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RESISTANCE OF BARLEY VARIETIES TO THE PATHOGENS OF LEAF SPOTTING ON THE ARTIFICIAL INFECTIOUS BACKGROUND

Ainash Nauanova

JSC "S. Seifullin Kazakh Agrotechnical University"
62 Pobeda Avenue, Nur-Sultan, 010000, Kazakstan

Abstract
Leaf spotting is one of the most common and harmful diseases of white straw crops in Northern Kazakhstan and is caused by some fungi as Drechslera graminea, Cochliobolus sativus Pine., Bipolaris sorokiniana, Alternaria fungi species: Alternaria arborescens, Alternaria tenuissima, Alternaria alternate, Alternaria triticina. The symptoms of leaf spotting vary, depending on the genotype of the host plant, the phase of plant development, and environmental conditions. The fungus infects through direct penetration into the epidermis of young leaves or through the stomata, forming clearly limited, dark brown spots. The first signs of the disease appear on the seedlings in spring, in the form of oval brown spots. Spots can develop on leaves and leaf sheaths at all stages of plant development.The majority of barley varieties, cultivated in the conditions of Northern Kazakhstan, have a comparative resistance to fungal diseases in terms of resistance to leaf spotting. As a result of studying the nature of stability of barley varieties, Solontsoviy variety was characterized by low plant damage during ontogeny. Such varieties as Donetsk 9, Astana 2007, Karaganda 5, Medicum 307, Tselinniy 30 and Tselinniy 93 are moderately resistant.

Keywords: barley varieties, infectious background, the infectious agents of leaf spots, striped spots, *helmintosporium*.

INTRODUCTION

There are a lot of harmful organisms that damage agriculture in Kazakhstan. *Septoria-helminthosporium* spots are widespread among wheat crops, causing dying of leaves, shortening of the plant vegetation periods, as well as blind-seed disease. The infection of white straw crops with spotting caused by various pathogenic micromycetes has significantly increased recently in Kazakhstan, Russia and many European countries, the yield loss can exceed 40 % or more [1-4]. The species of pathogens, causing spotting, have been very diverse and dynamic over the years. For example, according to E. E. Saari [5], in South and Southeast Asia, the most widespread and harmful diseases of wheat are leaf spotting caused by fungi *(Cochliobolus sativus (Ito et Kurib.) Drechs ex Dastur (conidial stage of Bipoiaris sorokiniana Sacc. m Sorok.)* and *Pvrenophora tritici-repentis*. Yellow spot has become a widespread disease for wheat in Australia and it has caused crop losses from 5 to 20 % together with Septoria for the last 20 years[6].

Reticulated spotting caused by *the deuteromycete Drechslera teres (SACC) Shoem* has become the most common and harmful diseases of barley in many regions of the world, including Central Asia and Northern Kazakhstan [7]. Yellow spotting of grain crops is also widespread, the infectious agent of which is the *ascomycete Pyrenophora tritici-repentis*. It is especially harmful in European Russia. Here, the loss of the barley crop from the disease can reach 20-45 %, and 60-90 % of yield loss in some years on susceptible varieties. In the Kuban region, *fungi Alternaria triticina, Drechslera tritici-repentis, Bipolaris sorokiniana, Septoria tritici* and other opportunistic micromycetes were selected from diseased winter wheat leaves with the symptoms of leaf spotting [8-9].

Northern Kazakhstan is the most affected region with dark brown spotting. Dark brown leaf spotting caused by the hemibiotrophic fungus *Bipolaris sorokiniana Shoem* is a common and harmful disease in many regions of barley cultivation. In 2007, in the steppe, forest-steppe and mountain-hill zones of the Akmola region, depending on the predecessors, spring wheat crops were affected by spots from 1-5 to 10-25 %. The greatest manifestation of the disease was observed on crops after fallow, mainly on the leaves of the lower and middle layers. The new crop-granary (rye-wheat, barley hybrid) was affected by yellow spots on 10-25%, winter rye - up to 10%. In the Kostanay region, on permanent crops of spring wheat, there was a noticeable development of fungal spots, the leaves of the lower tier were affected by up to 10-25 % , with the spread of diseases up to 90 -100% [4].

According to the well-known Kazakh phytopathologist M. K. Koishybayev [4], 3 types of helminthosporiosis of leaves are common for barley: dark brown spotting *(Bipolaris sorokiniana (Sacc.) Shoem.)*, striped spotting *(Drechslera graminea)* and reticulated spotting *(Drechslera teres)*. Dark brown spotting of barley leaves, caused by the fungus *Bipolaris sorokiniana (Sacc.) Shoem.,* has become increasingly important in recent years. Helminthosporium leaf spotting of white straw crops is common for spring wheat and barley everywhere. Introduction of intensive technologies of barley cultivation, including an increase in treatments of crops with herbicides, especially at high background of mineral nutrition, enhances barley affection with helminthosporium [10, 11].

