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RESEARCH PAPER

Predominance and prevalence of *Fusarium* head blight of wheat in northern parts of Karnataka

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Abstract: Fusarium head blight (FHB) is one of the destructive diseases of wheat worldwide. Epidemics of FHB disease are sporadic globally and have caused havocs due to the reduction in the yields and production of mycotoxins. Among the many species involved in the complex, *Fusarium poae* is reported as the causal organism in northern parts of Karnataka. However, the incidence and severity of FHB as well as the causal *Fusarium* speciesare reported to vary among geographical regions and years due to variation in climatic and weather conditions and cropping practices. A survey was conducted during *rabi* 2021-22 to record the incidence and severity of Fusarium head blight of wheat in major wheat growing regions of northern parts of Karnataka *viz.*, Dharwad, Bagalkote and Belagavi districts. The maximum FHB index was recorded in Belagavi district (12.20%) followed by Bagalkote district (11.89%) and the lowest FHB index was observed in Dharwad district (6.05 %). The maize-wheat sequential cropping system exhibited higher incidence and severity of the disease. The wheat sown during first fortnight of October and second fortnight of November recorded the maximum Fusarium head blight index.

Key words: FHB index, *Fusarium poae*, Head blight, Survey

Introduction

Fusarium head blight (FHB) is one of the rampant and ravaging diseases of wheat that has become a limiting factor of wheat production globally. This disease is known to cause severe damage not only to wheat, but also to many economically important cereal crops like barley, maize, paddy and oats. The recent global climatic change has even more notably aggravated the disease. FHB is strongly weather-dependent, and occurs when viable airborne inoculum and warm wet weather coincide with the anthesis stage of wheat. It has a direct impact on the grain yield since the affected wheat grains become shrivelled or 'tombstone' which results in significant yield loss due to reduced test weight. In some cases, up to 100 per cent yield loss is reported in susceptible cultivars under the most favourable conditions for disease (Panwar *et al*., 2016). Besides the direct or the quantitative losses pertaining to the reduced yield, there is also a serious concern due to the indirect or qualitative losses as a result of the mycotoxin produced by the pathogen.Trichothecenes, primarily deoxynivalenol (DON) or 'vomitoxin'is the most common mycotoxins associated with *Fusarium*infected wheat grain which are commonly associated with vomiting, feed refusal, bleeding, dizziness, and vertigo (Ji *et al.*, 2019). Therefore, the combination of reduced yield, poor grain quality, and mycotoxin contamination makes FHB a serious threat to the economics of cereal production on a global scale. The members of the *Fusarium graminearum* species complex (FGSC) are the primary etiological agents of FHB around the world. But these species cannot be classified as exclusive, as numerous novel etiological agents are being reported as incitants in the recent times. FHB has apparently come into the limelight in the recent times in northern parts of Karnataka, where the causal organism is reported as *Fusarium poae* (Peck) Wollenw. and there is a very minimal knowledge about the distribution dynamics of this pathogen in these locations. The objective of this study was to determine the incidence and severity of FHB across the wheat fields and to assess possible relationships between FHB index andfactorssuch as previous crop,variety and date of sowing.

Material and methods

A roving survey was conducted during *rabi* 2021-22 to record the incidence and severity of Fusarium head blight of wheat at anthesis stage in major wheat growing regions of northern parts of Karnataka *viz.*, Dharwad, Bagalkote and Belagavi districts. In each district one to five taluks and from each taluk four to five villages were surveyed. The wheat heads showing the symptoms of Fusarium head blight were collected from all the surrounding places in a *zig-zag* manner.

Disease parameters assessed in the survey are as follows:

$$1)\ \text{Disease incidence (\%) (DI)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

$$2)\ \text{Disease severity (\%) (DS)} = \frac{\text{Number of infected spikelets}}{\text{Total spikelets per spike}} \times 100$$

The above two parameters were used to calculate the FHB Index (Stack and McMullen, 1995):

$$\text{FHB Index (\%)} = \frac{\text{Disease Incidence (DI) x Disease Severity (DS)}}{100}$$

Isolation and maintenance of the pathogen

The samples collected from the diseased fields during *rabi* 2020-21 were used in the study. From each of infected heads and spikelets with symptoms of infection were washed well in tap water and surface sterilized using one per cent sodium

