Original Research Article

Survey and Disease Prevalence of Sorghum Zonate Leaf Spot in the Terai Region of Uttarakhand

ABSTRACT

Aims: The objective of the study was to conduct a disease survey to understand the regional dynamics of sorghum zonate leaf spot disease in the Uttarakhand Terai region.

Study design: The investigation was carried out usinga stratified random sampling technique.

Place and Duration of Study:GBPUA&T, Pantnagar and Terai Region of Uttarakhandduring Kharif 2024

Methodology: The survey was conducted from July to September 2024, covering several stages of sorghum crop development. A stratified random sampling technique was used to select fields, and observations were recorded on plants making five stops in a W-pattern to cover the whole field on foot. The disease incidence and severity were scored and recorded.

Results: The survey covered 25 fields and disease incidence& severitywere recorded using a standard scale.The study found that the prevalence and severity of zonate leaf spot disease (*G. sorghi*) varied significantly between locations, with the highest disease incidence in Chikaghat (71.11%) and lowest in Kanthgri(43.56%) from Sitarganj block.Environmental parameters such as temperature, humidity, and rainfall were directly linked to the occurrence and severity of zonate leaf spots.

Conclusion: The study concluded that zonate leaf spot disease is a significant problem in the Uttarakhand Terai Region. Developing efficient management techniques to reduce zonate leaf spot negative effects on crop productivity might be facilitated by knowledge of the distribution and contributing elements. To control zonate leaf spot in these areas, more study is required to investigate resistant cultivars and better agronomic methods.

Keywords: Zonate leaf spot, Gloeocercosporasorghi, Disease incidence, Sorghum, Uttarakhand, Terai region, Survey.

1. INTRODUCTION

A major grain crop, sorghum (*Sorghum bicolor* L.) ranks fifth in the world's production and is essential to food security, especially in arid and semi-arid areas. It is the perfect grain to grow in areas where other cereals are difficult to grow because of its resistance to drought and high temperatures (Khalifa and Eltahir, 2023). Sorghum has become a staple crop for millions of people, particularly in developing nations, and is widely farmed in Africa, Asia, the United States, and Australia. An estimated 58.38 million metric tons of sorghum will be produced worldwide in 2023–2024. The US, Nigeria, and India are major sorghum producers, with respective yields of approximately 8.07 million, 6.4 million, and 4.74 million metric tons (USDA, 2024). Its economic significance in animal feed, biofuel generation, and other industrial applications expands beyond its function in ensuring food security (Habyarimana *et al.,* 2020). Numerous serious diseases affect sorghum, a vital cereal crop, and reduce its productivity globally. Of these*, Gloeocercosporasorghi* zonate leaf spot of sorghum is still a major foliar disease that is on the rise, especially in tropical and subtropical areas. Worldwide, reports of the disease have come from the US, Brazil, Mexico, and some regions of Africa. In extreme circumstances, the disease has been known to cause significant yield losses. Pathogens produce symptoms on lower leaves starting with little lesions that grow into huge, purple-red, or dark brown lesions with two to eight rings. These lesions eventually take on a circular or target shape (Nagaraja*et al.,* 2021). Semi-oval lesions can be found close to the midrib or along the leaf border. The entire area becomes blighted in the latter stages, when dark-red to blackish-purple or brown lesions on leaves and leaf sheaths combine. The size and target appearance of certain zonate lesions vary. The slimy, salmon-coloured lumps on the upper surface of the blotch can occasionally be identified as *G. sorghi* sporodochia. In a linear pattern, black dots of spherical sclerotia appear on dead, greyish-tan tissue. The surface of severely diseased seeds has black oval dots and is either dark brown, crimson, or red-brown (Heo *et al.,* 1999).China reported sorghum yield losses of up to 30% (Jiang et al. 2018). In India, under ideal circumstances, the pathogen harmed up to 85% of the photosynthetic leaf area. As infection severity grew, leaf weight dropped and leaf dry matter content rose, which had an impact on fodder production (Anitha *et al.,* 2020).The emergence of sorghum zonate leaf spot disease in the Uttarakhand Terai region makes a disease survey essential to comprehending the regional dynamics of this foliar disease, particularly in light of the state's diverse agro-climatic zones.

