AATCC Review

20 July 2025: Received
10 September 2025: Revised
17 September 2025: Accepted
16 October 2025: Available Online

https://aatcc.peerjournals.net/

Original Research Article

Open Access

From hills to plains: understanding spatial patterns of wheat foliar blight in Uttarakhand

Surbhi Chauhan, Deepshikha* and and Archana Kushwaha

Department of Plant Pathology, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand, India

ABSTRACT

A field survey was conducted during the rabi seasons of 2023–24 and 2024-25 to assess the distribution and severity of foliar blight in major wheat-growing districts of Uttarakhand. Disease incidence was quantified using the Percent Disease Index (PDI) across multiple locations within Almora, Dehradun, Haridwar, Nainital, and Udham Singh Nagar. The results revealed substantial spatial variability in disease intensity. The highest mean PDI was recorded in Udham Singh Nagar (80.57%), followed by Haridwar (62.23%), indicating highly conducive environmental conditions for pathogen development in the plains and terai regions. Dehradun exhibited moderate severity with an average of approximately 27.06%, whereas the hill districts of Nainital (10.56%) and Almora (7.22%) showed the lowest disease levels. Location-level comparison further highlighted significant within-district variation, with Pantnagar, Jwalapur, and Selaqui identified as high-severity hotspots. The severity gradient from plains to hills reflects the influence of temperature, relative humidity, and cropping systems—particularly the widespread rice–wheat rotation that supports inoculum carryover. The study faced challenges due to differences in climate, terrain, and cropping conditions, as well as the difficulty of carrying out uniform disease assessments across both hill and plain regions. Despite these limitations, the study successfully provided a clear and comprehensive spatial assessment of foliar blight severity across Uttarakhand. Thus, the findings provide important baseline information on disease distribution and identify high-risk zones requiring targeted management interventions. The study highlights the need for developing and promoting region-specific strategies to mitigate foliar blight and enhance wheat productivity in Uttarakhand.

Keywords: *Foliar blight, Wheat (Triticum aestivum), Foliar blight, Disease severity, Percent Disease Index (PDI), Alternaria triticina, Bipolaris sorokiniana, Districts, Uttarakhand.*

Introduction

Wheat (*Triticum aestivum* L.), a member of the Poaceae family, is an important and widely grown cereal crop worldwide. It is one of the major staple foods for most of the world's population. The three major wheat species cultivated are *Triticum aestivum* L. (bread wheat), *Triticum durum* Desf. (macaroni or durum wheat), and *Triticum dicoccum* Schrank (emmer wheat). Bread wheat (*Triticum aestivum*), referred to as the "King of Cereals" is the predominant wheat species cultivated in India, contributing nearly 95% of the nation's total wheat production (1). The major wheat-producing countries are China, India, Russia, and the United States. It is cultivated over 220.7 mha worldwide, with a total production of about 793.24 mt. In India, wheat is grown on around 32.76 mha, producing approximately 117.51 mt, with an average productivity of 35.87 q/ha. India recorded an all-time high wheat production during the year 2024–25 (2). The major wheat-growing states are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, and Gujarat. Uttarakhand has 0.8 million ha of cultivated area constituting 16% of the total geographical area (3).

Corresponding Author:* ***Deepshikha*

DOI: https://doi.org/10.21276/AATCCReview.2025.13.04.815

Wheat production is adversely affected by a range of abiotic and biotic stresses, with biotic stress being major yield-limiting factor. In addition to well-known diseases such as rusts, powdery mildews, bunts and loose smut, foliar diseases have emerged as a major concern. Notably, foliar blight has become increasingly prevalent in India, especially in the Indo-Gangetic plains, due to continuous shifts in cropping patterns (4). This disease presents a complex pathological scenario, often involving co-infection by *Alternaria triticina* and *Bipolaris sorokiniana*, making field- level diagnosis challenging (5; 6). Yield losses due to this disease can range between 29.4% and 43.2%, with significant reductions in thousand-grain weight ranging from 15.2 to 30.5% (7). The disease apperars in wheat seedlings, increasing its severity toward crop maturity (8). Small, oval, discoloured lesions appear as initial symptoms on the foliage, later spreading irregularly into dark-brown to grey patches often bigger than 1 cm. In the context of increasing foliar blight prevalence roving survey on the incidence and severity of the disease was carried out for assessing the distribution of the disease across wheat growing regions of Uttarakhand. These insights are expected to facilitate the formulation of targeted and region-specific management strategies, thereby contributing to efforts aimed at mitigating the impact of this devastating disease.

