Spread, damage and control measures of powdery mildew disease of grain crops

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Abstract. This article presents the outcomes of comprehensive experiments carried out within the environments of Samarkand and Kashkadarya regions. These investigations were conducted at scientific experimental stations dedicated to grain and leguminous crops, as well as on farms cultivating corn. The primary focus of this research revolves around the study of the propagation and progression of powdery mildew diseases affecting both barley and wheat plants. Additionally, the article highlights the evaluation of chemical agents' efficacy in combating these diseases. The research outcomes, culled from these trials, constitute a significant portion of the article's content. These findings provide valuable insights into the nuanced dynamics of powdery mildew diseases in the context of the local regions. Furthermore, the assessment of chemical interventions and their effectiveness in mitigating these diseases is a crucial aspect of the research. By examining the data generated from these experiments, the article contributes to the understanding of disease dynamics and potential mitigation strategies within these specific agricultural settings. This research could potentially lead to improved disease management practices, which are pivotal in safeguarding crop yields and ensuring food security within the regions under scrutiny.

Keywords. Barley, wheat, disease, powdery mildew, fungus, disease spread, disease development, fungicide, biological efficiency.

1 Introduction

Barley (*N. sativum*) and common wheat (*T. aestivum*, *T. vulgare*), a group of grain crops, belong to the cereal family, have been cultivated for centuries in world agriculture, like other agricultural crops. The main grain producing countries are Russia, Kazakhstan, China, USA, India, and Canada [1]. Since the beginning of the 1990s, in order to ensure the grain independence of the republic in Uzbekistan, the areas under cultivation have been expanded (1.2 million ha). In Uzbekistan, the total cultivated area (thousand ha) is 3785.1, of which 1789.0 are grain crops (1618.6, including wheat 1507.2). These plants contain macro and micro elements that are very important for the human body [2-4].

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Protection of plants from harmful organisms during the growth period is one of the important measures in providing the population with quality food products. In recent years, due to the changing climatic conditions of the republic, it is observed that wheat diseases damage wheat during the growing season from year to year. It is noted that wheat powdery mildew causes a lot of damage, especially during the period of tillering, jointing, boot, flowering and grain fill of wheat [5-7].

The causative agent of wheat powdery mildew is Blumeria graminis DC.Speer's synonym (Erysiphe graminis DC.) family Erysiphaceae, order Erysiphales, Leotiomycetes class, phylum Ascomycota, kingdom Fungi, domain Eukaryota [8]. Blumeria graminis is a biologically diverse obligate parasite, highly specialized in parasitism on specific host species (special forms) and exists in numerous physiological races adapted to different cultivars of a particular host species. A special form is identified based on the ability of a given single-spore culture of Blumeria graminis to infect a specific plant species [9].

Eight specific forms of Blumeria graminis have been reported. Publication based on the host's specialty. These forms of the pathogen attack wildgrasses of the genera Dactylis, Agropyron, Poa, and Bromus, Triticum, Hor-deum, Secale, and Avena [10]. It can be assumed based on this classification that B. graminis f. sp. tritici mainly infects wheat, B. graminis f. sp. hordei infects barley, B. graminis f. sp. avenae infects oats, B. graminis f. sp. Secalis infects rye, and B. graminis f. sp. triticale infects triticale [11].

The B. graminis life cycle has two stages – ascosporal and conidial. In the ascosporal stage the fungus produces dark brown or black ascocarps (perithecia or cleistothecia or chasmothecia) 135 to 224 μm in diameter. Chasmothecia are covered with filamentous appendages and contain 8–25 asci 70–100 × 25–40 μm in size. Ascospores formed in asci in late summer or early autumn are ovoid, single-celled and 20–23 × 10–13 μm in size. After rainfall, ripe ascocarps break open and release ascospores that infect grass, volunteer cereal plants and germinating winter crops [12]. A white scurf on the infected plant is formed by mycelium, conidiophores and conidia. The pathogen overwinters as mycelium on winter cereals, volunteer plants and wild grasses and can survive until the next growing season [13].

In the spring, the growing mycelium produces conidiophores and conidia that spread infection to new plants. Conidia are colourless, ellipsoid, 24–35 × 12–17 μm in size and arranged in chains on conidiophores formed by hyphae growing on the surface of leaves. The dense mycelium of greyish colour is gradually formed [10].

