С.Сейфуллин атындағы Қазақ агротехникалық университетінің Ғылым жаршысы (пәнаралық) = Вестник науки Казахского агротехнического университета им. С.Сейфуллина (междисциплинарный). - 2020. - №4 (107). – P.70-80

THE USE OF MULTIVARIATE FACTOR ANALYSIS IN THE SELECTION OF SPRING BARLEY FOR ADAPTABILITY TO VARIOUS ENVIRONMENTAL CONDITIONS

Tokhetova L.A., *Dr. Agr. Sc., docent*
Akhmedova G.B., *doctoral student*
Akzhunis R.A., *master student*
NC JSC «Korkyt Ata Kyzylorda University»
120014, Kyzylorda, Aitekebie str. 29A, Kazakhstan
E-mail: lauramarat_777@mail.ru

Abstract

Multivariate analysis of variance of quantitative and morpho-biological traits of 155 samples of barley (Hordeum vulgare L.) of different ecological and geographical origin made it possible to identify the most adaptively valuable traits, which include the germination rate under saline conditions, the total weight of 14-day-old seedlings, the number and length of seminal roots. Of the production traits, the number of grains per ear, grain weight per ear and protein content in combination with early maturity are significant. Statistical analysis of the data has shown that the studied variety samples according to the “number of grains per ear” and “grain weight per ear” traits demonstrate a consistently high positive correlation relationship, regardless of the years of study and their cultivation areas. In this regard, the “number of grains per ear” trait can be used as the main factor in increasing crop yields in adverse ecosystems of the Aral Sea region of Kazakhstan.

Keywords: adaptability parameters, barley, correlation, variability, selection.

Introduction

Knowledge of the implementation feature of the genetic potential of plants, depending on environmental conditions, is essential in controlling the volume and quality of the yield of cultivated plants. Genetic improvement of crop yields under potential (Yp) and water scarce conditions (Yw) will be an important avenue to improved food security over the next four decades, at the end of which projected demand for food, feed and biofuel feedstock is expected to level out [1]. There are several routes to improve potential and water scarce conditions and a number of candidate traits and genes are available. Here we identify photosynthetic capacity and root system function as two which we believe offers most promise in the future. A major consideration is that most of the important traits are genetically complex creating an added challenge. In addition, there prevails an unrealistic view of the time taken to incorporate new traits into varieties for farmers. In the case histories we considered of successful examples of trait integration into breeding the timescale from initial research to the release of new cultivars to farmers or to proof-of-concept in elite germplasm was around 20 years [2]. Changes in crop productivity are difficult to predict but can be explored by scenarios that represent alternative economic and environmental pathways of future development. Ewerta et al [3] developed a simple static approach to estimate future changes in the productivity of food crops in Europe as part of a larger approach of land use change assessment for four scenarios of the IPCC Special Report on Emission Scenarios (SRES) representing alternative future developments of the world that may be global or regional, economic or environmental.

It is evident that in each of the areas of research directly or indirectly related to this task, one can distinguish different levels of achievements: from hypotheses and models to specific recommendations that the plant breeder and agronomist will be able to use in their practical activities [4]. For example in research by scientist Ramazan Ayranci [5] yield and yield components of 24 winter bread wheat cultivars selected according to registration years were examined and genetic progress was evaluated for these properties by regression analysis method. He found that the annual increase in yield of varieties with genetic progress was 1029 kg da-1. Plant breeders and geneticists as well as statisticians have developed long standing interest in investigating and integrating genotype (G) and genotype-by- environment (GE) in selecting superior genotypes in crop performance trials [7]. It also points out that, using the traditional variation analysis model (ANOVA) or the General linear model (GLM), which provides correct analysis only if all effects are fixed. Ignoring or mishandling random effects can inadvertently lead to inadequate analysis and, consequently, to questionable conclusions appearing in the scientific literature

.

