ECOSYSTEMS: ECOLOGY AND DYNAMICS, 2023, Vol. 7, No. 4, P. 126-139

CONDITION AND FUNCTIONING OF AGROECOSYSTEMS AND THEIR COMPONENTS

UDC 633.11

ADAPTIVENESS OF SPRING WHEAT BASED ON SOME PARAMETERS OF GRAIN QUALITY OF THE NEW VARIETIES FROM THE FAR EASTERN BREED

© 2023. N.M. Terekhin, L.N. Mishchenko, M.V. Terekhin

Far Eastern State Agrarian University
86, Politekhnicheskaya Str., Blagoveshchensk, 675002, Russia
E-mail: laridass2@mail.ru, rohan.1994@mail.ru

Receiver October 2, 2023. Revised November 1, 2023. Accepted November 15, 2023.

In this article we present the results of long-term wheat breeding aimed at creating varieties of spring soft wheat that can adapt to the specific environment of the Amur Region which is located in the area of risky agriculture. We conducted a comparative analysis of grain quality and adaptiveness properties (compensatory ability and stress tolerance) of 30 new varieties of spring wheat from the competition nursery. Experiments were conducted from 2020 to 2022, according to the standard method in the Research Laboratory of Grain Breeding of the Far Eastern State Agrarian University (Rus. "Dalnevostochny GAU" or "DalGAU"). It was revealed that the variety from the combination Long 98-4723 x Altayskaya 530 was the most valuable by the complex of its technological properties. The variety from the combination Krasa x DalGAU 1 had the best compensatory ability. The variety from Altayskaya 325 x Amurskaya 1495 had a good stress tolerance by all its properties. For the last two combinations the pollinators were from Amur breed. We have also identified the most promising regions of origin of varieties for their potential use as parental forms in hybridization. Chinese and Siberian varieties offer the best grain quality parameters for the Amur Region, and the majority of promising samples were created with these two varieties. Chinese varieties give a good compensatory ability to the next generations in vitreousness, grain unit and gluten content, but a low stress tolerance in gluten content. The Altai varieties produce generations with high gluten content, good compensatory ability and high stress tolerance.

Keywords: variety, 1000 grain weight, grain unit, grain vitreousness, gluten, α-Amylase, Hagberg falling number.
DOI: 10.24412/2542-2006-2023-4-126-139
EDN: DOEXJR

Creation of varieties adapted to the specific environments of a particular region has been and remains the primary goal of wheat breeding. The crop breeders carry out the most important tasks, such as selection of parental pairs, valuable samples, hybrids and lines (Murugova, 2016). The N.I. Vavilov All-Russian Institute of Plant Genetic Resources holds a huge number of spring wheat varieties, including those from different parts of the world, which are selected according to the needed parameters, ecology and geography. Along with high yield, the Institute works on achieving high grain quality, compensatory ability of varieties and their stress tolerance in different years and under different environmental conditions. The wheat quality is pursued globally (Herger et al., 2018).

Evaluation of new varieties from a competition nursery (Photo 1, 2) requires assessing how much a certain parameter is expressed, along with levels of stress tolerance and compensatory ability (Zykin et al., 1984; Decina et al., 2020). In recent years, varieties with these parameters have become of great value for consumers (Melekhina, 2015; Zykin, 2011). Unfavorable weather and climate of the Amur Region require vitreousness, natural weight, weight of 1000 grains, gluten content and Hagberg falling number of wheat to help new varieties survive in such difficult environment (Mishchenko, Teryokhin, 2019).

Photo 1. Competition nursery (photo by N.M. Teryokhin).

Photo 2. Harvest in a mass breeding nursery (photo by N.M. Teryokhin).

The aim of this study was to find the most valuable varieties of spring wheat in a competition nursery according to their quality and adaptiveness and to determine the most promising regions of varieties' origin for their use as parental forms in further hybridization.

Object and Methods

The samples were sown in the experimental fields of the Far Eastern State Agrarian University (Rus. "Dalnevostochny GAU" or "DalGAU") in the village of Gribskoye, Amur Region. The area of plots was 10 m^2; a SKS-6a seed drill and a Sampo-130 harvester were used.

We've been studying the technological properties of grain of 30 new varieties of spring soft wheat from the Far Eastern State Agricultural University from 2020 to 2022. These varieties were obtained by intraspecific hybridization (Photo 3), using various forms of spring wheat of domestic and foreign breeds. We have calculated the average values of the studied parameters, compensatory ability and stress tolerance of the samples, using DalGAU 3 variety as a standard (Photo 4).

Photo 3. Hybridization nursery (photo by N.M. Teryokhin).

In recent years, the climate of the Amur Region, aside from getting warmer, has been undergoing significant changes. The air temperature of the winter months is increasing, while the temperature of the summer months (June-August) has dropped by almost 1° (Demidova, 2015). There are no more droughts in June that were once common for an environment with rainfall sometimes reaching a total of 0 mm. Monsoons increase rainfall throughout the growing season and, combined with the large number of rivers that increase humidity, they cause fungus infections in plants. The distribution of precipitation and air temperature throughout decades can vary

significantly in different years; therefore, it is necessary to create varieties with high yield and good ecological adaptiveness that would allow them to withstand the changing weather of the Amur Region.

