Plant Archives Vol. 19 No. 1, 2019 pp. 1653-1658 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

ENZYMATIC ACTIVITY IN THE RESISTANCE STRESS OF WINTER WHEAT FROM DIFFERENT SOURCES IN THE NON-BLACK LAND OF THE CENTER OF RUSSIAN FEDERATION

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Abstract

This experiment were conducted in many laboratories and research centers in the period (2006-2016):- (Centre of the gene pool and plants biological resources (the old name of center was (MOVIR), and now (Russia Horticultural Institute for Breeding, Agro technology and Nursery, MIKHNEVO) and in the laboratory of All-Russian Research Institute of Phytopathology, *Bolshie Vyazemy* in Moscow region.

We used in this study (52) cultivars of wheat from different country and Moskovskaya 39 for comparison.

As a result of winter wheat screening from the All-Russian Institute of Plant Industry Collection of Plant Genetic Resources in the Central Non-black land of the Russian Federation on resistance of accessions to unfavorable a biotic (winter hardiness, damping, waterlogging) and biotic stressors (snow mold *Microdochium nivale* (Fr.) Samuels & I.C. Hallett, an enzyme-mycosis depletion seeds, yellow rust *Puccinia striiformis* West, brown rust *Puccinia recondite* Rob. ex Desm. f. sp. *tritici* (Erikss.) CO Johnson, stem rust *Puccinia graminis* (Pers.)) the stable forms have been revealed for using in breeding. Agrobiological characteristics of collectible accessions originating from Russia, Belgium, United Kingdom, Germany, the Netherlands, Sweden, Poland, Switzerland, Finland, the Czech Republic, Austria and Denmark. It is noted that for to day the cultivar Moskovskaya 39 exceeds the studied accessions from different countries on high adaptive potential, grain quality and polygenic resistance to enzyme-mycosis depletion seeds.

The object of research to study collectible accessions of winter wheat from different countries have been evaluated of resistance from different sources of stress.

Key words : Mycotic diseases, winter wheat, resistance diseases, biotic, biotic stressors, grain quality.

Introduction

Increasing grain yield has always been and will be the most important task of agriculture. At the same time, progress in the grain industry will occur not only due to the development of man-made means of grain production, but also due to more effective agroecosystems and agrolandscapes adaptation to environmental factors varying in time and space (Zhuchenko, 2004, 2011).

To acquire more information on genotype × environment interactions in plants grown under a biotic and/or biotic stresses and to understand a new approach on the complex mechanism of tolerance, a formula was set-up to estimate the number of genes interactive models (NGIM) acting in plants under stress. Some of previous results and ideas on this topic were taken into consideration, including morpho-physiological traits and molecular approaches (Elsahookie, 2014).

Zhuchenko (2004) reported that important role of abiotic and biotic environmental factors as determining not only the direction and pace of natural selection, but also acting as inducers of genetic variability (mutation, recombination, repair, transposition). He also noted the need to combine high potential productivity and grain quality of cultivars and hybrids with resistance to abiotic and biotic stressors. When considering this problem, the most relevant problem is enzyme-mycotic depletion or "expiration" of grain, which represents a difficult pathological complex. The starting mechanisms of this disease development are abiotic factors – high humidity and temperature, which are subsequently aggravated by factors of a biotic nature (many diseases).

Crop losses in some years reach to 30-50% or more.But not only the harvest is reduced, but at the same time the grain quality is deteriorating. This process takes place in almost all regions of Russia (Krasnodar region, non-black land, Siberia, Chelyabinsk region, etc.), when wet weather conditions coincide with the ripening of grain and, especially with harvesting.This has been repeatedly noted by academics such as Cholodny (1949), Dunin (1974, 1976), Dunin and Temirbekova (1978), Temirbekova (2008).

