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Geospatial survey of rice sheath blight in Uttarakhand

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ABSTRACT: Rice sheath blight, caused by *Rhizoctonia solani* AG1-1A, is a significant threat to rice cultivation, second only to rice blast. To evaluate its spatial distribution in Uttarakhand, a GIS-based survey was conducted across 13 districts during the Kharif seasons of 2022 and 2023. The surveys revealed distinct spatial patterns of disease incidence (DI) and percent disease index (PDI). The lowest DI and PDI were recorded in the hilly regions of Kumaon and Garhwal, while the highest values were observed in the plains of Kumaon, followed by the plains of Garhwal and the Bhabar regions of Kumaon. Among the districts, Udham Singh Nagar exhibited the maximum DI (64.49%) and PDI (46.60%), whereas Champawat recorded the lowest DI (6.53%) and PDI (2.25%). These findings highlight the role of GIS in identifying disease hotspots and informing targeted disease management strategies.

Key words: Disease index, geographic information system, percent disease index, Rice, *Rhizoctonia solani*

Rice (*Oryza sativa* L.) is a staple crop supporting nearly 67% of the world's population, with Asia being its largest consumer and producer (Mohanty, 2013). However, rice productivity faces persistent challenges from biotic and abiotic stresses. Among biotic stresses, fungal pathogens represent the most significant threat to sustainable rice production (Webster and Gunnell, 1992). Sheath blight, caused by *Rhizoctonia solani*, is the second most damaging fungal disease after rice blast, capable of causing yield losses between 20% and 50% depending on the se*variety* of the infection (Groth and Bond, 2007; Margani and Widadi, 2018). The rapid increase in sheath blight incidence is primarily driven by intensive agricultural practices such as the monoculture of high-yielding semi-dwarf varieties, excessive nitrogen fertilization and dense crop stands that create favorable microenvironments for the pathogen (Savary *et al.,* 1995; Cu *et al.,* 1996). The sheath blight was first reported in Japan in 1910 (Miyake, 1910), has become a global concern, with *R. solani* proving difficult to manage due to its broad host range and its ability to persist in soil and plant debris via sclerotia (Kozaka, 1965).

Accurate monitoring of plant diseases is critical for minimizing yield losses and informing effective management strategies. Traditional visual assessments, while widely used, are subjective and prone to inaccuracies, often leading to suboptimal disease control. Geographic Information Systems (GIS) have emerged as a transformative tool in plant pathology, enhancing the accuracy and efficiency of disease assessments. By integrating spatial and temporal data, GIS enables precise mapping of disease distribution and intensity, identifying hotspots and facilitating targeted interventions. This spatial approach minimizes human error, standardizes data collection and allows for a more systematic understanding of disease dynamics.

In the context of increasing sheath blight prevalence in rice, GIS-based analyses offer a reliable method for assessing the distribution of the disease across diverse agro-climatic zones. The present study aimed to employ GIS technology to map the se*variety* of rice sheath blight in Uttarakhand. These insights are expected to support the development of targeted and region-specific management strategies, aiding efforts to mitigate the impact of this devastating disease.

MATERIALS AND METHODS

A comprehensive roving survey was conducted during the Kharif seasons of 2022 and 2023 to assess the prevalence of rice sheath blight across all districts

of Uttarakhand, including Almora, Nainital, Pithoragarh, Bageshwar, Champawat, U.S. Nagar, Chamoli, Rudraprayag, Tehri Garhwal, Pauri Garhwal, Uttarkashi, Dehradun and Haridwar. The survey was conducted from the tillering to maturity stages of the crop covering 34 rice-growing areas in the Kumaon region and 42 locations in the Garhwal region, in each area, ten fields were randomly selected and sampling was performed by taking measurements from a 1 m² area at the four corners and the center of each field. Data collected included latitude, longitude, disease incidence and relative lesion height for each survey location. The data compilation, analysis and GIS maps were prepared in the Rice Pathology Lab, Department of Plant Pathology, GBPUA&T, Pantnagar.

$$Disease\ incidence = \frac{Total\ number\ of\ infected\ hills}{Total\ number\ of\ hills} \times 100$$

The relative lesion height (RLH) was calculated by formula given by Sharma *et al.* (1990).

$$RLH = \frac{\text{Maximum height at which lesion appeared}}{Plant\ height} \times 100$$

The Percentage Disease Index (PDI) was calculated by ranking the RLH on a 0-9 scale of Standard Evaluation System (SES) which gives a measure of disease se*variety*.