Literature review

In the breeding process, to characterize certain properties of the studied variety or group of varieties, as a rule, many different traits of plant are considered on the basis of the researcher's intuition, their practical experience, and, at the very best, logical analysis. Moreover, often, some of the traits turns out to be unnecessary, because it does not contain meaningful information or is very variable. Factor analysis allows, firstly, to single out from the whole variety of parameters under study the most significant ones and, secondly, to combine some of them into groups that have a common internal essence, i.e., to express the studied parameters in terms of externally hidden factors. The value of factor analysis also lies in the fact that it does not require preliminary hypotheses; on the contrary, it itself can serve as a method of hypothesizing based on data obtained by other methods [8]. «Manova» is a procedure for assessing differences among several nonmetric dependent variables based on the linear combination of several metric dependent variables. This procedure enables the simultaneous examination of several dependent variables. «Manova» was used by Golinski [9] to assess the effect two pathogens (Fusarium avenaceum and F. culmorum) on three yield components (1000-grain weight, and weight and number of kernels per winter wheat head) of 14 winter wheat cultivars in a two year study. Sanogo and Yang [10] provided remedial measures with examples, in which response variables are temporally and spatially dependent. They also provided a general guideline to choosing multivariate statistical tools based on the nature of independent, dependent and interdependent variables [11-13]. However, Nayak et al. [14] believe that the application of new advanced statistical tools, such as linear and nonlinear mixed models, in the analysis of disease epidemics has yet to be done. You should not expect that one method / model can cover everything and answer all the questions about a complex system. Biological processes are in a constant state of flux, and it is unlikely that all accidents can be considered by even the most complex model. The model should be quite complex, but no more than necessary to answer the questions posed. Among several models developed so far in the field of plant pathology, only one type of model is widely used in the agricultural industry, from farmers to researchers/ experts. Selecting durum wheat genotypes with broad adaptability in different environments is important before recommending them to achieve a high rate of genotype adoption. Thus, the combined ANOVA analysis of data on the yield of 20 media allowed by scientists to identify very significant differences between genotypes and media, as well as a significant interaction of GE indicated a differential performance of genotypes compared to test media. Such research allows you to purposefully conduct breeding work.

Source material, methods and conditions for research

The purpose of our research is based on the search for sources of morphological and economically valuable traits for creating highly productive barley varieties adapted to the stress conditions of the Aral Sea region using multivariate factor analysis methods.

Selection for one or several traits, without taking into account others associated with them, may lead to undesirable consequences. Therefore, to identify groups of traits unified in its essence, of the whole totality of the studied ones, we used the method of principal components, which allowed us to identify eight major factors, which accounted for 77% of the genotypic variance of the source traits, explaining the interdependence of the studied indicators for 155 varieties and collection numbers in two contrasting zones of Kazakhstan on soil and climatic conditions: - rice systems of the Kyzylorda region; - piedmont zone of the Almaty region.

The climate of the Kyzylorda region is sharply continental, hot, dry summers and cold winters with unstable snow cover. The average annual air temperature is 9.8^{0}C. The climate of the region is very arid. The mean annual precipitation is 129 mm. In some dry years, the fall of rain can be only 40-70 mm. The soil of the experimental field is meadow-boggy, typical for the rice crop rotation of the region. It has a low humus content of up to 1%, a low porosity and a rather high value of dissolved solids of up to 2%. Salinity is chloride-sulfate. Ground waters are at a depth of 1-2 m, salinization of the soil is 15–20 dS/m.

The climatic conditions of the piedmont zone of the Almaty region are characterized by cold winters, hot and dry summers, warm and dry autumn. The average air temperature is 7.6^{0}C. The mean annual precipitation is 414 mm. The soil cover is represented by light-chestnut, loamy, more rarely by sandy-loam soils. The humus content reaches up to 3%.

The object of research was 155 collection samples of the countries of near and far abroad. In laboratory conditions, the plants grown up to two weeks of age are taken for analysis: selection of the 10 most aligned plants, determination of seedling length, root length, leaf area, weight of leaves and roots, and a number of other derived values (leaf surface density, top-root weight ratio), as well as biometric analysis has been carried out according to the methodology of the N.I. Vavilov All-Russian Research Institute of Plant Industry [15, 16].