Photo 4. DalGAU 3 varieties in the fields of the Far Eastern State Agrarian University (photo by N.M. Teryokhin).

In 2020, due to such climate peculiarities as unstable summer temperatures, heavy precipitation in June-August, wind gusts and hails, agricultural and meteorological conditions for the growth and development of crops were difficult and significantly reduced grain quality.

The first half of summer 2021 was quite favorable for wheat. However, heavy rains, high air humidity and wet soil in the fields during the ripening period caused lodging and grain germination.

Meanwhile, 2022 had the most favorable weather conditions with a comparatively uniform distribution of precipitation, which did not exceed the average long-term rate and eventually resulted in a high quantity and quality of spring wheat.

Results and Discussion

We studied 30 new varieties of spring soft wheat, divided into 5 groups according to the origin of their parental breed: Amur Region, Altai Krai, Siberia (Krasnoyarsk, Novosibirsk), China and Khabarovsk Krai. We examined their properties and calculated averages both for varieties and groups, as well as their compensatory ability and stress tolerance (Decina et al., 2020).

One of the most important technological parameters of spring soft wheat is grain vitreousness. The bigger a transparent, light-transmitting zone within a single grain and the higher the number of such grains, the higher the vitreousness, and hence, the overall grain quality. Vitreousness is positively correlated with the natural weigh, quantity and quality of protein, and strongly depends on weather conditions, sharply decreasing in unfavorable years. During the humid year of 2020, vitreousness of some samples decreased down to 5-6%. The variety from the Long 98-4723 x Altayskaya 530 combination with vitreousness equal to 61% and the standard DalGAU 3 variety with 59% had the best parameters, almost corresponding to the "strong wheats" (whaets with protein ≥ 15%, gluten ≥ 28%). These combinations were closely followed by one of the lines from Krasa x Darya[1] with vitreousness equal to 44%. In favorable years, vitreousness increases significantly and reaches 88% (e.g. in DalGAU 3). In 2022, Altai 235 x Ke feng 11 (65%), which was the only variety among those that originated from Altai wheat, and more than half of the varieties based on Chinese breeds (up to 78%) could be referred to as strong wheats with their vitreousness equal to 60% or more; while 8 varieties could be classified as "valuable wheats" (i.e. with protein ≥ 13-14%, gluten ≥ 28%) with their vitreousness equal to 50% or more. The average grain vitreousness for the 3 years of our research ranged from 8.5% in Altayskaya 325 x Amurskaya 1495 to 76% in the standard variety. As for the groups, varieties with Chinese origin had the maximum vitreousness (Table 1).

Compensatory ability is the average value calculated for 2 years, the most favorable one and the most unfavorable one. The higher it is, the closely the variety's genotype matches the growing conditions. It was the best in varieties from the standard variety and the Chinese group.

Stress tolerance is a negative difference between the minimum and maximum values; it determines the resistance to surrounding environment. The smaller it is, the less it is affected by external factors. The varieties with the lowest vitreousness had the higher stress tolerance. There were two varieties with a relatively high vitreousness that had the best tolerance: one from the Krasa x Darya combination with a compensatory ability of 46% and a stress tolerance of -4, and one from Long 98-4723 x Altaiskaya 530 with a compensatory ability of 71.0% and a stress tolerance of -17.

Table 1. Vitreousness, 1000 grain weight and adaptiveness parameters of the new spring wheat varieties (2020-2022).

Varieties from different combinations	Vitreousness, %					Weight of 1000 grains, g				
	Min	Max	Ave-rage	X*	Y**	Min	Max	Ave-rage	X*	Y**
DalGAU 3 (standard)	59	88	76.0	73.5	-29	27.4	33.7	30.4	30.6	-6.3
Varieties based on the breed from the Amur Region										
PS-49-09 x Aktyubinka	11	25	18.0	18.0	-14	25.2	33.8	29.5	29.5	-8.6
Amurskaya 1495 x Lada	27	51	41.3	39.0	-24	29.8	35.1	31.6	32.5	-5.3
DalGAU 1 x Lada	19	50	34.5	34.5	-31	22.9	23.4	23.2	23.2	-0.5
Average			**34.5**	**30.5**	**-23**			**28.1**	**28.4**	**-4.8**
Varieties based on the breed from the Altai Krai										
Altaiskaya 90 x Aryuna	19	33	26.0	26.0	-14	22.1	22.5	22.3	22.3	-0.4
Altaiskaya 90 x Dartnitsa	24	47	35.5	35.5	-45	21.7	25.0	23.4	23.4	-3.3
Altaiskaya 98 x Pushkinskaya	5	23	14.0	14.0	-18	25.8	26.0	25.9	25.9	-0.2
Altaiskaya 325 x Pushkinskaya	6	39	22.5	22.5	-33	24.2	24.8	24.5	24.5	-0.6
Altaiskaya 325 x Amurskaya 1495	12	44	30.7	28.0	-22	24.1	30.9	26.6	27.5	-6.8

Continuation of Table 1.