The optimal temperature for the development of dark brown spotting of barley leaves is 30°C [12, 13]. A. I. Shirokov and A.V. Shorokhov [14] believe that the development of dark brown spotting of barley leaves is influenced by temperature

changes, late warming of the soil in spring, irregular rainfall.
Northern Kazakhstan is the most affected region with dark brown spotting. Barley has high nutritional, forage and agrobiological advantages and is the most important white straw crops. A significant factor that causes crop failure is the significant infestation of crops with leaf spotting. This is mainly due to the expansion of acreage occupied by genetically homogeneous susceptible varieties. The development of dark brown spots leads to the increased development of the" black germ " of seeds, which reduces the quality of the grain and its germination. Therefore, the study is aimed to identify the harmfulness of pathogens of leaf spotting, as well as the resistance of varieties to this disease.

RESEARCH MATERIALS AND METHODS

The objects of research have become the strains of the leaf spotting pathogens of barley varieties selected from the affected leaves in the conditions of Northern Kazakhstan.
The experiments have been conducted in field conditions and in the laboratory of Microbiology of S.Seifullin Kazakh Agrotechnical University.
Barley diseases have been monitored during the period of earning-milky-wax ripeness to study the distribution of white straw crops leaf spotting, when diseases caused by leaf-stem infection in the Northern region are most apparent.
Small-scale field experiments have been conducted to determine the effect of leaf spotting pathogens on the growth and development of barley. The most pathogenic strains have been used on 13 barley varieties to make the infectious background, such as *Alternaria tenuissima Alt. tm.5, Alternaria triticina Alt. tr. № 8, Drechslera graminea Dr. gr. 9, Alternaria alternata Alt. alt.10* and *Bipolaris sorokiniana B. sor. № 16*. The experience has been repeated three times, and the placement of plots has been randomized. The size of the working plots is 1 m^2. The sowing period is June 1. The seeding depth 6-7 cm, the seeding rate is 300 pcs/m^2. In the control variant, the plants are not infected with pathogens of barley disease. To create an infectious background, fungi cultures have been grown on shakers that provide shaking of flasks at a speed of 200 rpm in sterile Erlenmeyer flasks on a liquid nutrient medium of Chapek-Dox. After cultivation, the culture fluid was separated from the mycelium by filtration. For subsequent studies, both culture fluid and mycelium have been used. Barley infection has been carried out using a hand sprayer during the tillering-tubing period with a suspension of 10^6 spores/ml at the rate of 0.5 ml per plant. The inoculated plants have been kept in a wet chamber for 48 hours. The details of the disease progression have been carried out visually judging by the infected leaf surface, 2 weeks after being infected.

