ECOSYSTEMS: ECOLOGY AND DYNAMICS, 2023, Vol.7, No. 3, P. 60-69

CONDITION AND FUNCTIONING OF AGROECOSYSTEMS AND THEIR COMPONENTS

UDC 633.11

ADAPTIVENESS AND ECOLOGICAL VERSATILITY OF SPRING COMMON WHEAT OF FAR EASTERN VARIETIES DETERMINED ON A NUMBER OF GRAIN QUALITY PARAMETERS

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Received August 15, 2023. Revised August 29, 2023. Accepted August 30, 2023.

In this article we present the results of comparative analysis, which was carried out for the grain quality of new varieties of spring common wheat from the Amur breeding – DalGAU 3 (released in 2021) and DalGAU 4 (sent for a state variety trial in 2022); and for varieties that have been already released in the Far East Region – Amurskaya 75, Amurskaya 1495 and DalGAU 1. The nurseries were made according to the standard method, in the crop rotation of the Grain Breeding Laboratory. The new varieties DalGAU 3 and 4 surpass the previously released ones in vitreousness, grain content, gluten quantity and Hagberg falling number. Additionally, DalGAU 3 is the coarsest-grained one among the studied varieties. The new varieties of common wheat have higher compensatory ability and stress tolerance in some parameters compared to Amurskaya 75 and 1495 and DalGAU 1.
Keywords: variety, 1000 grain weight, grain unit, grain vitreousness, gluten, α-Amylase, Hagberg falling number, selection, hybrids, released variety.
DOI: 10.24412/2542-2006-2023-3-60-69
EDN: GYNLCE

Yield and quality of wheat depend on many factors, divided into 3 groups: genotype (variety), soil and climatic conditions, production technology. To obtain grain of higher quality it is necessary to optimize the level of these mutually dependent groups. Creation and use of high-yielding, ecologically versatile varieties of wheat are of particular importance in the increase and stability of yield and quality of grain (Novokhatin et al., 2022).

Along with yield, grain quality is also highly important for agriculture (Kuzmin, 2021). High-quality grain is more expensive and can be used in food, while its seeds are of higher sowing qualities. The properties of the produced grain are affected by genetic features of the variety, and agro-technical and climatic conditions of its cultivation.

Weather of the Amur Region can vary dramatically in different years in terms of heat level and precipitation volume. Our region requires varieties of wheat that have potentially high yields and grain quality, as well as high ecological versatility, which determines their ability to level negative environmental factors during their cultivation, and to have high stress tolerance in terms of the main and most important technological parameters of quality (Mishchenko, 2022; Terekhin, 2021; Guttieri, 2001).

Adaptive varieties with increased ecological versatility and ability to use bioclimatic resources more effectively in extensive conditions of cultivation become more and more important (Eberhart, 1966; Barkovskaya, 2023). The relesead varieties should have both high yield and ecological versatility. The versatility is determined in different regions of Russia by yield, elements of plant productivity and individual parameters of grain quality (Malokostova, 2019; Ismagilov, 2022; Sagendykova, 2021).

The aim of this work is to study and compare the adaptive properties of spring common wheat varieties of Far Eastern State Agrarian University's selection according to the technological qualities of its grain, and to identify the advantages of the new variety, DalGAU 4, which was put to the state variety trial in 2022.

Materials and Methods

The varieties of wheat were sown in the experimental fields of the Far Eastern State Agrarian University in the village of Gribskoye, Amur Region. The area of survey plots was 10 m^2. The sowing was done with a SKS-6a seeder, the harvesting was performed with a Sampo-130 harvester (Photo 1, 2). Then, we studied the adaptation of technological qualities of spring common wheat from the Far Eastern selection from 2020 to 2022, using DalGAU 3 variety as a standard.

Photo 1. Harvesting at the selection nurseries with a Sampo-130 harvester (photo by N.M. Terekhin).

Photo 2. Haystacks at the small selection nursery (photo by N.M. Terekhin).