2. MATERIALS AND METHODS

2.1 Survey and Sampling of Sorghum Zonate Leaf Spot Disease

The survey was carried out in Uttarakhand's Terai region during the sorghum growing season of 2024. The area consists of various blocks that are well-known for growing sorghum. The survey covered several stages of the development of the sorghum crop and was conducted from July to September. The fields used for illness assessment were chosen using a stratified random sampling technique. At regular intervals of 5 to 8 km, two sample fields were routinely taken at each point along the accessible roads. Zonate leaf spot occurrence and severity in the area, plant growth phases, GPS locations, and various cropping systems were used to classify sorghum farms. 25 fields in all, spread

among the main sorghum-growing regions, were surveyed. In each field, the observations were recorded on plants making five stops by following a W-pattern to cover the whole field on foot (Ngugi *et al.,* 2002).

2.2 Disease Scoring

Each location's zonate leaf spot severity and disease incidence were recorded. One square meter quadrants were marked in each field to assess ten randomly chosen plants. Out of all the plants observed, the proportion of infected plants was used to compute the incidence. To calculate disease incidence, Cooke *et al.* (2006) presented the following formula,

$$\text{Disease incidence} = \frac{Number\ of\ plants\ showing\ disease\ symptoms}{Total\ number\ of\ plant\ observed} \times 100$$

Disease severity was assessed by using the standard scale (1 to 9) as described by Thakur *et al*. (2007) in the **Table.1** and the Percentage Disease Index (PDI) was calculated using the following formula suggested by Wheeler (1969):

$$\text{Percent disease index (PDI)} = \frac{Sum\ of\ individual\ ratings}{Total\ unit\ assessed\ \times Maximum\ grade} \times 100$$

Disease severity was recorded using a 1-9 scale based on lesion size, necrotic area, and defoliation

Table 1. Disease Scale for Zonate Leaf Spot in Sorghum

Rating	Description
1	No symptoms on the leaf and perfectly healthy
2	1-5% of the total leaf area is affected by spot
3	6-10% of the total leaf area is affected by spot
4	11-20% of the total leaf area is affected by spot
5	21-30% of the total leaf area is affected by spot
6	31-40% of the total leaf area is affected by spot
7	41-50% of the total leaf area is affected by spot
8	51-75% of the total leaf area is affected by spot
9	>75% of the total leaf area is affected by spot

3. RESULTS AND DISCUSSION

3.1 Survey of Sorghum Zonate Leaf Spot Disease in the Terai Region of Uttarakhand

The prevalence and incidence of zonate leaf spot disease (*G. sorghi*) were evaluated by a thorough study of sorghum fields in the Terai region of Uttarakhand. Concentric rings of light brown to dark red lesions on the leaf surface were the typical symptoms seen in all regions like **Fig 1.**in badly afflicted

plants, these lesions merged to produce enormous necrotic patches. Premature defoliation was prevalent in strongly infested regions, which could result in crop losses and decreased plant vigor.

Fig 1. Characteristics symptoms of Zonate leaf spot of Sorghum recorded during the Kharif 2024 survey in the Terai region of Uttarakhand

3.2 Disease Incidence and Environmental Factors Influencing Sorghum Zonate Leaf Spot

The overall prevalence of zonate leaf spot severity ranges between 40% and 75%, depending on regional environmental conditions and agronomic approaches. The findings in **Table 2. and Fig 2.** revealed that disease incidence and severity differed significantly among locales. Disease incidence and severity in sorghum crops vary significantly across examined areas inUttarakhand's Terai region. At Baheri (Hathmana), 228 meters above sea level, disease incidence was 92%, corresponding to a Percent Disease Index (PDI) of 66.22%. Similarly, Rudrapur (Pantnagar), at an elevation of 244 meters, had a disease incidence of 92% and a slightly higher PDI of 68.89%, indicating significant disease development. Sitarganj (Chikaghat), with a disease incidence of 96%, had the highest PDI of 71.11%, indicating that this area suffered the most strong disease pressure of the investigated sites.

