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Phytoexamination of spring wheat seeds as a factor of optimization of sowing process in the conditions of the Pavlodar region

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Abstract. Wheat seeds provide a favorable environment for pathogenic microflora, which leads to a decrease in seed viability and the release of various mycotoxins that seriously affect plant growth and development. The initial growth of spring wheat seeds and the phytopathogenic load were studied as indicators of phytosanitary status and sowing quality. The phytosanitary state of spring wheat seeds in the conditions of the Pavlodar region was determined. A total of 22 varieties of spring wheat were analyzed. The sowing characteristics of spring wheat seeds of different varieties were determined and varietal differences affecting the sowing qualities of seeds were revealed. Phytosanitary results of seeds of grain varieties are presented to determine the composition and level of contamination of seeds. The results of the study revealed a high level of infection of spring wheat seeds with root rot pathogens: *Bipolaris sorokiniana,* such fungi as *Alternaria spp., Fusarium spp.* and the pathogens of spring wheat bacteriosis prevailed on the studied samples. The role of hydrothermal conditions in the invasion of seeds by plant pathogens was determined.

Keywords: phytoexamination, spring wheat, germination, sowing qualities, pathogen

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Introduction

Increasing the productivity of crops and cultivating high-yield varieties resistant to stress situations and pests is a primary issue in agricultural production [1]. Seeds containing all the genetic information necessary for growth and development during the growing season are key to a successful harvest of any agricultural crop. Possible unexplained losses during the growing period require the necessary knowledge to understand the processes of initial plant growth. Annual significant crop losses, in which pathogens are the main source of infection, are inherent to any seed's infectious load. Wheat seeds provide a favorable environment for pathogenic microflora, which, when developing, decreases seed viability and their nutritional value for seedlings. Additionally, many microorganisms are noted for producing various mycotoxins that significantly affect plant growth and development [2-5]. The study aims to establish the phytosanitary condition and sowing qualities of seed material of spring wheat based on indicators of initial growth and phytopathogenic load of seeds.

Methodology

The research was conducted at the Biological Research Laboratory of Toraighyrov University in 2022. The object of research was seeds of 22 varieties of spring wheat harvested in 2021. Among the varieties are seeds of the Omsk selection (Omskaya 18, Omskaya 35, Omskaya 36, Omskaya 37, Omskaya 38), Boevchanka, Memory of Asiev, Likomero, Trizo, Grani, Konditerskaya, Favorite, Saratovskaya 74, Stepnaya Volna, Pobeda, Severyanka, Alabuga, Irene, Kuryer, Voyevoda, Novosibirskaya and Uralosibirskaya. Seed analysis was conducted according to State standard 12044-93: macroscopic and biological methods and the roll method [6, 7]. Mycological and phytopathological analyses of spring wheat grain were performed using the methodologies of Pidoplichko and Bilay [8, 9].

Results and Discussion

The period of filling and ripening of spring wheat occurred in August 2021. The humid conditions of 2021, with 45 mm of precipitation and an average temperature of 19.8°C, gave the spring wheat that matured in August a slight advantage, allowing it to expand its ecological niche. These results confirm data previously obtained in the Pavlodar region. It was established that the dependence of Alternaria spp. on hydrothermal conditions during the ripening and maturation of spring wheat was higher than that of B. sorokiniana. In addition to the embryonic plasma, seeds were infected with Fusarium and Penicillium.

The optimal soil moisture for the crops is 70-75% of the minimum moisture content. Spring wheat requires easily accessible nutrients in the soil due to its short vegetative period and the low nutrient absorption capacity of its root system. Wheat is suppressed by high soil acidity. The optimal reaction is slightly acidic or neutral (pH 6.0-7.5). Shortly after germination, soft wheat roots spread widely and penetrate deeply into the soil compared to durum wheat. The type of

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soil affects root penetration depth. The root mass at maturity in sod-podzolic soil at a depth of 20 cm constitutes 68% of the total root mass, while in dark-clay soil it is 52%. In conditions of moisture deficit, root growth at shallower depths is halted.

