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Article

Fungal leaf diseases in wheat in some forest-steppe zones of Mongolia

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Abstract
Wheat is an important cereal crop in Mongolia and faces production challenges due to the lack of appropriate agronomic practices, weather uncertainties, weeds, insects, and disease outbreaks. Wheat leaf diseases are one of the biotic stresses that decreases production and grain quality. Leaf diseases were randomly assessed in 114 wheat fields, in the Bulgan and Orkhon provinces, from 2019 to 2023 in order to figure out the prevalence, incidence, and severity of wheat leaf diseases. The environmental and climatic conditions of the two regions were obtained, and the relevant data were almost identical. Wheat leaf diseases were identified, which included septoria leaf spot (*Phaeosphaeria nodorum*), leaf rust (*Puccinia recondita*) and spot blotch (*Bipolaris sorokiniana*). In Bulgan and Orkhon, during the assessment years, the mean incidence and severity of septoria leaf blotch was 58.1-81.7% and 9.7-12.8%. For leaf rust, the mean incidence and severity were 58.3–72.2% and 7.3–10.4%, and the mean incidence and severity of spot blotch were 0-5.5% and 0-6.5% respectively. Due to these biological factors such as leaf spot and leaf rust, it is suggested that designing appropriate technologies to alleviate disease problems is important. Using varieties resistant to leaf diseases and proper field management can reduce the risk of leaf diseases.

Key words: disease prevalence, incidence, severity

Introduction

In Mongolia, wheat is the most common agricultural crop. Wheat is strategic and has economic significance, serving as a daily food product for the population. Spring wheat occupies a leading place in crop production, with crop areas accounting for up to 60% (about 350 thousand hectares). However, in Mongolia, wheat diseases have not been studied sufficiently and the phytosanitary situation has recently worsened in crops. This is due to violations of the cultivation technology for this crop, and changes in hydrothermal conditions during the growing season, as well as susceptibility to diseases. Therefore, studies on the assessment of the phytosanitary condition of spring wheat are relevant and are of scientific and practical interest. To date, the issues of species composition of wheat pathogens remain poorly understood. Solving these problems will help identify possible ways to limit their spread in wheat crops. Pathogens play a detrimental role in decreasing global crop productivity. Losses caused by pathogens can be direct or indirect and have variations in their consequences. Pathogens collaborating with pests and weeds are responsible for 20-40% of total agricultural productivity losses [1]. Leaf, stripe, and stem rust, Septoria tritici blotch and Fusarium head blight, as such as major fungal pathogens of wheat have the probabilistic impact on wheat production. Almost 90% of the wheat area is at risk for at least one of these diseases, resulting in annual losses of more than 62 million tons [2]. The severity of leaf diseases is caused by late sowing of spring wheat, minimal soil cultivation and stubble sowing [3]. Therefore, research on this topic is economically justified. The aim of this study was to identify the species composition of fungal leaf disease pathogens, assess the prevalence, incidence, and severity of these diseases in spring wheat in provinces of the forest-steppe zone of Mongolia.

Materials and Metods

Study locations were selected in two provinces of the central agricultural region of Mongolia, where the natural vegetation is tall grass prairie. The Bulgan and Orkhon province grow season precipitation is 220-470 mm. The study included five soums (Orkhon, Khutag-Undur, Teshig, Selenge and Kgangal) of the Bulgan province and one soum (Jargalant) of the Orkhon province (Fig.1). The environmental and climatic conditions of the two regions were obtained, and the relevant data were almost identical. During the years of survey, climatic conditions were warmer and wetter in these provinces. The number of fields assessed in any year depended on the number of fields the producer planted to wheat. This varied annually from year to year, and Table 1 provides information on the number of fields sampled. From 2019 to 2023, leaves from three to five wheat fields per soum were collected on one occasion. On most occasions, all fields were sampled within a 2- to 3-day period. Sample leaf tissues, on average, were collected when plants were at milk-soft dough development ripe growth stage (GS) 73- 81 (Table 1). Infected leaf tissue (flag or flag-1) from 100-720 plants, depending on the area of the fields, was collected randomly. They represented the corners of a diamond-shaped transect with sides of 20 m, starting approximately 30 m from the field edge. Leaf tissue was dried and stored in paper envelopes at room temperature. The prevalence of the disease was assessed by noting the presence or absence of foliar spots in each field. Ten plants were selected to assess the disease incidence and severity. Percentage of prevalence and incidence was calculated according to the following formulae:

$$Field\ Prevalence\ \% = \frac{Number\ of\ infected\ fields}{Total\ fields\ infected} x100$$

