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ESTIMATION OF HOMEOSTATIC PARAMETERS OF BARLEY VARIETIES COLLECTION IN THE CONDITIONS OF THE NORTHERN FOREST-STEPPE OF SVERDLOVSK REGION

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ABSTRACT

The article shows the reaction of spring barley varieties to the meteorological conditions of The South-West of the Sverdlovsk region (2011-2019) in terms of grain yield. Of the 224 collectible varieties, 15 were selected. Based on Ebehart and Russel (1966) methodology, the most responsive to improvements in cultivation conditions, or plastic varieties are identified: Nevada, Farmer, Abava, Cecilia, Mona, Jaromir, Nur, and Sonet, which have ecological plasticity (Bi) more than 1. There are significant advantages of several genotypes that are most adaptive to the weather conditions of the region including Nevada, Vorsinsky, Farmer, and Omski 95 (common adaptive capability (CACi or v_i) 0.15-0.31, according to Kilchevsky and Khotyleva (1985)). The high degree of stability of the reaction was in the Acha variety (σ^2CACi 2.26; relative stability of yield (S_{gi}) 33.1%). To achieve an optimal balance in the selection of productivity and stability, the parameter S_{GI} (selection value of the genotype) is used. In our experience, the following varieties were distinguished by this parameter: Nevada (3.31), Omski 95 (3.31), and Acha (3.20). Nevada and Omski 95 combine a high adaptive capacity to the agro-climatic conditions of the region (vi 0.15-0.31) and relative stability of yield (S_{gi} 33.6-35.3%), also, Nevada belongs to the plastic varieties (Bi ≥ 1). Among the selection-valuable varieties, Acha is the least adaptive to local conditions, as characterized by the most stable yield (S_{gi} 31.1%).

Disciplinary: Agricultural and Crop Sciences.

1 INTRODUCTION

Sustainable yield growth in the variety change is the most important task of the selection of any

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agricultural crop. A promising genotype should ensure high grain yield in all conditions from stressful to favorable. The highest response in yield with improved growing conditions characterizes the genotype as having high ecological plasticity, the ability to maintain a stable yield under various environmental conditions as having a stable genotype response to productivity. The combination of these two characteristics ensures the selection of the most adaptable varieties to local conditions.

Various statistical approaches to the analysis of genotype X environment interaction are reflected in a large number of papers (Vorobyov, 2011; Arshadi et al., 2018; Zargar et al., 2018; Kosev et al., 2019). Among these approaches, the S.A. Ebehart, W.A. Russel (1966) method is widely used, where the ecological plasticity *(Bi)* and stability of genotypes (σ^2_d) are estimated using linear regression analysis. Linear regression is also used in the Tai (1971) method, where environmental changes are reflected as a linear response (α_i) by productivity, also, there is an indicator of deviation from the linear response (λ_i) (Eberhart & Russell, 1966; Tai, 1971). The adaptive response of genotypes is evaluated using the method of Kilchevsky and Khotyleva (1985) (Kilchevsky & Khotyleva, 1985a; Kilchevsky & Khotyleva, 1985b). Here, CAC_i (common adaptive capability (Vi)) is estimated as the difference between the average productivity of an individual variety $(\bar{x}_i)$ under various environmental conditions and the total average productivity *(u)* for all varieties and environments. Specific adaptive capability in a particular environment is estimated as a deviation from the sum of the CAC_i and the total average productivity *(u)* for all varieties and environments.

The object of the research performed is the selection of barley varieties most adaptive to the environmental conditions of the Northern forest-steppe of the Middle Urals.

2 CONDITIONS, MATERIALS, AND METHODS

The research was performed in 2011-2019 at the laboratory of barley breeding and seed growth of the Ural Research Institute of Agriculture - branch of the FSBSU UrFARC UrB RAS.

Figure 1: Research plots of field experience.