More recently, academician Sandukhadze (2017) in his interview in the journal "In the world of science" noted: "Being on a business trip in the one of regions a month before the harvest, the commission, in which he was, calculated the expected yield as 50-60 t/ha. But when the harvesting started – yield was 18-22 t/ha. And what happened? It turned out that when it became necessary to harvest the wheat, suddenly began to rain. Every day the wheat harvest decreased by one and a half centner. Rain – sun, rain – sun. Felt a spike, and there was empty. I would argue that my cultivars produce a crop even in such weather. And I think that the increase in grain production is much more important and effective than the sale of oil and gas. Wheat will always be in demand and bread is more important than atomic bombs."

In this regard, a lot of work has been done on study of resistance to abiotic and biotic stress factors of the region. The limiting factors are winter hardiness and resistance to the damaging effect of increased and excessive humidity on the ripening grain, which is the result of such a disease as enzyme-mycotic depletion of seeds (Temirbekova, 2008).

The aim of the research was to evaluate the winter bread wheat (*Triticum aestivum* L.) from the All-Russian Institute of Plant Industry collection on resistance to biotic and abiotic stress factors in natural environment of Moscow region, and detect of the initial material for use in breeding programs.

Materials and Methods

The object of research was to study collectible accessions of winter wheat from different countries. In a total 2,000 samples have been evaluated. The accessions that allocated on economically valuable signs in 2006-2016 were analyzed on grain quality. In field experiments conventional agricultural equipment for the region was used. Accession seeds were sown at the optimum time on plots with an area of 2m^2. Standard was the cultivar Moskovskaya 39 k-64160 (developed by Moscow agricultural research Institute "Nemchinovka"), it was placed after every 10 samples.

Evaluation of the wheat collection was carried out according to the Methodological instructions of All-Russian Institute of Plant Industry (10, 12), a wide unified classifier of the Council for Mutual Economic Assistance of the *Triticum* L. (Leningrad, 1989), for example: a score of 1 - is the minimum expression of a trait, 3 - is low, 5 - is medium, 7 - is high, 9 - is the maximum expression of trait.. The evaluation of seeds resistance to enzyme-mycotic depletion was carried out by original methods (Temirbekova, 1996).

Biochemical analysis of accessions was carried out on Spectra Star 2400 (USA) using the following methods of determination: protein–through determination of nitrogen by Kjeldahl and conversion factor 5,7 gluten –in accordance with GOST R 54478-2011 (GOST, 2013).

Growing conditions for wheat in the Moscow region

2012 : Weather conditions during the summer period were characterized by high air temperature (on average +2.2°C compared to the mean annual data). Precipitation fell unevenly.

A significant decrease in the maximum daily air temperature from +33.6°C at the beginning of the month to +13.4°C at it's end was observed in August. II and III decades of August were characterized by an abundance of precipitation (70.9 mm), which was higher than the average annual data on 24 mm. The average daily air temperature varied from 20.4°C at the beginning of the second decade to 11.4°C at the end of the third decade, approaching the average annual rate. Hydrothermal coefficient = 1.2.

Weather conditions of **2013** were excessively humid. Amount of rainfall was 334.8 mm during the growing season, the average long-term rate –264 mm. Temperature –18.4°C, at the average multi-year –15.1°C. Hydrothermal coefficient = 1.6.

Growing conditions of **2014** were characterized by high temperature – 17.7°C, and low rainfall – 175.4 mm. Hydrothermal coefficient =0.9.

The weather of **2015** was excessively humid in May-July. Amount of precipitation per growing season of wheat was 548.3 mm. Temperature was 17.6°C. Hydrothermal coefficient =1.7.

2016 : Weather conditions during the growing season were characterized by moderate average daily air temperatures –17.3°C, they were higher than the average long-term data on 2°C and an abundance of precipitation – 461.4 mm, which exceeded the norm by 1.7 times. These conditions contributed to the accumulation of phytopathogenic infection. The abundance of precipitation in August made it difficult to timely harvesting and obtaining high-quality seed harvest. Hydrothermal coefficient = 1.6.

Results and Discussion

In 2012/2013 an over wintering of wheat plants was quite satisfactory and good. It was rated by 4 and 5 points (on a five – point scale) for the most of accessions (64%). The death of plants was not observed. The weather conditions of spring and early summer also contributed to the good growth and development of winter wheat plants, due to the optimal air temperature and humidity of the soil (according to the weather station COS VIUA).