The incidence of leaf diseases in a given field was calculated using the following formula based on 100–720 plants, depending on the field area:

$$Disease\ insidence\ \% = \frac{Number\ of\ infected\ plants}{Total\ number\ of\ plant\ assessed} x100$$

The average incidence percentage during the wheat growing period, at the soum and province's levels, was calculated using the following formula:

$$Average\ insidence\ \% = \frac{Sum\ of\ the\ multiplications\ of\ \ the\ area\ of\ each\ field\ by\ the\ \ corresponding\ disease\ incidence\ of\ that\ field}{Total\ area\ of\ fields}$$

Leaf rust severity was recorded according to Peterson et al., 1948. and septoria leaf spot severity assessed by James' key. Disease severity for bipolaris spot blotch was assessed on a 0-5 visual rating scale, where 0= no symptom, 1=1-5% few spots on < 50% of leaves, 2 = 5-20% spots on < 50% of leaves, 3= 5-20% spots on > 50% of leaves 4= 20-50% spots on < 50% leaves and 5= > 50% on > 50% leaves [4].

In the laboratory, to determine the species composition of fungi causing the disease, two pieces of leaf tissue with lesions (approximately 1 cm^2) from each of five leaves from different plants, were surface-sterilized in 1% Sodium hypochlorite solution for 30 seconds and rinsed in sterile distilled water for 1 minute. Surface-sterilized leaf tissue was placed in moist chambers consisting of glass petri dishes with dry filter paper on the lower surface and moistened filter paper in the lid. The leaf pieces were incubated at 20°C for 5–7 days before examination for sporulation. Pathogens were identified based on conidial morphology, using dissecting and compound microscopes [5,6].

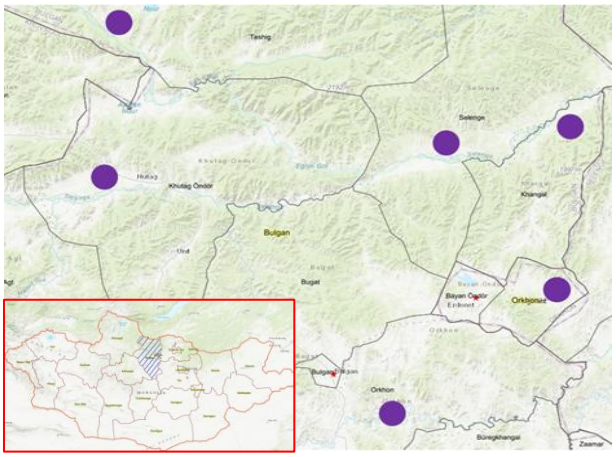

Figure 1. Location of fields, where studies were conducted, Bulgan and Orkhon, 2019-2023.

Results and discussion

The studies of the prevalence, incidence, and severity of fungal leaf diseases of the wheat growing period was conducted in 2019-2023 in wheat fields in 6 soums of the Bulgan and Orkhon provinces. These provinces belong to the central agricultural zone of Mongolia. Over the years of studies, 3 fungal leaf pathogens were found on wheat, causing diseases, including septoria leaf blotch (*Phaeosphaeria nodorum* (E.Müll.) Hedjar), leaf rust (*Puccinia recondita* Roberge ex Desm) and spot blotch (*Bipolaris sorokiniana* Shoemaker). During the study years, leaf septoria and leaf rust were found in all wheat fields in Bulgan and Orkhon aimag soums, indicating 100% prevalence. However, spot blotch was not found in Orkhon Bulgan aimag soums during the study years and was found in 1-3 wheat fields in other 5 soums of both provinces, indicating a prevalence of 20.5-66.7% (Table 1, Fig 2).

Table 1.