Khatima (Banusi) and Khatima (Khatima) had moderate disease incidence (88% and84%, respectively), with PDIs of 66.26% and 60.00%. Sitarganj (Kanthgri) had the lowest disease incidence (76%), but its PDI was still substantial (43.56%), showing disease spread although at a lower severity than in other places. Champawat (372 m) had a disease incidence of 76% and a PDI of 57.33%, indicating that the infection was less severe despite its greater altitude. Rudrapur (Bari) and Sitarganj (Sitarganj) had disease incidence rates of 84% and 76%, respectively, with PDIs of 63.11% and 59.11%. The change in disease incidence and PDI across different elevations and locations may indicate potential environmental impacts, such as humidity, temperature, and soil conditions, that require more investigation to identify the primary contributing components.

Environmental parameters, including temperature, humidity, and rainfall, were directly linked to the occurrence and severity of zonate leaf spots. Zonate leaf spot is regarded as a minor disease that causes insignificant output losses in drier sorghum-producing countries. Nonetheless, the disease can result in notable yield and quality losses in humid and rainy environments, particularly on sweet sorghum and fodder (Prom and Isakeit, 2022).

Table 2. Disease Incidence of Sorghum Zonate Leaf Spot in the Terai Region of Uttarakhand during Kharif 2024

S. No	Block	Location	Latitude/ Longitude	Altitude (m)	Disease Incidence (%)	Per Cent Disease Index (%)
1	Baheri	Hathmana	28.881038°N 79.574629°E	228	92	66.22
2	Champawat	Champawat	28.98366°N 79.062477°E	372	76	57.33
3	Khatima	Khatima	28.936564°N 79.912259°E	219	84	60.00
4	Khatima	Banusi	28.935654°N 79.915555°E	212	88	66.26
5	Rudrapur	Bari	28.863337°N 79.616342°E	208	84	63.11
6	Rudrapur	Pantnagar	29.0080960°N 79.5125136°E	244	92	68.89
7	Sitarganj	Kanthgri	28.871373°N 79.629631°E	234	76	43.56
8	Sitarganj	Chikaghat	28.931449°N 79.737094°E	234	96	71.11
9	Sitarganj	Baghroga	28.931736°N 79.729997°E	234	80	60.44
10	Sitarganj	Sitarganj	28.903346°N 79.700507°E	234	76	59.11
Mean DI & PDI					**84.4**	**61.60**