Sowing of the collection samples was carried out manually. The row length was 1 m in three replications; the placement of the samples was randomized. The distance between the rows was 15 cm, between the seeds in a row was 5 cm. tending the crops of experimental plots was carried out during the growing season. Harvesting was carried out manually as they matured. The main indicators and elements of the yield structure was determined in the plants selected in the full maturity stage: the duration of the growing season, plant height; productive tilling capacity; last internode length; ear length; number of spikelets per ear; number of grains per ear; grain weight per ear, per plant; thousand grain weight; grain weight per 1 m². Factor and correlation analyzes were performed using the ANOVA application program package according to the data for 2014-2019.

The hydrothermal index (HTI) was determined as the ratio of the precipitation amount for a certain period, multiplied by 10, to the sum of effective temperatures above 10°C for the same period. Humidification is optimal if HTI = 1–1.5, excess if HTI is more than 1.6, insufficient if HTI is less than 1, low if HTI is less than 0.5. Or classification of humidification zones according to HTI: wet – 1.6-1.3; slightly arid 1.3-1.0; arid – 1.0-0.7; very arid 0.7-0.4; dry - <0.4.

Research results

Lack of attention to climate changes at the present time is fraught with major economic consequences in the future [17-19]. No economy in the world today is able to actively resist global climate changes and the increasing frequency of formation of extreme weather events. Studies of many years have shown that to date the most cost-effective method for overcoming negative environmental factors is the selection-genetic one, which allows overcoming the water scarcity and a number of other limiting factors owing to adaptive productive varieties.

The Kyzylorda region is geographically located in extremely unfavorable conditions for crop production, where there is a decrease in the water resources of the transboundary Syrdarya river, which creates certain threats in ensuring guaranteed water supply to irrigated lands, causing intense desertification, salinization and deflation of soils, which can become the main obstacle to sustainable economic growth and social development of Kazakhstan. Therefore, within the framework of the crop production diversification program of the Kyzylorda region, it is planned to expand the area under less-water-consuming agricultural crops, including fodder-grain crop - barley, which is one of the leading crops in the world, due to its adaptive capabilities, high yield and versatile use.

It should be noted that various conditions of moisture supply and temperature regime during the years of research made it possible to give an objective assessment of the collection samples of spring barley. Thus, the most adverse weather and climate conditions were the years 2014, 2017, 2018 and, according to the hydrothermal index, they were characterized as hyperarid. The hydrothermal index for the entire growing period was not more than 0.12. The average daily temperatures during the initiation of reproductive organs exceeded the long-time average annual indicators by 5 and 3°C. During the flowering period of barley, daytime temperatures reached more than 40°C, which significantly reduced the set of grains. Precipitation during the "earing-ripening" period did not have a positive effect on the crop yield, since during this period the plants were in the wax-ripeness stage. Such conditions contributed to the rapid passage of the key stages of barley development, in particular, "tillering-booting" (HTI = 0.03) and "booting- earing" (HTI = 0.04), except for the "sowing-seedlings" period, when the sum of effective temperatures were insufficient for germination of grain, which led to the late emergence of seedlings and a decrease in field germination. In this regard, in 2014 a shortening of the growing period was observed and averaged 74 days. The proportion of early-maturing samples in the collection was more than 75%.

Although, according to HTI for the entire growing period of 2015, 2016, 2019, they are described as arid, but they are characterized by sufficient moisture supply during such critical periods as "tillering-booting" (HTI = 1.55) and "booting- earing" (HTI = 1.17), which has positively affected the formation of reproductive organs and determined the high yield of barley in these years.

To determine the dependence of the duration of the growing period on meteorological conditions, a correlation analysis was carried out between the moisture and heat supply, as well as the hydrothermal index and the duration of the growing stages by varieties. A strong influence of moisture supply conditions on the duration of the barley growing period has been revealed, which is confirmed by high correlation coefficients ($r = 0.83 \dots 0.91 \pm 0.2$). Regardless of the variety, an increase in precipitation and a decrease in the sum of effective temperatures contributed to the extension of the growing period. Analyzing the correlation dependence between the interstage periods and the duration of the growing period, it has been found that a change in the duration of any period leads to a significant change in the duration of the entire growing period. Thus, an analysis of the duration of the growing period showed that simultaneously ripening variety samples often differ sharply in the duration of individual stages [20].