Prevalence of wheat diseases in the fields of Bulgan and Orkhon provinces, %

Soums	Pathogens	Prevalence of wheat diseases (number/percentage of affected fields), by year				
		2019	2020	2021	2022	2023
		Bulgan				
Orkhon	*Phaeosphaeria nodorum*	4/100	3/100	3/100	3/100	NT
	Puccinia recondita	4/100	3/100	3/100	3/100	NT
	Bipolaris sorokiniana	N/D	N/D	N/D	N/D	NT
Khutag - Undur	*Phaeosphaeria nodorum*	3/100	5/100	4/100	4/100	4/100
	Puccinia recondita	3/100	5/100	4/100	4/100	4/100
	Bipolaris sorokiniana	2/66,7	3/60,0	2/50,0	2/50,0	1/25,0
Teshig	*Phaeosphaeria nodorum*	4/100	4/100	4/100	4/100	4/100
	Puccinia recondita	4/100	4/100	4/100	4/100	4/100
	Bipolaris sorokiniana	1/25,0	N/D	N/D	1/25,0	N/D
Selenge	*Phaeosphaeria nodorum*	3/100	5/100	4/100	4/100	4/100
	Puccinia recondita	3/100	5/100	4/100	4/100	4/100
	Bipolaris sorokiniana	N/D	2/40.0	1/25.0	N/D	N/D
Khangal	*Phaeosphaeria nodorum*	3/100	5/100	4/100	4/100	4/100
	Puccinia recondita	3/100	5/100	4/100	4/100	4/100
	Bipolaris sorokiniana	N/D	N/D	1/20,5	N/D	N/D
		Orkhon				
Jargalant	*Phaeosphaeria nodorum*	4/100	4/100	4/100	5/100	4/100
	Puccinia recondita	4/100	4/100	4/100	5/100	4/100
	Bipolaris sorokiniana	N/D	1/25,0	1/25,0	N/D	N/D

N/D-non detected, (NT)-not studied

Figure 2. Symptoms of diseases on the leaves of the wheat:
A.Septoria nodorum blotch (*P.nodorum*), B.Leaf rust (*P.recondita*), C.Spot blotch (*B.sorokiniana*)

The highest septoria blotch incidence (81.7%) was recorded in Jargalant fields in 2021, while the lowest incidence (51.9%) was recorded in Teshig fields in 2019. The highest septoria nodorum blotch severity (13.8%) was seen on wheat planted fields in Khutag-Undur in 2020 and the lowest severity (6.4%) was recorded in Teshig fields in 2019. The highest disease incidence (76.5%) and severity (14.0%) of leaf brown rust was recorded in the Selenge (2022 and 2019). The lowest leaf brown rust incidence (43.7%) and severity (5.2%) was seen in the Khutag-Undur wheat fields. The highest spot blotch incidence (5.3%) and severity (3.6%) was recorded on Khutag-Undur fields in 2020, and in some years, this disease was not detected in some areas (Table 2).

Table 2.

Incidence and severity of wheat leaf diseases in Bulgan and Orkhon, 2019-2023

	Soum	Septoria leaf blotch *Phaeosphaeria nodorum*		Leaf brown rust *Puccinia recondita*		Spot blotch *Bipolaris sorokiniana*	
		I,%	**S**,%	**I**,%	**S**,%	**I**,%	**S**,%
		2019					
		Bulgan					
1	Orkhon	56.1	10.1	67.9	9.5	0.0	0.0
2	Khutag-Undur	54.6	9.1	46.5	5.2	2.5	2.5
3	Teshig	51.9	6.4	51.2	6.9	1.3	1.3
4	Selenge	63.9	10.9	69.7	14.0	0.0	0.0
5	Khangal	65.2	11.0	61.9	11.4	0.0	0.0
Average by province		58.1	9.4	58.3	9.0	0.8	0.8
		Orkhon					
1	Jargalant	71.1	11.6	66.7	10.1	0.0	0.0
Average by province		71.1	11.6	66.7	10.1	0.0	0.0
		2020					
		Bulgan					
1	Orkhon	77.3	11.0	65.6	11.3	0.0	0.0
2	Khutag-Undur	62.6	13.8	50.3	7.9	5.3	3.6
3	Teshig	59.5	10.8	71.8	10.3	0.0	0.0
4	Selenge	67.4	11.3	75.1	10.5	3.0	3.0
5	Khangal	63.2	10.2	61.3	8.1	0.0	0.0
Average by province		64.4	12.4	59.9	9.0	3.5	2.6