Spring wheat is characterized by uneven and shaggy buds, which can be explained by increased soil acidity in northern regions and seed invasion by Fusarium spp fungi. Seeds of spring wheat germinate at temperatures of +1... +2°C; viable sprouts germinate at +4... +5°C for germination. However, at these temperatures, germination and emergence of seedlings occur very slowly. If the soil temperature at the depth where the seeds are placed is 5°C, the shoots will appear on the 20th day, on the 13th day at 8°C, on the 9th day at 10°C, and on the 7th day at 15°C. Sprouts can withstand short-term frosts up to -10°C. Spring wheat is most resistant to negative temperatures in the early stages of development. For example, it can withstand frosts from -6 to -13°C during seed germination and from -8 to -9°C during the vegetative period. During flowering and ripening, it can be damaged by frosts from -1 to -2°C.

At temperatures of 10-12°C, it tolerates wilting well. Low soil temperatures at this time contribute to the formation and development of nodal roots and increase yield. The optimal temperatures for grain formation during ear emergence and ripening are 16-23°C. Negative temperatures during ripening can damage the grain. Frozen grain has low technical quality and seed viability. Spring wheat is sensitive to high temperatures, 38...40°C, and paralysis from heat stress occurs within 10-17 hours. The negative impact of high temperatures is exacerbated by dry winds during hot seasons.

Varieties of spring wheat adapted to northeastern Kazakhstan are most resistant to high temperatures. Among early spring grain crops, wheat is the most resistant to high temperatures when well-watered. Water consumption at various stages of development is distributed as follows: during seedling emergence - 5-7% of total water consumption for the entire growing season; during tillering - 15-20%; during tube formation and ear emergence - 50-60%; during milking stage - 20-30%; during wax ripeness - 3-5%. From germination to milk ripeness, it accounts for 70-80%.

If the spring water reserve in a meter layer is less than 100 mm, a water deficit arises; if it is less than 60 mm, yield decreases sharply. Critical periods for water absorption are the tillering and ear emergence stages. A lack of moisture in the soil during this period leads to an increase in the number of barren spikelets, which is often observed in northeastern Kazakhstan. Subsequent precipitation (including heavy rain) cannot compensate for the lack of moisture at this time. Under such conditions, wheat quickly transitions from one stage to another, and yield decreases rapidly. In northern Kazakhstan, later sowing dates provide optimal conditions for growth and development.

Research results conducted under laboratory conditions show that among low-stature varieties, Omskaya 38 and Trizo have the shortest coleoptile lengths of 4.2 cm and 4.1 cm respectively. Other varieties can be classified as medium coleoptile based on Y.S. Larionov's grading [10]. In terms of sprout length, those exceeding 11 cm include Memory of Aziev, Likomero, Omskaya 35, Boevchanka, and Uralosibirskaya, as presented in Table 1.

Table 1

Sowing qualities of spring wheat seeds of the harvest 2021

Variety	Length, cm			Germination, %
	root	coleoptile	sprout	
Memory of Asiev	12.2	5.8	13.4	97
Likomero	10.8	4.8	11.9	96
Omskaya 18	10.5	6	12.2	77
Omskaya 35	14	5.3	17.1	96
Omskaya 36	11.4	5.2	18	95
Omskaya 37	13.2	5.5	14.7	91
Omskaya 38	11	4.2	5.7	97
Boevchanka	12	5.3	16.9	90
Trizo	6.3	4.1	8.2	91
Grani	13.4	4.7	7.4	98
Uralosibirskaya	12.3	5	18.7	87
Konditerskaya	8.5	6.5	11.9	93
Favorite	9.5	6	14.3	89
Saratovskaya 74	7.7	4.6	11.6	65
Stepnaya Volna	12.6	5.6	13.3	88
Pobeda	7.5	5	9.5	90
Severyanka	9.5	5.2	11.1	80
Alabuga	10.7	6	14.1	84
Irene	13.6	6.1	15.2	90
Kuryer	13.5	6.5	15.3	79
Voyevoda	12.3	6	12.8	86
Novosibirskaya	12.9	5.3	15.8	96
Average	11.3	5.8	13.5	84

All studied varieties samples had germination rates above 80%, except for the varieties Omskaya 18 (77%) and Kuryer (79%). The maximum possible germination rates of 97-98% were shown by the varieties Memory of Aziev, Omskaya 38, and Grani. Table 2 presents data on the ratio of healthy to infected seeds, the prevalence of root rot, and its pathogens in spring wheat seeds.

