AZERBAIJAN REPUBLIC

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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

SELECTION OF RESISTANT GENOTYPES TO POWDERY MILDEW (B*lumeria graminis (DC) Speer f .sp. tritici March*) FROM LOCAL AND INTRODUCED WHEAT EMBRYO PLASMA, THE STUDY OF THE DISEASE EFFECTS ON PRODUCTIVITY AND SOME PHYSIOLOGICAL PARAMETERS

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AZƏRBAYCAN RESPUBLİKASI KƏND TƏSƏRRÜFATI NAZİRLİYİ AZƏRBAYCAN DÖVLƏT AQRAR UNİVERSİTETİ

GENERAL DESCRIPTION OF THE RESEARCH

Relevance and degree of completion of the topic. Diseases and pests are some of the main factors decreasing the productivity of the wheat plant *(Triticum*). Therefore, the elimination of damage to wheat is one of the most pressing issues facing scientists today, and the development and implementation of scientifically based, effective measures to combat diseases are of great importance. Also, using breeding to select resistant varieties, the creation and application of new varieties will strengthen farms economically and there will not be any need for chemical control measures in the field. Taking into account the widespread of fungal diseases in wheat fields of our country, the urgency of studying the development of these diseases and the scale of damage, in 2016-2018, the impact of powdery mildew on productivity and quality indicators of the wheat plant was studied [3]. Powdery mildew disease occurs in early spring in cereal crops in Azerbaijan and has a negative impact on productivity and grain quality [4, 12]. The main feature of this disease is its spread in the upper-tier leaves of the plant, which causes serious damage. Because the upper-tier leaves of the plant play a more important role in the vital activity and especially in the process of photosynthesis [7, 9]. Powdery mildew occurs mainly on the leaves, but the disease also has the ability to infect all the above-ground organs of the plant. "According to S.S. Sanin et al., production losses due to powdery mildew reach 10-15%, sometimes 30-35 %". Some researchers believe that powdery mildew is a harmful disease due to its prevalence and infection rate in autumn wheat fields, depending on soil and climatic conditions. Favorable conditions for the development of the disease result in an epiphytotic outbreak of the disease, its rapid spread to large areas from this point of view, under the leadership of academician J.Aliyev, for the first time, a complex selection program was made to create an experimental and theoretical basis to develop highly-productive varieties with high-quality indicators that meet the demands of agriculture, tolerant to biotic and abiotic factors under various soil and climatic conditions of our country.

Powdery mildew disease is widespread in our country and its distribution area is expanding.

Materials of the research: To study resistance to powdery mildew disease, 220 genotypes, and 56 local varieties from nurseries containing over 2000 embryo plasmas of wheat introduced from International Centers ICARDA and CIMMYT were selected as

research materials. Experiments were carried out in 4 replications, in the experimental field of the Absheron Auxiliary Experimental Farm. Local varieties Nurlu 99, Mirbashir 128, Murov, and a foreign variety Morocco were grown in beds with an area of 1 m^2. The control (I) variants sprayed with fungicides, and the experimental-infected variants (II) were used in the study.

The purpose and tasks of the research. Identification of sources resistant to powdery mildew from local and introduced embryo plasma and creation of new adaptive selection materials with complex economic value and photosynthetic properties:

1. Performing retrospective analysis of epiphytotia of powdery mildew observed in wheat fields in Azerbaijan for the last 30 years;
2. Evaluation of local and introduced embryo plasma of wheat for powdery mildew and selection of resistant genotypes for obtaining initial materials;
3. Determination of the degree of damage, caused by the disease, to productivity and structural elements;
4. Determination of the effect of powdery mildew disease on wheat quality indices and its damaging properties;
5. Study of samples in the nursery collection for identification of resistant and tolerant forms of powdery mildew against the background of provocation;
6. Study of the effect of the powdery mildew disease on physiological parameters of wheat varieties.

Research methods. Evaluation of samples for powdery mildew was performed based on a 9-point scale developed by N. Simlakovich (1966) and based on methodological guidelines proposed by V.I.Krivchenko, et al. (1980).

Phenological observations were performed by the F.M. Cooperman method, the assimilation surface areas of leaves, stems, and spikes were measured by the automatic area meter (AAC-400, Hayashi Denkon Co., LTD, Japan), gas exchange parameters were determined by LI-6400 XT portable photosynthesis system (LI-COR Biosciences, Lincoln, NE, USA), the total chlorophyll content was determined using the SPAD 502 (Spectrum Technologies, Inc., USA) device after keeping the plant in a thermostat at 105^0C until the dry biomass reached a constant weight.

The grain quality analysis was carried out in the "Grain Quality" laboratory of the Research Institute of Crop Husbandry based on generally accepted "Methodological guidelines for assessing the quality of grain." The protein content in the grain was determined by the Kjeldahl micromethod.

Soil pH, total phosphorus, mobile phosphorus, total potassium, and exchangeable potassium were determined by the methods of I.V.Tyurin, K.E.Ginzburg, B.P.Machigin, P.K.Smith, and P.V.Protasov, respectively. Mathematical calculations of the research were performed by using SPSS-26 software package was used to verify the accuracy of the results obtained during the study.

