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Comparative evaluation of fungal diseases in cucumber across growth stages and cropping seasons

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Abstract
A field investigation was conducted to assess seasonal patterns of fungal disease incidence in cucumber across the *Kharif*, Rabi, and Zaid seasons. The experiment included twelve cucumber hybrids grown under natural epiphytotic conditions without fungicide application to monitor disease development. Four major fungal diseases, viz., Fusarium wilt, powdery mildew, downy mildew, and gummy stem blight, were analysed at four distinct growth stages: vegetative, reproductive, fruiting, and harvesting. Disease incidence (DI) and Area Under Disease Progress Curve (AUDPC) were recorded to assess seasonal disease pressure and to quantify cumulative disease development. During the *Kharif*, downy mildew showed the highest DI at harvest (74.44%), followed by gummy stem blight (40.00%) and powdery mildew (39.16%). In Rabi, downy mildew remained predominant (66.11%), followed by powdery mildew (55.83%). Conversely, the Zaid season recorded the highest overall disease pressure, driven by powdery mildew (57.08%) and fusarium wilt (36.11%), while in the later stages by downy mildew (42.92%). AUDPC analysis revealed marked seasonal variation in cumulative disease development. downy mildew recorded the highest AUDPC in *Kharif*-2023 (1831.20) and Rabi-2023 (1685.32), whereas powdery mildew dominated in Zaid-2024 (1471.80), followed by fusarium wilt (858.22). This study highlights a significant increase in the prevalence of fungal pathogens across different growth stages and seasons in cucumber, providing baseline information on disease dynamics under natural epiphytotic conditions.

Keywords: Cucumber, disease incidence, AUDPC, *Kharif*, Rabi, Zaid

Introduction
Cucumber (*Cucumis sativus L.*; 2n = 2x = 14) is one of the most important and widely cultivated vegetable crop in the family Cucurbitaceae, grown extensively in tropical and subtropical regions worldwide. It is valued for its nutritional and economic importance and is consumed both as a fresh salad vegetable and in processed forms. Cucumber is a rich source of dietary fibre, vitamins (B, C, D, and K), and essential minerals such as calcium (Ca), potassium (K), sodium (Na), and phosphorus (P), along with trace elements like copper (Cu), magnesium (Mg), zinc (Zn), and iron (Fe) (Yawalkar, 1985; Lim, 2012; Sattar *et al.*, 2024; Gebhardt *et. al.*, 2010) [13, 6, 9, 4]. The fruit, characterized by high water content and low calorific value, also possesses cooling, astringent, and antipyretic properties and is considered beneficial for conditions such as constipation, jaundice, and indigestion (Vashistha, 1974) [11]. In India, cucumber is cultivated throughout the year under diverse agro-climatic conditions, particularly during *Kharif*, Rabi, and Zaid seasons. India ranks as the second-largest producer of cucumbers after China and occupies a leading position in cucurbit production (FAOSTAT, 2024) [3]. During 2024–25, cucumber production in India was estimated at 2112 MT (MoA&FW, 2025) [7]. The crop also exhibits considerable genetic variability, providing substantial scope for improvement in yield and other agronomic traits through selection and breeding approaches.
Cucumber production is significantly affected by various biotic stresses, especially fungal diseases that harm both yield and fruit quality. Key fungal afflictions include Fusarium wilt, Powdery mildew, Downy mildew, Alternaria leaf blight, Cercospora leaf spot, Gummy stem blight, and other leaf spot diseases. The occurrence of these diseases is heavily influenced by environmental factors such as temperature, humidity, and rainfall, with seasonal variations playing a vital role in their spread. To develop resistant varieties, it is essential to thoroughly study the long-term and seasonal patterns of pathogen behaviour, understand the biology of the main fungi, and analyse how weather conditions affect disease progression and plant interactions.

The *Kharif* season, with high humidity, warm temperatures, and frequent rainfall, favours rapid disease development. Conversely, the Rabi season typically sees moderate disease levels due to cooler temperatures and less humidity, while the Zaid season, characterised by high temperatures and low moisture, is less conducive to fungal growth. Additionally, disease severity tends to escalate as the crop matures, often peaking during fruiting and harvest.