Table 1. Designation of the isolates of *Fusarium poae* causing head blight of wheat from major wheat growing districts of northern parts of Karnataka

Districts	Village	Isolate designation
Dharwad	Yadawad	DwYdF
Dharwad	Belavatgi	DwBlF
Belagavi	Munuvalli	BgMnF
Belagavi	Ugar	BgUgF
Belagavi	Nanagundikoppa	BgNkG
Belagavi	Nippani	BgNpF
Belagavi	Nilagi	BgNlF
Belagavi	Arabhavi	BgAbF
Bagalkote	Mudhol	BkMdF
Bagalkote	Belagali	BkBlF

hypochlorite solution for 60 sec and washed repeatedly thrice in sterilized distilled water to remove the traces of sodium hypochlorite if any before transferring them to sterile potato dextrose agar (PDA) plates under aseptic conditions. The plates were incubated at a temperature of 27±1°C to obtain good fungal growth. Ten isolates were established and designated with codes based on the location of their collection as presented in the Table 1.

Identification of Pathogen

The pathogen was identified by observing under microscope for various morphological characters on the basis of cultural features and conidial ontogeny (Nelson *et al.*,1983; Leslie and Summerell, 2006). The ten isolates were further subjected to molecular studies using species-specific EF1 primer sets for further confirmation of the pathogen.

Proving the pathogenicity

Pathogenicity test was conducted in the polyhouse of AICRP on wheat and barley, University of Agricultural Sciences Dharwad. The pathogen was multiplied on potato dextrose broth. Spore suspension containing a load of 10^6 conidia ml^{-1} was prepared from ten days old culture and sprayed on the healthy wheat heads during anthesis stage by using hand atomizer. Control plants were sprayed in a similar manner with sterile distilled water. Humidity was maintained for 72 hrs post-inoculation period by covering each spike with a plastic bag and misting at least once in a day and the spikes were regularly examined for the appearance of the disease symptoms. The pathogen was re-isolated from the diseases tissues and compared with the original culture for the confirmation of fungus.

Results and discussion

The results pertaining to the survey are presented in Table 2, Fig 1 and 2. The maximum FHB index was recorded in Belagavi district (12.20%) followed by Bagalkote district (11.89%) while, the lowest FHB index was observed in Dharwad district (6.05%). In Bagalkote district, the highest FHB index was recorded in Bagalkote taluk (13.36%) followed by Mudhol taluk (12.59%), while the lowest FHB index was recorded in Badami taluk (9.71%). In Belagavi district, the maximum FHB index was recorded in Gokak taluk (19.24%) followed by Ramadurga (14.86%), Hukkeri (13.60%) and Raibagh (12.46%) while, the least FHB index was observed in Saundatti taluk (7.54%). In Dharwad district, the highest FHB index was noticed in Navalgund taluk (5.83%) and the lowest index was recorded in Dharwad taluk (6.27%).The higher the index value, the more severe the disease and the greater the danger of FHB-related losses. The pathogen's prevalence may be ascribed to a variety of factors in these regions, one of which being the impact of climate.

The survey results also revealed that the maximum Fusarium head blight was recorded in wheat plots preceded by maize