Main points presented to the defense of the dissertation:

- The study of biological properties of powdery mildew disease in Azerbaijan, the spread of the disease and the caused damage;
- Establishing the effect of powdery mildew disease on the physiological parameters, productivity and quality indices of local and introduced wheat plants;
- Evaluation of resistance of local and introduced wheat genotypes against powdery mildew disease on the background of provocation and selection of resistant forms;
- The study of productivity and quality indices of wheat genotypes introduced from International Centers and chosen for resistance against powdery mildew and establishing a correlation between these parameters;
- Use of genotypes, which differ in complex disease resistance, economy, and quality indicators, in the selection program.

Scientific novelty of the research. For the first time in Azerbaijan, over 2,000 wheat genotypes introduced from International Centers (CIMMYT, ICARDA) were studied for resistance to powdery mildew, and 30 selected samples were handed over to “Plant Breeding Department” of the institute for using in the selection process and studying their economic suitability. From 56 specimens, 20 were found to be highly resistant to powdery mildew disease. For the first time, the effect of powdery mildew disease on the quantity and quality indices, physiological parameters has been studied.

Theoretical and practical significance of the research results. During the research, more than 2,000 local and introduced wheat genotypes were evaluated for their resistance to powdery mildew, and 30 samples selected for complex traits were included in the Selection Program of the Research Institute of Crop Husbandry as initial material.

As a result of complex selection researches, phytopathological and physiological assessments carried out at the Institute of Crop Husbandry within the wheat program, the new Baba 75 bread wheat variety, developed jointly with the breeders of the Institute, was regionalized and patented in the State Register of Selection

Achievements of the Republic of Azerbaijan (patent No 00248). The bread wheat varieties Gulustan 100 (2018), Yubiley 90 (2018), Chempion (2020) and Leader (2020) were submitted to The Agency for Agrarian Services for regionalization. Currently, ecological testing of these varieties continues.

The resistance of wheat samples to powdery mildew was assessed in Absheron Auxiliary Experimental Farm and Gobustan Regional Experimental Station of the Research Institute of Crop Husbandry and the scale of the damage caused by the disease, as well as the economic efficiency of productivity was determined, which further enhanced the practical value of the research.

Approbation and application of the work. The results of the research were presented at the Scientific Report Meetings of the Research Institute of Crop Husbandry (2016-2018), at the III International Scientific Conference "Ecology: Problems of Nature and Society" dedicated to the 110th anniversary of Academician Hasan Aliyev (Baku, 2017), in the International Scientific Conference "Actual Problems of Modern Nature and Economic Sciences" (Ganja, 2018) dedicated to the 95th anniversary of National Leader Heydar Aliyev, various seminars organized by the Research Institute of Crop Husbandry, and in the proceedings of the Kurgan State Agriculture Academy Collection of articles based on the materials of the international scientific-practical conference dedicated to the 125th anniversary of T.S Maltsev "Development and application of modern technolgies in order to modernize the complex of agro-industry" were discussed.

Name of the organization where the dissertation was performed. The dissertation work was carried out at the Research Institute of Crop Husbandry of the Center for Agrarian Science and Innovation of the Ministry of Agriculture of the Republic of Azerbaijan.

Total volume of the dissertation in characters with an indication of the separate volumes of the structural units. The dissertation consists of the introduction, 5 chapters, results, recommendations for producers, the reference list, and appendices. The introduction consists of 8 pages (16671 characters), chapter 1– 26 pages (55697 characters), chapter 2- 18 pages (32710 characters), chapter 3 – 23 pages (41772 characters), chapter 4 – 35 pages (60783 characters), chapter 5 - 31 pages (50141 characters), results – 2 pages (3269 characters), recommendatıons for producers - 1 page (831 characters) and the reference list – 23 pages (44573 characters). The dissertation consists of 233 pages of computer

typing, the total volume is 372793characters (234598 tabies, figures, characters, excluding the list of the used literature and appendices). There are 40 tables, 24 figures (and 56 tables in appendices), and 211 references (90 in Azerbaijani, 67 in Russian, and 54 in English) in the dissertation.

CONTENT OF THE WORK

The **Introduction** substantiates the relevance of the topic and presents the general characteristics of the dissertation.

Chapter one provides a review of the literature on the spread of powdery mildew and damage caused by this disease, the problems, and strategies of wheat selection for disease resistance, the level of the study of this disease in wheat in Azerbaijan.

Chapter two presents the soil and climatic conditions of the regions where the research was conducted, research materials, and methods. The research was performed in 2016-2018 in Absheron AEF and Gobustan RES of the Research Institute of Crop Husbandry, which differ in the soil and climatic conditions. The soil type in the experimental field in Absheron is gray-brown, and in Gobustan RES is light chestnut. In Absheron AEF, the pH of the plow layer (0-25 cm) is 8.5-8.6 and has high alkaline properties. Total nitrogen content is 0.079-0.081%, humus-1.27-1.32%, easily hydrolyzed nitrogen per 1kg of soil is 35-38 mg, mobile phosphorus is 12.1-14.5 mg, and exchangeable potassium content is 261-272 mg. In Gobustan RES these parameters are pH 8.3; 0.166%; 2.23%, 56 mg; 35.8 mg; 315 mg, respectively.

