesting that higher temperature and wind speed may be associated with increased dieback severity. Other parameters like morning and evening relative humidity, sunshine, PAN evaporation, and rainfall showed non-significant correlations, indicating a weaker or non-existent relationship with dieback severity (Table 2). The findings are in line with the reports of Mohod *et al.* (2017) who found that, the results of weather parameters with disease severity on fruit drop caused by *Colletotrichum gloeosporioides* was correlated on Nagpur mandarin and found that a significant correlation of weather parameters with fruit drop was recorded with a minimum temperature (r= -0.771) during 2009, where a negative and significant correlation was observed with maximum and minimum temperature (r=-0.582 and r=-0.704) during 2010.

Similarly, Kumar and Garg (2012) observed a significant correlation with temperature and premature fruit drop of Kinnow mandarin. Singh *et al.* (2009) and Iqra *et al.* (2022) also reported positive correlation with temperature and disease in guava dieback caused by *C. gloeosporioides.* The present finding further revealed that, the minimum temperature range between 25-30°C played a crucial role in the development of dieback disease severity. Pandey *et al.* (2012) observed that *C. gloeosporioides* fungus grows maximum in the temperature range between 28 to 32°C. The weather factors (temperature and wind) play a potent role in the epidemiology of dieback disease. The fungus appressoria present in latent conditions on dead twigs and branches produced infection hyphae in favorable temperature (25-32°C) and optimum relative humidity conditions. The conidia are produced on dead twigs and dispersed by wind to developing leaves, flower and fruits. The fungus conidia are

On Line Copy

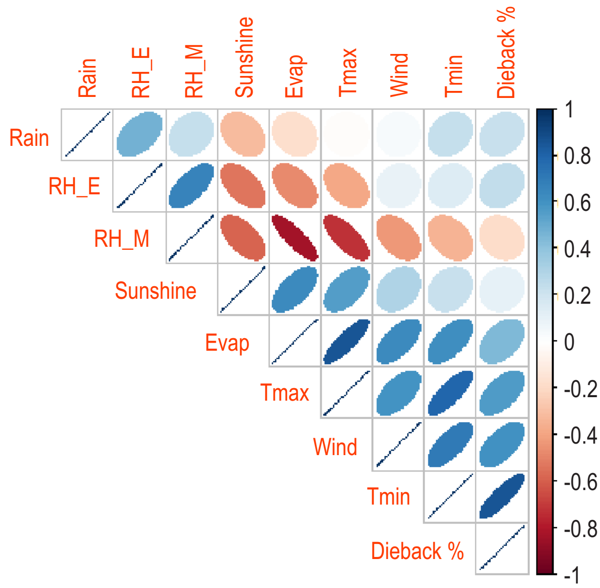


Fig. 2: Correlation matrix depicting the correlation between dieback disease severity with weather parameters.

usually considered as primary inoculum and are responsible for the infection in trees due to wound caused by pruning or mechanical damage or physiological weakness of the plant. Similarly, the maximum sporulation of conidia was also observed at 28°C in *C. gloeosporioides* by Nelson *et al.* (2015) which corroborated with the findings of this study. It was also observed that when the temperature exceeded 35°C, the disease severity of dieback decreased, which also revealed that, for survival, perpetuation, multiplication and infection, dieback disease requires a temperature in the range of 25 to 30°C. Similar results were also reported by Iqra *et al.* (2022), Bryceson's (2023) and Edy *et al*. (2024) in the dieback of guava and cocoa which is in agreement with the findings of this study.