The first component accounts for 25% of the total variation and, irrespective of cultivation zones, has maximum loads on the length of 14-day-old seedlings (0.33 and 0.32), the length (0.33 and 0.32) and area of seedling leaf (0.32), and the total weight of 14-day-old seedlings (0.32) in 1.5% NaCl solution (table 1).

Table 1 - Factorial table of selection traits of barley samples (Kyzylorda region)

Traits	1	2	3	4	5	6	7	8
Growing period, days	0.01	-0.13	0.15	0.20	0.07	**0.33**	0.18	0.13
Plant height, cm	0.02	0.21	0.16	0.01	**0.37**	-0.29	0.10	0.31
Number of ears 1 m²	0.03	0.13	**0.31**	0.26	-0.11	0.24	-0.08	-0.01
Upper internode length, cm	-0.01	0.25	-0.06	**0.34**	0.15	-0.12	0.09	0.12
Ear length, cm	-0.04	0.18	0.01	0.07	0.01	-0.08	-0.21	-0.07
Number of grains per ear, pcs	-0.06	**0.33**	0.25	-0.07	0.22	-0.07	-0.05	0.15
1000-grain weight, g	0.06	-0.02	**0.30**	0.25	-0.18	0.06	0.03	-0.36
Grain weight per ear, g	-0.04	**0.31**	0.30	0.13	0.07	-0.05	-0.15	0.00
Yield, g/m²	-0.05	0.26	**0.32**	0.24	0.05	0.05	-0.08	0.09
Protein, %	-0.01	**0.27**	-0.35	-0.01	0.09	-0.29	-0.11	-0.11
Starch, %	-0.01	-0.18	0.26	0.12	-0.09	**0.31**	0.26	0.19
Extractivity, %	0.01	-0.02	0.13	-0.02	0.10	**0.45**	-0.02	-0.23
Germination rate in 1.5% NaCl solution	**0.32**	-0.04	0.12	0.12	0.18	0.16	0.08	-0.01

Length of 14-day-old seedlings, cm	**0.33**	0.02	0.06	-0.09	0.03	-0.02	0.08	-0.02
Length of seminal roots, cm	0.25	-0.13	0.12	-0.01	0.03	-0.21	0.01	0.06
Length of seedling leaf, cm	**0.33**	-0.01	0.13	-0.09	0.01	-0.06	0.05	-0.04
Area of seedling leaves, cm	**0.32**	-0.01	0.12	-0.11	0.01	-0.06	0.05	0.01
Leaf surface density, mg/cm²	-0.14	0.14	-0.28	0.08	0.24	0.09	**0.36**	0.03
Weight of seedling leaves, g	0.29	0.12	-0.04	-0.11	0.17	0.08	**0.27**	-0.04
Weight of seedling roots, g	0.18	-0.28	0.05	**0.30**	-0.08	-0.22	-0.07	0.01
Radicle thickness, mm	-0.01	0.21	0.09	-0.04	-0.39	-0.16	**0.45**	-0.13
Stem thickness, mm	0.06	-0.21	-0.11	0.05	**0.44**	0.14	-0.33	0.19
Layers of leaves, pcs	-0.02	-0.08	0.05	-0.15	**0.33**	0.03	0.09	-0.49
Total weight of 14-day-old seedlings, g	**0.32**	-0.04	0.16	0.07	0.09	-0.05	0.18	-0.02
Total weight ratio to leaf area, mg/cm²	-0.06	-0.03	-0.26	**0.37**	0.15	-0.01	0.28	0.04
Top-root weight ratio, mg	-0.04	0.09	-0.01	-0.43	-0.14	0.18	0.02	**0.35**
Root-top weight ratio, mg	0.09	-0.31	0.07	**0.31**	-0.20	-0.20	-0.15	0.02
Germination rate in sucrose solution 14 atm.,%	0.29	0.19	-0.23	0.04	-0.14	0.16	-0.02	**0.30**
Number of seminal roots of 7-day-old seedlings in sucrose solution, pcs	**0.31**	0.22	-0.17	**0.24**	-0.13	0.04	-0.28	-0.08
Length of seminal roots of 7-day-old seedlings in sucrose solution, cm	0.29	0.20	0.18	0.06	-0.12	0.19	-0.12	0.06
Variance of components, %	*8.16*	*4.03*	*3.59*	*2.55*	*2.11*	*1.93*	*1.73*	*1.47*
Impact ratio of components, %	*25*	*12*	*11*	*8*	*6*	*6*	*5*	*4*
Cumulative value, %	*25*	*37*	*48*	*56*	*62*	*68*	*73*	*77*