In Maharashtra, cucumber is widely cultivated during the *Kharif* and Zaid seasons, each fostering unique environmental conditions for disease development. Although reports exist on individual diseases, comprehensive epidemiological studies addressing multiple pathogens, seasonal variations, and crop stages are scarce. This study aimed to measure disease progression across the vegetative, reproductive, fruiting, and harvest stages under natural epiphytotic conditions, without applying fungicidal sprays, to assess the baseline susceptibility of cucumber hybrids. Since host susceptibility and pathogen establishment vary with crop phenology, understanding stage-specific disease development is crucial for identifying critical periods of infection. Comparative assessment helps to monitor disease incidence across different growth stages under three cropping seasons, namely *Kharif*, Rabi, and Zaid, to elucidate the interaction between crop stage and seasonal factors. Such information is essential for developing stage-specific and timely disease management strategies.

Material and Methods

Experimental site

The field experiment was conducted during *Kharif*-2023 (June-September), Rabi-2023 (October-January) and Zaid-2024 (February-May) at the Research field of Ellora Natural Seeds Pvt. Ltd., Chhatrapati Sambhajinagar, Maharashtra to assess the influence of varying environmental conditions on disease dynamics.

Experimental design

The selected 12 Cucumber F1 hybrids were sown in a Randomised Completely Block Design (RCBD) with three replications under a mixed population to simulate natural field diversity, following 1.0m × 0.5m spacing in each season. Standard horticultural practices, including trellis support, weeding, and fertigation, were followed as per the regional package of practices, except for fungicidal applications to allow natural disease progression.

Disease monitoring and growth stages

Disease observations were recorded systematically at four growth stages of the Cucumber across *Kharif*, Rabi and Zaid:

a) Vegetative Stage: (20–35; days after sowing (DAS))
b) Reproductive Stage: (Onset of flowering; 40–50 DAS)
c) Fruiting Stage: (Peak fruit development; 55–65 DAS)
d) Harvesting Stage: (Picking and senescence; 70–80 DAS)

Targeted fungal diseases

The six major fungal diseases were evaluated during the trial, *viz.*, Fusarium Wilt (FW), Powdery Mildew (PM), Downy Mildew (DM), and Gummy Stem Blight (GSB).

Assessment of disease incidence

For each disease, ten plants per replication were randomly tagged for periodic assessment.

Percent disease incidence (DI)

DI was calculated as the percentage of plants showing visible symptoms of the respective disease:

$$DI\ (\%) = \frac{\text{Number of infested or wilted vines}}{\text{Total number of vines in the plot}} \times 100$$

For foliar diseases (PM, DM, ALB, GSB, and FW), incidence was recorded using a standard 0–5 numerical rating scale as suggested by Kumar (2026) [1]. Since Fusarium wilt is a vascular disease, the scale is based on the degree of systemic wilting rather than leaf area.

Foliar disease scale

Grade	Percent Disease Incidence (PDI)	Visual symptoms	Resistance level
0	0	Healthy	Immune
1	1-10	Slight chlorosis	Resistant
2	11-25	Moderate	Moderately Resistant
3	26-50	Extensive	Moderately susceptible
4	51-75	Severe with wilting	Susceptible
5	>75	Plant death	Highly susceptible

Fusarium wilt scale

Percent Disease Incidence (PDI)	Resistance level	Visual Symptoms
0	Highly resistant	Free From Disease (DRR)
≤ 10 %	Low disease pressure	Resistant
10.1 % – 20 %	Moderately resistant	Manageable infection
20.1 % – 30 %	Moderately Susceptible	Threshold for concern
30.1% – 50.0%	Susceptible	Significant crop damage
> 50.0%	Highly susceptible	Severe epidemic spread

Area under disease progress curve (AUDPC)

The raw data were recorded for disease incidence percentage across replication plots. Since the data were expressed as percentages (0 to 100%), they were normalized by performing an angular transformation using the arc-sine square root method, degrees = arcsin (√((p)/(100))) For each replication the area under disease progress curves (AUDPC) was calculated as per Wilcoxon *et al.*, (1975)[12]. The formula was used and follows:

$$AUDPC = \sum_{i=1}^{n-1} \left(\frac{y_i + Y_{i+1}}{2} \times (X_{i+1} - X_I \right)$$

y_i = Disease incidence at i th observation
Y_{i+1} = Disease severity at next observation
X_i = Time (days) at i th observation
X_{i+1} = Time at next observation
n = Total number of observations

Result and Discussion

Table 1: Fungal disease incidence (DI) across growth stages of Cucumber in the Kharif-2023.