Varieties from different combinations	Vitreousness, %					Weight of 1000 grains, g				
	Min	Max	Ave-rage	X*	Y**	Min	Max	Ave-rage	X*	Y**
Varieties based on the breed from the Altai Krai										
Altaiskaya 325 x Amurskaya 1495	8	34	24.7	21.0	-26	26.5	35.0	29.7	30.8	-8.5
Altaiskaya 325 x Amurskaya 1495	12	19	15.5	15.5	-7	26.3	27.4	26.9	26.9	-1.1
Altaiskaya 325 x Amurskaya 1495	6	11	8.5	8.5	-5	24.1	28.4	26.3	26.3	-4.3
Altaiskaya 325 x Omskaya	30	47	38.5	38.5	-17	23.1	25.9	24.5	24.5	-2.8
Altaiskaya 235 x Kef eng 11	26	44	35.0	35.0	-18	24.7	25.2	25.0	25.0	-0.5
Altaiskaya 235 x Kef eng 11	21	65	37.3	43.0	-44	27.3	35.5	30.2	31.4	-8.2
Average			**26.2**	**26.1**	**-23**			**25.9**	**26.2**	**-3.3**
Varieties based on the breed from Siberia										
Krasa x Darya[1]	44	48	46.0	46.0	-4	30.0	30.5	30.3	30.3	-0.5
Krasa x Darya[2]	20	50	36.7	35.0	-30	27.6	36.7	30.9	32.2	-9.1
Krasa x Darya[3]	3	46	26.0	24.5	-43	25.4	29.9	26.9	27.7	-4.5
Aleksandrina x KSI-16	8	31	23.0	19.5	-23	28.0	35.4	30.6	31.7	-7.4
Aleksandrina x Khabarovchanka	7	14	10.0	10.0	-7	28.0	30.2	29.1	29.1	-2.2
Katyusha x DalGAU 1	22	24	23.0	23.0	-2	34.0	36.2	35.1	35.1	-2.2
Average			**27.5**	**26.3**	**18**			**30.5**	**31.0**	**-4.3**
Varieties based on the breed from the Khabarovsk Krai										
(Khabarovchanka x (F9 x Dalnevostochnaya 10)) x Primorskaya 39	32	55	42.3	43.5	-23	24.8	32.4	29.4	28.6	-7.6
Lira 98 x P-2-06	18	38	30.0	28.0	-20	25.2	27.0	26.1	26.1	-1.8
Lira x k-56104	10	28	19.0	19.0	-18	26.1	31.6	28.6	28.9	-5.5
Average			**30.4**	**30.1**	**-20**			**28.0**	**27.9**	**-5.0**
Varieties based on the breed from China										
Long 98-4723 x Altayskaya 530	61	78	71.0	69.5	-17	29.2	34.8	31.9	32.0	-5.6
Long 98-4723 x Aleksandrina	12	56	34.7	34.0	-44	26.2	30.6	28.2	28.4	-4.4
Long 98-4723 x Long 98-5582	16	48	32.0	32.0	-32	25.2	27.4	26.3	26.3	-2.2
Long 98-5582 x Yelegiya Mironovskaya	40	66	56.0	53.0	-26	24.6	34.4	28.8	29.5	-9.8
Long 98-5582 x Leguan	21	74	48.3	47.5	-53	33.8	39.2	35.7	36.5	-5.4
Long 98-5501 x Amurskaya 1945	18	55	39.0	36.5	-37	25.9	32.4	28.7	29.2	-6.5
Kef eng 11 x Yelegiya Mironovskaya	38	63	38.0	50.5	-25	30.3	37.3	36.0	33.8	-7.0
Average			**45.6**	**46.1**	**-21**			**30.8**	**30.8**	**-5.8**

Notes to Table 1-3, 5: X*– compensatory ability, Y** – stress tolerance.

There are no state standards for grain size, but it is still considered an important technological parameter. The weight of 1000 grains was 21.7 g in the unfavorable 2020 in the variety from the Altayskaya 90 x Darnitsa combination, and up to 39.2 g in the favorable 2022 in the variety from Long 98-5582 x Leguan. On average, over 3 years of our research, the grain larger than that of the standard DalGAU 3 (30.4 g) was found in the variety from Amurskaya 1495 x Lada (31.6 g), Katyusha x DalGAU 1 (35.1 g), Long 98-4723 x Altayskaya 530 (31.9 g), Long 98-5582 x Leguan (35.7 g) and Kef eng 11 x Yelegiya Mironovskaya (36.0 g; Table 1) combinations.

Compensatory ability, which was higher than that of the standard variety, was found in 9 new varieties: 4 had Siberian parent, 3 had Chinese parent, 1 was based on Amurskaya 1495, and 2 had an Altai parent. In general, varieties with the largest grains were produced from Siberian and Chinese varieties. For the most part, the new varieties were more stress tolerant than the standard DalGAU 3 in terms of 1000 grain weight, the best of them being the varieties with small grains. The Krasa x Darya1 and Katyusha x DalGAU 1 combinations had a high stress tolerance and relatively high compensatory ability.