During the research years in Absheron, the average annual temperature varied between 15.1-16.0°C, the average temperature in January was 1-5^{0}C, and the average monthly temperature in July was 21-27^{0}C. The maximum temperature was 38-42^{0}C. The average annual precipitation in the peninsula was 346 mm. The average annual relative humidity varied in the range of 72.3-77.0%. In Gobustan, the average multi-annual monthly temperature of the air was 10.7^{0}C, and the average temperature during the research years was 10.3^{0}C, 11.6^{0}C, and 12.3^{0}C respectively; The multi-annual amount of precipitation was 406 mm, and in the research years, respectively, 381.9; 453.0; 360.0 mm. The average multi-annual relative humidity varied between 74% and 72-73% over the years of the research.

Chapter three. The study of resistance of wheat genotypes to powdery mildew disease and selection of resistant genotypes.

Depending on soil and climatic conditions, the causative agent of powdery mildew disease has the ability to spread at different levels [1]. The experiments were carried out in two different regions, in Absheron and Gobustan under irrigated and rainfed conditions, respectively. In the studies conducted in Absheron AEF in 2016, 96 out of 220 samples were disease-resistant and moderately resistant (1-3 points), and 124 samples (5-9 points) were susceptible and moderately susceptible. In 2017, 76 out of 96 samples showed resistance (0-2 points), and 20 samples showed sensitivity to the disease (6-9 points). Of the 76 samples obtained as initial material in 2018, 30 were completely resistant (0-2 points) and 46 (5 points) were moderately susceptible. Of the 56 local varieties, 20 (0-2 points) showed resistance to the disease, and 36 samples showed sensitivity (5-9 points). The main trait of resistant plant varieties developed by selection is their natural protection from diseases and pests. *One of the main conditions is to create new resistant varieties to reduce crop losses from diseases* [11].

In Absheron AEF, structural analyses of 30 wheat genotypes introduced from International Centers and differing in resistance to powdery mildew, and biological and economic characteristics were carried out and the following results were obtained: spike mass was in 6 samples (20.0%), spike width - 14 (46.7%), spike length-5 (16.7%), the number of spikelets -13 (43.3%), the number of grains per spike-14 (46.7%), the mass of 1000 grains-5 (56.7%) and productivity in 5 samples (16.7%) was higher than the standard (Nurlu 99 variety).

Correlation analysis was performed between the structural indicators and productivity of wheat genotypes. A positive correlation was found between the spike mass and spike width, the number of spikelets, the number of grains per spike and mass of the spike, spike width and length, spike length and the number of spikelets, the number of grains per spike, and the mass of grains per spike. However, there was a negative correlation between plant height and grain yield (Table 1).

In Absheron AEF, quality indices of wheat genotypes selected from various international nurseries for their resistance to powdery mildew were established (Table 2). The grain yield of the studied wheat genotypes varied between 430-790 g/m^2 and the grain yield (690-790 g/m^2) of the selected 4 wheat genotypes was higher than that of the standard Nurlu 99 variety (683 g/m^2). In the studied wheat varieties, the mass of 1000 grains varied between 37.0-57.6 g, the highest value compared to the standard was in Kualgan (57.6 g), and

the lowest in Mv05-13 (36.1 g) genotypes. The amount of protein in the grain varied between 11.7-15.4%, the highest value was in Kualgan (15.4%) compared to the standard, and the lowest (11.7%) was in the genotype MV35-13. Protein yield per hectare varied between 653.3-924.3 kg/ha, 6 genotypes differed, and in 12 genotypes this parameter was below the standard.

Table 1. Correlation between various biometric indices of wheat genotypes selected for their resistance to powdery mildew disease

	SM	SW	SL	SN	SGN	SGM	PH	ThGM	GY
SM	1								
SW	0.585**	1							
SL	0.315	0.406*	1						
SN	0.415*	0.276	0.488**	1					
SGN	0.475**	0.467**	0.264	0.126	1				
SGM	0.675**	0.543**	0.209	0.097	0.638*	1			
PH	0.177	0.036	0.151	0.102	0.078	0.045	1		
ThGM	0.094	0.194	0.052	0.168	0.146	0.091	0.146	1	
GY	0.036	0.327	0.039	0.135	0.011	0.046	-0.451**	0.020	1

** significance level of 0.01, * significance level of 0.05

Note: the abbreviations in the table: SM-spike mass, SW-spike width, SL-spike length, SN-number of spikelets, SGN- number of grains per spike, SGM-grain mass per spike, PH-plant height, ThGM-1000 grain mass, GY-grain yield.

The gluten content in the grain varied between 25.6-36.6% and was higher in 8 genotypes (31.6-36.6%) and lower in 10 genotypes (25.6-29.2%) compared with the standard. The Gluten Deformation Coefficient (GDC) varied between 86.3-115.0 units, which was below the standard (84.1 units). Although GDC of these genotypes was lower than that of the standard variety, Chervona // KS82W409 / SPN / 3Trocadero (86.3 units), F06325G1 (89.3 units), Victoria (91.1 units), Kualgan (91.8 units), Lebed (93.4 units) genotypes were classified as Grade II and Grade III by the quality of gluten, following the State Standard, while other specimens were classified as Grade III and Grade IV, respectively. Vitreousness in grains of wheat genotypes varied between 23.0-66.0%, it was higher than the standard in 5 genotypes and lower in 13 genotypes. In the grain of wheat genotypes, the value of sedimentation, which includes the

baking quality and the strength of flour, ranged from18.0 to 39.0 ml. High sedimentation indices were recorded in Fo6476g5-1inc1 (39 ml), Kualgan (33.5 ml), F06325g1 (32 ml), Owl * 2/7 / t.sph /2* (31.5 ml), Mv35-13 (31.5 ml) genotypes.