Correlation matrix in the form of a heat map is displayed as a lower triangle matrix with ellipses showing the correlation between different meteorological variables. Each ellipse represents the correlation between two variables. The horizontally oriented ellipses indicate a negative correlation and vertical ellipses signify a positive correlation. The color and fill of each ellipse correspond to the strength and direction of the correlation, ranging from-1 (perfect negative correlation) to +1 (perfect positive correlation). Strong positive correlations are represented by solid or nearly solid blue ellipses and strong negative correlations by solid or nearly solid red ellipses. There was a strong positive correlation between T_{max} and T_{min}, as indicated by the nearly vertical dark blue ellipse. On the other hand, rain and sunshine appeared to have a negative correlation, demonstrated by the horizontal dark red ellipse (Fig. 2). The multiple regression analysis further explores the influence of weather parameters on dieback disease. The regression equation and coefficients for each parameter (X_1 through X_8) are

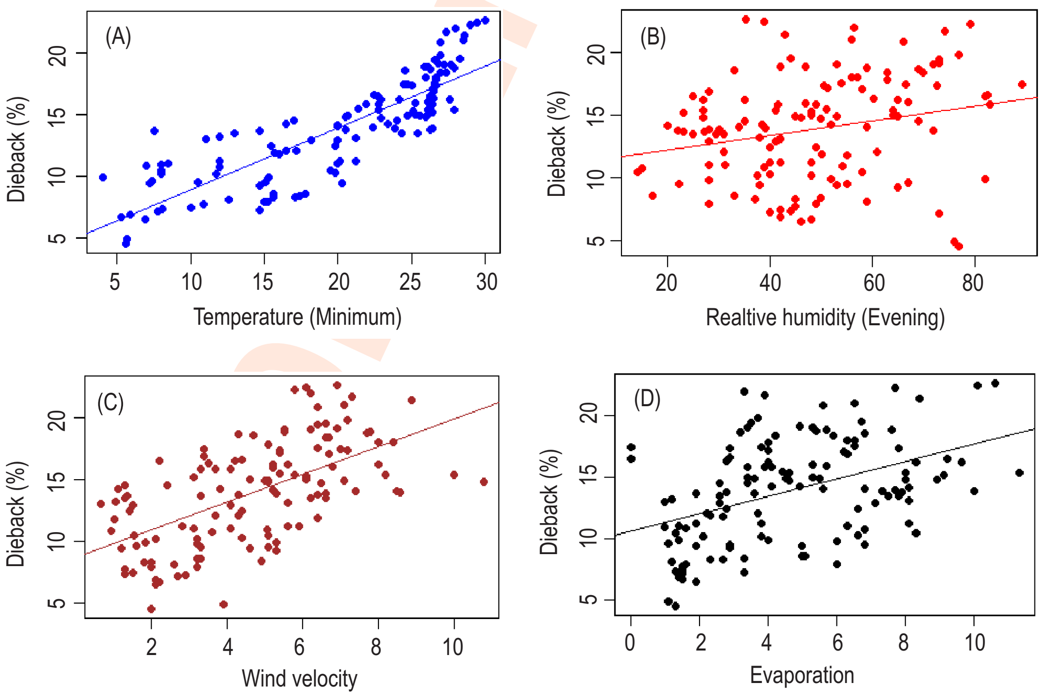


Fig. 3: Relationship of dieback disease severity with minimum temperature (A); relative humidity (B);wind velocity (C) and Evaporation (D).

Table 3: Multiple regression analysis for influence of weather parameters on dieback disease during 2021-23

Intercept	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
6.023	-0.191	0.601	0.016	0.003	0.024	-0.009	0.155	-0.004
	Regression equation		Multiple R	R^2	RSE		F-statistic	
$Y=6.023-0.191X_1+0.601X_2+0.016X_3+0.003X_4+0.024X_5-0.009X_6+0.155X_7-0.004X_8$		0.742	0.724	2.199		42.09		

Where, X_1- Max. Temperature, X_2- Min. Temperature, X_3- Morning RH, X_4- Evening RH, X_5-Wind speed, X_6- Sun shine, X_7- PAN evaporation, X_8- Rainfall, RSE-Residual standard error

given, alongside the multiple R, R^2, residual standard error, and F-statistic values.