Natural weight is one of the most significant parameters of grain quality. It is the weight of 1 liter of grain measured on a grain-unit scale (Rus. “purka”). The greater it is, the higher the density of the grain, and thus the higher its quality. When this parameter is equal to 750 g/l or higher, the wheat is considered strong; when it is 730 g/l or higher, the wheat is considered valuable. In the new varieties, the weight varied from 630 g/l in unfavorable 2020 to 810 g/l in favorable 2022. In the humid 2020, aside from the standard variety, two other varieties were classified as valuable: Long 98-4723 x Altai 530 and Long 98-4723 x Long 98-5582, both based on Chinese breeds. In 2022, the year of the most comfortable precipitation level, most varieties met the parameters of valuable wheats, while 13 were considered strong ones. The standard DalGAU 3 had the maximum natural weight (Table 2). On average, for 3 years of our research, new varieties from Long 98-4723 x Altayskaya 530 (765.0 g/l) and Ke f eng 11 x Elegya Mironovskaya (746.7 g/l) combinations had the best natural weight.

Table 2. Natural grain weight and adaptiveness parameters of the new varieties of the spring wheat (2020-2022).

Varieties from different combinations	Natural weight, g/l				
	Min	**Max**	**Average**	**X***	**Y****
DalGAU 3 (standard)	740	810	786.7	775	-70
Varieties based on the breed from the Amur Region					
PS-49-09 x Aktyubinka	655	690	672.5	672.5	-35
Amurskaya 1495 x Lada	680	760	726.7	720	-80
DalGAU 1 x Lada	660	710	685.0	685	-50
Average			**694.7**	**692.5**	**-55**
Varieties based on the breed from the Altai Krai					
Altaiskaya 90 x Aryuna	660	705	682.5	682.5	-45
Altaiskaya 90 x Dartnitsa	660	720	690.0	690	-60
Altaiskaya 98 x Pushkinskaya	610	695	652.5	652.5	-85
Altaiskaya 325 x Pushkinskaya	620	690	655.0	655	-70
Altaiskaya 325 x Amurskaya 1495	670	755	718.3	712.5	-85
Altaiskaya 325 x Amurskaya 1495	620	740	693.3	680	-120
Altaiskaya 325 x Amurskaya 1495	640	730	685.0	685	-90
Altaiskaya 325 x Amurskaya 1495	710	730	720.0	720	-20
Altaiskaya 325 x Omskaya	720	730	725.0	725	-10
Altaiskaya 235 x Kef eng 11	660	740	700.0	700	-80
Altaiskaya 235 x Kef eng 11	650	760	716.7	705	-110
Average			**694.4**	**691.5**	**-71**
Varieties based on the breed from Siberia					
Krasa x Darya[1]	685	745	715.0	715	-60

Continuation of Table 2.

Variety from a certain combination	Natural weight, g/l				
	Min	**Max**	**Average**	**X***	**Y****
Varieties based on the breed from Siberia					
Krasa x Darya^2	640	740	705.0	690	-100
Krasa x Darya^3	700	760	730.0	730	-60
Aleksandrina x KSI-16	680	765	731.7	722.5	-85
Aleksandrina x Khabarovchanka	680	730	705.0	705	-50
Katyusha x DalGAU 1	720	770	745.0	745	-50
Average			**722.0**	**717.9**	**-68**
Varieties based on the breed from the Khabarovsk Krai					
(Khabarovchanka x (F9 x Dalnevostochnaya 10)) x Primorskaya 39	690	725	698.3	707.5	-35
Lira 98 x P-2-06	630	750	693.3	690	-120
Lira x k-56104	680	740	720.0	710	-60
Average			**703.9**	**702.5**	**-72**
Varieties based on the breed from China					
Long 98-4723 x Altaiskaya 530	730	785	765.0	757.5	-55
Long 98-4723 x Aleksandrina	650	760	716.7	705	-110
Long 98-4723 x Long 98-5582	730	730	730.0	730	0
Long 98-5582 x Yelegiya Mironovskaya	650	760	716.7	705	-110
Long 98-5582 x Leguan	680	745	721.7	712.5	-65
Long 98-5501 x Amurskaya 1495	700	750	726.7	725	-50
Kef eng 11 x Yelegiya Mironovskaya	715	770	746.7	742.5	-55
Average			**731.9**	**725.3**	**41**

The Katyusha x DalGAU 1 and Kef eng 11 x Yelegiya Mironovskaya combinations had higher compensatory ability; while the overall highest value was observed in the Chinese group. Altai varieties showed the highest stress tolerance. The Chinese varieties, albeit showing the best compensatory ability, were less stress tolerant in this parameter.

The amount of gluten is a very important for grain processing, as it directly correlates with protein content. Most of the new varieties had fairly high gluten content even in unfavorable years. For example, in 2020, out of 30 new varieties, 11 were strong and 6 were valuable. In favorable years, the gluten content increases significantly: 24 samples were strong (with 28% or more gluten), and 4 were valuable (25% or more). The highest amount of gluten was found in the varieties from Long 98-5582 x Yelegiya Mironovskaya (40%) and Altayskaya 235 x Kef eng 11 (39%) combinations, both of which had Chinese origin. On average for 3 years, these same varieties turned out to be the best at this parameter (Table 3).