Weather varied significantly throughout the years of our study. The year of 2022 was the most favorable one, with moderate precipitation in May-July – 256 mm. Meanwhile, in 2020, a high precipitation (384 mm) during the same period deteriorated the grain quality. From May to June of 2021, there was moderate precipitation, however, a heavy one (160 mm) in July significantly reduced the quality of the crop since it happened during the grain formation. Excessive precipitation during the ripening and harvesting of spring wheat is one of the main problems in the Amur Region; therefore, one of the breeding aims there was to create the early maturing varieties. However, over the last 20-30 years the climate has changed drastically. At the end of the 20th century the amount of precipitation from June to early July was insignificant, as little as 0-15 mm in June

during some years, but nowadays heavy rains can continue throughout the entire growing season, thus, forcing us to search for new directions in grain breeding in the Amur Region (Photo 3).

Photo 3. Flowering wheat (photo by N.M. Terekhin).

Experiments. Over the past 5 years, a couple of new varieties of Far Eastern University selection were sent to the state variety testing system. DalGAU 3 was successfully released in 2020 and defined as a standard in the state variety plots. The new variety, DalGAU 4, has been under testing since 2022. Over the last 3 years, the 5 most important quality parameters of new varieties were studied in comparison with previously released ones, such as Amurskaya 75, Amurskaya 1495 and DalGAU 1. These parameters are as follows: vitreous, weight, 1000 grain weight, gluten, and falling number.

Results and Discussion

Grain vitreousness is a parameter defined by government standard for valuable and strong wheat varieties. It is determined by the ability of grains to transmit light: grains can be entirely transparent (vitreous) or partially transparent (with yellowed patches, Rus. “zheltobochka”); a grain that barely transmits light or does not transmit it at all is called powdery. Vitreousness is measured as a percentage: the greater the proportion of transparency, the higher the vitreousness, therefore, the higher the vitreousness, the higher the quality of the grain. According to some authors (Kurdina, 1981), vitreousness is positively correlated with grain unit, amount of protein, gluten and gluten quality. Table 1 shows that this trait is higher in new varieties than in previously released ones, both in favorable and unfavorable years, as well as the average for 3 study years. The grain vitreousness of the new varieties DalGAU 3 and 4 (Photo 4, 5) is twice higher than of those

released in the 20th century. Every year, DalGAU 3 corresponded to the parameters of strong wheat because its vitreousness was 60% or even higher. In favorable years, the vitreousness of DalGAU 1 and Amurskaya 1495 reached that of the valuable varieties (i.e. 50% and more), while peaking up to 93% in DalGAU 4.

Compensatory ability of new varieties DalGAU 3 and 4 is higher than that of previously released ones. The complex weather and climate conditions of the Amur Region require our own specific varieties that could be highly adapted to such environment. This is the average indicator for 2 years, i.e. the most favorable and the most unfavorable years. The greater the value of this indicator, the higher the correspondence between the genotype of the variety and the environment.

Table 1. Vitreousness of spring wheat varieties of the Far Eastern State Agrarian University selection and their adaptability parameters (%).

Variety	Release year	Min	Max	Average	Compensatory ability	Stress tolerance
Amurskaya 75	1964	10	46	30.7	28.0	-36
Amurskaya 1495	1998	18	49	37.0	33.5	-31
DalGAU 1	2005	12	54	37.0	33.0	-42
DalGAU 3 (standard)	2020	59	88	76.0	73.5	-29
DalGAU 4	–	47	93	75.7	70.0	-46

Photo 4. Spikes of DalGAU 4 wheat (photo by N.M. Terekhin).

DalGAU 3 had the best stress tolerance in terms of grain vitreousness, while DalGAU 4 turned out to be inferior to the other varieties. Stress tolerance is determined by the difference between the value of the indicators in the most favorable and the most unfavorable years; therefore, it has a negative value. The lower its value, the less influence the environment has on it, and thus the higher grows the stress tolerance of the variety. This is extremely important in the conditions of the Amur Region where vegetation conditions vary significantly in different years.