			Orkhon				
1	Jargalant	74.1	11.3	69.7	10.4	1.7	1.7
	Average by province	74.1	11.3	69.7	10.4	1.7	1.7
			2021				
			Bulgan				
1	Orkhon	65.7	11.6	59.4	11.6	0.0	0.0
2	Khutag-Undur	68.1	12.7	58.6	8.9	2.2	2.2
3	Teshig	65.4	11.3	71.8	12.2	0.0	0.0
4	Selenge	72.2	13.4	76.4	11.7	1.0	1.0
5	Khangal	73.2	10.2	71.9	11.2	2.6	2.6
	Average by province	68.9	12.2	66.3	10.4	1.5	1.5
			Orkhon				
1	Jargalant	81.7	12.7	72.2	9.7	5.5	6.5
	Average by province	81.7	12.7	72.2	9.7	5.5	6.5
			2022				
			Bulgan				
1	Orkhon	63.3	9.8	47.1	7.1	0.0	0.0
2	Khutag-Undur	63.7	10.6	55.0	8.0	0.4	0.4
3	Teshig	62.4	10.3	62.1	8.2	2.0	1.4
4	Selenge	70.3	11.3	77.2	10.4	0.0	0.0
5	Khangal	69.7	10.1	67.2	8.8	0.0	0.0
	Average by province	65.3	10.5	60.1	8.4	0.5	0.4
			Orkhon				
1	Jargalant	74.1	11.0	70.5	9.4	0.0	0.0
	Average by province	74.1	11.0	70.5	9.4	0.0	0.0
			2023				
			Bulgan				
1	Orkhon	NT	NT	NT	NT	NT	NT
2	Khutag-Undur	58.5	10.0	43.7	8.7	2.1	1.2
3	Teshig	60.1	8.5	69.4	10.6	0.0	0.0
4	Selenge	67.9	12.5	55.8	8.2	0.0	0.0
5	Khangal	66.2	9.76	66.8	8.9	0.0	0.0
	Average by province	61.9	10.3	54.5	9.0	0.9	0.5
			Orkhon				
1	Jargalant	73.6	10.8	63.9	7.3	0.0	0.0
	Average by province	73.6	10.8	63.9	7.3	0.0	0.0

Note: I-incidence; S-severity

The highest infestation of septoria leaf blotch (68.9%) and leaf rust (66.3%), on wheat in Bulgan, was scored in the year 2021 cropping season. In Orkhon province, these indicators were also the highest (81.7% and 72.2%) in 2021(Fig 3 and 4).