Materials and Method

A comprehensive roving survey was conducted during the *Rabi* seasons of 2023-24 and 2024-25 to assess the prevalence,

severity and distribution of wheat leaf blight across five districts of Uttarakhand which include Almora, Dehradun, Haridwar, Nainital and Udham Singh Nagar. The survey was conducted across 25 wheat-growing areas in the Kumaon and Garhwal regions, spanning the crop's development from tillering to maturity. In each area, ten fields were randomly selected. Within each field, sampling was performed by recording data from five $1m^2$ quadrats—one at each corner and one at the centre. The data collected for each location included latitude, longitude, and the percentage disease index. All subsequent data compilation, analysis were conducted in the Wheat Pathology Lab at the Department of Plant Pathology, GBPUA&T, Pantnagar.

Disease Severity: The Percent Disease Index (PDI) was determined by evaluating the severity of infection on individual plants using a double digit-scale (00-99) (Table 1) suggested by Saari and Prescott (1975) (9) and (10) to assess foliar blight diseases in wheat by visually scoring the per cent diseased area on the flag leaf (F) and penultimate (F-1) leaves.

$$PDI = \frac{\text{Sum of all disease rating}}{\text{Total no. of plants assessed} \times \text{maximum disease grade}} \times 100$$

Table 1: A double digit scale for appraising disease severity

Severities** Rating			
Top flag leaf (F)	Second top leaf (F-1)	Diseases responses	Range of values
0	0-1	Immune (I)	00-01
1-2	2-4	Resistant (R)	12-24
3-4	4-6	Moderately resistant (MR)	34-46
5-6	6-8	Moderately susceptible (MS)	56-68
7-8	8-9	Susceptible (S)	78-89
9	9	Highly susceptible (HS)	99

First and second values represent per cent blighted area on the top (flag) and second top leaves** Values 1, 2, 3, 4, 5, 6, 7, 8 and 9 correspond to 10, 20, 30, 40, 50, 60, 70, 80, and 90 per cent blighted area respectively.

Preparation of Disease prevalence map using GIS

A prevalence map of foliar blight of wheat in Uttarakhand was generated using QGIS, an open-source geographic information system. This map was developed using data collected during an extensive roving survey carried out across five districts of Uttarakhand.

Results and Discussion

The survey conducted across five districts of Uttarakhand during the 2023-24 and 2024-25 *Rabi* seasons revealed a significant prevalence of foliar blight in wheat. Across all surveyed districts, the mean PDI values showed a wide range, reflecting substantial geographical variation. The data on Percent Disease Index (PDI%) has been presented in Table 2. Additionally, the spatial distribution of wheat foliar blight prevalence is depicted in Figures 1 and 2, offering a clear visual representation of the disease's impact across the various rice-growing regions.

Table 2: Percent Disease Index of foliar blight across different locations in Uttarakhand during the Kharif seasons of 2023 and 2024

					PDI%		
Division	Districts	Location	Latitude	Longitude	2023	2024	Mean
Kumaon	Almora	Hawal Bagh	29.589	79.642	4.44	6.67	5.56
		Bhanoli	29.498	79.956	7.78	9.44	8.61
		Ranikhet	29.643	79.432	6.11	8.89	7.50
			Mean		6.11	8.33	7.22
	Nainital	Betalghat	29.560	79.350	9.44	11.67	10.56
		Haldwani	29.170	79.522	8.33	11.11	9.72
		Halduchaur	29.112	79.524	8.02	12.35	10.19
		Kathgodam	29.269	79.544	12.78	15.43	14.11
		Lalkuan	29.068	79.518	10.56	12.42	11.49
		Lamachaur	22.220	79.250	7.11	11.44	9.28
		Ramnagar	29.395	79.127	7.22	9.95	8.59
			Mean		9.07	12.05	10.56
	Udham Singh Nagar	Bajpur	29.159	79.146	81.11	83.33	82.22
		Gadarpur	29.040	79.250	78.33	81.67	80.00
		Nanakmatta	28.941	79.816	77.80	80.56	79.18
		Pantnagar	29.017	79.426	84.89	86.11	85.50
		Rudrapur	28.988	79.414	77.78	79.44	78.61
		Kashipur	29.210	78.950	78.92	81.94	80.43
		Kichha	28.889	79.586	76.11	78.33	77.22
		Sitarganj	28.924	79.701	80.55	82.22	81.39
			Mean		79.44	81.70	80.57
Garhwal	Dehradun	Baronwala	30.300	77.954	26.38	28.89	27.64
		Raiwala	30.300	77.954	23.33	27.23	25.28
		Ranipokhari	30.181	78.211	21.67	23.89	22.78
		Selaqui	30.368	77.865	29.44	32.77	31.11
		Banjarawala	30.260	78.030	27.66	30.00	28.83
		Vikasnagar	30.470	77.670	24.53	28.89	26.71
			Mean		25.50	28.61	27.06
	Haridwar	Jwalapur	29.927	78.087	62.78	64.44	63.61
		Bahadrabad	29.919	78.038	59.89	61.67	60.78
		Roorkee	29.854	77.888	61.11	63.51	62.31
			Mean		61.26	63.21	62.23