The multiple regression equation was fitted to the data and the regression equation arrived for all the weather parameters of the years 2021-23 was $Y=6.023 - 0.191X_1 + 0.601X_2 + 0.016X_3 + 0.003X_4 + 0.024X_5 -0.009X_6 + 0.155X_7 - 0.004X_8$. Hence, the weather factors influence the disease severity for 2021-23 to the extent of 72 percent. This analysis aims to predict dieback severity based on weather conditions, with minimum temperature (X_2) showing a particularly strong influence. The model's R^2 (coefficient of multiple determination) value suggests a substantial proportion of variance in dieback severity which can be explained by these weather parameters. The results also showed values of multiple R (0.742), R^2 (0.724), Residual standard error (2.199) and F-statistic (42.09) for dieback disease severity of Kinnow mandarin in Haryana (Table 3).

The relationship of minimum temperature with mean dieback disease severity suggested a positive correlation between the minimum temperature and the severity of dieback, as the trendline showed an upward slope, indicating that higher minimum temperatures may lead to increased dieback severity (Fig. 3a). Similar trend of temperature was also noticed on dieback of guava (Iqra *et al*., 2022). Similarly, evening relative humidity showed a slightly negative trend with the dotted trendline descending, hinting that higher relative humidity in the evening might correlate with a decrease in the dieback severity (Fig. 3b), while the rising wind velocity trendline indicated a positive correlation and suggested that stronger wind may correspond with greater dieback disease severity (Fig. 3c). Hameed *et al*. (2022) predicted the effect of climatic factors on citrus canker and found significantly positive correlation of minimum temperature (27°C), rainfall (4.7-7.1 mm) and wind speed (8 km hr^{-1}) which corroborates with our study. Lastly, the trendline showed a weak positive correlation between evaporation and the severity of dieback (Fig. 3d). Thus, it is inferred from the above results that the weather parameters viz., minimum temperature, and wind speed played a significant role and offered favorable climatic conditions for the perpetuation, multiplication and development of disease severity of dieback in Kinnow orchards.

The present study also suggests that dieback severity can be effectively managed by the timely adoption and implementation of management strategies by Kinnow mandarin farmers. The present results may be further utilized for making advanced decisions to combat the severity and disease development appropriately with congenial climatic conditions..

Acknowledgment

The authors are grateful to the Director, ICAR- National Centre for Integrated Pest Management, New Delhi for their complete support and cooperation during the study.

Authors' contribution: P. N. Meena: Experiment was conceptualized and designed, executed the experiment, performed data analysis and wrote the manuscript; **D. Raghavendra:** Experiment was conceptualized and designed, and edited the manuscript; **M. Choudhary:** Statistical analysis the datas of this manuscript in R software; **S. Singh:** Guided the experiments; **N. Kumar:** monitoring the disease, collecting all-weather parameter data and disease observations and summarized statistical analysis; **S.K. Singh:** Revised the manuscript and gave suggestions for improvement of manuscript; **S. Chander:** Revised and edited the final manuscript.

Funding: Not applicable.

Research content: The research content of manuscript is original and has not been published elsewhere.

Ethical approval: Not applicable.

Conflict of interest: The authors declare that is there is no conflict of interest.

Data availability: Not applicable.

Consent to publish: All authors agree to publish the paper in *Journal of Environmental Biology.*

References

Agrios, G.N.: Plant Pathology. 5th Edn., Academic Press, San Diego, Burlington, MA, 922 pages (2005).

Bryceson, S.R., J.W. Morgan, P.J. McMahon and P.J. Keane: A sudden and widespread change in symptoms and incidence of vascular streak dieback of cocoa (*Theobroma cacao*) linked to

Online Copy

environmental change in Sulawesi, Indonesia. *Agric. Ecosyst. Environ.,* **350**, 1066-1084 (2023).

Cannon, P.F., U. Damm, P.R. Johnston and B.S. Weir: *Colletotrichum* – current status and future directions. *J. Mycol.,* **73**,181-213 (2012).

Chaube, H.S. and U.S. Singh: Plant Disease Management: Principles and Practices. CRC Press, Boca Raton, pp.1-319 (1991).

DA and FW: Department of Agriculture and Farmers Welfare. Final Estimates of 2023-24 of Area and Production of Horticultural Crops, 92 pages (2024).