Table 2. Quality indices of wheat genotypes selected from international nurseries

Genotypes	Productivity g/m^2	1000 grain mass, g	Protein, %	Protein yeild, kg/ha	Vitreousness, %	Gluten %	GDC, units	Sedimentation, ml
Nurlu-99 standard	683	44.4	12.0	819.6	56	29.5	84.1	31.0
OWL*2/7/T.SPH/2*H. 567.71//CMH	650	53.6	12.8	832.0	37	28.8	107.2	31.5
MV05-13	670	36.1	12.8	857.6	41	27.6	100.0	27.0
MV35-13	790	43.1	11.7	924.3	38	28.4	100.3	31.5
F08347G8	470	40.5	13.9	653.3	57	32.8	100.0	24.0
Fo6476G5-1INC1	690	37.0	13.0	897.0	45	30.0	101.0	39.0
MV14-2000//Shark /F4105W2.1	470	40.5	14.1	662.7	66	33.6	100.4	29.5
Chervona//KS82W409 /SPN/3Trocadero	650	44.8	12.4	806.0	38	27.6	86.30	26.0
Kualgan	430	57.6	15.4	662.2	65	36.6	91.80	33.5
Ostrov	620	46.8	12.8	793.6	45	29.2	101.3	30.0
Kalym	580	40.7	13.7	794.6	47	31.9	96.10	25.5
Lebed	690	39.6	12.5	862.5	39	30.8	93.40	18.0
CV.Nemchinovskaya 24	585	46.2	13.5	789.8	55	31.6	102.9	30.0
MV-Pengo	660	43.4	12.1	798.6	23	25.6	102.2	27.0
Karahan-99	510	43.3	13.9	708.9	63	28.0	101.2	28.5
Viktoriya	710	40.8	12.0	852.0	31	27.2	91.10	25.5
KR 11-9823	620	40.2	13.0	806.0	34	28.0	96.50	28.5
Hubara-2/Qafzah-21//dovin-2	600	42.3	13.2	792.0	53	32.8	115.0	24.0
F06325g1	670	41.9	14.9	789.7	63	29.2	89.30	32.0

Thus, 18 out of 30 genotypes of wheat introduced from International Centers were selected for their resistance to powdery mildew disease, and Kualgan, F06325g1, C.V. Nemchinovskaya 24, Ostrov, Fo6476g5-1inc1 genotypes met the requirements of the baking industry. Correlations between the quality and productivity of samples selected from introduced genotypes of wheat for resistance to powdery mildew were established (Table 3).

In the studied bread wheat varieties, a significant negative relationship was observed between grain yield and protein content of the grain, between grain vitreousness, and gluten content, and a significant positive relationship between grain yield per hectare.

Between protein content in the grain and protein yield per hectare – a significant negative relationship, between grain vitreousness and gluten content – a significant positive relationship, between grain yield per hectare and grain vitreousness, and gluten content – a significant negative relationship, and a positive significant correlation was detected between grain vitreousness and gluten content.

Table 3. Correlations between quality and productivity indices of the selected wheat genotypes

	GY	ThGM	GPC	PYH	GV	GL	GDC	GS
GY	1							
ThGM	-0.303	1						
GPC	-0.906**	0.293	1					
PYH	0.951**	-0.323	-0.741**	1				
GV	-0.821**	0.168	0.875**	-0.695**	1			
GL	-0.664**	0.333	0.700**	-0.588*	0.721**	1		
GDC	0.047	0.030	-0.137	0.018	0.031	0.100	1	
GS	-0.066	0.271	0.270	0.065	0.226	0.055	0.057	1

** significance level of 0.01, * significance level of 0.05

Note: the abbreviations in the table: GY-grain yield, ThGM-1000 grain mass, GPC-protein content of the grain, PYH-protein yield per hectare, GV-grain vitreousness, GL-Gluten, GDC-deformation coefficient of gluten, GS-grain sedimentation.

Chapter four. The effect of powdery mildew disease on physiological parameters of wheat in Azerbaijan.

When plants are infected, certain changes occur in morphophysiological signs, the intensity of respiration accelerates, which ultimately leads to a decrease in productivity and quality indices [7, 8]. The development dynamics of powdery mildew disease and its effect on the assimilation surface area were studied in various phenophases of wheat varieties with contrasting sensitivity. For this purpose, the effect of powdery mildew on physiological parameters of 3 local (Nurlu 99, Mirbashir 128 and Murov) and 1 foreign (Morocco) wheat varieties differing in sensitivity was studied in Absheron AEF.

It should be noted that in the 2016-2018 research years, the plants were highly infected with powdery mildew disease at the level

of 7-9 points (50-95%). During the vegetation period, in the earing phase, the assimilation surface area of the main stem of all varieties was in the range of 125.9-134.5 cm^2 in the control variant, while it decreased to 95.47-98.62 cm^2 in the experimental variant. In spike, this indicator varied in the range of 54.77-64.10 cm^2 in the control variant and the range of 39.02-49.42 cm^2 in the experimental variant. Depending on the size of the spikes, these parameters were lower in both variants of Morocco and Murov varieties, and higher in Nurlu 99 and Mirbashir 128 varieties. During the milk ripeness phase of the grain, the assimilation surface area in the stem and spike was higher in tall Murov (140.9 and 64.19 cm^2, respectively) and Mirbashir 128 (143.7 and 70.43 cm^2, respectively) varieties in the control plants and decreased in the infected varieties by 18.6 and 18.4%, 24.0 and 26.4%, respectively During the wax ripeness phase, this parameter decreased in all studied varieties. Therefore, in all varieties, the minimum values of this parameter (9.84-10.42 cm^2) were observed in the wax ripeness phase.