Status of foliar blight in Kumaon region and Garhwal region

Three districts i.e. Almora, Nainital, Udham Singh Nagar in the Kumaon region and two district, Dehradun and Haridwar from Garhwal region were surveyed to understand the prevalence of foliar blight of wheat.

Almora district

Within Almora, the mean PDI values showed a narrow range, with the highest severity recorded at Bhanoli (8.61%), followed by Ranikhet (7.50%), while Hawal Bagh (5.56%) exhibited the minimum disease intensity.

Nainital District

A wider variation was observed in Nainital, where Kathgodam (14.11%) exhibited the highest mean PDI, followed by Lalkuan (11.49%), Betalghat (10.56%) and Halduchaur (10.19%), whereas the lowest values were recorded at Haldwani (9.72%) and Lamachaur (8.59%).

Udham Singh Nagar District

The Udham Singh Nagar district showed consistently high disease pressure across all locations. Pantnagar was a hotspot with a maximum mean PDI (85.50%), followed by Bajpur (82.22%), Sitarganj (81.39%), Kashipur (80.43%) and Gadarpur (80.00%), while the lowest mean values were observed at Rudrapur (78.61%) and Kichha (77.22%).

Dehradun District

In Dehradun, disease severity was highest at Selaqui (31.10%), followed by Banjarawala (28.83%), Baronwala (27.64%), Vikasnagar (26.71%) and Raiwala (25.28%), whereas Ranipokhari (22.78%) recorded the lowest mean PDI.

Haridwar district

In the Haridwar district, Jwalapur (63.61%) showed the maximum mean PDI, followed closely by Roorkee (62.31%), while Bahadrabad (60.78%) recorded the minimum.

Among all districts, Udham Singh Nagar recorded the maximum mean PDI (80.57%), indicating extremely high disease pressure across all locations. This was followed by Haridwar with a mean PDI of 62.23%, also reflecting severe and widespread foliar blight incidence. Dehradun showed moderate disease intensity, with an overall mean PDI of approximately 27.06%, placing the district in an intermediate category. In contrast, the hill districts exhibited substantially lower infection levels. Nainital recorded a mean PDI of 10.56%, while Almora exhibited the minimum mean PDI (7.22%), representing the lowest disease severity observed in the state.