The field experiment took place at the site of the Krasnoufimsky Breeding Center in the Western part of the Sverdlovsk region (56°37′ North latitude, 57°46′ East longitude). Experimental plots were laid during 2011-2019 on dark gray forest soil (pH ha (4.9-6.9), hydrolytic acidity (4.11-5.20 mg, EQ/100g of soil), humus content (6.6-8.1%), easily hydrolyzed nitrogen (83...149 mg/kg), volume potassium (131-184 mg/100 g), phosphorus content (289-409 mg/kg)). The plot area was 5 m^2. (Figure 1). Tier – three times. Background with pure steam, Harvesting combine Hege-125A, Harvest accounting after threshing and conditioning, with a reduction to 14 percent humidity, and one hundred percent purity.

Environmental changes during 2011-2019 have average daily air temperature 13.4-17.9°C, the sum of temperatures over 10°C 1200-1800°C, precipitation 86-374 mm, moisture reserves in soil meter-deep layer 66-194 mm, HTC - 0.71...2.44.

HTC - Selyaninov Hydrothermal Coefficient (HTC). It is determined by the ratio of the sum of precipitation (r) in mm for a period with average daily air temperatures above 10 °C to the sum of temperatures (∑t) for the same time, reduced by 10 times (HTC = r / 0.1 Σ t) (Gordeev et al., 2006).

Samples of spring two-row barley were used, of which the article lists 15 of the best in terms of homeostaticity.

To check the influence of genotypes and environmental conditions on yield, this study used two-factor analysis of variance ANOVA (Dospekhov, 1985), adaptive capability and stability of varieties according to Kilchevsky and Khotyleva (1985), ecological plasticity and stability (Ebehart, and Russel, 1966).

The study uses a formula for determining the overall adaptive capacity, which is taken from the Kilchevsky and Khotyleva methodology (1985):

$$\text{CACi} = \text{vi} = \bar{x}_i - u, \quad (i = 1, \dots, m) \qquad (1),$$

where vi is the common adaptive capacity, dimensionless, effect of the i-th genotype; $\bar{x}_i$ is the average value of a variable quantitative characteristic i-th genotype, depending on the effect of environments; u – the total average value of the quantitative trait for all environments and genotypes; m – the number of genotypes in the experiment.

3 RESULTS AND DISCUSSIONS

After the analysis of variance carried out, the predominant influence of environmental factors was revealed (86.5%). The grading factor determined only 0.7% of yield changes, and genotype X environment interaction 12.8%. The null hypothesis for all factors is rejected, since ($F_f > F_{05}$).

Estimation of homeostatic parameters using the Ebehart and Russel (1966) method identified two groups of genotypes. The first group includes genotypes that under the influence of the external environment are subject to a relatively higher change in yield, they have Bi>1: Nevada, Farmer, Abava, Cecilia, Mona, Yaromir, Nur, and Sonet. Especially plastic variety - Mona (Bi = 1.16). The second group (Bi<1) is characterized by lower yield variation under different environmental conditions: Vorsinsky, Omski 95, Birka, Gostinets, Gonar, Raushan, and Acha and Binom (Table 1).

According to stability (σ^2_d - 0.14-0.25), the following varieties should be distinguished: Nevada, Cecilia, Gostinets, and Gonar. These varieties are not highly homeostatic: Vorsinsky and Mona (σ^2_d 1.11-1.68) (Table 1).

Table 1: Parameters of ecological plasticity and stability of varieties, according to Ebehart and Russel (1966), 2011-2019.