In 14 new varieties the compensatory ability was higher than that of the standard variety: 4 had parental breed from Altai, 4 from Siberia, 1 from Khabarovsk, and 5 from China. Unlike other parameters, stress tolerance does not really depend on the compensatory ability in terms of gluten. Thus, varieties with high stress tolerance can have high compensatory ability: varieties from Altayskaya 325 x Amurskaya 1495, Altayskaya 325 x Omskaya, Alexandrina x Khabarovichanka with -1, Krasa x Darya^2 (-2), Long 98-4723 x Altaysk 530, and Altayskaya 235 x Kef eng 11 (-4).

Table 3. Hagberg falling number, gluten content and adaptiveness parameters of new varieties of spring wheat (2020-2022).

Varieties from different combinations	Gluten content, %					Falling number, seconds				
	Min	Max	Ave-rage	X*	Y**	Min	Max	Ave-rage	X*	Y**
DalGAU 3 (standard)	25	31	27.7	28.0	-6	105	336	211	220	-231
Varieties based on the breed from the Amur Region										
PS-49-09 x Aktyubinka	18	20	19.0	19.0	-2	61	213	137	137	-152
Amurskaya 1495 x Lada	19	28	24.3	23.5	-9	61	241	124	151	-180
DalGAU 1 x Lada	26	27	26.5	26.5	-1	61	215	138	138	-154
Average			**23.3**	**23.0**	**-4**			**133**	**142**	**-162**
Varieties based on the breed from the Altai Krai										
Altaiskaya 90 x Aryuna	13	22	17.5	17.5	-9	61	196	128	128	-135
Altaiskaya 90 x Dartnitsa	20	32	26.0	26.0	-12	72	196	134	134	-124
Altaiskaya 98 x Pushkinskaya	19	26	22.5	22.5	-7	61	79	70	70	-18
Altaiskaya 325 x Pushkinskaya	19	28	23.5	23.5	-9	61	215	138	138	-154
Altaiskaya 325 x Amurskaya 1495	16	27	22.3	21.5	-11	61	228	140	144	-167
Altaiskaya 325 x Amurskaya 1495	25	30	28.0	27.5	-5	61	218	130	139	-157
Altaiskaya 325 x Amurskaya 1495	26	27	26.5	26.5	-1	61	149	105	105	-88
Altaiskaya 325 x Amurskaya 1495	30	31	30.5	30.5	-1	83	137	110	110	-54
Altaiskaya 325 x Omskaya	31	32	31.5	31.5	-1	189	247	218	218	-58
Altaiskaya 235 x Kef eng 11	29	33	31.0	31.0	-4	61	61	61	61	0
Altaiskaya 235 x Kef eng 11	34	39	36.7	36.5	-5	61	298	152	179	-237
Average			**26.9**	**26.7**	**-6**			**126**	**129**	**-108**
Varieties based on the breed from Siberia										
Krasa x Darya[1]	30	34	32.0	32.0	-4	67	184	125	125	-117
Krasa x Darya[2]	29	31	29.7	30.0	-2	61	262	128	161	-201
Krasa x Darya[3]	20	29	24.0	24.5	-9	61	302	159	181	-241
Aleksandrina x KSI-16	22	28	25.3	25.0	-6	61	277	168	169	-216
Aleksandrina x Khabarovchanka	33	34	33.5	33.5	-1	61	77	69	69	-16
Katyusha x DalGAU 1	29	33	31.0	31.0	-4	83	235	159	159	-152
Average			**29.3**	**29.3**	**-4**			**134**	**144**	**-157**
Varieties based on the breed from the Khabarovsk Krai										
(Khabarovchanka x (F9 x Dalnevostochnaya 10)) x Primorskaya 39	22	30	26.7	26.0	-8	176	316	234	246	-140
Lira 98 x P-2-06	28	33	30.0	30.5	-5	61	196	125	128	-135
Lira x k-56104	19	24	21.5	21.5	-5	61	64	62	62	-3
Average			**26.1**	**26.0**	**-6**			**140**	**145**	**-93**
Varieties based on the breed from China										
Long 98-4723 x Altaiskaya 530	30	34	33.0	32.0	-4	114	317	231	215	-203
Long 98-4723 x Aleksandrina	19	29	25.3	24.0	-10	76	292	180	184	-216
Long 98-4723 x Long 98-5582	28	36	32.0	32.0	-8	125	223	174	174	-98

Continuation of Table 3.