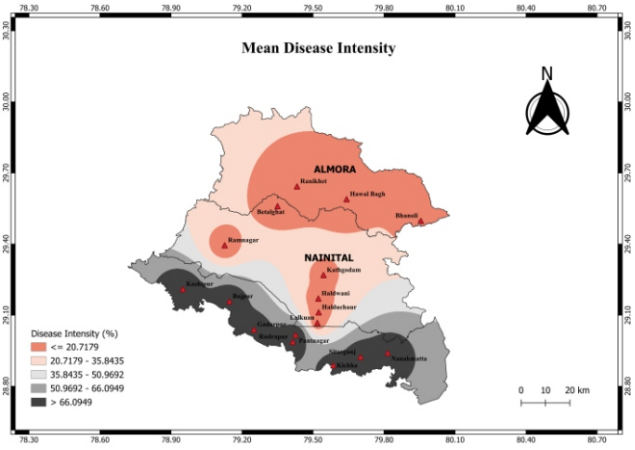

Figure 1: Status of percent disease index in Kumaon region of Uttarakhand

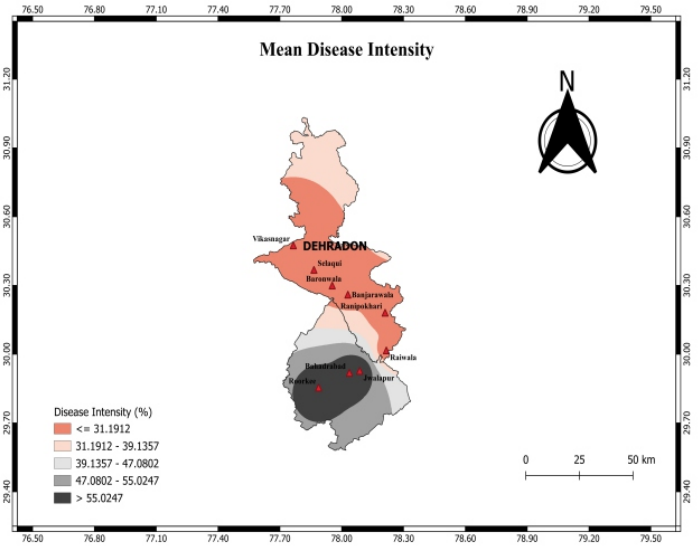

Figure 2: Status of percent disease index in Garhwal region of Uttarakhand

The survey clearly indicated that foliar blight severity was markedly higher in the plains and terai regions, particularly in Udham Singh Nagar and Haridwar, whereas the hilly districts of Almora and Nainital exhibited very low levels of infection. Foliar blight is known to intensify under high relative humidity and elevated temperatures, especially when coupled with imbalanced soil fertility (11) and spreads rapidly when the temperature exceeds 26°C (12). Therefore, the variation in disease severity may be because the warm and humid environment of the plains provides highly favourable conditions for rapid disease development, in contrast to the cooler and less humid climates of Almora and Nainital, where disease development is naturally suppressed. This fact can be supported by the findings of (13) who reported that foliar blight of wheat is one of the major concerning diseases in warm and humid regions of the India sub-continent. Similar observations have been recorded by (14) that wheat grown under a hot and humid climate is attacked by foliar blight pathogens i.e *B. sorokiniana* and *A. triticina*. Similarly, differences in disease severity linked to climatic variation have also been documented by (15). These findings are consistent with the findings by (8) that the presence of high relative humidity prolongs leaf wetness within the canopy, creating a conducive environment for infection and subsequent pathogen development.

We noticed that the incidence of disease in adult plants was higher as compared to young seedlings. It can be attributed with the fact that the average temperature of January and February remains low, while increasing in the March and April. It has been reported that the average temperature for foliar blight pathogens ranges from 24 ° C to 28 ° C (16). Similar findings were reported by (17) who observed that disease intensity increases with the crop maturity and becomes maximum during harvesting, in the month of April. Similarly, (18) reported that the average incidence of foliar blight pathogens, *B. sorokiniana* and *A. triticina* at crop maturity was 62% and 43% respectively.

It has also been observed while surveying that the majority of farmers in the high-severity districts follow a rice–wheat rotation, which plays a critical role in maintaining the pathogen inoculum. Earlier studies have shown that rice can serve as an alternate host for the pathogen in rice-wheat cropping system (8). Therefore, rice stubble may act as an important substrate for pathogen survival after harvest, facilitating inoculum carryover to the succeeding wheat crop.

The seed-borne nature of these pathogens further compounds the problem; without adequate seed health testing and fungicidal treatment, infection can be introduced directly into fields (19).

Conclusion

The present study concludes that foliar blight is a widespread, economically significant and progressively worsening disease of wheat in Uttarakhand. The combined influence of conducive microclimatic conditions in the plains and the intensive rice–wheat cropping system strongly favours pathogen survival and epidemic development, resulting in significantly higher foliar blight severity compared to the hill districts. Therefore, there is a need for developing and implementing region-specific, integrated disease management (IDM) strategies. Extension efforts should be prioritised in the high-severity districts, focusing on resistant varieties, strategic fungicide application, and crucially, cultural practices like crop residue management to break the disease cycle and enhance wheat production in Uttarakhand.

Future prospects

The future work should focus on developing climate-based predictive models for disease outbreaks, screening and promoting resistant wheat varieties suited to plains and terai regions, and implementing integrated disease management strategies that combine cultural practices, seed treatment and judicious use of fungicide in high-risk zones. Further research on pathogen variability, seed-borne infection, and the role of rice residues in disease carryover is needed. Developing and promoting simple, region-specific integrated disease management practices will help reduce disease severity and improve wheat productivity in Uttarakhand.

Acknowlwdgements

The author is thankful to the College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand, for providing the necessary facilities and support to carry out the research.

Conflict of Interest

The authors declare there is no conflict.