Disease se*variety* rating scale: (Source: IRRI, 2014). 0 = No infection; 1 = lesion limited to the lower 20% of plant height; 3 = lesion limited to the lower 20-30% of the plant height; 5 = lesion limited to the lower 31- 45% of the plant height; 7 = lesion limited to the lower 46- 65% of the plant height; 9 = lesion more than 65% of the plant height

$$PDI = \frac{sum\ of\ all\ disease\ rating}{total\ number\ of\ hills\ \times maximum\ disease\ grade} \times 100$$

Preparation of Disease Prevalence Map Using GIS

A map illustrating the prevalence of rice sheath blight in Uttarakhand was created using QGIS, a free and open-source geographic information system. The map was based on the data gathered during the comprehensive roving survey conducted across all districts of Uttarakhand.

RESULTS AND DISCUSSION

In order to understand the prevalence and distribution of sheath blight disease across various rice-growing regions, we conducted a comprehensive survey focusing on geographic, incidence and se*variety* metrics. This study aims to map the spatial variability in sheath blight occurrence, which can provide insights into potential environmental or regional factors influencing disease spread and impact. By examining these variations, we can better assess areas of high vulnerability and inform targeted disease management practices. The geographic coordinates, disease incidence and percent disease index of the surveyed locations are detailed in Table 1. Additionally, the spatial distribution of rice sheath blight prevalence is illustrated in Figures 1 and 2, providing a visual representation of the disease's impact across the different rice-growing regions.

Status of rice sheath blight in Kumaon region

Hills of Kumaon

Six districts come under Kumaon division, out of six five districts are hilly whereas only one district is plain in geography. Many places in hilly areas like Deoli, Barechhina, Petshal, Panuwanaula and Lohaghat zero disease incidence and percent disease index were recorded. Maximum DI and PDI was recorded in Hawalbagh with (30.37 %) and (21.23 %) respectively.

Bhabar region of Kumaon

Bhabar is a narrow belt of about 8 to 16 km in width lying parallel to the slopes of the Shiwaliks in Uttarakhand state of India which includes lower areas of Nainital district. Minimum record of DI and PDI was observed in Kotabagh with (32.69 %) and (24.55 %) respectively. Highest DI was recorded in Haldwani (65.12 %) and maximum PDI was recorded in Halduchaud (43.39 %).

Palins of Kumaon

The plains of Kumaon also known as Tarai or Terai, it is lowland region that lies south of the outer foothills of Himalaya, the Shiwalik hills and north of Indo-Gangetic plain. In Uttarakhand most of the area of Udham Singh Nagar district comes under Tarai region. Maximum disease incidence was recorded in Dineshpur (71.51 %) and minimum was found in Pantnagar (53.87 %), whereas maximum

Table 1: Incidence and percent disease index of rice sheath blight at different locations of Uttarakhand during Kharif season 2022 and 2023