Rice is the main crop in the irrigated agriculture zone of the Aral Sea region of Kazakhstan. The rice culture is hygrophytic and requires a large amount of irrigation water as well as a washing irrigation regime, which contributes to the leaching of salts from rice paddies. In the rice crop rotation, an active process of salt accumulation in the soil occurs after the rice stage. This happens because of the secondary soil salinization. In the conditions of the Kyzylorda region, the highest loads are also observed in the germination rate in 1.5% NaCl solution (0.32) and the number of seminal roots of 7-day-old seedlings in sucrose solution (0.31). Based on the meaning of these traits, the first component can be called the adaptability factor, which has the greatest impact on the volume and quality of the yield in the environmentally unfavorable conditions of the Aral Sea region of Kazakhstan. Thus, the intensity of the early growth determines the resistance to salinity in the early stages of ontogenesis of barley plants, accordingly, to the fullness of seedlings, optimal plant stand and total yield. The number of seminal roots in sucrose solution to a large extent predetermines adaptive capacity to drought, associated with low relative air humidity during the formation of reproductive organs.

In studies by Acreche [1] of different wheat varieties representing different epochs of genetic improvement in the Mediterranean region of Spain, yields were linearly and positively related to the number of grains per m2, while the average grain weight did not show any clear trend with the year of production of varieties. The increase in the number of grains was more associated with an increase in the number of grains per ear than with differences in the number of ears per m^2.

Abera K. [21] has identified the strong positive correlation of root length with thousand seed weight, harvest index and grain yield in combination with other agronomic performances in the field could be used as selection criteria for drought tolerance. Our analysis has revealed that the maximum loads on the second factor (13% of the total variance) in the conditions of the Almaty region have the number of grains per ear, 1000-grain weight, grain weight per ear, yield and is construed as a productivity factor (table 2). In the conditions of the Kyzylorda region, the production traits are conditionally divided into two types, so on the second factor, with a maximum load of the total variance of 12%, has included the number of grains per ear, grain weight per ear, protein content and is called the ear productivity factor, the third factor (11% of the total variance), combining the number of ears per 1 m^2, 1000-grain weight and yield is called the plant productivity factor. The cumulative variance of the final productivity factor in the conditions of the Kyzylorda region is 23%. The third (10%) and fifth factors (6%) in the Almaty region; the fourth (8%), seventh (5%) and eighth (4%) factors in the Kyzylorda region are characterized by us as physiological.

The main limiting factor in the conditions of the Aral Sea region of Kazakhstan is the climate aridity, in this respect, the physiological factor that have maximum loads on the upper internode length (0.34), the weight of roots of 14-day-old seedlings (0.30), the total weight ratio of plants to leaf area, mg/cm² (0.37), the root-top weight ratio (0.31), the radicle thickness (0.45) determines the resistance of the varieties during critical growing periods, that is, at an earlier age.