The damage caused to the assimilation surface area of various above-ground organs of the studied varieties by powdery mildew disease was evaluated (Figure 1). The maximum loss of the area was observed in the VII, and the minimum loss in the VIII tier leaves and varied in the range of 19.1-37.3% and 19.6-39.5%, respectively

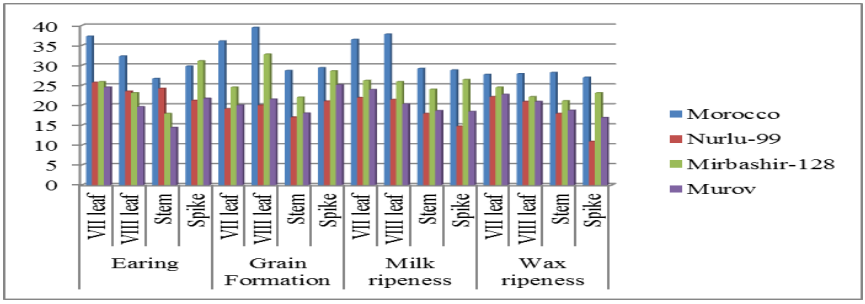

Figure 1. The effect of powdery mildew disease on the assimilation surface area of wheat genotypes during various developmental phases, % (3-year average).

The maximum amount of loss by powdery mildew on assimilation surface area of the leaves has been on VII leave and in 19,1-37,3% və 19,6-39,5% interval. During the vegetation period, the greatest loss was observed in Morocco (37.3 and 39.5%,

respectively), and the smallest loss in Nurlu 99 (10.9 %, respectively). Thus, the most damage was recorded in the Morocco variety (29.2% and 29.8%, respectively) and the least damage in the Nurlu-99 variety (19.4% and 23.9%, respectively).In Murov variety the loss in the 8th leave and stem has been relatively low. Mirbashir 128 variety studied for this parameter was in an intermediate position.

Powdery mildew reduces the productivity of the plant, affecting not only the assimilation surface area of the leaves but also the dynamics of accumulation of dry biomass. Unlike other fungal diseases, powdery mildew infects cereals in early spring, in the tillering phase when the conditions are favorable, and affects the growth of the plant, causing a decrease in dry biomass [6, 13]. Losses of the dry biomass due to powdery mildew varied in the ranges of 17.3-31.1% and 26.2-40.7% during the earing phase and the wax ripeness phase, respectively (Figure 2).

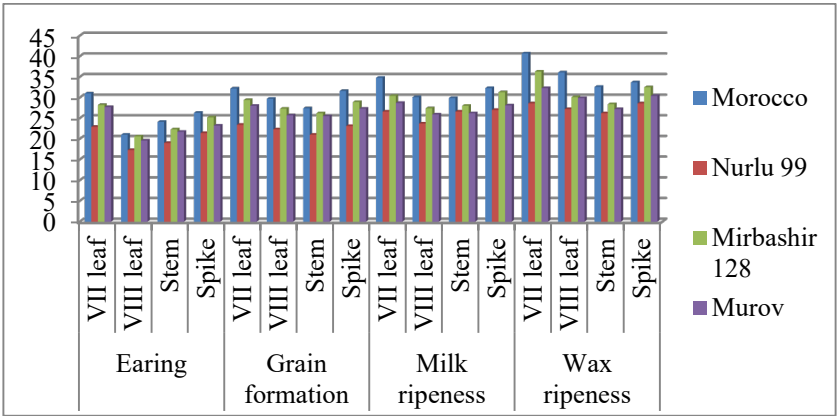

Figure 2. Loss of dry biomass caused by powdery mildew disease in various developmental phases of the wheat varieties, % (3-year average)

The difference between the variants was higher in the wax ripeness phase. In all phases, the biggest difference between the variants was observed in the local varieties Morocco and Mirbashir 128, and the smallest in the Nurlu 99 variety. Spike dry biomass increased from the earing phase to the end of the wax ripeness phase and a sharper increase occurred due to the grain filling dynamics. Similar to the stem, in the spike, the maximum loss, 26.3-33.7%, was observed in the Morocco variety and the minimum loss, 21.4-28.6%

in the Nurlu 99 variety. Mirbashir 128 and Murov varieties tested for this parameter were in an intermediate position.

Thus, the formation of dry biomass in wheat during the vegetation period depends not only on the stage of disease onset but also on the level of infection and the duration of the disease.

Infection of wheat genotypes with powdery mildew leads to disruption of photosynthesis and increased transpiration in leaves, resulting in yellowing of leaves, incomplete grain filling, the formation of small and weak grains [5]. These factors eventually lead to serious crop losses. Therefore, the effect of powdery mildew disease on the gas exchange parameters (photosynthesis rate, stomatal conductance, CO_2 concentration in the intercellular space, transpiration rate) of the VII and VIII tier leaves of wheat was studied (Figure 3).