Division	District	Area	Location	Latitude	Longitude	Disease incidence		Mean	Percent Disease Index (PDI)		Mean
						2022	2023		2022	2023	
Kumaon (34)	U. S. Nagar (6)	Plains	Jaspur	29.04	79.24	59.98	58.87	59.42	47.98	46.56	47.27
			Sitarganjh	29.27	78.82	66.34	63.87	65.10	46.67	46.76	46.71
			Kashipur	29.21	78.95	74.56	68.45	71.50	42.22	46.56	44.39
			Khatima	29.25	79.17	65.23	65.87	65.55	47.78	45.35	46.56
			Dineshpur	29.17	79.13	72.78	70.24	71.51	48.89	47.87	48.38
			Pantnagar	29.04	79.33	58.98	48.76	53.87	45.56	44.56	45.06
			Mean			66.31	62.68	64.49	46.52	46.28	46.40
	Almora (6)	Hills	Kwarab	29.55	79.60	20.98	22..87	20.98	18.89	20.45	19.67
			Hawalbagh	29.63	79.63	29.98	30.76	30.37	21.11	21.34	21.23
			Deoli	29.57	79.62	0	0	0	0	0	0
			Barechhina	29.64	79.75	0	0	0	0	0	0
			Petshal	29.62	79.72	0	0	0	0	0	0
			Panuwanaula	29.64	79.82	0	0	0	0	0	0
			Mean			8.49	6.15	8.55	6.67	6.97	6.82
	Nainital (7)	Bhabar	Kaladungi	29.29	79.34	42.87	48.98	45.93	36.67	35.45	36.06
			Halduchaud	29.11	79.52	55.98	58.36	57.17	43.33	43.45	43.39
			Haldwani	29.22	79.51	63.89	66.34	65.12	41.11	42.45	41.78
			Kathgodam	29.27	79.54	48.98	30.45	39.72	32.22	34.45	33.34
			Kotabagh	29.40	79.29	37.45	27.93	32.69	26.67	22.44	24.55
			Bailpadao	29.31	79.19	48.98	46.62	47.8	35.56	33.45	34.50
			Ramnagar	29.43	79.11	58.98	66.43	62.71	40	45.44	42.72
			Mean			51.02	49.30	50.16	36.51	36.73	36.62
	Pithorgarh (7)	Hills	Berinag	29.77	80.05	10.63	13.24	11.94	4.44	6.45	5.45
			Dharchula	29.84	80.53	0	2.65	1.325	0	1	0.5
			Didihat	29.80	80.24	9.45	15.34	12.40	3.33	8.67	6.00
			Gangolihat	29.65	80.03	0	8.34	4.17	0	2	1
			Kanali Chhina	29.67	80.27	3.12	4.65	3.89	1.11	1.11	1.11
			Munakot	29.67	80.30	2.84	0	1.42	1.11	0	0.56
			Pithoragarh	29.55	80.20	24.88	27.24	26.06	15.56	14.56	15.06
			Mean			7.27	10.21	8.74	3.65	4.83	4.24
	Champawat (4)	Hills	Barakot	29.46	80.07	0	6.24	3.12	0	2.33	1.165
			Bajrikot	29.31	80.09	10.45	19.32	14.89	3.33	6.55	4.94
			Lohaghat	29.40	80.09	0	0	0	0	0	0
			chaniya	29.34	80.08	9.84	6.39	8.12	3.33	2.45	2.89
			Mean			5.07	5.07	6.53	2.22	2.83	2.25
	Bageshwar (4)	Hills	Bageshwar	29.83	79.76	7.34	9.43	8.39	1.11	3.11	2.11
			Kapkot	29.93	79.89	8.34	5.8	7.07	4.44	4.67	4.56
			Garur	29.89	79.61	15.34	16.45	15.90	8.89	7.9	8.39
			kanda	29.81	79.82	13.45	13.54	13.50	7.78	6.98	7.38
			Mean			11.12	11.31	11.21	5.56	5.66	5.61
Garhwal (42)	Chamoli (6)	Hills	Saikot	30.36	79.30	22.57	33.23	27.9	12.22	13.65	12.94
			Pipalkoti	30.43	79.42	12.67	15.57	14.12	5.56	7.86	6.71
			Ghat	30.25	79.44	6.73	0	3.36	1.11	0	0.56
			Kulsari	30.08	79.46	10.45	12.23	11.34	4.44	6.54	5.49
			Aadi badri	30.15	79.22	9.47	7.34	8.40	4.44	2.76	3.60
			Langasu	30.28	79.27	13.34	10.56	11.95	5.56	6.56	6.06
			Mean			12.54	13.16	12.85	5.56	6.23	5.89
	Rudraprayag (5)	Hills	Rudraprayag	30.28	78.98	17.98	19.09	18.54	7.78	8.01	7.89
			Jakholi	30.39	78.89	6.98	10.89	8.94	1.11	2.65	1.88
			Augustyamuni	30.39	79.03	15.66	14.87	15.27	7.78	7.88	7.83
			Gholtir	30.29	79.09	9.98	6.77	8.38	1.11	3.65	2.38