Table 2 - Factorial table of selection traits of barley samples (Almaty region)

Traits	1	2	3	4	5	6	7	8
Growing period, days	0.06	-0.05	-0.22	-0.02	0.16	0.19	-0.18	0.05
Plant height, cm	-0.01	0.24	-0.09	0.05	0.26	-0.07	-0.10	**0.35**
Number of ears 1 m²	0.01	0.02	-0.09	-0.13	0.27	-0.01	**0.28**	-0.50
Upper internode length, cm	0.08	0.11	-0.03	-0.05	-0.09	-0.19	**0.37**	-0.09
Ear length, cm	0.03	0.18	0.16	-0.06	-0.13	0.05	0.03	0.42
Number of grains per ear, pcs	0.04	**0.36**	-0.01	-0.12	-0.18	0.13	0.11	-0.14
1000-grain weight, g	0.11	**0.33**	0.01	0.01	0.15	0.12	-0.31	-0.01
Grain weight per ear, g	0.09	**0.43**	0.03	-0.06	0.01	0.15	-0.14	-0.10
Yield, g/m²	0.09	**0.43**	-0.01	-0.07	0.07	0.13	-0.08	-0.18
Protein, %	-001	0.16	-0.19	**0.32**	0.02	-0.36	0.11	-0.06
Starch, %	-0.03	0.01	0.17	-0.29	0.09	**0.31**	0.23	0.01
Extractivity, %	0.05	-0.15	0.05	-0.21	-0.13	**0.30**	-0.09	0.02
Germination rate in 1.5% NaCl solution	0.24	0.02	0.12	0.24	-0.13	-0.13	-0.18	-0.03
Length of 14-day-old seedlings, cm	**0.32**	-0.01	0.01	-0.05	0.11	-0.11	0.02	0.08
Length of seminal roots, cm	0.24	0.02	-0.22	-0.05	0.09	-0.14	-0.06	-0.06
Length of seedling leaf, cm	**0.32**	-0.04	-0.02	-0.14	0.06	-0.09	0.03	0.05
Area of seedling leaves, cm	**0.32**	-0.05	-0.02	-0.13	0.08	-0.09	-0.01	0.01
Leaf surface density, mg/cm²	-0.14	0.11	0.16	**0.33**	0.30	0.19	0.18	0.01
Weight of seedling leaves, g	0.28	-0.01	0.16	0.03	**0.29**	0.07	0.14	-0.01
Weight of seedling roots, g	0.18	0.05	-0.38	0.03	-0.26	0.09	0.02	0.06
Radicle thickness, mm	0.01	0.25	0.24	-0.15	-0.08	-0.25	**0.27**	0.18
Stem thickness, mm	0.05	-0.22	-0.24	**0.24**	0.16	**0.25**	-0.24	-0.18
Layers of leaves, pcs	-0.03	-0.17	-0.09	-0.08	**0.28**	0.07	0.21	**0.39**
Total weight of 14-day-old seedlings, g	**0.32**	0.13	-0.06	0.05	0.09	0.09	0.11	0.03

Total weight ratio to leaf area, mg/cm²	-0.06	0.12	-0.09	**0.41**	0.04	0.26	0.26	0.03
Top-root weight ratio, mg	-0.04	-0.05	**0.25**	-0.04	0.13	-0.41	-0.30	-0.08
Root-top weight ratio, mg	0.09	0.06	-0.39	0.01	-0.38	0.02	-0.05	0.10
Germination rate in sucrose solution 14 atm.,%	0.20	0.03	**0.29**	0.27	-0.13	-0.01	-0.07	0.04
Number of seminal roots of 7-day-old seedlings in sucrose solution, pcs	0.16	-0.14	**0.28**	0.18	-0.24	0.06	0.01	-0.04
Length of seminal roots of 7-day-old seedlings in sucrose solution, cm	0.17	0.13	**0.25**	0.23	-0.17	0.05	0.02	-0.22
Variance of components, %	*8.34*	*4.15*	*3.27*	*2.80*	*2.04*	*1.89*	*1.62*	*1.40*
Impact ratio of components, %	*25*	*13*	*10*	*8*	*6*	*6*	*5*	*4*
Cumulative value, %	*25*	*38*	*48*	*56*	*62*	*68*	*73*	*77*