Observed Diseases		FW	PM	DM	GSB
Stages of Growth	Vegetative Stage (30 Days)	(14.97) 6.67	(6.75) 1.38	(13.28) 5.28	(10.51) 3.33
	Reproductive Stage (45 Days)	(20.18) 11.90	(25.96) 19.16	(29.07) 23.61	(23.01) 15.28
	Fruiting Stage (60 Days)	(27.74) 21.67	(31.81) 27.78	(49.96) 58.61	(32.86) 29.44
	Harvesting Stage (75 Days)	(33.90) 31.11	(38.74) 39.16	(59.63) 74.44	(39.23) 40.00
AUDPC		786.90	1008.15	1831.20	995.77

Table 2: Fungal disease incidence (DI) across growth stages of Cucumber in the Rabi-2023.

Observed Diseases		FW	PM	DM	GSB
Stages of Growth	Vegetative Stage (35 Days)	(9.10) 2.50	(11.17) 3.75	(12.55) 4.72	(6.05) 1.11
	Reproductive Stage (50 Days)	(18.79) 10.38	(21.77) 13.75	(28.88) 23.33	(16.78) 8.33
	Fruiting Stage (65 Days)	(22.45) 14.58	(36.52) 35.42	(47.07) 53.61	(23.22) 15.55
	Harvesting Stage (80 Days)	(25.66) 18.75	(48.35) 55.83	(54.40) 66.11	(32.86) 29.44
AUDPC		533.77	1184.40	1685.32	587.33

Table 3: Fungal disease incidence (DI) across growth stages of Cucumber in the Zaid-2024.

Observed Diseases		FW	PM	DM	GSB
Stages of Growth	Vegetative Stage (25 Days)	(15.59) 7.22	(12.92) 5.00	(14.96) 6.66	(5.23) 0.83
	Reproductive Stage (40 Days)	(21.18) 13.05	(27.74) 21.67	(18.83) 10.42	(9.10) 2.50
	Fruiting Stage (55 Days)	(28.32) 22.50	(42.37) 45.41	(22.79) 15.00	(16.35) 7.92
	Harvesting Stage (70 Days)	(36.94) 36.11	(49.07) 57.08	(40.93) 42.92	(23.11) 15.41
AUDPC		858.22	1471.80	753.15	278.10

*Note: FW = Fusarium Wilt; PM = Powdery Mildew; DM = Downy Mildew; ALB = Alternaria Leaf Blight; CLS = Cercospora Leaf Spot; ANT = Anthracnose and AUDPC = Area under Disease Progress Curve

The field evaluations conducted across three consecutive cropping seasons – *Kharif*-2023 (Table 1), Rabi-2023 (Table 2), and Zaid-2024 (Table 3), demonstrated a progressive increase in the incidence of all four observed fungal diseases, Fusarium Wilt (FW), Powdery Mildew (PM), Downy Mildew (DM), and Gummy Stem Blight (GSB) as the cucumber crop advanced from the vegetative stage to the final harvesting stage.

Fungal diseases incidence in Kharif season

During the *Kharif*-2023 (Table 1), Downy Mildew (DM) emerged as the most devastating and aggressive pathogen. During the *Kharif* season, downy mildew (DM) emerged as the predominant fungal disease (Ranpise *et al.*, 2010) [8]. It initiated at a modest incidence of 5.28% during the vegetative stage (30 DAS) and escalated drastically to 23.61 at the reproductive stage (45 DAS), 58.61 at the fruiting stage (60 DAS), and ultimately peaked at 74.44% during harvest (75 DAS). This explosive outbreak was corroborated by an exceptionally high AUDPC value of 1831.20. High relative humidity facilitates the occurrence of downy mildew (Tatlioglu, 1993) [10]. Powdery Mildew (PM) and Gummy Stem Blight (GSB) followed next in overall incidence, recording peak harvesting-stage incidences of 39.16% (AUDPC = 1008.15) and 40.00% (AUDPC = 995.77), respectively after 70-75 DAS. Fusarium Wilt (FW) progressed more conservatively but still increased significantly from 6.67% to 31.11% (AUDPC = 786.90).