Variety	Origin	Yield, t/ha	Plasticity (Bi)	Stability, (σ^2_d)
Nevada	Russia	5.37	1.01	0.14
Vorsinsky	Russia	5.24	0.99	1.68
Farmer	Russia	5.22	1.10	0.43
Omski 95	Russia	5.21	0.85	0.74
Abava	Latvia	5.20	1.05	0.93
Cecilia	Sweden	5.20	1.00	0.18
Birka	Sweden	5.18	0.92	0.46
Gostinets	Belarus	5.05	0.97	0.24
Mona	Sweden	5.03	1.16	1.11
Gonar	Belarus	5.02	0.93	0.25
Raushan	Russia	4.99	0.94	0.33
Yaromir	Russia	4.90	1.06	0.62
Nur	Russia	4.84	1.13	0.35
Acha	Russia	4.84	0.74	0.56
Sonet	Russia	4.81	1.14	0.53

The following varieties were characterized by the highest common adaptive capability (v_i) (Kilchevsky and Khotyleva method (1985): Nevada, Vorsinsky, Farmer, and Omski 95 (v_i 0.15-0.31). The least adaptive in the study years were Nur, Acha, and Sonet (v_i -0.22 to -0.37).

This method also determines the stability of genotypes (parameter σ^2_{CACi}), among the selected varieties, this characteristic is the highest for the Acha variety (σ^2_{CACi} 2.26), the most unstable varieties are Mona and Vorsinsky (σ^2_{CACi} 4.82-5.71). The relative stability (S_{gi}) fluctuated in the range of 33.1-47.5 %. Acha also has an advantage in this indicator (33.1%). Thus, fluctuations in environmental factors are projected to a lesser extent on the yield of the Acha variety.

Table 2: Parameters of adaptive capability and stability of varieties, according to Kilchevsky and Khotyleva (1985), 2011-2019.

Variety	Yield, t/ha	Common adaptive capability, CAC, v_i	The variance of specific adaptive capability, σ^2_{CACi}	Relative stability, S_{gi}	Selective genotypic value SGV_i
Nevada	5.37	0.31	3.59	35.3	3.31
Vorsinsky	5.24	0.17	4.82	41.9	2.84
Farmer	5.22	0.15	4.60	41.1	2.88
Omski 95	5.21	0.15	3.06	33.6	3.31
Abava	5.20	0.14	4.61	41.3	2.86
Cecilia	5.20	0.13	3.56	36.3	3.14
Birka	5.18	0.11	3.28	35.0	3.21
Gostinets	5.05	-0.01	3.42	36.6	3.03
Mona	5.03	-0.04	5.71	47.5	2.42
Gonar	5.02	-0.05	3.12	35.2	3.09
Raushan	4.99	-0.06	3.26	36.2	3.02
Yaromir	4.90	-0.16	4.43	42.9	2.61
Nur	4.84	-0.22	4.76	45.0	2.47
Acha	4.84	-0.23	2.26	31.1	3.20
Sonet	4.81	-0.37	4.67	46.0	2.34

However, the most informative parameter is considered to be the selective genotypic value (SGV_i). Mathematically, this parameter has a broader meaning, since it combines two qualities of adaptability: on the one hand, it is the common adaptive capability (CAC_i), on the other hand, the stability of the reaction over the years (σ^2_{CACi}). That is, varieties with high values of this indicator can maintain a high yield under these conditions, while it is stable over the years. In our experiment the following varieties were distinguished by this parameter: Nevada (3.31), Omski 95 (3.31) and Acha (3.20). Varieties: Sonet, Nur, Yaromir, and Mona are distinguished by separate indicators, but they do not have a high selective value (SGV_i 2.34-2.61) (Table 2).

4 CONCLUSION

According to the results of studying the reaction of two-row barley varieties of spring barley in the Northern forest-steppe of the Sverdlovsk region to environmental changes that were observed during 2011-2019, three selective-valuable (SGV_i) genotypes were identified including Nevada (3.31), Omski 95 (3.31), and Acha (3.20). Nevada and Omski 95 combine a high adaptive capability to the agroclimatic conditions of the region (CAC 0.15-0.31) and relative stability of yield (S_{gi} - 33.6-35.3%), in addition, Nevada belongs to plastic varieties (Bi≥1). Acha is the less adaptable to local conditions among the selective-valuable varieties, but it is characterized by the most stable yield (S_{gi} 31.1%).

5 AVAILABILITY OF DATA AND MATERIAL

Information can be made available by contacting the corresponding author.

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