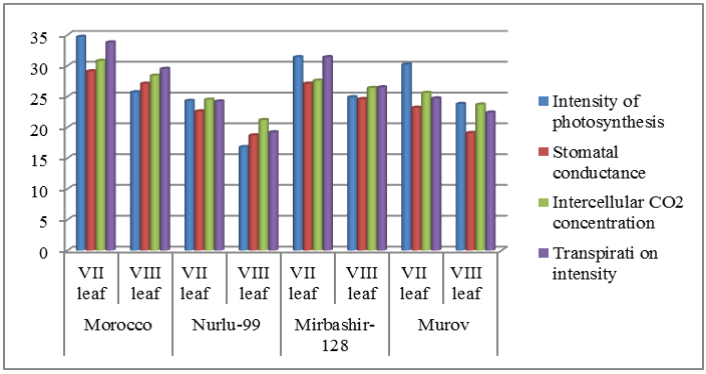

Figure 3. The effect of powdery mildew on gas exchange parameters of the wheat varieties, % (3-year average)

The difference between the variants regarding the photosynthetic gas exchange parameters was greater in the VII tier leaves of the plant than in the VIII tier leaves. This can be explained by the fact that powdery mildew infects the leaves from bottom to top, and as a result, the VII tier leaves are infected relatively quickly. The Morocco variety was more susceptible to powdery mildew than other varieties, so the photosynthetic gas exchange parameters in the leaves were low. In the Nurlu 99 variety, the difference between the variants regarding these parameters was relatively small.

The difference between the variants in Nurlu 99 and Morocco regarding the intensity of photosynthesis, stomatal conductance,

intercellular carbon dioxide concentration, intensity of transpiration in the VII tier leaves was 24.3 and 34.7%, 22.6 and 29.1%, 24.5 and 36.6%, 24.2 and 33.8%, respectively. In the VIII tier leaves, this difference was 16.8 and 25.7%, 18.7 and 27.1%, 21.2 and 28.4%, 19.2 and 29.5%, respectively. Due to the high depression of gas exchange parameters in the leaves of the VII and VIII tiers of the Morocco variety, the difference between the variants was higher, and in the fast-growing Nurlu 99 variety, it was lower than in the other studied varieties. The local Mirbashir 128 and Murov varieties tested for these parameters were in an intermediate position.

By covering leaves, powdery mildew disrupts chlorophyll, thereby affecting photosynthetic parameters, resulting in a decrease in productivity and quality indices [2, 10].

Total chlorophyll content decreased from the earing phase to the end of the wax ripeness phase in the experimental variant, while a relative increase was observed in the control variant.

Due to the existence of the optimal temperature for the pathogen, the loss in all phases of the development was higher in the susceptible Morocco variety (Figure 4).

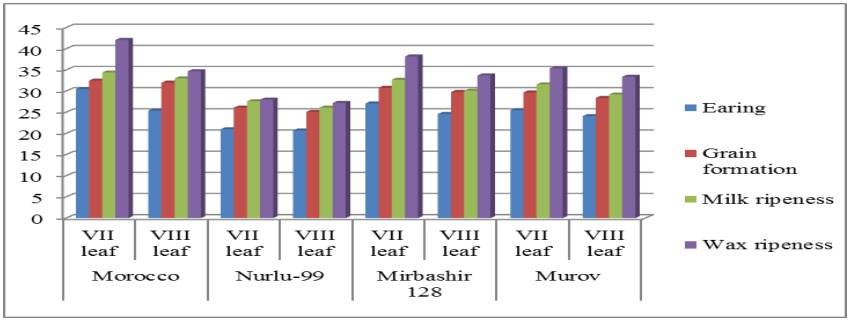

Figure 4. The effect of powdery mildew disease on total chlorophyll content of leaves in various developmental phases of wheat genotypes, % (3-year average)

Thus, the loss was 30.5% in the VII tier leaves during the earing phase and 42.1% in the wax ripeness phase. In the VIII tier leaves the loss during the earing phase was 25.4% and in the wax ripeness phase, it increased and amounted to 34.7%. In the earing phase, these parameters changed in the VII tier leaves of the studied varieties from 21.0% to 30.5%, and in the VIII tier leaves from 20.7% -25.4%,

whereas, in the wax ripeness phase, the change occurred in the ranges of 28.0% - 42.1% and 27.2% - 34.7%. respectively. The loss in the Nurlu 99 variety was relatively less compared with the Morocco variety.

As the leaves of the plants are more infected, powdery mildew causes a sharp decrease in chlorophyll [10].

Thus, in the earing phase, this loss amounted to 21.0% and 20.7% in the VII and VIII tier leaves, respectively. However, the loss in the wax ripeness phase was 28.0% and 27.2%, respectively. During the earing phase, in the VII and VII tier leaves of the local Mirbashir 128 variety, this parameter was 11.2% and 3.15% less compared to that of the Morocco variety. During the wax ripeness phase, it was 9.27% and 2.88% less, respectively. The Murov variety tested for this parameter was in the intermediate position.

Chapter five. The study of the impact of powdery mildew on the productivity, quality indices, and economic efficiency of local and introduced wheat varieties. Losses in productivity are different in varieties due to powdery mildew vary depending on weather conditions, plant development phases, and even the biological characteristics of the variety [12]. Many studies confirmed that the scale of the damage caused by powdery mildew disease during the vegetation period is related to the initial stages of the plant development.