During the growing season of the winter wheat phonological evaluations were carried out in accordance with the Methodological instructions of VIR (Grain, 2017; Gretchaninov and Filatenko, 1985).

The height of plants for these accessions reached 130-160 cm, while for the majority of accessions it was within 90-120 cm. The stem length of plants of the cultivar Moskovskaya 39 was only 100-105 cm.

High grain yield – up to 60-70 t/ha (in terms of hectare) was obtained for some accessions. The harvest of the cultivar Moskovskaya 39 was 57-60 t/ha. Level of diseases development (brown rust, powdery mildew) was in the range of 10-30%, enzyme-mycotic depletion of seeds was not noted.

In 2012/2013, there was no sowing of winter crops due to water logged soil, which sometimes reached a depth of 80 cm. However, ten accessions allocated as resistant to a complex of diseases and characterized by high winter hardiness and high productivity were estimated by laboratory and field methods on resistance to enzyme-mycotic depletion of seeds and grain quality, namely on content of protein, gluten and starch in comparison with a crop of 2012 (dry summer) (table 1).

The study of resistance to enzyme-mycotic depletion of seeds by laboratory and field methods was showed that cultivar Pang k-62035 (Poland), and the standard cultivar Moskovskaya 39 had the highest resistance – 85.7%. It should be noted, the grain protein content of Moskovskaya 39 was high (15.84%) in conditions of wet 2013 year and in conditions of dry 2012 was 16.60%. In 2010-2014 the standard cultivar had grain protein content within 14.1-17.0%, gluten content – 25.0-38.2%, weight

Table 1 : Influence of contrasting growing conditions on grain quality of winter wheat accessions for in 2012-2013.

No.	VIR catalogue number	Name	Country	Year	Protein (No.5,7), %	Difference %	Gluten %	Difference %	Starch %	Difference %
1	62035	Pang	Poland	2012	12,71	0,55	24,4	3,4	61,23	0,91
				2013	12,16		21,0		60,32	
2	63907	Caprimus	United Kingdom	2012	13,16	3,16	23,7	7,0	62,16	1,91
				2013	10,00		16,7		60,25	
3	63999	Alidos	Germany	2012	14,52	2,48	28,4	6,0	60,00	1,04
				2013	12,04		22,4		58,96	
4	64003	Hai	Germany	2012	13,45	0,89	25,0	1,2	61,14	29,98
				2013	12,56		23,8		30,16	
5	-	Skipetr	Russia	2012	12,00	0,86	30,7	11,0	56,7	10,9
				1013	11,14		19,7		45,8	
6	Standard	Russia, Moscow region	Moskovs-kaya 39	2012	16,60	0,76	33,16	1,66	57,27	0,36
				2013	15,84		31,5		56,91	

Table 2 : The best samples from different countries, distinguished by winter hardiness and economically valuable characteristics for 2006-2016.