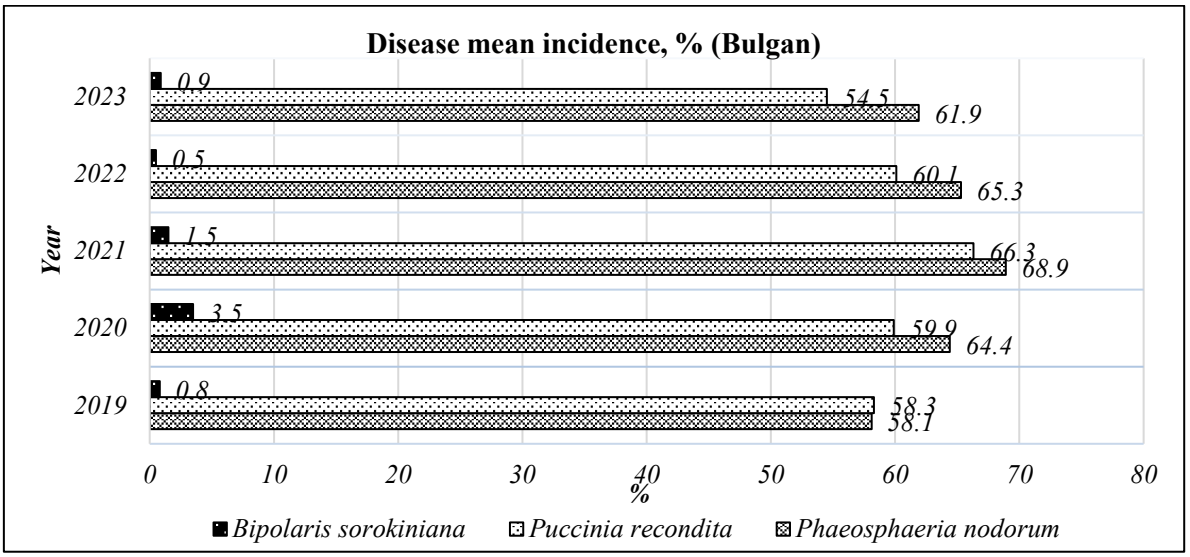

Figure 3. Disease mean incidence in 2019-2013 in Bulgan, Mongolia

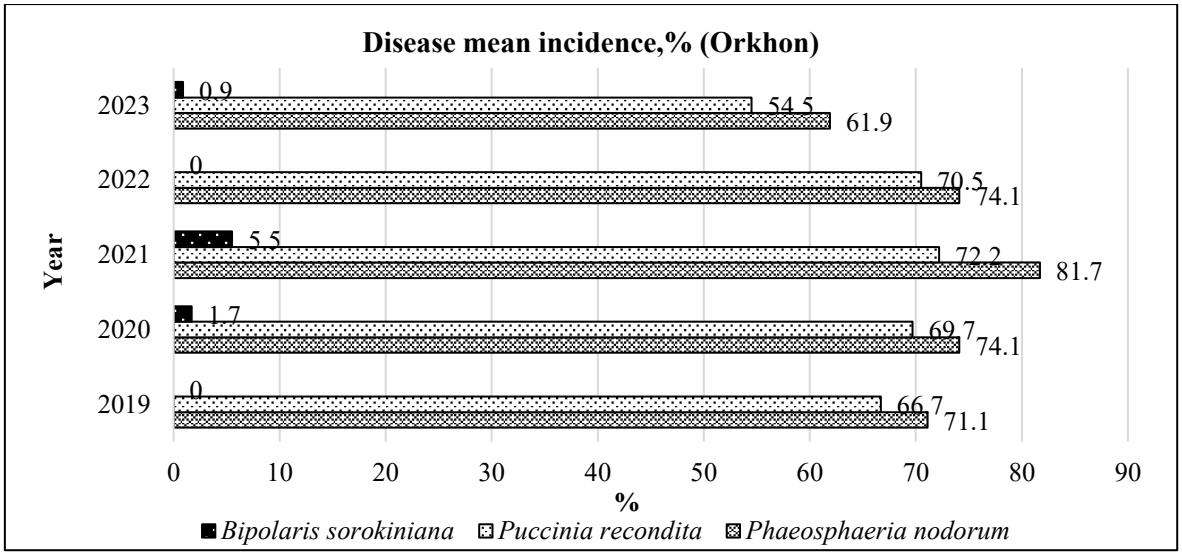

Figure 4. Disease mean incidence in 2019-2023 in Orkhon, Mongolia

Conclusion

The study indicated wheat septoria leaf blotch and leaf rust were the most prevalent and destructive diseases in the cropping season. In major wheat growing areas, such as Bulgan and Orkhon provinces. The mean disease incidence and severity of septoria leaf blotch in the area were 58.1-81.7% and 9.7-12.8%, respectively. And for leaf rust, the mean incidence and severity were 58.3–72.2% and 7.3–10.4%, respectively. Due to these biological factors such as leaf spot and leaf rust, it is suggested that designing appropriate technologies to alleviate disease problems is important. Using varieties resistant to leaf diseases and proper field management can reduce the risk of leaf diseases. Therefore, breeding for resistance to leaf rust and leaf spot should be given high priority.

Conflict of Interests

The authors declare no conflict of interests.

Contribution

D.T. designed the concept of this study. Ts.D. and D.T. equally conducted laboratory work. Ts.D.analyzed data and validated. Writing including original draft preparation, review, and editing was performed by Ts.D. All authors read and approved the final manuscript

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