Dalal, R.P.S., Vijay, H. Saini, B.S. Beniwal and R. Singh: Bearing behavior and correlation of fruit development stages with weather parameters in Kinnow mandarin under semi-arid irrigated conditions. *Indian J. Hort.,* **75**, 591-596 (2018).

Das, S., V. Pandey, H.R. Patel and K.I. Patel: Effect of weather parameters on pest-disease of okra during summer season in middle Gujarat. *J. Agric. Meteorol.,* **13**, 38-42 (2011).

Dean, R., J.A.L. Van Kan, Z.A. Pretorious, K.E. Hammond-Kosack, A.DiPietro, P.D. Spanu, J.J. Rudd, M. Dickman, R. Kahmann, J. Ellis and G.D. Foster: The Top 10 fungal pathogens in molecular plant pathology. *Mol. Plant Pathol.,* **13**, 414-430 (2012).

Deka, S., S. Mukesh. R.K. Kakoti and A.C. Barbora: Module analysis for insect pest management of khasi mandarin (*Citrus reticulata* Blanco) under climatic conditions of north-eastern India. *J. Entomol. Zool. Stud.,* **6**, 857-861 (2018).

Dolkar, D., P. Bakshi, D. Kachroo, K. Kour, R. Kumar, N. Sharma and A. Singh:Effect of meteorological parameters on plant growth and fruit quality of Kinnow mandarin. *Indian J. Agric. Sci.,* **88**, 1004-1012 (2018).

Edy, N., S. Hamid, I. Lakani, A. Anshary, F. Balosi and Zulfadli: Traits of farming practice affecting vascular streak dieback disease on cacao in Central Sulawesi. *IOP Confer. Ser.: Earth Environ. Sci.,* **Vol. 1355,** 012019 (2024). doi 10.1088/1755-1315/1355/1/012019

Ezeibekwe, I.O.: Study of citrus disease prevalence on four citrus varieties at the National Institute of Horticultural Research (NIHORT) Mbato, Okigwe, Imo State, Nigeria. *Afr. J. Plant Sci.,* **5**, 360-364 (2011).

Hameed, A., M. Atiq, Z. Ahmed, N.A. Rajput, M. Younas, A. Rehman, M.W. Alam, S. Sarfaraz, N. Liaqat, K. Fatima, K. Tariq, S. Jameel, H.M.Z.U. Ghazali, P. Vachova, S.H. Salmen and M.J. Ansari: Predicting the impact of environmental factors on citrus canker through multiple regression. *PLoS ONE,* **17,** e0260746 (2022).

Hartman, J.R., L. Parosi and P. Bautrais: Effect of leaf wetness duration, temperature, and conidial inoculum dose on apple scab infection. *Plant Dis.,* **83**, 531-534 (1999).

Hyde, K.D., L.Cai, E.H.C. McKenzie, Y.L. Yang, J.Z. Zhang and H. Prihastuti: *Colletotrichum*: a catalogue of confusion. *Fungal Divers.,* **39**,117-124 (2009).

Iqra, I. Ul Haq, R.W.K. Qadri, L. Amrao and S. Ijaz: Effect of environmental conditions (temperature and precipitation) on severity of guava die-back caused by *Colletotrichum* spp. under climatic conditions of Pakistan. *J. Plant Pathol.,* **104**, 179–190 (2022).

Kassahun, T., T. Hussein and P.K. Sakhuja: Management of Phaeoramularia fruit and leaf spot disease of citrus in Ethiopia. *Agric. Tropica. Subtropica.,* **39**, 242-248 (2006).

Klotz, J.: Color Handbook of Citrus Diseases. University of California, Riverside, CA., pp. 67-184 (1961).

Knorr, L.C.R., F. Suit and E.F. Duchareme: Handbook of Citrus Disease in Florida. Univ.Fia. Agric. Expt. Sta. Bull. No. 587, 157 pages (1957).

Kumar, A. and R.C. Garg: Epidemiology and management of premature fruit drop of Kinnow. *J. Mycol. Pl. Pathol.,* **42**, 443-449 (2012).

Meena, A.K., F. Dutta, M.C. Marak and R.K. Meena: Citrus decline. *Int. J. Curr. Microbiol. App. Sci.,* **7**, 2807-2815 (2018).