Sporing is favoured by dry and warm weather [5]. B. graminis is an ectoparasite. The fungus assimilates nutrients necessary for its growth and development using haustoria penetrating epithelial cells of the host plant. Plants are infected in a wide temperature range of 5 to 30 °C and air humidity of 50–100%, but the optimal conditions are 12–20 °C and high humidity. Powdery mildew produces conidia as often as every 7 to 10 days [4].

In regions where chasmothecium are an important source of infection (e.g. southern Europe, USA), asci are released from the perithecium under favourable weather conditions and give rise to primary infections. Experimental studies have demonstrated that fungal spores can be dispersed by wind for several hundred kilometres, initiating many successive cycles of secondary infections during the growing season [10].

The first symptoms of powdery mildew of cereals and grasses develop on winter cereals in late autumn or early spring. The most severe symptoms of powdery mildew are observed on the lower leaves. Infection spreads gradually from the lower leaves to higher parts of the stem. Initially, small, fluffy white-grey pustules develop on the surface of leaves or under neath leaves [14].

Over time, the disease progresses, and under favourable weather conditions, white fluffy pustules cover increasingly larger area of leaves, sheaths, stems and ears. The scurf on infected parts of plants is white, later turning grey and farinose. Severely infected leaves become chlorotic and gradually die back. In a darkening scurf, small dark brown or black

chasmothecia can be seen. The first symptoms of powdery mildew on ears occur on the inner side of the spikelets. Later, the scurf can cover the whole ear. Kernels in infected ears are poorly developed, small, and sometimes malformed [5]

Powdery mildew of wheat can cause up to 45% yield loss if initial infection occurs early and environmental conditions remain favorable for disease emergence and development during the growing season [13]. Popkova and Alexopoulos found that Blumeria graminis causes powdery mildew on the cereal crops and using haustoria (soother) for feeding. The fungi feed by sending haustoria, or root-like structures, into the epidermal (top) cells of the plant. Different formes of haustoria and dignostic sign is used to identify species of fungi [1].

Each of the many species of powdery mildew infects only one type of host plant. Of these, the monocotyledonous species Blumeria graminis is highly host specialized, and there are various specialized forms of this species. Wheat B.graminis f.sp.tritici, barley B.graminis f.sp. hordei damage.

N.G.Zaprometov, P.N.Golovin, N.I.Gaponenko in their scientific works on the study of the types of fungi that cause powdery mildew in the conditions of Uzbekistan, gave a detailed description of the fungi that cause powdery mildew [6, 7, 11].

2 Materials and methods

In addition to the detection of disease-causing fungi, our research also included the determination of their rate of damage, so we constantly calculated the degree of plant infection by pathogens.

We calculated the rate of spread of the disease according to the following formula:

$$R=P*100/N$$

where: R-Disease spread rate in %, N-Total number of plants in samples, pcs., and P-Number of diseased plants in samples, pcs.

When monitoring the spread of powdery mildew diseases in the central and southern regions of Uzbekistan in 3 regions, the widest distribution was observed in the Kashkadarya region (Table 1).

Table 1. Spread of powdery mildew diseases of grain crops in the central and southern regions of Uzbekistan.

Provinces	**District names**	**Prevalence of disease, in %**
Jizzakh	Sharof Rashidov, Pakhtakor, Gallaorol	16
Samarkand	Payariq, Ishtikhan, Akdaryo	20
Kashkadarya	Kasbi, Yakkabog, Kitab, Shakhrisabz	25

We calculated the biological effectiveness of fungicides against diseases using the following formula:

$$C = \frac{P_{k-P_0}}{P_k} * 100$$

where: C-biological efficiency, in %, Pk- disease development index in the control and Po disease development index in the experimental field (for 15, 30 or 45 days, in points).

Experiments on the use of fungicides against powdery mildew of barley were carried out in the 14 ha barley field belonging to "Kokhna Kesh Favvorasi" LLC, Kashkadarya province, Shakhrisabz district. Barley variety Amir Temur. 4 ha of the total barley area was treated with fungicides Top Krof 40% (**c.s.c**), 4 ha Titul Duo 40% (**c.s.c**), 4 ha Top-Az 10% (em.k), and 2 ha was left as a control.

During our research, Top Krof 40% (cake), Titul Duo 40% (cake) and Top-Az 10% (em.k) fungicides were tested against barley powdery mildew (Table 2).

Table 2. Damage of barley by powdery mildew (Production experience, May 9 2023, Kashkadarya province, Shakhrisabz district, "Kukhna Kesh Favvorasi" LLC).