Varieties from different combinations	Gluten content, %					Falling number, seconds				
	Min	Max	Ave-rage	X*	Y**	Min	Max	Ave-rage	X*	Y**
Varieties based on the breed from China										
Long 98-5582 x Yelegiya Mironovskaya	31	40	36.0	35.5	-9	61	350	176	205	-289
Long 98-5582 x Leguan	23	37	30.3	30.0	-14	61	272	149	166	-211
Long 98-5501 x Amurskaya 1495	22	28	25.7	25.0	-6	71	327	189	199	-256
Kef eng 11 x Yelegiya Mironovskaya	26	36	31.0	31.0	-10	63	256	131	159	-193
Average			**30.5**	**29.9**	**-9**			**176**	**186**	**-209**

Hagberg falling number describes the activity of α-amylase in grain, an enzyme that plays a major role in baking. Exceeding or lacking enzyme activity leads to a deterioration of bread quality. In the studied sample, the preferred falling numbers (Herger, 2018; Lipka, 2017) were 250 seconds. However, this trait is very variable because it strongly depends on weather conditions. Thus, in the unfavorable and humid 2020, the enzyme activity was extremely high and amounted to 61 seconds. At the same time, there were 5 varieties with a lacking enzyme activity that did not break down starch well enough; their falling number ranged from 114 to 189 seconds. In years with favorable precipitation, the activity of α-amylase in the grain decreased and the falling number reached 350 seconds (in the variety from Long 98-5582 x Yelegiya Mironovskaya). The varieties from Amurskaya 1495 x Lada (241 sec.), Altayskaya 325 x Omskaya (247 sec.), Krasa x Darya[2] (262 sec.), Alexandrina x KSI-16 (277 sec.), Long 98-5582 x Leguan (272 sec.), and Kef eng 11 x Yelegiya Mironovskaya (256 sec.) combinations were closest to the optimal falling number.

The compensatory ability of the standard variety was 220.5 seconds, while the closest to it were varieties from combinations (Khabarovichanka x (F9 x Dalnevostochnaya 10)) x Primorskaya 39 with 246 seconds, Altayskaya 325 x Omskaya with 218 seconds, and Long 98-4723 x Altayskaya 530 with 215 seconds. Compensatory ability can vary a lot among different varieties, from 62.5 seconds in the Lira x k-56104 combination to 215.5 seconds in Long 98-4723 x Altai 530. Stress tolerance varies as well, from 0 in the Altayskaya 325 x Kef eng 11 to -289 in Long 98-5582 x Yelegiya Mironovskaya. The optimal balance between compensatory ability and stress tolerance was observed in the variety from the combination Altayskaya 325 x Omskaya (-58).

The study of grain quality of new varieties of spring wheat obtained by hybridization using different ecological and geographical origin of source material revealed valuable wheat varieties among them. Table 4 lists the best spring wheat from the competition nursery (Photo 5), the parental forms of which came from Siberia (Novosibirsk and Krasnoyarsk) and China. These varieties met the requirements for strong or valuable wheats in most parameters during the 3 years of our research. Among them, the variety from the Long 98-4723 x Altayskaya 530 combination should be noted separately, which produced a fairly good yield (3.5-5.0 t/ha) and corresponded to strong wheat in all quality parameters of its grain (Table 4).

Varieties based on Altai breeds had high gluten content, but were inferior to the aforementioned varieties in the rest of parameters.

The compensatory ability of some new varieties was higher than that of the standard variety judging by the weight of 1000 grains, gluten content and falling number. There were some varieties with the best vitreousness and natural weight, but they were still inferior to the standard variety DalGAU 3. Most of the new ones were more stress tolerant compared to the standard. Table 5 lists the best varieties according to their adaptiveness parameters; the most promising among them is the

variety from the Long 98-4723 x Altayskaya 530 combination, which is also the best in terms of its technological qualities.

The Altai varieties, used as parental breeds, produce varieties with high gluten content, good compensatory ability and high stress tolerance.

Photo 5. Nursery of variety testing (photo by N.M. Teryokhin).

Table 4. Quality parameters of the best new varieties of spring common wheat from the competition nursery of the Far Eastern State Agrarian University (average for 2020-2022).

Varieties from different combinations	Vitreous-ness, %	Weight of 1000 grains, g	Natural weight, g/l	Gluten content, %	Falling number, seconds
DalGAU 3 стандарт	76.0**	30.4	786.7**	27.7**	211**
Krasa x Darya[1]	46.0	30.3	715.0	32.0**	125
Krasa x Darya[2]	36.7	30.9	705.0	29.7**	128
Aleksandrina x KSI-16	23.0	30.6	731.7*	25.3*	168
Katyusha x DalGAU 1	23.0	35.1	745.0*	31.0**	159
Long 98-4723 x Altayskaya 530	71.0**	31.9	765.0**	33.0**	231**
Long 98-4723 x Long 98-5582	32.0	26.3	730.0*	32.0**	174
Long 98-5582 x Yelegiya Mironovskaya	56.0*	28.8	716.7	36.0**	176
Long 98-5582 x Leguan	48.3	35.7	721.7	30.3**	149
Kef eng 11 x Yelegiya Mironovskaya	38.0	36.0	746.7*	31.0**	131

Notes to Table 4: * – values required for the valuable (protein ≥ 13-14%, gluten ≥ 28%) wheat varieties, ** – values required for the strong (protein ≥ 15%, gluten ≥ 28%) varieties.

Table 5. Adaptiveness parameters of the best varieties of the spring common wheat among the new ones of the DalGAU breed from the competition nursery (average for 2020-2022).