		Kalimath	30.56	79.08	7.8	11.88	9.84	4.44	5.77	5.11
			Mean		11.68	12.7	12.19	4.44	5.59	5.02
Tehri	Hills	Ghansali	29.98	78.52	14.34	19.14	16.74	8.89	10.65	9.77
Garhwal (8)		Chamba	32.54	76.12	7.98	8.98	8.48	4.44	4.77	4.61
		Narendranagar	30.14	78.28	8.99	9.56	9.27	4.44	5.08	4.76
		Kirtinagar	30.21	78.74	15.78	12.45	14.12	7.78	7.98	7.88
		Maletha	30.23	78.71	11.78	16.45	14.12	7.78	8.77	8.27
		Byasi	30.06	78.46	7.77	8.56	8.17	2.22	4.65	3.44
		Nainbagh	30.57	78.00	5.89	0	2.95	1.11	0	0.56
		Thatyur	30.49	78.16	0	0	0	0	0	0
			Mean		9.07	9.39	9.23	4.58	5.24	4.91
Pauri	Hills	Sumari	30.21	78.76	6.98	13.42	10.2	5.56	5.9	5.72
Garhwal (6)		Kot	30.14	78.69	14.7	16.46	15.58	7.78	8.56	8.16
	Plain	Kotdwar	29.75	78.52	35.76	35.46	35.61	23.33	24.76	24.04
	Hills	Satpuli	29.91	78.71	13.44	11.87	12.66	7.78	7.98	7.87
		Paithani	30.14	78.98	18.56	16.55	17.56	10	9.98	9.99
		Dhumakot	29.74	79.01	0	0	0	0	0	0
			Mean		14.91	15.63	15.27	9.07	9.53	9.30
Uttarkashi (5)	Hills	Uttarkashi	30.73	78.39	20.34	23.45	21.90	12.22	14.43	13.33
		Purola	30.88	78.09	8.98	14.98	11.98	4.44	5.98	5.21
		Barkot	30.80	78.20	12.67	11.99	12.33	5.56	6.09	5.82
		Chinyalisaur	30.57	78.32	25.89	27.89	26.89	15.56	15.99	15.77
		Dunda	30.70	78.34	4.35	3.22	3.785	1.11	1	1.06
			Mean		14.45	16.31	15.38	7.78	8.70	8.24
Dehradun (6)	Plains	Rishikesh	30.07	78.28	48.98	46.25	47.61	36.67	37.99	37.33
		Thano	30.24	78.15	50.79	51.48	51.13	36.67	36.87	36.77
		Banjarawala	30.26	78.03	65.89	60.68	63.28	45.56	46.56	46.06
		Naya gaon	30.31	77.89	66.23	64.24	65.23	46.67	47.35	47.01
		Vikash-Nagar	30.44	77.73	58.34	55	56.67	42.22	41.87	42.05
		Raipur	30.31	78.08	67.89	65.87	66.88	43.33	43.98	43.66
			Mean		59.69	57.25	58.47	41.85	42.44	42.14
Haridwar (6)	Plains	Raiwala	30.03	78.20	56.67	65.34	61.01	44.44	42.78	43.61
		Badrabad	29.92	78.03	60.56	62.45	61.51	45.56	40.98	43.27
		Laksar	29.75	78.01	53.24	58.93	56.09	46.67	46.34	46.50
		Khanpur	29.65	78.01	64.78	66.78	65.78	42.22	40.65	41.44
		Narsan	29.70	77.84	58.23	64.24	61.24	45.56	43.88	44.72
		Roorkee	29.87	77.91	54.34	65.45	59.90	40	42.89	41.44
			Mean		57.97	63.87	60.92	44.07	42.92	43.50

PDI was observed in Dineshpur (48.38 %) and least was recorded in Kashipur (44.39 %).

Status of rice sheath blight in Garhwal region

Hills of Garhwal

Uttarakhand is a hilly state, except Udham Singh Nagar and Haridwar district remaining all districts has hilly areas, most of the areas of hills comes under rainfed rice cultivation so the rice production in hills is less compare to plains area. In Garhwal region out of seven, six districts have hilly terrain. The places like Thatyur and Dhumakot no disease incidence and se*variety* were recorded. Maximum disease incidence was recorded in Saikot followed by Chinyalisaur and Uttarkashi with 27.9, 26.89 and 21.90 percent respectively. However maximum PDI was recorded in Chinyalisaur (15.77 %) followed by Uttarkashi (13.33 %) and Saikot (12.94 %).