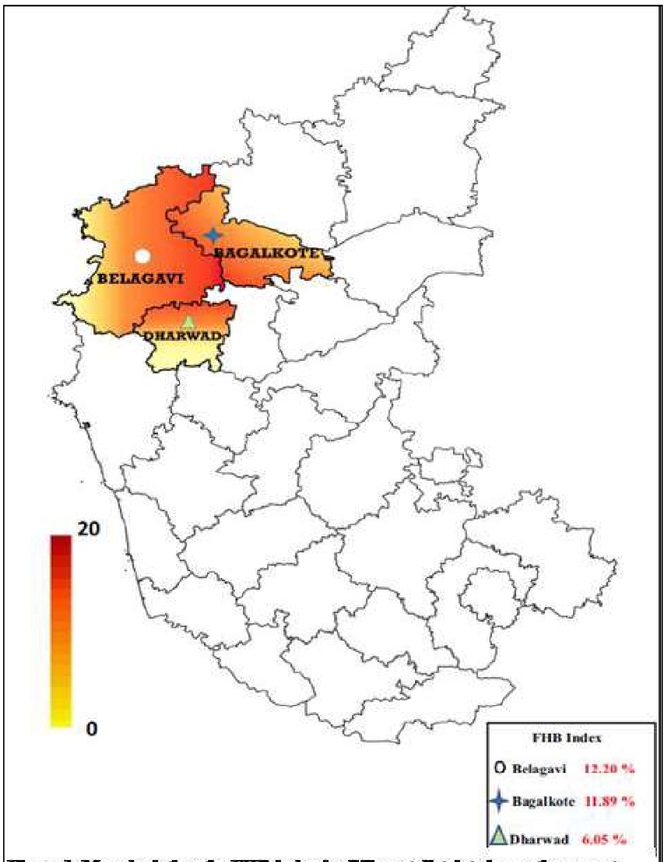


Figure 1. Map depicting the FHB index in different districts in northern parts of Karnataka during the survey in *rabi* – 2021-22

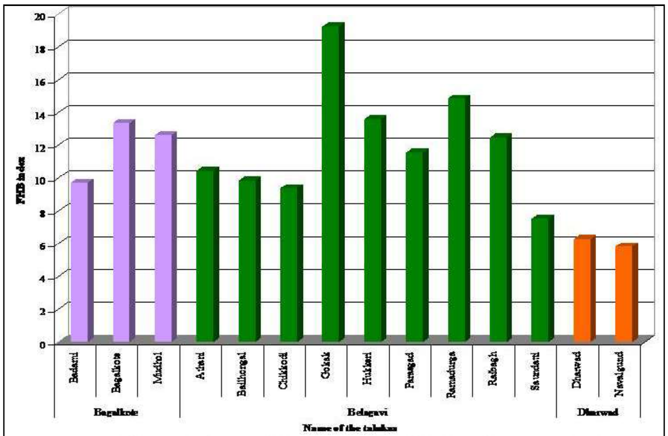


Fig. 2: Taluk and district-wise index of Fusarium head blight during the survey *rabi* 2021-22

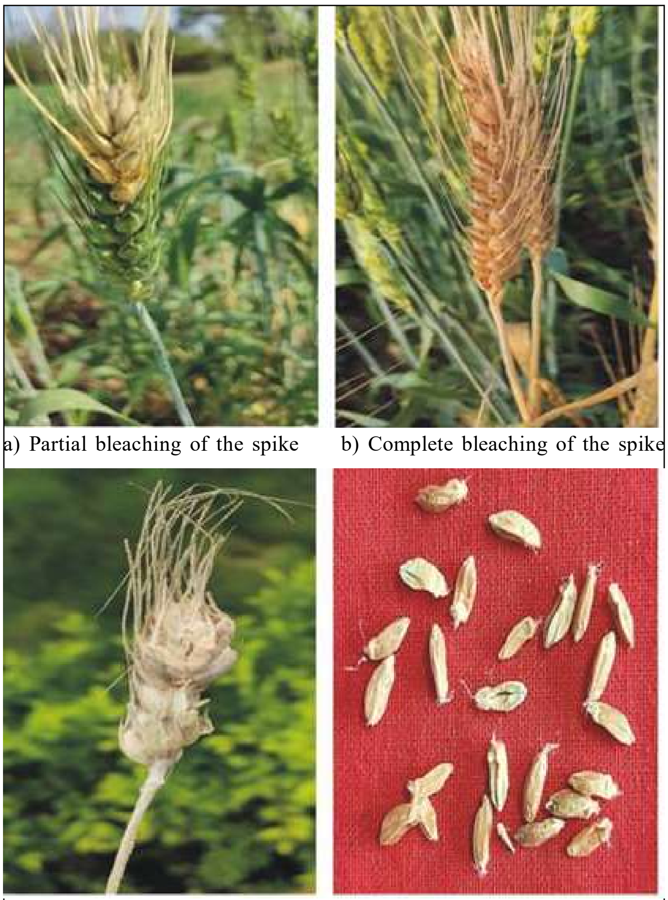
Table 2. Survey for incidence and severity of Fusarium head blight on wheat in northern parts of Karnataka