Variants of experiment, rate of consumption of fungicides	Average damage (in points) after how many days			
	until processing	15	30	45
Top Krof 40% (c.s.c) 0.2 l/ha	4.3	1.0	2.5	4.6
Title Duo 40% (c.s.c) 0.25 l/ha	3.7	1.8	3.1	4.8
Top-Az 10% (em.k) 0.15 l/ha	3.5	2.3	3.6	5.1
Control, unprocessed	3.3	9.5	12.0	13.0
EKF $_{05}$	2.4	1.3	0.9	1.1

As can be seen from Table 2, 4.3% of powdery mildew found on barley leaves was dramatically reduced by Top Krof fungicide on days 15, 30 and 45. Other drugs tested showed similar results.

When calculating the biological efficiency (Table 3), 15 days after treatment, Titul Duo at 0.2 kg/ha showed 72.1%, Top-Az at 0.15 l/ha -70.4%. Top Krof 40% (cake) had a biological efficiency of 88.9%. From the obtained results, we can see that although all three preparations have high efficiency, Top Krof fungicide is more effective.

Table 3. Biological effectiveness of drugs belonging to the group of fungicides when used against barley powdery mildew (Production experience, 16.05.2023, Kashkadarya province, Sharisabz district, "Kokhna Kesh Favvorasi" LLC).

Variants of experiment, rate of consumption of fungicides	Biological effectiveness after how many days		
	15	30	45
Top Krof 40% (c.s.c) 0.2 l/ha	88.9	84.1	75.3
Title Duo 40% (c.s.c) 0.25 l/ha	72.1	68.0	65.1
Top-Az 10% (em.k) 0.25 l/ha	70.4	67.9	62.1
Control, unprocessed	-	-	-
EKF $_{05}$	1.6	1.8	2.4

3 Results and discussion

The central and southern regions of the Republic of Uzbekistan have a high incidence of disease, the spread and development of disease-causing agents, and the level of disease in their different soil and climate conditions. We conducted targeted monitoring in Jizzakh, Samarkand and Kashkadarya regions in order to determine the development, spread and damage of powdery mildew disease in wheat and barley fields, to prepare a herbarium from infected plants, as well as to develop scientifically based measures to combat powdery

mildew disease. According to agricultural experts, wheat powdery mildew disease is dangerous and economically important after rust and scab. Among the above diseases, the appearance and spread of wheat powdery mildew is regularly observed and controlled, but in the following years cases of wheat powdery mildew damage during vegetation are regularly observed. Geographical location of our country, abundant precipitation in spring and high relative humidity of the air cause the development and spread of powdery mildew in grain fields.

The first symptoms of the disease begin with the formation of a white cotton-like powdery layer on the leaves of plants. Then the layer thickens and becomes gray or yellowish-gray, bulging pads. The disease spreads from leaves to stem leaves and spikes. Conidia of the disease-causing fungus appear on the pads (Figure 1).

Figure 1. (A and B) Wheat and barley leaves affected by powdery mildew and (C) Conidia of the fungus Blumeria graminis f.sp.hordei causing powdery mildew in barley.

Conidia are single-celled, colorless, cylindrical, and are carried by the wind to other plants. The disease spreads and develops very quickly when the air temperature is 15-20 ^{0}C and the relative humidity is 96-99%.

In unfavorable conditions, the wintering phase of the fungus, i.e. fruit bodies, appears in infected plants. Asci, and ascospores ripen inside them and damage the sprouted autumn grain crops. The fungus overwinters on spiky plants and wild grasses (Figure 2).

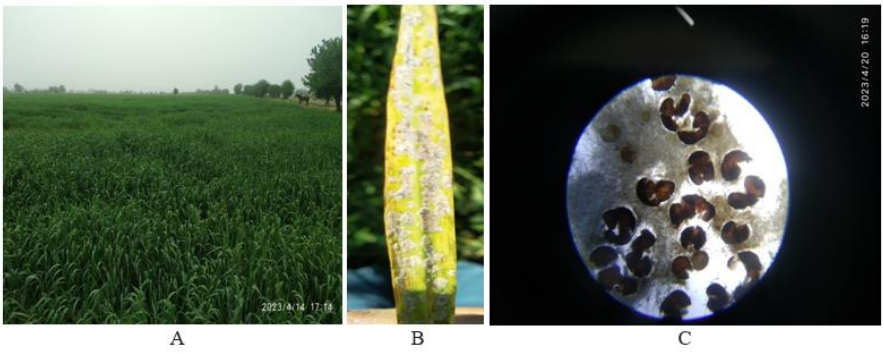

Figure 2. (A) Barley field affected by powdery mildew; (B) Fruiting body of the powdery mildew fungus; and, (C) Cracked state of the fruiting body of the fungus that causes powdery mildew.