RESEARCH RESULTS AND DISCUSSIONS

In arid conditions, the infection of barley with the suspension of the *Alt. tm.5* strain at the phase of full ripeness has led to a decrease in the safety of barley varieties by 16.7-39.5%, lagging in the growth of the Astana 2007 variety by almost 1.7 times. Despite the well-developed ears, they turned out to be empty, the absence of ears ranged from 76.0% to 82.8%. Barley infection with the pathogen of Alternaria spotting contributed to the decrease of the yield by 87.8% on an infectious background. Such barley varieties as Liniya 26 and Karaganda 5 were infected with a suspension of *Alternaria triticina Alt. tr. №* 8 strain during the phase of milk-wax ripeness by the end of the growing season, due to the death of plants, the plant safety decreased to 18.9%. The harmfulness of the fungus, firstly, was felt when calculating the number of grains in the ear, on an infectious background, their number was 18.5 times lower than on the control (Table 1).
The harmfulness of the *Drechslera graminea fungus Dr. gr. No. 9* was manifested on such barley varieties as Tselinniy and Tselinniy 91, these varieties formed puny, defective grains. The yield of these infected varieties was lower by 2.5-3.5 times. The barley variety Medicum 307 showed high resistance to the pathogen of striped leaf spotting, the yield of this barley variety was higher than the testing varieties.
When infecting with the *Alternaria alternata Alt.alt.10* strain on the infectious background, plant viability of Liniya 28 variety was reduced. The marked pathogen, like all the marked micromycetes, contributed to the state of empty ears, it was not possible to calculate the mass of 1000 grains due to the lack of the necessary number of seeds from 1 m^2. The yield of barley on an infectious background decreased by an average of 58.5%.
When barley is infected with the fungus *Bipolaris sorokiniana B. sor. No. 16*, the same pathogenicity patterns as of the above-mentioned strains can be observed.
In dry weather conditions with a lack of moisture, generative organs suffered more due to adverse conditions of abiotic and biotic factors. Increased harmfulness of phytopathogens in dry years is due to the fact that pathogens of leaf spotting develop more actively in conditions of moisture deficiency. On the one hand, with low humidity, pathogenic fungi do not have competitors-antagonists in the air, and on the other hand, plants in arid conditions have weakened immunity to diseases.
The considered diseases of spotting belong to the category caused by many phytopathogenic representatives from various families and classes of fungi. White straw crops leaves, affected with *Helminthosporium-Alternaria* had rounded, elongated, dark brown spots with blurry edges. The highest level of the disease progress was observed at the ear-formation stage. In some cases, great infestation has led to complete necrotizing of the leaves and their shrinking, which was the reason for a decrease in the weight of the grain. Barley yield loss ranged from 47.1% to 89.8% due to a decrease in the assimilation surface of the leaves, as well as the decay of the plants leaves. This had a negative impact on quality indicators such as the weight of a thousand grains, and ultimately on productivity.
The barley yield and its stability is determined by many features and properties, the duration of the leaf system functioning is the most important among them. The deterioration of the photosynthetic function of the plant contributed to a decrease in yield by an average of 62-73. 2%. The severity of *Helminthosporium-Alternaria* spotting manifested in all phases of plant development. Developing on leaves, the disease leads to a decrease in their assimilation surface, lagging in growth and premature drying. Infection of plants with pathogens of the noted disease led to empty ears of plants, the grains were puny, light and wrinkled.
The first signs of the disease appeared during the tillering-stooling stage on the infectious background from the infection that remained on crop residues. The increase of the disease occurred before the milky stage of the grain. The spread of the disease ranged from 9.7% to 66.2% by the milky stage in the testing variant, without the infection of plants with pathogens. The disease progression was lower on a natural background of such varieties as Complex, Astana 2007, Medicum 307, Tselinniy 30, Solontsoviy, Tselinniy 93 [15].