Varieties from different combinations	Vitreous-ness, %		Weight of 1000 grains, g		Natural weight, g/l		Gluten content, %		Falling number, seconds	
	X*	Y**	X*	Y**	X*	Y**	X*	Y**	X*	Y**
DalGAU 3 стандарт	73.5	-29	30.6	-6.3	775	-70	28.0	-6	220	-231
Алтайская 325 x Amurskaya 1495	8.5	-5	26.3	-4.3	720	-20	30.5	-1	110	-54
Алтайская 325 x Omskaya	38.5	-17	24.5	-2.8	725	-10	31.5	-1	218	-58
Краса x Darya[1]	46.0	-4	30.3	-0.5	715	-60	32.0	-4	125	-117
Katyusha x DalGAU 1	23.0	-2	35.1	-2.2	745	-50	31.0	-4	159	-152
Long 98-4723 x Алтайск 530	69.5	-17	32.0	-5.6	757.5	-55	32.0	-4	215	-203
Long 98-5582 x Leguan	47.5	-53	36.5	-5.4	712.5	-65	30.0	-14	166	-211
Kef eng 11 x Yelegiya Mironovskaya	50.5	-25	33.8	-7.0	742.5	-55	31.0	-10	159	-193

Conclusions

1. When the complex of studied technological properties and adaptiveness parameters are considered, the most valuable variety is the one produced from the combination Long 98-4723 x Altaiskaya 530.

2. Varieties from China and the Siberia (Novosibirsk, Krasnoyarsk) offered the best traits of grain quality traits suitable for the environmental conditions of the Amur Region; they produced the most promising breeds. Chinese varieties provided good compensatory ability in terms of vitreousness, natural weight and gluten amount, but a low stress tolerance according in terms of gluten amount. Altai varieties used as parental forms make it possible to obtain breeds with high gluten and a good compensatory ability, as well as with high stress tolerance.

Funding. This work was carried out as part of the state task “Creation and Study of Spring Soft Wheat Source Material in Environmental Conditions of Amur Region for Obtaining High-Yielding Food Varieties”.

REFERENCES

1. Demidova TS. Dynamics of air temperature and vegetation in the Amur region [*Dinamika temperatury vozdukha i rastitel'nosti v Amurskoy oblasti*] *VI All-Russian Scientific and Practical Conference [VI Vserossiyskaya nauchno-prakticheskaya konferentsiya] Ecology and life safety [Ekologiya i bezopasnost' zhiznedeyatel'nosti]*. Khabarovsk, 2015:32-35.
2. Detsina AA Illarionova IV, Shcherbinina VO. Calculation of parameters of ecological plasticity and stability of oilseed sunflower varieties bred by the All-Russian Research Institute of Oilseeds

СПИСОК ЛИТЕРАТУРЫ

1. *Демидова Т.С.* 2015. Динамика температуры воздуха и растительности в Амурской области // VI Всероссийская научно-практическая конференция. Экология и безопасность жизнедеятельности. Хабаровск. С. 32-35.
2. *Децина А.А., Илларионова И.В., Щербинина В.О.* 2020. Расчет параметров экологической пластичности и стабильности

[Raschet parametrov ekologicheskoy plastichnosti i stabil'nosti maslichnykh sortov podsolnechnika selektsii VNIIMK]. *Oilseeds: Scientific and Technical Bulletin of the All-Russian Research Institute of Oilseeds [Maslichnyye kul'tury: Nauchno-tekhnicheskiy byulleten' VNIIMK]*. 2020;3 (183):31-38.

3. Zykin VA. Ecological plasticity of agricultural plants (methodology and assessment) [*Ekologicheskaya plastichnost' sel'skokhozyaystvennykh rasteniy (metodika i otsenka)*]. Ufa, 2011:97.
4. Zykin VA, Meshkov VV, Canera VA. Parameters of ecological plasticity of agricultural plants, their calculation and analysis: Methodological recommendations [*Parametry ekologicheskoy plastichnosti sel'skokhozyaystvennykh rasteniy, ikh raschet i analiz: Metodicheskiye rekomendatsii*]. Novosibirsk: Sibirskoye Otdeleniye VASKHNIL, 1984:1-24.
5. Melekhina TS. Ecological plasticity and stability of varieties of spring and winter wheat, winter rye in terms of yield and grain quality in the conditions of the South-East of Western Siberia [*Ekologicheskaya plastichnost' i stabil'nost' sortov yarovoy i ozimoy pshenitsy, ozimoy rzhi po urozhaynosti i kachestvu zerna v usloviyakh Yugo-Vostoka Zapadnoy Sibiri*] *PhD thesis for agricultural sciences [Avtoref. dis. ... kand. s.-kh. nauk: 06.01.05]*. Kemerovo, 2015:49.
6. Mishchenko LN Terekhin MV. New variety of spring soft wheat of the Amur breed DalGAU 3 [Novyy sort yarovoy myagkoy pshenitsy amurskoy selektsii Dal'GAU 3]. *Far Eastern Agrarian Bulletin [Dal'nevostochnyy agrarnyy vestnik]*. 2019;2 (50):53-57.
7. Murugova GA. Assessment of the source material of spring barley for environmental plasticity in the conditions of the Primorsky Territory [Otsenka iskhodnogo materiala yarovogo yachmenya po ekologicheskoy plastichnosti v usloviyakh Primorskogo kraya]. *Agrarian Bulletin of Primorye [Agrarnyy vestnik Primor'ya]*. 2016;3 (3):26-30.
8. Herger N, Angelil O, Abramowitz G, Donat M, Stone D, Lehmann K. Calibrating Climate Model Ensembles for Assessing Extremes in a Changing Climate. *Journal of Geophysical Research: Atmospheres.* 2018;123 (11):5988-6004.