District	Taluk	Village	Area (acre)	Latitude (°N)	Longitude (°E)	Soil type	Previous crop	Date of sowing	Wheat type	Farming situation	DI (%)	DS (%)	FHB Index (%)	Other diseases noticed
Bagalkote	Badami	Kerur	3	16.02.16	75.33.16	Black	Sunflower	II FN(N)	Bread/Dicoccum	I	15.65	10.32	1.62	Leaf rust
		Mamatageri	4	15.5642	75.31.05	Black	Maize	II FN(N)	Bread	R/I	44.36	26.78	11.88	Leaf rust
		Yargoppa	4	16.04.16	75.34.27	Black	Maize	IFN(D)	Bread	R/I	52.08	30.00	15.62	Leaf rust
	Bagalkote	Bagalkot	5.5	16.10.48	75.41.80	Black	Maize	II FN(N)	Bread	I	59.55	33.11	19.72	Leaf rust
		Gaddankeri	4	16.11.23	75.42.45	Black	Maize	II FN(N)	Dicoccum	I	17.33	11.45	1.98	-
		Kaladgi	3	16.11.65	75.20.74	Black	Maize	I FN(D)	Bread	I	46.24	39.77	18.39	Leaf rust
	Mudhol	Belagali	3.5	16.22.63	75.10.68	Black	Maize	II FN(N)	Bread	R	65.00	33.20	21.58	Spot blotch
		Lokapur	4.5	16.10.01	75.23.68	Black	Maize	II FN(N)	Bread	R	55.54	37.45	20.80	Leaf rust
		Mugalkhod	5	16.16.21	75.23.52	Black	Sorghum	II FN(N)	Dicoccum	I	30.88	29.32	9.05	Leaf rust
		Shirol	3	16.20.23	75.29.34	Black	Maize	II FN(N)	Bread	R	40.22	28.67	11.53	Leaf rust
		Soragavi	2	16.21.16	75.14.14	Black	Sorghum	II FN(N)	Dicoccum	R	0.00	0.00	0.00	-
Belagavi	Athani	Chincholi	4	16.33.73	74.48.94	Black	Maize	I FN(O)	Bread	R	49.32	37.66	18.57	Leaf rust
		Kuduchi	2	16.36.35	74.50.42	Black	Maize	II FN(N)	Durum	I	37.22	35.31	13.14	Leaf rust
		Ugarkhurd	1.5	16.39.23	74.49.12	Black	Maize	II FN(N)	Bread	I	63.00	43.76	27.57	Leaf rust
	Bailhongal	Nilaji	5	15.38.48	74.53.23	Black	Soybean	II FN(N)	Bread	R	47.88	32.38	15.50	-
		Belawadi	3.5	15.41.76	74.54.95	Red	Maize	II FN(N)	Bread	R	58.20	36.29	21.12	Leaf rust
		Naganur	3	15.51.17	74.44.78	Black	Groundnut	II FN(N)	Durum	R	35.03	30.49	10.68	Leaf rust
		Nanagundikoppa	1.5	15.43.56	74.51.34	Black	Maize	II FN(N)	Bread	I	45.00	32.00	14.40	-
		Nayanagar	2	15.45.87	74.52.32	Red	Soybean	II FN(O)	Durum	I	69.00	18.4	12.70	-
Belagavi	Chikkodi	Itnal	3	16.22.44	74.41.15	Black	Soybean	II FN(N)	Bread/Dicoccum	R	68.21	14.33	9.77	Leaf rust
		Kabbur	1.5	16.19.46	74.43.25	Black	Maize	II FN(N)	Bread/Dicoccum	R	51.38	35.55	18.26	Spot blotch
		Kerurwadi	4	16.18.45	74.34.67	Black	Groundnut	II FN(N)	Bread	R/I	0.00	0.00	0.00	Spot blotch
		Nippani	1	16.21.34	74.38.56	Black	Maize	II FN(N)	Bread	R/I	55.87	30.77	17.19	Leaf rust
	Gokak	Arabhavi	2.5	16.13.79	74.49.44	Black	Maize	II FN(N)	Bread	I	82.26	45.00	37.02	Leaf rust
		Benachinamaradi	2	16.76.68	74.51.66	Black	Maize	II FN(N)	Bread	I	45.75	31.44	14.30	Leaf rust
		Ghataprabha	4	16.23.95	74.75.86	Black	Maize	II FN(N)	Durum	I	48.17	25.00	13.97	Leaf rust
		Kallolli	2	16.25.48	74.50.21	Black	Maize	II FN(N)	Bread	R/I	67.6	38.00	25.69	Leaf rust
		Mudalgi	1.5	16.28.34	74.49.87	Black	Sorghum	II FN(N)	Durum	R/I	32.44	15.80	5.13	Leaf rust
	Hukkeri	Hulloli	6	16.26.03	74.65.32	Black	Maize	II FN (O)	Bread	R	46.00	31.6	14.54	Leaf rust
		Jangatihal	4	16.27.34	74.64.67	Red	Maize	II FN(N)	Bread	R	33.28	31.32	10.42	Leaf rust
		Sankeshwar	5.5	16.25.67	74.68.92	Black	Maize	II FN(N)	Bread	I	48.32	32.77	15.83	Leaf rust
	Parasgad	Idakol	2.5	15.74.54	75.14.07	Black	Groundnut	II FN(N)	Dicoccum	I	48.32	19.43	9.39	-
		Munuvalli	4	15.83.45	75.18.34	Black	Maize	II FN(N)	Bread	I	53.32	38.87	20.73	-
		Shirasangi	2	15.78.65	75.19.32	Black	Maize	II FN(N)	Dicoccum	R	34.78	21.21	7.38	Leaf rust
	Ramadurga	Godachi	5	16.01.39	75.10.48	Black	Maize	II FN(N)	Bread	I	88.00	45.32	39.88	Leaf rust
		Katkol	5	15.40.64	75.05.62	Black	Maize	II FN(N)	Bread	I	42.11	27.34	11.51	Spot blotch
		Ujjinakoppa	4.5	15.40.66	75.05.52	Black	Sorghum	II FN(N)	Bread	I	36.32	22.1	8.03	Leaf rust
	Raibagh	Harugeri	2.5	16.54.95	74.76.74	Black	Maize	II FN(N)	Bread	I	57.44	32.36	18.59	Leaf rust
		Jalalpur	3	16.52.45	74.72.45	Black	Maize	II FN(O)	Dicoccum	I	34.57	18.29	6.32	Leaf rust