Table 2

Results of phytoexamination of spring wheat seeds of the harvest 2021, %

Variety	Healthy seeds	Seeds infected with pathogens:	Including				bacteriosis
			B. sorokiniana	*Alternaria spp.*	*Fusarium spp.*	*Penicillium spp.*	
Memory of Asiev	59	41	4	38	2	3	2
Likomero	64	36	5	12	7	5	3
Omskaya 18	60	40	4	37	2	6	41
Omskaya 35	38	62	3	7	12	7	4
Omskaya 36	28	72	0	4	0	8	16
Omskaya 37	42	58	4	21	28	2	34
Omskaya 38	49	51	10	44	13	0	4
Boevchanka	76	24	17	52	2	2	28
Trizo	62	38	12	31	3	1	14
Grani	37	63	0	37	20	4	22
Uralosibirskaya	27	73	2	46	9	0	10
Konditerskaya	31	69	0	44	7	0	30
Favorite	36	64	6	45	4	3	18
Saratovskaya 74	51	49	1	61	2	2	10
Stepnaya Volna	39	61	5	39	18	9	39
Pobeda	30	70	6	55	7	3	29
Severyanka	68	32	2	49	7	3	26
Alabuga	76	24	5	39	2	2	35
Irene	67	33	3	45	5	1	41
Kuryer	69	31	9	39	5	6	33
Voyevoda	24	76	4	25	49	2	48
Novosibirskaya	60	40	1	19	17	1	6
Average	51.5	48.5	3.9	44.9	15.6	2.0	34.1

The pathogens causing seed mold were mainly represented by *Penicillium spp.*

The composition and level of seed infection on spring wheat varieties are shown in Figure 1.

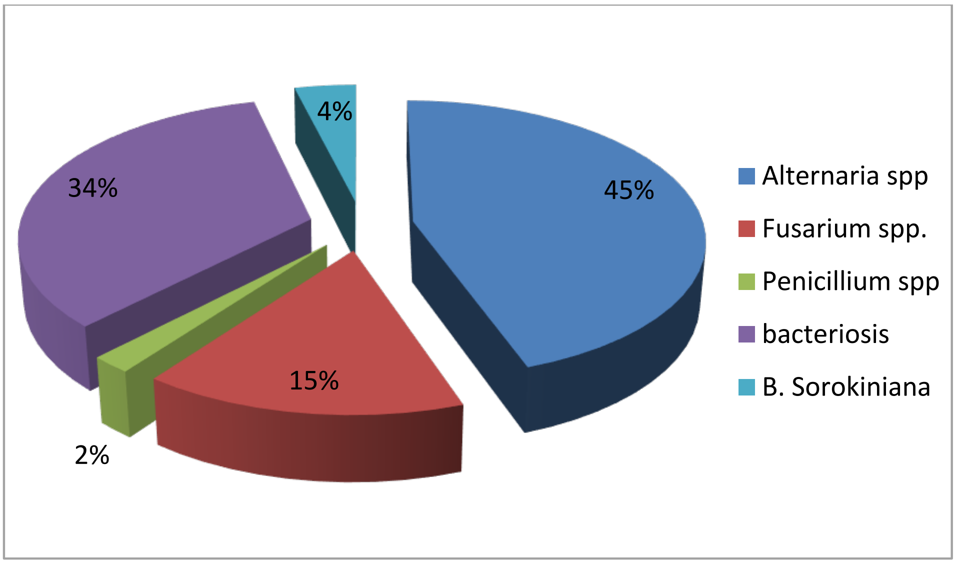

Figure 1. Composition and level of seed infection on spring wheat varieties in 2021, %

Moreover, it has been noted that even when seeds are heavily colonized by fungi causing root rot, they do not necessarily exhibit disease symptoms at the germination stage. Therefore, not all varieties with the highest degree of fungal invasion showed signs of root rot, except for Uralosibirskaya and Voyevoda varieties, which had the highest percentage of infected seeds and consequently more seedlings with signs of root rot.

Phytosanitary examination of seeds is an integral part of modern production technology and has the potential to protect crop yields and grain quality, as it can predict the likelihood of plant disease. Only accurate disease diagnostics, knowledge of their causes, and specifics of development form the basis for successful preventive and protective measures [2, 6]. Quality seed treatment with fungicides should begin with mandatory phytosanitary examination.

According to numerous studies, the main causative agent of root rot is Fusarium spp [11-13]. Infection of ears by fungi of the genus *Fusarium spp.* leads to a decrease in grain quantity, seed germination, and partial seedling death. *Fusarium spp.* infection can result in yield losses of up to 50%. Yield losses can exceed 10%, and seed germination may decrease by 40%. Fungi produce mycotoxins that are hazardous to humans and livestock.