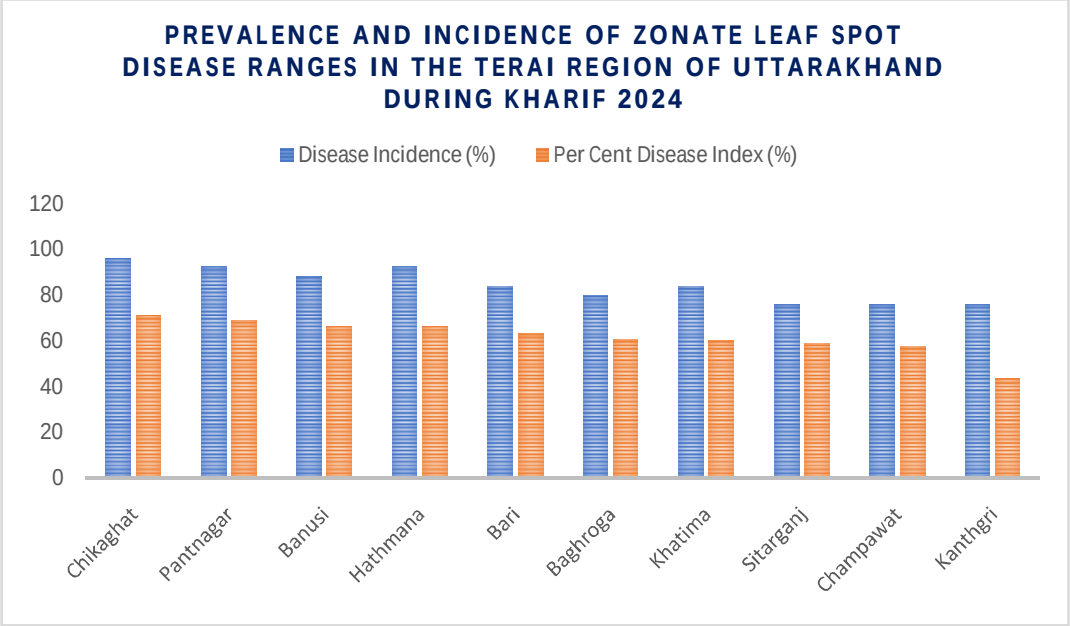

Fig 2. Prevalence and Incidence of Zonate Leaf Spot Disease Ranges in the Terai Region of Uttarakhand during Kharif 2024

CONCLUSION

The study focuses on the considerable impact of zonate leaf spot (*Gloeocercosporasorghi*) on sorghum in the Terai region of Uttarakhand during the 2024 kharif season. The study finds that disease incidence varies between assessed areas, with incidence rates ranging from 40% to 75%, with Chikaghat (71.11%) and Pantnagar (68.89%) showing very high levels. Disease progression, characterized by concentric lesions and premature defoliation, highlights the susceptibility of sorghum crops to favorable weather circumstances such as high humidity and rainfall. The findings underscore the importance of regional disease surveillance and adaptive management measures in reducing yield losses. Furthermore, knowing the interaction of environmental factors and pathogen dynamics is critical for creating resilient sorghum cultivars.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) nowdeclare that generative AI technologies such as Large Language Models, etc. have been used during the editing of manuscripts.This explanation will include the name, version, model, and source of the generative AI technology as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. ChatGpT

2.Grammarly

REFERENCES

Anitha, K., Das, I. K., Holajjer, P., Sivaraj, N., Reddy, C. R., &Balijepalli, S. B. (2020). Sorghum diseases: diagnosis and management. *Sorghum in the 21st century: food–fodder–feed–fuel for a rapidly changing world*, 565-619.

Cooke, B. M., Jones, D. G., & Kaye, B. (Eds.). (2006). *The epidemiology of plant diseases* (Vol. 2). Dordrecht, The Netherlands: Springer.

Habyarimana, E., De Franceschi, P., Ercisli, S., Baloch, F. S., &Dall'Agata, M. (2020). Genome-wide association study for biomass related traits in a panel of Sorghum bicolor and S. bicolor× S. halepense populations. *Frontiers in Plant Science*, *11*, 551305.

Heo, C., Kim, J. N., Hyun, I. H., & Heo, N. Y. (1999). Zonate Leaf Spot of Sorghum Caused by Gloeocercosporasorghi in Korea. *The Plant Pathology Journal*, *15*(4), 242-246.

Khalifa, M., & Eltahir, E. A. (2023). Assessment of global sorghum production, tolerance, and climate risk. *Frontiers in Sustainable Food Systems*, *7*, 1184373.

Nagaraja, A., Chethana, B. S., & Jain, A. K. (2021). Biotic stresses and their management. In *Millets and Pseudo Cereals* (pp. 119-142). Woodhead Publishing.

Ngugi, H. K., King, S. B., Abayo, G. O., & Reddy, Y. V. R. (2002). Prevalence, incidence, and severity of sorghum diseases in western Kenya. *Plant Disease*, *86*(1), 65-70.

Prom, L. K., &Isakeit, T. (2022). Incidence of Zonate Leaf Spot on Sorghum Accessions Under Disease-Conducive Growing Conditions Burleson County, Texas. *Journal of Agriculture and Crops*, *8*(1), 35-38.

Thakur, R. P., Reddy, B. V., & Mathur, K. (2007). *Screening techniques for sorghum diseases. Information: Bulletin No. 76*. International Crops Research Institute for the Semi-Arid Tropics.

U.S. Department of Agriculture Foreign Agricultural Service. (2024). *Sorghum production and supply data* [Internet]. Washington, DC: USDA. Retrieved November 26, 2024, from https://fas.usda.gov/data/production/commodity/0459200

Wheeler, B. E. J. (1969). An Introduction to Plant Diseases. *The English language Book SocityAnd Wiley and Sons Ltd*.