According to phytopathological observations, among the above varieties, Ahmed, Navbahor, Durdona and many other varieties are affected by powdery mildew, but the most severe damage is Kesh 2016, Vekha. Recorded in Yaksart. Homer varieties. A high level of damage was noted in all 3 returns of the experimental area where this variety was planted.

Table 4 shows that when Top Krof 40% (cake) was used against wheat powdery mildew, leaf infection decreased from 20.1% to 2.5-3.5-4.2%.

Table 4. Effect of fungicides on the development of powdery mildew of wheat (small field experiment, May 8 2023, Samarkand province, Ishtikhon district, "Samarkand Branch of the Scientific Experimental Station of Cereals and Leguminous Crops").

Variants of experiment, rate of consumption of fungicides	Average damage (in points) after how many days			
	Until processing	15	30	45
Top Krof 40% (c.s.c) 0.2 l/ha	20.1	2.5	3.5	4.2
Title Duo 40% (c.s.c) 0.25 l/ha	17.6	3.5	7.6	11.6
Top-Az 10% (em.k) 0.15 l/ha	15.2	4.6	8.4	12.8
Control, unprocessed	17.1	20.3	31.2	36.3
EKF $_{05}$	-	1.1	2.4	2.1

All the above three drugs are highly effective, but it can be seen from Table 5 that Top Krof fungicide has a higher biological efficiency.

Table 5. Biological effectiveness of fungicides against powdery mildew of wheat (small field experiment, May 8 2023, Samarkand province, Ishtikhon district, "Samarkand Branch of the Scientific Experimental Station of Cereals and Leguminous Crops").

Variants of experiment, rate of consumption of fungicides	Biological effectiveness after how many days, %		
	15	30	45
Top Krof 40% (c.s.c) 0.2 l/ha	88.3	80.3	78.5
Title Duo 40% (c.s.c) 0.25 l/ha	78.6	74.9	68.0
Top-Az 10% (em.k) 0.25 l/ha	73.8	67.4	60.8
Control, unprocessed	-	-	-

The results show that after 15 days, Titul Duo has the highest efficiency with 78.6%, Top Az with 73.8%, and Top Krof fungicide with 88.3%.

In total, 52 varieties of wheat are planted on a total of 1 ha of land belonging to the "Samarkand Branch of the Scientific Experimental Station of Cereals and Leguminous Crops", Ishtikhon District, Samarkand Region, and they are as follows: Krasnadar 99, O‘zbekiston 25, Drujba, Mars-1, Davr, Asr, Velena, Yog‘du, Zimnitsa, Yuk, Grom, Aziz, Navbahor, Veha, Gurt, Taniya, Alekseich, Antonina, Chillaki, Zvezda, Andijon-2, Bezostaya-100, Andijon-4, Bobur, G‘ozg‘on, Kesh 2016, Shams, Turkiston, Yaksart, Durdona, Makuz 3, Istiqlol, Mingchinor, Yoqut 2014, Langar, Hisorak, Javohir, Hamkor, Temiryazovka 150, Vaniya, Asl chilgisi, Ahmad, Agat-donskaya, Yangi taraqqiyot, Kristella, Grand, Kovalerka, Gomer, Soberbosh, Yelanchiq, Oqdaryo fermer, Shukrona. Each variety was planted in 3 replicates in experimental plots of 0.3 ha (Table 6).

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Table 6. Planting pattern of grain crops and prevalence of powdery mildew disease in different varieties.