	VIR catalogue number	Name	Country	Wintering, score	Protein (Nõ5,7), %	Weight of 1000 grains, g	Productivity, g
1-	56826	David	Austria	9	16,5	42	400
2-	56827	Pocal	Austria	9	15,1	43	410
3-	56828	Gigant	Austria	9	13,4	40	400
4-	56829	Rinner	Austria	7	14,4	41	350
5-	56834	Agron	Austria	9	16,3	47	400
6-	56836	Verbesserter St.Johanner	Austria	7	15,8	40	390
7-	56848	Laisach/Karnten	Austria	7	15,2	36	400
8-	49824	Bocquiau	Belgium	7	13,4	49	400
9-	54099	Arno	Belgium	9	14,5	42	350
10-	54100	Anouk	Belgium	7	13,7	40	370
11-	54705	Maris Kinsman	United Kingdom	9	15,1	43	330
12-	56761	Rapier	United Kingdom	5	14,6	44	400
13-	57231	Venture	United Kingdom	7	14,7	40	400
14-	57944	Maris Ploughman	United Kingdom	9	14,0	43	450
15-	58418	Steel	United Kingdom	7	15,7	37	370
16-	56904	Remus	Germany	7	13,8	38	530
17-	57008	TAW 7032/74	Germany	7	14,0	41	300
18-	57582	Fakta	Germany	7	15,1	43	400
19-	57585	Compal	Germany	7	14,7	42	420
20-	59019	Almus	Germany	9	14,2	40	500
21-	50745	Kormoran	Germany	7	14,4	38	390
22-	54135	Feldman	Germany	9	15,0	42	410
23-	56920	Cariplus	Germany	9	14,2	43	360
24-	57579	Tukan	Germany	7	13,8	43	560
25-	57610	Caristerm	Germany	9	15,5	36	450
26-	59547	Urban	Germany	9	13,5	41	450
27-	56289	Hvede Sarah	Denmark	7	13,0	47	410
28-	56290	Trfolium 33	Denmark	7	14,5	48	500
29-	44831	Bonus	The Netherlands	7	13,8	35	350
30-	53496	Ricardo	The Netherlands	7	14,8	47	400
31-	55220	Rmo	Poland	7	13,8	45	450
32-	56766	Jana	Poland	9	12,4	39	490
33-	57580	Liwilla	Poland	9	14,0	45	500
34-	57581	Gama	Poland	7	13,7	42	440
35-	57614	Kadav	Poland	7	14,1	42	450
36-	57618	PP 114-74	Poland	9	14,3	42	550
37-	57445	Jo 3151	Finland	7	14,3	39	400
38-	57970	Aura	Finland	9	14,2	39	450
39-	56400	UH 290/74	Czech Republic	7	15,5	53	420
40-	57624	UH-597	Czech Republic	7	13,9	37	350
41-	57528	Arina	Switzerland	7	16,5	43	350
42-	56872	Helge	Sweden	7	14,1	36	310
43-	56875	WW 23977	Sweden	9	13,5	40	450
44-	58035	Salut	Sweden	9	14,3	37	500
45-	58036	Folke	Sweden	7	13,8	38	500
46-	58137	Kosack	Sweden	7	13,2	36	450
47	64160	Moskovskaya 39	Russia	9	17,0	43	650

Fig. 1 : Leakage of biopolymers of wheat grain under the influence of the enzyme stage of enzyme-mycotic depletion of seeds (x20).

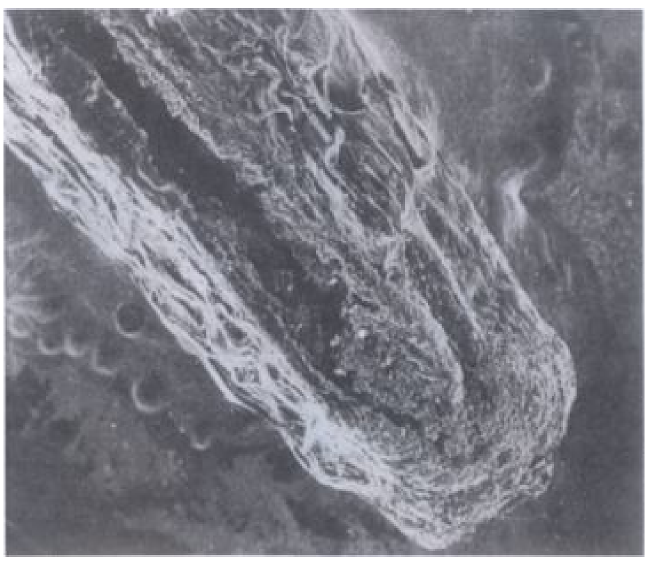

Fig. 2 : Severe injury of winter rye grain(x 35).

of 1000 grains – 42.5-49.6 g, yield – 700-750 g/m^2. The cultivar Moskovskaya 39 is resistant to such limiting factor of the region as increased and excessive humidity during the ripening period.