According to the observations, in Absheron, the Morocco variety was infected with powdery mildew disease in the early period of vegetation - during the tillering phase (Table 4).

Table 4. Effect of powdery mildew disease on the roductivity of wheat varieties, % (3-year average)

Varieries	Variants	2016		2017		2018		3-year average loss	
Morocco	I	406	29.3	429	31.5	435	31.9	423	31.0
	II	287		294		296		292	
Nurlu 99	I	677	13.9	682	13.4	690	14.2	683	13,8
	II	583		559		592		578	
Mirbashir 128	I	622	14.4	671	16,2	695	22.3	663	17,9
	II	533		532		540		535	
Murov	I	640	11.6	675	12.7	690	18.6	668	14,4
	II	566		550		562		559	

Note: I-variant sprayed with fungicides (control), II-variant infected (experiment)

The disease effect lasted until the end of the wax ripeness phase and the infection rate was 9 points (95%). The production loss in the Morocco variety was higher (29.3% in 2016, 31.5% in 2017, 31.9% in 2018, and an average annual loss was 31%) compared with the other tested varieties.

Contrary to other varieties, the Nurlu 99 variety was infected later, at the end of the leaf-tube formation phase and due to the low infection rate (7 points-50%), the productivity loss was also slight (over the years, 13.9%, 13.4%, and 14.2%, respectively). Yield loss in the Nurlu 99, Mirbashir 128, and Murov varieties amounted to 50.3%, 20.3%, and 5.5% less, respectively, compared with the standard, and the three-year average loss was 13.8%.

The Mirbashir 128 variety was infected at the end of the tillering phase and the level of infection was 8 points (85%). The loss of productivity over the years was 14.3%. 16.2%. 22.3%, respectively, and a 3-year average loss was 17.9%. In the Murov variety, this parameter was lower than in the varieties Morocco and Mirbashir 128 and higher than in Nurlu 99. The Murov variety was infected with powdery mildew at the beginning of the leaf-tube formation phase at the level of 8 points (70%), the difference between the variants in 2016, 2017, and 2018 was 11.6%, 12.7%, and 18.6%, respectively, and a three-year average loss was 14.4%. Thus, the degree of damage to productivity caused by powdery mildew disease depends on the availability of favorable conditions for the development of the pathogen, the phase and the degree of infection, due to the biological characteristics of the varieties.

Quality parameters are considered as some of the most important and significant indicators of productivity. The amount and quality of gluten play a key role in the production of bread. During the research years, the average difference between the variants in the Morocco variety was 28.1% for grain vitreousness, 19.8% for gluten, 18.4 units for GDC, and 12.1% for sedimentation. In the Nurlu 99 variety, 17.9%, 5.4%, 14.8 units and 6.5%, in the Mirbashir-128 variety, 23.0%, 14.5%, 15 units, and 6.5%, in the Murov variety, 26.6%, 9.3%, 16.5 units and 8%, respectively (Table 5).

The loss in 1000 grain mass caused by powdery mildew disease was 34.0%, 19.6%, 24.9%, and 22.9% in the varieties Morocco, Nurlu 99, Mirbashir 128, and Murov, respectively.

Studies have shown that powdery mildew disease affects the economic efficiency of the varieties studied, leading to a decrease in profitability.

In the control variant of the Morocco variety, the cost price of 1 tonne of grain was 183.1 manats, profitability was 64.5%, in the experimental variant the cost price was 255.1 manats, profitability was 17.6% when using fungicides, 363.5 manats additional income was received from grain yield per hectare. In the control variant of Morocco, the total yield per hectare was 1269 manat, net income was 494.5 manat, profitability was 64.5%, while in the experimental variant it was 876 AZN and 131.0 AZN, respectively, and profitability was 17.6%. The profitability in the control variant was 165.5%, while in the experimental variant it was 117.4% in Nurlu-99 variety. When using fungicide against powdery mildew in the crops of Nurlu-99 variety, 400 manat additional income was obtained from 1 hectare area compared to the experimental variant. In Mirbashir-128 and Murov varieties, 297.5 and 354.5 AZN of additional income was obtained due to the additional grain harvested from 1 hectare, and the profitability was 156.8 and 158.7% in the control variant and 115.5 and 125.1% in the experimental variant.

Table 5. Effect of powdery mildew disease on quality indices of wheat varieties, % (3-year average)

Varieties	Variants	Vitreousness, %		Gluten, %		GDC, c.g.		Sedimentation, ml		1000 grain mass, %	
Morocco	I	57	28.1	29.3	19.8	90.7	18.4	33.0	12.1	38.3	34.0
	II	41		23.5		109		29.0		25.2	
Nurlu 99	I	56	17.9	29.5	5.4	84.1	14.8	31.0	6.50	48.6	19.6
	II	46		27.9		98.9		29.0		38.2	
Mirbashir 128	I	61	23.0	29.7	14.5	90.1	15.0	31.0	6.50	51.1	24.9
	II	47		25.4		105		29.0		38.4	
Murov	I	60	26.6	30.3	9.3	89.6	16.5	25.0	8.00	53.4	22.9
	II	44		27.5		106		23.0		41.2	

Note: I-variant sprayed with fungicides (control), II-variant infected (experiment)

Based on the results of the research, it was recommended to use promising varieties with high productivity to achieve high profitability when using fungicides against powdery mildew disease.