Fungi of the genus *Alternaria spp.* colonize seeds during plant development in the field before harvest. Seeds affected by alternariosis have low germination energy and germination rates. The harmfulness directly depends on the climatic conditions under which the grain ripened and the conditions of its storage. *Alternaria spp.* has the ability to produce toxins that are dangerous not only to plants but also to humans and animals.

In addition to phytopathogenic fungi, saprotrophic mold fungi (species of the genus *Penicillium spp.)* can cause significant damage to seed material. In field conditions, these fungi develop in years with high humidity during grain ripening and harvesting. Seeds affected by saprotrophic fungi can become reinfected during storage [4].

Bacterial diseases cause decay at the root stem, hollow stem, and in the germination zone of seeds. The most dangerous of the aforementioned diseases is invasion in the seed germination zone. Sometimes up to 50% of spring wheat seeds have blackened embryos, leading to a 35% reduction in seed germination and a decrease in plant density, severe root rot, and a sharp decline in yield. Overall, complexes of seed infections reduce yield by 30-70% and germination by 35%.

As shown by the conducted phytosanitary examination, no seeds free from pathogenic microflora were found among the studied spring wheat varieties. The minimum infection load among all studied varieties was noted for Boevchanka and Alabuga varieties, with 76% healthy seeds. On average across all varieties, 51.5% of infected seeds were identified (ranging from 24% to 76%).

The most affected samples were Omskaya 38, Omskaya 35, Grani, Omskaya 36, Uralosibirskaya, and Voyevoda (with 51% to 73% infected seeds).

It should be noted that the most harmful root rot pathogens, such as *Bipolaris sorokiniana,* were not found as actively in the seeds from the 2021 harvest; the highest infection rate was observed for Boevchanka variety at 17% infection. The majority of pathogenic microflora in the seeds consisted of fungi from the genera *Alternaria spp.*, bacterial pathogens, and *Fusarium spp.*

If seeds that are heavily infected with plant pathogens are used for sowing, prolonged outbreaks of fusariosis and premature appearance of *Alternaria spp* may occur. Crop losses can reach 50%, while the quality of fiber and seeds decreases. In confirmed phytosanitary conditions, it is undesirable to use seeds infected with a higher number of plant pathogens than indicated; however, in cases of extreme necessity, forced thermal treatment (heating) and pre-sowing seed treatment should be carried out. To enhance plant resistance, it is also recommended to treat seeds with a complex of microelements and growth regulators, as well as to adhere to effective sowing conditions for spring wheat seeds.

Since antagonistic microorganisms are the most important natural factors suppressing parasitic activity and survival of root rot fungi, the toxicity threshold of root rot fungi varies by zones and soil types and depends on soil suppression.

Seed treatment should not be viewed as the sole method for improving seed quality; it should be used in conjunction with other technical measures that enhance plant resistance and chemical effectiveness. Heating, calibration, and exposure to pulsed low-frequency electric fields are very effective for improving sowing qualities of seeds and phytosanitary parameters. Grain crop seeds are heated at 20°C for 5 days in a stirred storage facility or in an open area. Seeds can be ripened in a dryer for 1.5-2 hours (maximum 5-8 hours) at a carrier temperature of 45-50°C and in a humid heap at 25-30°C for 15-20 hours. Calibration increases field germination by 10-12%, especially for grain harvested in cold, wet weather in autumn and seeds with physiologically immature embryonic plasma. Calibration removes small grains (less than 2.5-3 mm in diameter), and its effect on improving germination ranges from 5 to 20% depending on the batch and variety, while the biological effect against root rot and septic fungi is 30% or more.

Seed treatment should be conducted using preparations according to the "List of Pesticides and Agrochemicals," such as Vitavax 200FF (2 l/t), Raxil Ultra (0.2 l/t), Dividend Star (1.0 l/t), Tebu 60, ME (0.4–0.5 kg/t). These preparations are widely used in the Pavlodar region. Good results under favorable conditions are also provided by growth regulators like Biosil.

To enhance the physiological resistance of plants to harmful organisms when there is a deficiency of microelements in the soil, ammonium molybdate and zinc sulphate (2 kg/t), boric acid (1.5 kg/t), copper sulfate (1–2 kg/t), as well as plant growth regulators, are added to the treatments.