Fungal diseases incidence in Rabi season

In the Rabi-2022 season (Table 2), Downy Mildew remained the dominant fungal disease, reaching a terminal incidence of 66.11% after 75-80 DAS (AUDPC = 1685.32). During the Rabi season, downy mildew remained the dominant pathogen and exhibited the highest disease severity among all diseases evaluated. The disease showed a gradual increase from early crop stages (Manjusha *et al.*, 2017) [5] However, a striking shift was observed in Powdery Mildew (PM) dynamics; it exhibited an intense surge during the later growth stages, increases from 13.75% at the reproductive phase (50 DAS) to a substantial terminal incidence of 55.83% at harvest (80 DAS), yielding a prominent AUDPC of 1184.40. Conversely, both FW (18.75%, AUDPC = 533.77) and GSB (29.44%, AUDPC = 587.33) were significantly suppressed compared to the *Kharif* season.

Fungal diseases incidence in Zaid season

The epidemiological landscape shifted profoundly during the Zaid-2023 season. Powdery Mildew (PM) superseded all other diseases to become the primary pathogen. PM incidence began at 5.00% during the vegetative phase (25 DAS) and expanded vigorously to hit 57.08% at harvest after 70 DAS, logging the highest seasonal AUDPC of 1471.80. The intensity of powdery mildew was higher from March to May, as noted by (Khan and Khan, 1992) [2]. Fusarium Wilt (FW) also expressed its maximum severity during this hot season, terminating at 36.11% (AUDPC = 858.22). Interestingly, Downy Mildew progression was markedly restrained during the vegetative and reproductive phases (6.66% to 10.42%), though it spiked later to reach 42.92% at harvest (AUDPC = 753.15). GSB remained minimal throughout the Zaid trial, concluding at just 15.41% (AUDPC = 278.10).

Stage-wise disease progression

Across all seasons, disease incidence and severity increased consistently from the vegetative to the harvesting stage, demonstrating a clear temporal progression of fungal diseases in bitter gourd. Disease levels remained relatively low during the vegetative stage but increased markedly during the reproductive and fruiting stages, ultimately peaking at harvest. The most pronounced increases in DI were observed during the fruiting-to-harvest transition, indicating that this period represents a critical epidemiological window during which the crop becomes highly susceptible to pathogen colonisation. Increased canopy density, prolonged leaf wetness, and physiological stress associated with fruit development may contribute to enhanced disease development during this stage.

Comprehensive analysis of seasonal disease patterns

The comparison across *Kharif*, Rabi, and Zaid seasons clearly shows that the fungal disease complex of Cucumber is heavily influenced by seasonal environmental conditions and crop growth stages. Pathogens that thrive in moisture, such as downy mildew, were more common during *Kharif*, when high rainfall, humidity, and moderate temperatures created ideal conditions for their sporulation and spread. During the Rabi season, downy mildew severity increased and powdery mildew also developed more, due to cooler nights and longer leaf wetness from dew. In the Zaid, the main constraints shifted to powdery mildew and Fusarium wilt, as warm, dry conditions favoured rapid dispersal of airborne conidia and increased activity of soil-borne pathogens under heat and plant stress. Throughout all seasons, disease progression exhibited a consistent temporal pattern, with low infection rates during early vegetative growth and a notable increase in both incidence and severity in later crop development stages. The shift from fruiting to harvest was identified as the most crucial epidemiological phase, as physiological stress from fruit development, combined with denser canopy and optimal microclimatic conditions, heightens host susceptibility and promotes pathogen growth. These results highlight that disease outbreaks in cucumber are not random but result from a complex interplay of pathogen biology, seasonal climate, and crop growth stages. Consequently, disease management should employ season-specific and stage-targeted strategies rather than relying solely on periodic, calendar-based fungicide applications.