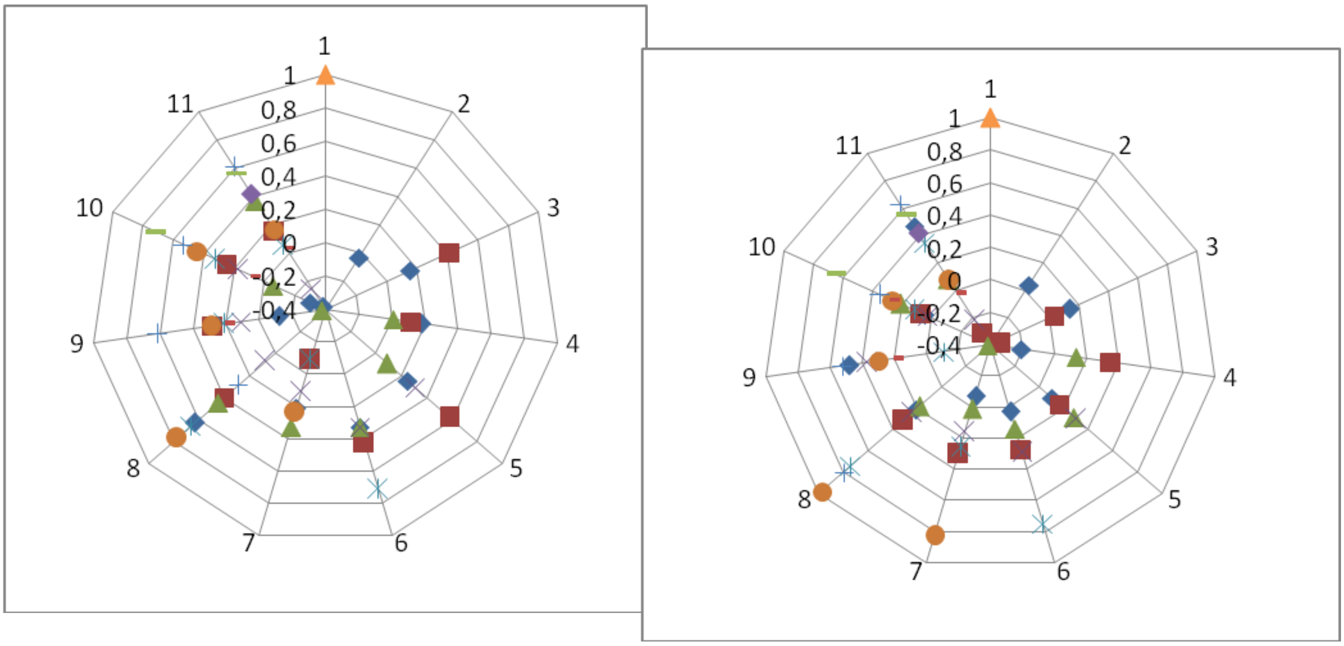
The fifth (6%) under the conditions of rice systems and the eighth (4%) factors in the piedmont zone were defined as morphological and included the plant height, layers of leaves in a 1.5% NaCl solution.

In both zones, the sixth factor (6%) is characterized by the values of protein and starch content, and extractivity, that is, it is associated with quality indicators of grain, in combination with a longer growing period, and protein with early maturity.

Further, to increase the effectiveness of the selection by the factor analysis method, we determined the interdependence of various biological and economically valuable parameters. The close contingence of traits allows to evaluate indirectly the parameters of one according to the indicators of the other. However, the contingence of traits of plant productivity varies significantly depending on the soil and climatic conditions of cultivation [22].

It was established that in the conditions of saline soils of rice systems in the Aral Sea region of Kazakhstan, a high positive correlation relationship was found between the grain weight per ear and the grain weight per 1 m² (r = 0.77); the number of grains per ear and the grain weight per ear (r = 0.72); the number of grains per ear and the grain weight per 1 m² (r = 0.66). The average correlation relationships with positive values were found between the number of ears per 1 m² and the grain weight per 1 m²; the plant height and the number of grains per ear (figure).