масличных сортов подсолнечника селекции ВНИИМК // Масличные культуры: Научно-технический бюллетень ВНИИМК. Вып. 3 (183). С. 31-38.

3. *Зыкин В.А.* 2011. Экологическая пластичность сельскохозяйственных растений (методика и оценка). Уфа. 97 с.
4. *Зыкин В.А., Мешков В.В., Canera B.A.* 1984. Параметры экологической пластичности сельскохозяйственных растений, их расчет и анализ: Методические рекомендации. Новосибирск: Сибирское Отделение ВАСХНИЛ. С. 1-24.
5. *Мелехина Т.С.* 2015. Экологическая пластичность и стабильность сортов яровой и озимой пшеницы, озимой ржи по урожайности и качеству зерна в условиях Юго-Востока Западной Сибири. Автореф. дис. … канд. с.-х. наук: 06.01.05. Кемерово. 49 с.
6. *Мищенко Л.Н., Терехин М.В.* 2019. Новый сорт яровой мягкой пшеницы амурской селекции ДальГАУ 3 // Дальневосточный аграрный вестник. № 2 (50). С. 53-57.
7. *Муругова Г.А.* 2016. Оценка исходного материала ярового ячменя по экологической пластичности в условиях Приморского края // Аграрный вестник Приморья. № 3 (3). С. 26-30.
8. *Herger N., Angelil O., Abramowitz G., Donat M., Stone D., Lehmann K.* 2018. Calibrating Climate Model Ensembles for Assessing Extremes in a Changing Climate // Journal of Geophysical Research: Atmospheres. Vol. 123. No. 11. P. 5988-6004.
9. *Lipka O.N.* 2017. Methodological Approaches to Climate Change Vulnerability Assessment of Protected Areas // Nature Conservation

9. Lipka ON. Methodological Approaches to Climate Change Vulnerability Assessment of Protected Area. *Nature Conservation Research.* 2017;2 (3):68-79. Research. Vol. 2. No. 3. P. 68-79.

УДК 633.11

АДАПТИВНОСТЬ НОВЫХ СОРТОВ ЯРОВОЙ ПШЕНИЦЫ ДАЛЬНЕВОСТОЧНОЙ СЕЛЕКЦИИ ПО НЕКОТОРЫМ ПАРАМЕТРАМ КАЧЕСТВА ЗЕРНА

© 2023 г. Н.М. Терехин, Л.Н. Мищенко, М.В. Терехин

Дальневосточный государственный аграрный университет
Россия, 675002, г. Благовещенск, ул. Политехническая, д. 86
E-mail: laridass2@mail.ru, rohan.1994@mail.ru

Поступила в редакцию 02.10.2023. После доработки 01.11.2023. Принята к публикации 15.11.2023.

В статье представлены результаты многолетней селекционной работы по созданию сортов яровой мягкой пшеницы, приспособленных к специфическим экологическим условиям Амурской области, относящейся к зоне рискованного земледелия. Проведен сравнительный анализ 30 новых сортообразцов яровой пшеницы из питомника конкурсного сортоиспытания по качеству зерна и адаптивным свойствам сортов – компенсаторной способности и стрессоустойчивости. Закладка опытов производилась по стандартной схеме в севообороте Научно-исследовательской лаборатории селекции зерновых культур Дальневосточного государственного аграрного университета (Дальневосточного ГАУ) с 2020 по 2022 гг. Наиболее ценным по комплексу изученных технологических свойств является сорт из комбинации Long 98-4723 х Алтайская 530. Компенсаторная способность была лучшей у сорта из комбинации Краса х ДальГАУ 1. Хорошая стрессоустойчивость отмечена по всем признакам у сорта из комбинации Алтайская 325 х Амурская 1495. В обеих комбинациях опылителями были сорта амурской селекции. Были так же определены наиболее перспективные регионы происхождения сортов для использования в качестве родительских форм в гибиридизации. Китайские и сибирские сорта оказались наиболее ценными донорами признаков качества зерна для условий Амурской области, большинство перспективных образцов создано с их участием. Использование китайских сортов дает хорошую компенсаторную способность их потомкам по стекловидности, натуре и количеству клейковины, однако обуславливает низкую стрессоустойчивость по последнему признаку. Использование в качестве материнских форм алтайских сортов позволяет получать образцы, у которых высокое содержание клейковины при хорошей компенсационной способности сочетается с высокой стрессоустойчивостью.

Финансирование. Работа выполнена в рамках темы Госзадания «Создание и изучение исходного материала яровой мягкой пшеницы в условиях Амурской области для получения высокоурожайных сортов продовольственного назначения».

Ключевые слова: сорт, масса 1000 зерен, натура, стекловидность, клейковина, альфа-амилаза, число падения.

DOI: 10.24412/2542-2006-2023-4-126-139
EDN: DOEXJR