REFERENCES

1. Kalender, N., & Dogan, Y. (2021). Durum wheat (*Triticum turgidum* ssp. *durum*) and its comparison to bread wheat in some aspects. *MAS Journal of Applied Science, 6*, 807–813.

2. ICAR-Indian Institute of Wheat and Barley Research. (2025, November 9). *Director's Desk*. https://iiwbr.org.in/director-desk/

3. Anonymous. (2025, November 7). *Uttarakhand*. Indian Council of Agricultural Research. https://icar.org.in/en/node/17293

4. Kakraliya, S. S., Choskit, D., Pandit, D., & Abrol, S. (2017). Effect of bio-agents, neem leaf extract and fungicides against *Alternaria* leaf blight of wheat (*Triticum aestivum* L.). *Natural Products Chemistry & Research, 6*(3), 23–34.

5. Karwasra, S. S., Beniwal, S. S., & Singh, R. (1998). Occurrence, cultivar reaction and yield losses due to leaf blight of wheat. *Indian Phytopathology, 51*, 363–364.

6. Goel, L. B., Nagarajan, S., Singh, R. V., Sinha, V. C., & Kumar, J. (1999). Foliar blights of wheat: Current status in India and identification of donor lines for resistance through multilocational evaluation. *Indian Phytopathology, 52*(4), 398–402.

7. Kommeta, M., Kapadiya, I. B., & Akbari, L. F. (2019). Evaluation of different fungicides against leaf blight (*Alternaria triticina*) of wheat under *in vitro* condition. *International Journal of Current Microbiology and Applied Sciences, 8*(6), 1751–1758.

8. Acharya, K., Dutta, A. K., & Pradhan, P. (2011). *Bipolaris sorokiniana* (Sacc.) Shoem.: The most destructive wheat fungal pathogen in the warmer areas. *Australian Journal of Crop Science, 5*(9), 1064–1071.

9. Saari, E. E., & Prescott, J. M. (1975). A scale for appraising the foliar intensity of wheat diseases. *Plant Disease Reporter, 59*(5), 377–380.

10. Eyal, Z., Scharen, A. L., Prescott, J. M., & van Ginkel, M. (1987). *The Septoria diseases of wheat: Concepts and methods of disease management*. CIMMYT.

11. Sharma, R. C., & Duveiller, E. (2004). Effect of Helminthosporium leaf blight on performance of timely and late seeded wheat under optimal and stressed levels of soil fertility and moisture. *Field Crops Research, 89*(2), 205–218.

12. Chaurasia, S., Chand, R., & Joshi, A. K. (2000). Relative dominance of *Alternaria triticina* Pras. et Prab. and *Bipolaris sorokiniana* (Sacc.) Shoemaker in different growth stages of wheat (*T. aestivum* L.). *Journal of Plant Diseases and Protection, 107*, 176–181.

13. Joshi, A. K., Chand, R., & Arun, B. (2002). Relationship of plant height and days to maturity with resistance to spot blotch in wheat. *Euphytica, 123*, 221–228.

14. Mukherjee, S., Chowdhury, A. K., Bhattacharya, P. M., & Singh, G. (2011). Incidence of Helminthosporium leaf blight of wheat and biochemical background of disease resistance in the Eastern Gangetic Plains. *Journal of Wheat Research, 3*(1), 1–6.

15. Ashwini, R., & Patil, P. V. (2019). Survey on spot blotch of wheat in northern parts of Karnataka. *International Journal of Current Microbiology and Applied Sciences, 8*(2), 1318–1330.

16. Nema, K. G. (1969). *Studies on Helminthosporium leaf blight of wheat* (Doctoral dissertation). Indian Agricultural Research Institute, New Delhi.

17. Joshi, L. M., Gera, S. D., Adalakha, K. L., Srivastava, K. D., Ram, B., & Palmar, L. T. (1974). Some foliar diseases of wheat during 1967–70 crop seasons. *Indian Phytopathology*, 27, 178–181.

18. Singh, R., Sengar, R. M. S., & Singh, S. (2012). Incidence of foliar blight pathogens of wheat (*Triticum aestivum* L.) in Agra region. *Indian Journal of Life Sciences, 1*(2), 39–41.

19. Sharma, R. C., & Duveiller, E. (2003). Effect of stress on Helminthosporium leaf blight in wheat. In J. B. Rasmussen, T. L. Friesen, & S. Ali (Eds.), *Proceedings of the 4th International Wheat Tan Spot and Spot Blotch Workshop* (pp. 140–144). North Dakota State University.