Contd.............

Belagavi	Saundatti	Haranakoppa	4	15.53.49	74.55.02	Black	Maize	II FN (O)	Bread	I	60.76	21.42	13.01	Leaf rust
		Jeevapur	3.5	15.55.35	75.03.46	Red	Maize	II FN(N)	Durum	I	44.00	39.22	17.26	Leaf rust
		Murgod	4	15.54.39	74.55.23	Black	Soybean	II FN(N)	Durum	I	36.33	27.47	9.98	Spot blotch
		Ranapur	3	15.57.58	75.01.65	Black	Groundnut	II FN(N)	Bread	I	41.23	28.34	11.68	Spot blotch
		Yaragatti	5.5	16.11.30	74.49.82	Black	Maize	I FN(D)	Bread	R/I	62.32	45.00	28.04	Leaf rust
Dharwad	Dharwad	Kamalapur	1.5	15.50.24	74.48.21	Black	Soybean	II FN(N)	Bread	I	28.54	23.67	6.76	-
		Lakmapur	2	15.31.99	75.00.77	Black	Groundnut	II FN(N)	Bread/Durum	I	36.22	25.50	9.24	Leaf rust
		Lokur	3.5	15.27.69	75.09.13	Black	Maize	II FN(N)	Bread	I	33.38	30.22	10.09	Leaf rust
		Mangalagatti	1.5	15.54.32	74.96.40	Black	Soybean	II FN(N)	Durum	R	0.00	0.00	0.00	Leaf rust
		Narendra	2	15.51.05	74.97.64	Black	Maize	II FN(N)	Bread	R	35.00	23.22	8.13	Leaf rust
		Tadakod	2	15.50.24	74.82.15	Black	Groundnut	II FN(N)	Durum	I	25.00	14.67	3.67	Leaf rust
		Uppinbetageri	0.5	15.35.66	75.00.34	Red	Sorghum	II FN(N)	Bread	R	0.00	0.00	0.00	Spot blotch
		Yadawad	2	15.33.41	74.89.36	Red	Maize	I FN(D)	Bread	R	43.23	28.34	12.25	Spot blotch
	Navalgund	Amargol	5	15.39.95	75.08.98	Black	Soybean	II FN(N)	Durum	R	32.33	20.11	6.50	Leaf rust
		Belavatgi	1	15.59.65	75.34.84	Black	Maize	II FN(N)	Bread	R	56.78	37.48	21.28	Leaf rust
		Hallikeri	1.5	15.35.07	74.91.69	Black	Soybean	II FN(N)	Bread	R	0.00	0.00	0.00	Spot blotch
		Kannur	2.5	15.50.06	75.29.00	Black	Soybean	II FN(O)	Durum	R	21.00	14.47	3.04	Spot blotch
		Tirlapur	3	15.54.69	75.24.72	Black	Chickpea	II FN(N)	Bread	I	21.00	10.00	2.10	Leaf rust
		Yamanur	3	15.32.75	75.16.34	Black	Groundnut	II FN(N)	Bread	R	15.32	13.55	2.08	Leaf rust