Conclusion

The present study highlights the pronounced seasonal and phenological influence on the development of fungal diseases in Cucumber. Distinct pathogen dominance was observed across seasons, with downy mildew during the *Kharif* season, downy mildew and powdery mildew intensifying during the Rabi season, and powdery mildew and Fusarium wilt becoming the major constraints in the Zaid season. Across all seasons, disease incidence increased progressively with crop growth, reaching maximum levels during the harvesting stage. The transition from fruiting to the harvesting stage emerged as the most critical epidemiological window for disease escalation. This progressive accumulation of disease incidence over time was conclusively validated by the Area Under Disease Progress Curve (AUDPC) values. Downy mildew exhibited the highest overall seasonal disease pressure during the *Kharif* season, followed closely by the Rabi season. Conversely, the Zaid season shifted the epidemiological footprint heavily toward powdery mildew, which recorded its maximum seasonal disease accumulation. The disparity observed between seasonal disease incidence and the corresponding AUDPC metrics further indicates variations in pathogen infection behaviour, environmental compatibility, and host response over time. Overall, the findings demonstrate that fungal disease dynamics in cucumber are strongly season and stage dependent. These insights provide a valuable epidemiological baseline for developing seasonspecific and stage-oriented integrated disease management strategies to reduce yield losses and improve crop health.

References

1. Kumar A. Scoring Techniques for Fungal Disease Resistance. In: Yadav R, Hooda KS, Chander S, Kumari J, Chandra P, Tripathi K, Singh M, Mohapatra KP, Gautam RK, Singh GP, eds. Plant Genetic Resources Management and Utilization-Contemporary Approaches. New Delhi: ICAR-National Bureau of Plant Genetic Resources; 2026.
2. Khan AU, Khan AM. Incidence and severity of cucurbit powdery mildew in Uttar Pradesh. Indian Phytopathology. 1992;4(2).
3. FAOSTAT. World Food and Agriculture - Statistical Yearbook 2023/2024. Food and Agriculture Organization of the United Nations; 2024.https://www.fao.org/faostat/en/#data/QCL.
4. Gebhardt SE, Lemar LE, Pehrsson PR, Exler J, Haytowitz DB, Showell BA, *et al.* USDA national nutrient database for standard reference, release 23. USDA National Nutrient Database for Standard Reference. 2010;1-10. Available from:http://www.ars.usda.gov/nutrientdata.
5. Kumari M, Kothikar RB, Koche M, Surpam AN. Epidemiological studies on downy mildew of bitter gourd caused by *Pseudoperonospora cubensis*. Research Journal of Agriculture and Forestry Sciences. 2017;5(8):1-5.
6. Lim TK. *Cucumis sativus*. In: Lim TK, eds. Edible medicinal and non-medicinal plants. Netherlands: Springer; 2012:239-249.
7. Ministry of Agriculture and Farmers Welfare. Agricultural Statistics at a Glance: 2024-25. Government of India; 2025:175-176.
8. Ranpise SA, Bhokare SS, Pachankar PB. Effect of different training systems on incidence of pest, diseases and yield of bitter gourd (*Momordica charantia* L.) ev. KONKAN TARA under Konkan conditions of Maharashtra. 2010;4(2):281-284.
9. Sattar S, Ali F, Iftikhar M, Saleem A, Maha M, Wajid M, *et al.* Biological Components in Cucumbers (*Cucumis* Sativus L.): Implications for Pickle Manufacturing and Health Benefits in Fresh and Processed Varieties. Qeios. 2024;1-10.https://doi.org/10.32388/0U4W8B.2.
10. Tatlioglu T. Cucumber (*Cucumis sativus* L.). In: Kalloo G, Beorgh BO, eds. Genetic Improvement of Vegetable Crops. Oxford: Pergamon Press; 1993:197-233.
11. Vashista PC. Taxonomy of angiosperms. New Delhi: P. B. M. Press; 1974:599.
12. Wilcoxson RD, Skovamand B, Atif AH. Evaluation of wheat cultivars for ability to retard development of stem rust. Annals of Applied Biology. 1975;80:275-281.
13. Yawalkar KS. Vegetable Crops of India. Nagpur: Agri Horticultural Publishing House; 1985.