8.Yog‘du +	7. Velena +	6. Asr +	5. Davr +	4. Mars-1 +	3.Drujba +	2.O‘zbekiston 25 +	1. Krasnadar +
23.Andijon-4 +	22.Bezostaya-100 ++	21.Andijon -2 +	20.Zvezda +	19.Chillaki +	18.Antonina +	17.Alekseich +	16.Taniya +
38.Hamkor qattiq +	37.Javohir qattiq +	36.Hisorak qattiq +	35.langar qattiq -	34.Yoqut - 2014 qattiq -	33.Mingchinor qattiq -	32.Istiqlol qattiq -	31.Makuz-3 qattiq -
1. Krasnadar +	52.Shukrona +	51.Oqdaryo fermer ++	50.Elanchik +	49.Soberbosh +	48.Gomer ++	47.Kovalerka +	46.Grand +
16.Taniya +	15.Gurt +	14.Veha ++	13.Navbahor +	12.Aziz +	11.Grom -	10.Yuka -	9.Zimnitsa -
31.Makuz-3 qattiq -	30.Durdona +	29.Yaksart ++	28.Turkiston +	27.Shams +	26.Kesh-2016 +++	25.G‘ozg‘on -	24. Bobur -
46.Grand +	45.Kiristella qattiq +	44.Yangi taraqqiyot qattiq +	43.Agat-donskaya qattiq +	42.Ahmad +	41.Asl chilgisi +	40.Vaniya +	39.Temiryazovka-150 +
9.Zimnitsa -	8.Yog‘du -	7. Velena +	6. Asr +	5. Davr +	4. Mars-1 +	3.Drujba +	2.O‘zbekiston 25 +
24. Bobur -	23.Andijon-4 +	22.Bezostaya-100 ++	21.Andijon-2 +	20.Zvezda +	19.Chillaki +	18.Antonina +	17.Alekseich +
39.Temiryazovka-150 +	38.Hamkor qattiq +	37.Javohir qattiq +	36.Hisorak qattiq +	35.langar qattiq -	34.Yoqut-2014 qattiq -	33.Mingchinor qattiq -	32.Istiqlol qattiq -
2.Jasmina	1.Starshina	52.Shukrona +	51.Oqdaryo fermer ++	50.Elanchik +	49.Soberbosh +	48.Gomer ++	47.Kovalerka +

2 Jasmina	15.Gurt +	14.Veha + +	13.Navbahor +	12.Aziz +	11.Grom -	10.Yuka -	9.Zimnitsa -
3.Brigada	30.Durdona +	29.Yaksart ++	28.Turkiston +	27.Shams +	26.Kesh-2016 +++	25.G‘ozg‘on -	24. Bobur -
4.Farboma	45.Kiristella qattiq +	44.Yangi taraqqiyot qattiq +	43.Agat-donskaya qattiq +	42.Ahmad +	41.Asl chilgisi +	40.Vaniya +	39.Temiryazovka-150 +
Vaxshskaya javdar	8.Yog‘du +	7. Velena +	6. Asr +	5. Davr +	4. Mars-1 +	3.Drujba +	2.O‘zbekiston 25 +
Rossiya javdar	23.Andijon-4 +	22.Bezostaya-100 ++	21.Andijon-2 +	20.Zvezda +	19.Chillaki +	18.Antonina +	17.Alekseich +
Shalola Javdar	38.Hamkor qattiq +	37.Javohir qattiq +	36.Hisorak qattiq +	35.langar qattiq -	34.Yoqut-2014 qattiq -	33.Mingchinor qattiq -	32.Istiqlol qattiq -
Vaxshskaya javdar	1. Krasnadar	52.Shukrona +	51.Oqdaryo fermer ++	50.Elanchik +	49.Soberbosh +	48.Gomer ++	47.Kovalerka +
Rossiya javdar	16.Taniya +	15.Gurt +	14.Veha ++	13.Navbahor +	12.Aziz +	11.Grom -	10.Yuka -
Shalola Javdar	31.Makuz-3 - qattiq	30.Durdona +	29.Yaksart ++	28.Turkiston +	27.Shams +	26.Kesh-2016 +++	25.G‘ozg‘on -
Oqdaryo *fermer*	46.Grand +	45.Kiristella qattiq +	44.Yangi taraqqiyot qattiq +	43.Agat-donskaya qattiq +	42.Ahmad +	41.Asl chilgisi +	40.Vaniya +
2Markuz-3	*1.Soberbosh*	4.Starshina	3. Brigada	2. Pervesta-Kroshka	1.Starshina	4.Farboma	3. Brigada

Note: + light damage, ++ medium damage, +++ strong damage, - no damage

4 Conclusions

The fungicide Top Krof has exhibited noteworthy efficacy against the powdery mildew disease affecting both barley and wheat plants. With a biological efficiency rating of 88.9% for barley and 88.3% for wheat, this fungicidal treatment proves to be a reliable and potent solution for managing powdery mildew. These impressive effectiveness rates underscore the safe and reliable applicability of Top Krof in combating this fungal ailment.

By achieving such high levels of disease control, Top Krof emerges as a valuable tool for agricultural practitioners seeking effective and secure measures to address the challenges posed by powdery mildew in both barley and wheat cultivation. This research-driven solution promises to contribute significantly to the health and productivity of these crops, supporting sustainable agricultural practices and safeguarding crop yields.

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