Meena, P.N.,D. Raghavendra, S. Singh, N. Kumar, M.K. Khokhar, S. Chander, M.K. Lal, R.K. Tiwari and R. Kumar: Integrated Pest management techniques in a Kinnow mandarin (*Citrus reticulata Blanco*) orchard with an emphasis on yield improvement. *Heliyon*, **11**, e42574 (2025).

Mohod, Y.N., D. Mina, R.B. Koche, Kothikar and G.K. Giri: Influence of weather parameters on fungal fruit drop of Nagpur mandarin in Ambica bahar. *Biosci Trends.,* **10**, 9243-9244 (2017).

Nelson, B.L., W.G. Lima, J.M. Tovar-Pedraza, S.J. Michereff Marcos and P.S. Câmara: Comparative epidemiology of *Colletotrichum* species from mango in North-eastern Brazil. *Eur. J. Plant Pathol.,* **141**,679-688 (2015).

Pandey, A., L.P. Yadav, R.K. Mishra, B.K. Pandey, M. Muthukumar and U.K. Chauhan: Studies on the incident and pathogenesis of *Colletotrichum gloeosporioides* Penz. causes anthracnose of mango. *Int. J. Nat. Sci.,* **3**, 220-232 (2012).

Pathania, M., J.K. Arora and P.K. Arora: Incidence and severity of insect-pests and diseases of Kinnow mandarin, Indian. *J. Horti.,* **78**, 280-286 (2021).

Peres, N.A., S.J. MacKenzie, T.L. Peever and L.W. Timmer: Post bloom fruit drop of citrus and key lime anthracnose are caused by distinct phylogenetic lineages of *Colletotrichum acutatum. Phytopathology,* **98**, 345-352 (2008).

Ramos, A.P., P. Talhinhas, S. Sreenivasa prasad and H. Oliveira: Characterization of *Colletotrichum gloeosporioides,* as the main causal agent of citrus anthracnose and *C. karstii* as species preferentially associated with lemon twig dieback in Portugal. *Phytoparasitica,* **44**, 549-561(2016).

Sarker, M.N., I. Barman, S.C. Islam, M.M. Islamand A.S. Chakma: Role of lemon (*Citrus limon*) production on livelihoods of rural people in Bangladesh. *J. Agril. Econ. Rural Develop.,* **3**, 167-175 (2017).

Savita, V.G.S. and A.Nagpal: Citrus diseases caused by *Phytophthora* species. *GERF Bull. Bioscience,* **3**,18-27 (2012).

Shaner, G. and R.E. Finney: The effect of nitrogen fertilization on the expression of slow-mildewing resistance in Knox wheat. *Phytopathology,* **67**,1051-1056 (1977).

Sharma, D.R.: Population dynamics in relation to abiotic factor and management of citrus psylla in Punjab. *Indian J Horti.,* **65**,17-422 (2008).

Singh, A., K.S. Verma and C. Mohan: Perpetuation and host range of dieback pathogen (*Colletotrichum gloeosporioides*) of guava. *J. Mycol. Pl. Pathol.,* **39**, 513-515 (2009).

Singh, S., D.R. Sharma, H.S. Rattanpal, S. Kaur, A. Arora and G. Singh: Current scenario of insect and mite pests of citrus in the Punjab. In: New Horizons in Insect Science, International Conference on Insect Science (Eds.: A.K. Chakravarthy, C.T. Ashok Kumar, A. Verghese and N.E. Thyagaraj), University of Agricultural GKVK, Bangalore, pp. 1-156 (2013).

Singh, V.P., A.S. Jena, N.P. Malik and L.Bhatt: Managing citrus dieback at farmer's fields in District Ctiamoii of Uttarakhand, Progress. *Agric.,* **8**, 116-117 (2008).

Wutscher, H.K., R.E. Schwarz, H.G. Campiglia, C.S. Moreira and V.T.I. Rossetti: Blight like citrus tree declines in South America and South Africa. *Horti. Sci.,* **15**, 588-590 (1980).