In the years of excess moisture the cultivar Pang (Poland) and the standard cultivar Moskovskaya 39 showed a decrease in grain protein content on 0.55 and 0.76%, gluten – 3.4 and 1.66 %, starch-0.91 and 0.36 %, in comparison with the cultivars k-63907 Caprimus, k-63999 Alidos, k-64003 Hai (table 1). However, it should be noted, these cultivars were characterized by a satisfactory grain quality in dry 2012 and in wet 2013 lost 7.0; 6.0; 1.2% of gluten, protein –3.16, 2.48, 0.89% and starch –1.91, 1.04 and 29.98%, respectively.

The cultivar Skipetr was also evaluated on resistance to enzyme-mycotic depletion of seeds and the quality of the harvest in 2012 and 2013. This cultivar at optimum atmospheric humidity and mild temperatures (20-25°C) had a high yield (350-450 g/m^2), grain protein content of 12.0%, gluten – up to 30.7%, starch – 56,7%. However, at excess humidity in 2013 the cultivar Skipetr had formed depleted grain with a protein content 11.14%, gluten – 19.7% and starch – 45.8%. It is not resistant to grain depletion, in 2013 the lodging of it's plants was observed.

In the study of various crops in the Moscow region, we have shown and proved that the best cultivars-standards of European countries not always withstood excessive humidity and were subjected to enzyme-mycotic depletion of seeds – biological injury to in the maturation phase. The seeds were formed depleted, light weight and with injuries (figs. 1, 2).

A distinctive feature of Moskovskaya 39 from the other cultivars in conditions of high and excessive humidity was resistance to enzyme-mycotic depletion of seeds. The cultivars from Germany, United Kingdom, the Netherlands and Sweden valued in this research were not able to quickly heal injuries and disorders of the cover tissues in rainy weather and were prone to enzyme-mycotic depletion of seeds. This opened the "gate" for the introduction in wheat plants of pathogens beginning from the flowering phase of the cultivars to their full ripeness. As a result, the cultivars have formed dissipated and lightweight grains.

Table 2 presents winter-hardy samples from different countries, which were separated as a result of many years of study 2006-2016.

Based on the study of the winter wheat of different countries, which is presented at the VIR collection, we can give it the following summary characteristics.

The cultivars from United Kingdom are not tolerant to root rot, they are weakly winter hardy, of late maturing, resistant to lodging, and their productivity is lower than that of the standard. They are strongly affected by snow mold *Microdochium nivale*, they are subjected by enzyme-mycotic depletion of seeds.

The cultivars from Belgium are late ripening, unstable to root rot, with average winter hardiness, more resistant to lodging than the standard Moskovskaya 39, affected in medium degree by powdery mildew, leaf rust and snow mold, amazed by enzyme-mycotic depletion of seeds. The formed grain is poor quality.

The cultivars from the Netherlands are unstable to root rot, late maturing, their resistance to lodging above average level.

They were not resistant to defeat by diseases (powdery mildew, leaf rust, snow mold, enzyme-mycotic depletion of seeds).

The most of the cultivars from Germany are resistant to lodging, root rot and snow mold. Their maturing period was on 3-5 days later than the standard.

The cultivars from Sweden exhibited high resistance to root rot, snow mold and enzyme-mycotic depletion of seeds. Some of them are also resistant to powdery mildew and leaf rust. These accessions are recommended for use in breeding.

The evaluated cultivars from Czech Republic up to 1992 were not sustainable to root rot and snow mold.

The cultivars from Russia Moskovskaya 39 showed complex resistance to abiotic and biotic stress factors and were recommended for involvement in the breeding process.

Conclusion

So, among the accessions of winter bread wheat from Russia and other countries, which are maintained in VIR's collection of plant genetic resources, there are valuable sources of resistance to unfavorable abiotic and biotic environments of Moscow region. The important characteristics of winter wheat for grain production in this region are high winter-hardiness, resistance to snow mold and root rot, tolerance to increased and excessive humidity during period on ripening grain. The standard-cultivar Moskovskaya 39 with high adaptive potential continues to be one of the best on comparison with evaluated foreign cultivars.

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