DI: Disease incidence; DS: Disease severity; R: Rainfed ; I: Irrigated; I FN: First fortnight; II FN: Second fortnight; III FN: Third fortnight; O: October ; N: November; D: December



a) Partial bleaching of the spike b) Complete bleaching of the spike

c) Fungal colonization of the spike d) Shrunken and shrivelled grains (Tombstone symptom)

Symptoms of Fusarium head blight of wheat

cultivation.According to Dill-Macky and Jones (2000) the wheat-maize rotation increases the reservoir of FHB inoculum in the soil because *Fusarium poae* overwinters in partially degraded cereal residues which may be contributing to the survival of the pathogen in these regions. Also, the disease index was recorded to be much higher in the irrigated conditions than the rainfed fields.

It is also evidenced from the survey results that the highest FHB index was recorded in the crop sown in first fortnight of October and second fortnight of November compared to the crop sown in the first fortnight of November, which had relatively lower FHB index.This could be attributed to the sowing dates coinciding with favourable weather conditions such as maximum temperature of 28 to 33^0C and relative humidity ranging from 70 to 80 per cent coinciding with the anthesis stage, which is known to result in the highest FHB disease index. These studies are in agreement with Ezzat *et al.* (2012), who proved that late sowing of wheat resulted in development and transmission of the inoculum of *Fusarium poae*.

Isolation and maintenance of the pathogen

The isolates of *Fusarium poae* were randomly selected from different geographical locations of northern parts of Karnataka and used for studying the variability among the isolates. The pure cultures of all the ten isolates were maintained by repeated subculturing. A similar method of collection, isolation and maintenance of the pathogen in the medium was also conducted earlier by Sekar *et al.* (2018) and Alisaac *et al.* (2020)

Identification

The fungus produced white to yellowish pink, dense mycelia and hyaline septate hyphae. Macroconidia were sickle-shaped, dorsoventrally curved with an elongated basal cell ending in a prominent long foot; the apical cell was also elongated, tapered, slightly curved. The chlamydospores, if present, were thick-walled, spherical, rough, yellowish-brown, in mycelial hyphae, which occurred singly, in pairs, or were produced in clumps or chains.Similar observations were also reported by Mueller *et al.* (2018). The molecular studies with species specific EF1 primer set revealed that all the ten isolates showed similarity to *Fusarium poae*. This is the first report of *Fusarium poae* causing head blight of wheat in India.

Proving the pathogenicity

The characteristic head blight symptoms were observed in the inoculated wheat spikes. While, no symptoms were observed in the uninoculated control pots. The plants initially showed bleaching in single spikelet after seven days of inoculation, which eventually spread to the entire spike. After about 14 days of inoculation, the spikes showed blighted appearance with pinkish or orangish mass of mycelia grown on the affected region. The pathogen was further re-isolated from the respective infected plants, examined under the microscope and confirmed the similar morphological features as that of the originally inoculated pathogen.The result is also in accordance with Kumar (2021) who observed pink to orange spore mass after 14 days of inoculation.

Conclusion

The present study provides an overview on the incidence and severity of the Fusarium head blight in Bagalkote, Belagavi and Dharwad districts. The locations with higher FHB index among the surveyed districts depict better adaptability of the pathogen due to the conducive environmental conditions and as a result, these locations can be considered as the major hotspots of the disease. Understanding the dynamics of pathogen distribution in these major wheat growing districts provides insight into the epidemiology and evolutionary potential of *Fusarium poae* that has resulted in better management tactics under the current climate change scenario.

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