Conclusion

Thus, by checking seeds in phytosanitary conditions, it is possible to accurately determine their state, select fungicides with a specific spectrum of action, and carry out treatment in a differentiated manner (that is, with minimal impact on nature and maximum economic benefit for the enterprise). The results of this research can be used in breeding work to select varieties with specific resistance to seed infection and diseases during the growing season. Phytosanitary examination of cereal seeds allowed for the identification of the main phytopathogens transmitted through spring wheat seeds: *Bipolaris sorokiniana,* fungi of the genera *Alternaria spp.,* and *Fusarium spp.*

As a result of the research, a high degree of contamination of seeds with root rot pathogens was identified. The studied samples were dominated by: alternariosis up to 44.9%, bacteriosis up to 34.1%, fusariosis up to 15.6%*, Bipolaris sorokiniana* up to 3.9%, and seed mold *Penicillium spp*. up to 2.0%. An exceedance of the economic threshold value (ETV) for *Alternaria spp.* on wheat was noted at 44.9%. Based on the results of the phytosanitary examination, the most effective seed treatments and growth regulators have been recommended.

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Conflict of interest

There is no conflict of interest between the authors.

Authors' contribution

Ualiyeva R.M.: Contribution to the concept, execution of the claimed scientific research, creation of a scientific article.

Zhaksybek M.A.: interpretation of the claimed scientific research.

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Павлодар облысы жағдайында егіс технологиясын оңтайландыру факторы ретінде жаздық бидай тұқымының фитоэкспертизасы

Аңдатпа. Бидай тұқымдары патогендік микофлора үшін қолайлы орта болып табылады, бұл тұқымның өміршеңдігінің төмендеуіне және өсімдіктердің өсуі мен дамуына елеулі әсер ететін әртүрлі микотоксиндердің бөлінуіне әкеледі. Жаздық бидай тұқымының бастапқы өсу деңгейі және фитопатогендік жүктеме фитосанитарлық жағдай мен егістік сапасының көрсеткіштері ретінде зерттелді. Павлодар облысы жағдайында жаздық бидай тұқымының фитосанитарлық жағдайы анықталды. Барлығы жаздық бидайдың 22 түрі зерттелді. Жаздық бидай сорттарының тұқымдық сипаттамалары және тұқымның себу сапасына әсер ететін сорттық айырмашылықтар анықталды. Тұқымның құрамы мен зақымдану деңгейін анықтау үшін дәнді дақылдар сорттары тұқымдарының фитосанитарлық нәтижелері ұсынылған. Зерттеу нәтижелері жаздық бидай тұқымдарының тамыршірік қоздырғыштарымен зақымдануының жоғары деңгейін анықтады: Bipolaris sorokiniana, Alternaria spp. және Fusarium spp. тұқымдасының саңырауқұлақтары және жаздық бидай бактериозының қоздырғыштары зерттелген үлгілерде басым болды. Гидротермиялық жағдайлардың өсімдік патогендерінің тұқым инвазиясындағы рөлі анықталды.

Түйін сөздер: фитоэкспертиза, жаздық бидай, өнгіштік, себу сапасы, патоген

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Фитоэкспертиза семян яровой пшеницы как фактор оптимизации технологии посева в условиях Павлодарской области

Аннотация. Семена пшеницы являются благоприятной средой для патогенной микофлоры, которая вызывает снижение жизнеспособности семян и выделение различных микотоксинов, серьезно влияющих на рост и развитие растений. Были исследованы начальный рост семян яровой пшеницы и фитопатогенная нагрузка как показатели фитосанитарного состояния и посевных качеств. Установлено фитосанитарное состояние семян яровой пшеницы, в условиях Павлодарской области. В общей сложности было проанализировано 22 сорта яровой пшеницы. Определены посевные характеристики семян сортов яровой пшеницы и выявлены сортовые различия, влияющие на посевные качества семян. Представлены фитосанитарные результаты семян сортов зерновых культур для определения состава и уровня зараженности семян. Результаты исследования выявили высокий уровень зараженности семян яровой пшеницы возбудителями корневых гнилей: Bipolaris sorokiniana, грибами рода Alternaria spp., Fusarium spp. и возбудители бактериозов яровой пшеницы преобладали на исследуемых образцах. Была определена роль гидротермических условий в инвазии семян патогенами растений.

Ключевые слова: фитоэкспертиза, яровая пшеница, всхожесть, посевные качества, патоген

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