Natural grain weight is one of the main indicators of wheat grain quality, determined by the weight of 1 liter of grain: the greater the weight, the higher its density, plumness and, eventually, quality. According to the government standard (Government standard …, 2019), the grain is considered strong when its index is higher than 750 g/l, and is considered valuable when it's higher than 730 g/l. The new varieties showed higher quality than previously released ones; the differences between them were especially noticeable in the unfavorable year, when the two new varieties corresponded to valuable wheat by their grain unit, while the previously released varieties had lower indicators (Table 2). In a favorable year, the natural weight of DalGAU 3 and 4 was above 800 g/l, thus meeting the requirements for strong wheat, while the previously released ones did not even meet those requirements.

Photo 5. Grains of DalGAU 4 wheat (photo by N.M. Terekhin).

Compensatory ability of new varieties also turned out to be higher. It was the highest for the old variety Amurskaya 75; meanwhile, the new varieties had a stress tolerance higher than that of Amurskaya 1495 and DalGAU 1, but lower than Amurskaya 75.

Grain coarseness is an important parameter of its processing. Coarse grain is more profitable in flour production, and the industry prefers varieties with larger grains. The mass of 1000 grains of Amur selection was 24.2 g in unfavorable 2020, and 33.7 g in 2022 (Table 3). DalGAU 3 is known

for the largest grain, with an average mass of 1000 grains equal to 30.4 g. DalGAU 4 had the smallest grain (22.3 g) for three years in average. The best stress tolerance was observed in DalGAU 4, while DalGAU 3 showed less tolerance, while having the highest compensatory ability.

Table 2. Natural grain weight of spring wheat of Far Eastern selection and some parameters of its adaptability (g/l).

Variety	Min	Max	Average	Compensatory ability	Stress tolerance
Amurskaya 75	670	715	695.0	692.5	-45
Amurskaya 1495	610	725	673.3	667.5	-115
DalGAU 1	610	740	683.3	675	-130
DalGAU 3 (standard)	740	810	786.7	775	-70
DalGAU 4	730	805	775.0	767.5	-75

When releasing the varieties, the frequency and stability of their formation of high quality grains should be taken into account. The main parameter of the technological merits of the grain of spring common wheat (that defines its adaptability) is the content and quality of gluten, a criteria that is part of the government standard (Government standard …, 2013 Novokhatin et al., 2022).

Table 3. Weight of 1000 grains of spring wheat of Far Eastern selection and some parameters of its adaptability (g).

Variety	Min	Max	Average	Compensatory ability	Stress tolerance
Amurskaya 75	25.4	29.3	27.0	27.4	-3.9
Amurskaya 1495	24.6	31.2	27.0	27.9	-6.6
DalGAU 1	24.2	30.3	26.9	27.3	-6.1
DalGAU 3 (standard)	27.4	33.7	30.4	30.6	-6.3
DalGAU 4	25.4	27.3	22.3	26.4	-1.9

The amount of gluten is extremely important because it directly correlates a with the protein content of the grain. By this parameter only, every year new varieties could be classified as valuable ones (with 25% or more), while the amount of gluten (28% or more) made DalGAU 4 a strong variety in a favorable year. The oldest variety, Amurskaya 75, lost a lot of gluten in an unfavorable year; in favorable years, however, gluten amount corresponded to strong varieties and even exceeded the parameters of new varieties (Table 4). The DalGAU 4 has the greatest compensatory ability and a fairly good stress tolerance. Minimal tolerance was noted in the Amurskaya 75, the amount of gluten of which varied significantly from year to year depending on weather.