Palins of Garhwal

Haridwar district and some area of Dehradun and Pauri Garhwal district from Garhwal region comes under plain area, these areas are the major rice producers from Garhwal region. Maximum disease incidence was recorded in Raipur (66.88 %) followed by Khanpur (65.78 %) and Naya gaon (65.24 %), maximum PDI was found in Naya gaon, (47.01 %) followed by Laksar (46.50 %) and Banjarawala (46.06 %). Minimum DI and PDI was recorded in Kotdwar with 35.61 and 24.04 percent

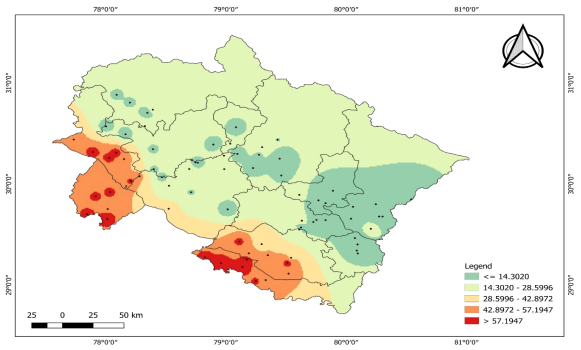

Fig.1: Status of disease incidence in different geographical region of Uttarakhand

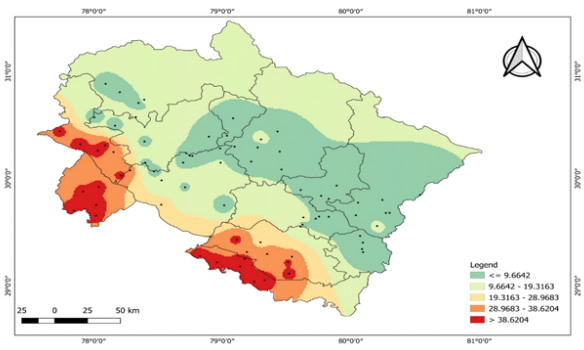

Fig.2: Status of percent disease index in different geographical region of Uttarakhand

respectively.

When average of districts was considered, the highest disease incidence (%) was found in U. S. Nagar district (64.49 %) followed by Haridwar (58.47 %) and Dehradun (60.92 %) whereas lowest disease incidence was found in Champawat district (6.53 %). Maximum PDI was found in U. S. Nagar district (46.40 %) followed by Haridwar (43.50 %) and Dehradun (42.14 %), minimum PDI was observed in Champawat district (2.25 %).

The maximum disease incidence and PDI was observed in U. S. Nagar district it is may be because due to in this areas rice production is done in very large scale and farmers usually takes two crops of rice in a year. Taking two crops in a year they use fertilizer in a very large amount especially nitrogenous fertilizers which favors the disease. This fact can be supported by the findings of Savary *et al.,* 1995 who found that, heavy doses of nitrogenous fertilizers and the favourable microenvironment facilitated by the crop density are implicated as the major factors favoring the sharp increase in the disease incidence. This district comes under Tarai region of Uttarakhand which is more humid than other district the similar results were observed by Kabdwal *et al.,* 2021 who also studied occurrence of sheath blight of rice in U. S. Nagar district and Nainital district. Bisht *et al.,* 2022 also surveyed U. S. Nagar, Nainital and Almora districts with similar findings, highest DI and PDI was recorded in Tarai region and minimum in hills of Almora district.

In general correlation between crop growth stage and PDI was not recorded. However, only in U. S. Nagar, Haridwar and few areas of Nainital district a positive correlation between the growth stage of crop and PDI was observed, where PDI was about 20-25% at early stage and it increased to 45-46 % when crop reached to the maturity stage. These results are in accordance with findings of Dutta *et al.* (2012) who found that the disease was present in all the rice growing areas of Jammu and Kashmir. Maximum disease incidence of 46.6 and 85.6 percent was observed during stem elongation and maturity stages respectively in Maal Shah of Jammu district. Similar results were observed by Reddy *et al.* (2018) in Telangana India, initially disease score was three when crop progressed towards maturity the score increase to nine.

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