Table 1. Structural analysis of barley on an infectious background

Variant	Plant	Number	Number	Plant	Ear	Number of	The	Weight	Yeild

	viability (number of plants per 1 m2), units	of stems, pcs.	of productive stems, pcs.	height, cm	length, cm	spikelets, pcs.	number of grains, pcs	of 1000 grains, g	g/m2
1	2	3	4	5	6	7	8	9	10
Infected with a suspension of strain Alt. tm.5									
Compleksniy (C)	280	2,3±0,5	1,1±0,1	46,3±0,4	3,6±0,3	7,1±0,7	3,9±2,0	-	11,9
Compleksniy	233	2,8±0,7	1,7±0,3	32,1±0,9	4,7±0,6	11,9±0,2	2,2±1,3	-	13,7
Donetskiy 9 (C)	303	2,8±0,2	1,4±0,3	40,8±1,3	5,4±1,2	13,8±1,3	12,8±1,2	37,8	95,7
Donetskiy 9	190	1,7±1,1	2,4±0,8	36,9±1,5	4,2±1,5	10,6±1,6	2,2±0,7	-	13,4
Astana 2007 (C)	243	2,5±1,0	2,0±1,1	38,0±2,6	6,2±2,4	15,8±2,9	5,0±0,8	37,8	106,9
Astana 2007	147	2,3±2,3	1,4±0,8	14,9±2,7	6,2±2,8	10,6±2,1	1,2±1,2	-	10,8
Infected with a suspension of strain Alt. tr. №8									
Liniya 26 (C)	305	2,5±0,2	1,8±0,7	39,3±2,1	5,8±0,3	12,9±0,3	10,7±1,5	38,3	96,1
Liniya 26	197	2,8±0,7	1,0±1,6	38,4±0,7	4,2±0,3	8,6±0,8	1,8±1,9	-	11,0
Karagandinskiy 5 (C)	291	1,9±0,8	1,5±1,2	45,5±1,9	7,7±0,6	16,1±1,2	13,0±2,0	-	9,4
Karagandinsliy 5	236	2,5±1,4	4,3±2,5	31,3±1,4	4,2±0,7	12,3±1,9	0,7±2,1	-	3,4
Infected with a suspension of strain Dr. gr. № 9									
Tselinniy (C)	271	6,0±0,6	3,0±2,7	18,4±0,8	6,0±0,6	13,0±2,5	12,0±1,4	35,3	79,4
Tselinniy	223	2,7±0,9	2,6±1,4	33,3±0,9	5,1±1,9	12,3±2,9	13,0±1,9	-	22,0
Medikum 307(C)	294	2,4±1,6	1,9±0,5	39,9±1,4	5,2±2,3	9,3±2,7	6,7±0,8	33,7	44,9
Medikum 307	233	4,0±1,8	2,0±0,9	37,0±1,1	5,0±2,8	12,0±1,3	7,0±0,7	37,7	64,5
Tselinniy 91(C)	291	2,4±2,0	2,0±0,7	37,9±1,4	4,3±1,2	11,0±1,1	8,7±0,3	31,0	33,8
Tselinniy 91	237	2,9±2,5	2,1±0,4	32,1±0,1	5,2±1,9	10,8±0,9	2,9±1,9	-	12,6
Infected with a suspension of strain Alt.alt.10									
Tselinniy 30 (C)	284	2,6±2,9	2,7±0,2	36,9±0,7	4,9±0,4	13,7±0,4	8,1±1,4	-	17,4
Tselinniy 30	269	2,6±1,1	1,4±0,4	35,2±0,6	6,7±0,5	10,7±0,9	8,8±1,8	-	5,2
Liniya 28 (C)	283	2,4±0,7	0,9±1,3	38,2±1,6	4,1±1,2	11,9±0,78,9±	8,0±1,7	18,0	20,8
Liniya 28	207	2,3±0,5	1,2±1,6	36,1±1,4	4,8±1,6	1,2	1,3±0,9	-	11,0
Solontsoviy (C)	285	2,2±0,4	1,4±1,8	38,2±2,1	5,1±1,9	12,1±1,9	9,5±1,9	32,5	40,9
Solontsoviy	221	3,5±0,3	0,3±0,6	38,0±2,9	4,0±2,0	7,5±2,1	1,8±0,7	-	17,4
Infected with a suspension of strain B.sor.№16									
Astana 2000 (C)	304	3,5±0,8	2,8±2,1	41,0±2,4	5,8±2,5	14,6±2,1	12,9±0,9	39,4	61,8
Astana 2000	189	3,2±0,9	1,8±2,4	36,0±2,7	5,5±2,3	1,8±2,3	7,4±1,1	-	8,0
Tselinniy 93(C)	270	2,3±1,3	1,8±0,5	34,4±1,8	4,9±1,8	14,6±1,6	7,4±1,5	-	27,7
Tselinniy 93	265	3,8±1,1	2,2±0,8	34,2±1,4	5,8±0,9	8,7±1,7	1,7±2,7	-	10,6
Note: (C)-control									

The most aggressive strains of the pathogens of barley leaf spotting have been identified in the field. When infected with a suspension of the *Alt. tm.5 strain*, the spread of the disease on barley crops exceeded 2.5-4.5 times the infestation of plants. The infection with a suspension of phytopathogens led to high plant infestation, the spread of the disease reached 82.2-97.3% in some variants on an infectious background. All the characteristic symptoms of leaf spotting appeared on infected plants (Picture 1).

А Б

Picture 1. Affected barley leaves with the pathogens of spotting
A-striped; B-dark brown spotting

CONCLUSIONS

In dry conditions, the infection of barley with suspension of the *Alt. tm.*5 strain by the full ripeness phase has led to a decrease in the safety of barley varieties by 16.7-39.5%, and the state of having empty-ears ranged from 76.0% to 82.8%. The infection of barley with the pathogen of *Alternaria* spotting contributed to a decrease in the yield by 87.8% on the infectious background. The harmfulness of *the Drechslera graminea fungus Dr. gr. No. 9* appeared on such barley varieties as Tselinniy and Tselinniy 91, these varieties formed puny, defective grains.

Barley varieties are differentiated by the intensity of disease progression in terms of resistance. Solontsoviy variety can be referred to the resistant one, this variety was characterized by low plant damage during ontogeny. Donetsk 9, Astana 2007, Karaganda 5, Medicum 307, Tselinniy 30 and Tselinniy 93 are the moderately resistant varieties. The progression of the disease on an infectious background ranged from 22.1% to 45.3%. The main share of samples can be marked as susceptible, such barley varieties as Compleksniy, Tselinniy, Tselinniy 91, Astana 2000 can be included to this group, where the progression of the disease on an infectious background exceeded 50% or higher.

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