Hagberg falling number characterizes the activity of α-amylase in grain, influencing greatly the quality of bread. This amylase is an enzyme that breaks starch down into monosaccharides. Enzyme activity that is too low, which causes starch to break down slowly, and enzyme activity that is too high, which causes starch to break down quickly, are both highly undesirable. The optimal indicator is the interval of 250 seconds during which the press would fall in our test sample. Table 5 shows that old varieties are characterized by greater enzyme activity, which significantly reduced the quality of grain in the unfavorable 2020. The new varieties DalGAU 3 and 4 are closer to the optimal value than the previously released ones, and the compensatory abilities of the new varieties

are higher than those of the old ones. At the same time, the stress tolerance of new varieties is somewhat lower than that of previously released ones.

Table 4. The amount of gluten in the grain of spring wheat of Far Eastern selection and some parameters of its adaptability (%).

Variety	Min	Max	Average	Compensatory ability	Stress tolerance
Amurskaya 75	23	36	30.3	29.5	-13
Amurskaya 1495	20	26	23.3	23.0	-6
DalGAU 1	14	16	15.0	15.0	-2
DalGAU 3 (standard)	25	31	27.7	28.0	-6
DalGAU 4	29	33	31.3	31.0	-4

Table 5. Falling number of spring wheat of Far Eastern selection and some parameters of its adaptability (sec).

Variety	Min	Max	Average	Compensatory ability	Stress tolerance
Amurskaya 75	98	298	191.3	198.0	-200
Amurskaya 1495	61	210	111.7	135.5	-149
DalGAU 1	62	258	128.0	160.0	-196
DalGAU 3 (standard)	105	336	211.1	220.5	-231
DalGAU 4	138	397	242.0	267.5	-259

Conclusions

1. New varieties of spring common wheat of the Far Eastern State Agricultural University selection, such as DalGAU 3 and DalGAU 4, are better than previously released varieties in such parameters as vitreous, weight, gluten and falling number. Their compensatory ability is higher than previously released varieties in such parameters as vitreous, grain unit and falling number.
2. DalGAU 3 is the coarsest among the studied varieties. It has a better compensatory ability judging by the 1000 grain weight, and it has a higher stress tolerance judging by its grain vitreousness.
3. DalGAU 4 has the highest compensatory ability for the amount of gluten, and the highest stress tolerance for the 1000 grain weight and gluten. Currently, this variety is undergoing state variety testing, the results of which can potentially allow it to be released in the Far East Region.

Funding. This work was carried out as part of the state task “Creating and Researching the Original Material of the Spring Common Wheat in the Conditions of the Amur Region to Obtain Highly Profitable Food Varieties”.

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УДК 633.11

АДАПТИВНАЯ СПОСОБНОСТЬ И ЭКОЛОГИЧЕСКАЯ ПЛАСТИЧНОСТЬ СОРТОВ ЯРОВОЙ МЯГКОЙ ПШЕНИЦЫ ДАЛЬНЕВОСТОЧНОЙ СЕЛЕКЦИИ ПО РЯДУ ПАРАМЕТРОВ КАЧЕСТВА ЗЕРНА

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Поступила в редакцию 15.08.2023. После доработки 29.08.2023. Принята к публикации 30.08.2023.

В статье представлены результаты сравнительного анализа качества зерна новых сортов яровой мягкой пшеницы амурской селекции – ДальГАУ 3 (районирован в 2021 г.) и ДальГАУ 4 (передан в государственное сортоиспытание в 2022 г.) с ранее районированными сортами по Дальневосточному региону местными сортами Амурская 75, Амурская 1495 и ДальГАУ 1. Закладка питомников производилась по стандартной схеме в севообороте лаборатории селекции зерновых культур. Новые сорта ДальГАУ 3 и ДальГАУ 4 лучше ранее районированных по стекловидности, натурной массе, количеству клейковины и числу падения. Сорт ДальГАУ 3 является наиболее крупнозерным из изученных сортов. Новые сорта обладают более высокой компенсаторной способностью и стрессоустойчивостью по ряду параметров по сравнению с сортами Амурская 75, Амурская 1495 и ДальГАУ 1.

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

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».

DOI: 10.24412/2542-2006-2023-3-60-69
EDN: GYNLCE