Results

1. The infestation degree of the different genotypes of the wheat with powdery mildew was different as the vegetation occurred at different stages of development. During the research years plants were infected with powdery mildew at a high level of 7-9 points (50-90%).

2. More than 2,000 wheat genotypes were introduced by international selection centers and 30 promising samples were selected and given to the institute's selection program, 18 genotypes had high quality indicators and met the requirements of the standard.

3. In the studied wheat genotypes, the period up to the flowering phase was relatively long due to the effects of powdery mildew, shortening from the grain formation phase. The period from germination to full maturity varied between 48-50 days in the control genotypes of wheat, 36-47 days in the experimental variant, and 207-216 days and 201-212 days in the total vegetation period, respectively.

4. In all studied wheat genotypes, the leaves of the 7th tier were affected the most and the 8th tier were affected the last by powdery mildew according to assimilation surface area and the difference between variants ranged from 22.2-34.4% and 21.4-34.3%, respectively. Powdery mildew disease has negatively affected the accumulation of total dry biomass during the growing season. According to the accumulation of total dry biomass, the three-year average difference between the variants varied from 24.0 to 29.5%, and in some organs this loss was 34.7% in the VII tier leaves, 29.2% in the VIII tier leaves, 28.5% in the trunk, and 31.0%. in the spike.

5. The intensity of photosynthesis in the leaves, the permeability of the stomas, the density of the intercellular carbon dioxide, and the intensity of transpiration reached their maximum values in the spike phase in the control variant. These indicators decreased by 16.8-34.7% due to the impact of the disease in the experimental variant. The intensity of photosynthesis in the studied wheat genotypes decreased between 24.3-34.7% in VII tier leaves and 16.8-25.7% in VIII tier leaves due to the disease.

6. The total amount of chlorophyll in the leaves of the VII and VIII tiers of the studied wheat genotypes varied between 28.0-42.1% and 27.2-34.7%, respectively, due to the disease. According to this indicator, a large difference between the variants was recorded in Morocco variety (42.1% and 34.7%), a small difference in Nurlu-99 variety (28.0% and 27.2%).

7. During the years of research, it was found that powdery mildew, also had a negative effect on grain quality on the studied genotypes. From this point of view, the loss was higher in disease-susceptible genotypes, 28.1% according to the three-year average, gluten 19.8%, sedimentation 12.1%, and in relatively less infected genotypes the loss was expressed in minimal values, respectively 17.9%, 5 , 4% and 6.5%, respectively.

8. Depending on the natural-climatic conditions, the biological characteristics of the genotype, the phase of the development of the disease, the level and duration of the disease, the loss of yield in susceptible genotypes was 17.9-31.0%, and in less infected with disease genotypes the loss was 13.8-14.4. %. Profitability in wheat genotypes infected with powdery mildew ranged from 17.6 to 125.1%, in the control variant it varied from 64.5 to 165.5%.

Recommendations for producers

1. It is recommended that 30 wheat genotypes selected from wheat seedlings introduced by international selection centers for complex characteristics, agronomic and quality indicators to be used as donors in the breeding work to create varieties resistant to powdery mildew.

2. The selection process can be accelerated by creating an artificial background of infection using the disease-sensitive Morocco variety and assessing the resistance of materials to powdery mildew disease in this background.

3. It is recommended to farmers to use high-yielding and high-quality wheat varieties to achieve high yields using appropriate fungicides against powdery mildew in cereal crops.

The main points of the dissertation are presented in the following articles:

1. Karimova, Sh.R., Ibrahimov E.R., Sadigov Sh.F Selection of wheat genotypes resistant to powdery mildew disease under conditions of Absheron and Gobustan // - Baku: Azerbaijan Agrarian Science, Scientific Theoretical Journal, - 2016. № 3, - pp. 84-86.

2. Karimova, Sh.R., Talai J.M., Abdulbagiyeva S.A.Study of the effect of powdery mildew disease on the chlorophyll content and productivity in the wheat plant // - Baku: Azerbaijan Agrarian Science, Scientific Theoretical Journal, - 2017. No3, - pp. 98-101.

3. Karimova, Sh.R., Shikhlinski H.M. Study of the effect of powdery mildew disease on productivity and quality parameters of wheat under conditions of Absheron. // - Baku: Proceedings of the Research Institute of Crop Husbandry, - 2017. Volume XXVIII, - pp. 196-200.

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6. Karimova, Sh.R., Study of the effect of powdery mildew disease on some physiological indices and productivity of the wheat plant // International Scientific Conference on "Actual problems of contemporary natural and economic sciences" dedicated to the 95th anniversary of National Leader Heydar Aliyev. Part III, -Ganja: (n.y), - 04-05 May, - 2018, - pp. 118-120 (in Azerbaijani).

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12. Kerimova, Sh.R. Effect of powdery mildew disease on productivity and quality indices of wheat // - Moscow: Agrarian science,-2020. Vol.340, No7-8, -pp. 118-121 (in Russian).

13. Karimova Sh.R., Talai J.M., Shikhlinski H.M., Abdulbagiyeva S.A. Study of powdery mildew effects on the dynamics of dry biomass in the wheat plant // World journal of pharmacy and pharmaceutical sciences SJIF, - İndia: - 2018. Vol.7, № 4, - p.1530-1535.

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