In the piedmont zone of the Almaty region, a similar picture is observed in the contingence of production traits, but productivity depends largely on 1000-grain weight, which has a significantly high positive correlation r = 0.80 (number of grains per ear) and r = 0.83 (grain weight per ear).



A B

Figure - Correlation coefficients between production and morpho-biological traits of spring barley in various soil and climatic conditions of Kazakhstan
A-Kyzylorda region; B- Almaty region:
1-number of ears per 1 m², 2-plant height, 3- upper internode length; 4-ear length; 5-number of grains per ear; 6- grain weight per ear; 7-1000-grain weight; 8-grain weight per 1 m², 9-germination rate in saline solution; 10-total weight of 14-day-old seedlings; 11-seminal root length

Note: critical r values at 99% significance level = 0.39

Statistical analysis of the data has shown that the studied variety samples according to the "number of grains per ear" and "grain weight per ear" traits demonstrate a consistently high positive correlation relationship, regardless of the years of study and their cultivation areas. In this regard, the "number of grains per ear" trait can be used as the main factor in increasing crop yields in adverse ecosystems of the Aral Sea region of Kazakhstan.

In both zones, according to the results of studying the correlation of 21 traits according to growth indicators at the early stages of ontogenesis under saline (1.5% NaCl) and drought (15% sucrose solution) conditions, the most informative traits were the germination rate, the total weight of 14-day-old seedlings and the seminal root length having an average positive correlation with the 1000-grain weight.

Conclusion

Thus, the presented research results confirmed the dominant importance of adaptive reactions for the normal growth and development of barley in the environmental conditions of Kazakhstan. The selection of barley for adaptability is especially relevant in the conditions of the Aral Sea region of Kazakhstan, where salinity and drought are the main limiting environmental factors. The most adaptively valuable traits include the germination rate under saline conditions, the total weight of 14-day-old seedlings, the number and length of seminal roots of seedlings. Of the production traits, the number of grains per ear, grain weight per ear and protein content in combination with early maturity are most significant.

References

1. Acreche M.M., Briceño-Félix G. , J.A. Martín Sánchez, G.A. Slafer (2008) Physiological bases of genetic gains in Mediterranean bread wheat yield in Spain Eur. J. Agric., 28, p. 162-170 https://doi.org/10.1016/j.eja.2007.07.001
2. Halla A.J, Richard A. (2013) Prognosis for genetic improvement of yield potential and water-limited yield of major grain crops. Field Crops Research, Volume 143, Pages 18-33 https://doi.org/10.1016/j.fcr.2012.05.014
3. F.Ewerta F., Rounsevellb M.D.A., Reginsterb I., M.J.Metzgera, R.Leemansc. (2005) Future scenarios of European agricultural land use: I. Estimating changes in crop productivity. Agriculture, Ecosystems & Environment, Volume 107, Issues 2–3, Pages 101-116 https://doi.org/10.1016/j.agee.2004.12.003
4. Cozzolino D., Allder K., Roumeliotis S., Eglinton J. (2012) Feasibility study on the use of multivariate data methods and derivatives to enhance information from barley flour and malt samples analysed using the Rapid Visco Analyse. Journal of Cereal Sciencemr, Volume 56, Issue 3, Pages 610-614 https://doi.org/10.1016/j.jcs.2012.07.004
5. Ramazan AYRANCI Yield performances of winter wheat (t. aestivum) genotypes improved for dry environmental region of Turkey (2020) Volume 25 , Issue 1, Pages 74 – 82 https://doi.org/10.17557/tjfc.664891
6. R.C. Yang (2010) Towards understansing and use of mixed-model analysis of agricultural experiments. Can J Plant Sci, 90 (5) pp. 605-630 https://doi.org/10.4141/CJPS10049
7. Peter J. Bradbury, Zhiwu Zhang, Dallas E. Kroon, Terry M. Casstevens, Yogesh Ramdoss, Edward S. (2007) TASSEL: software for association mapping of complex traits in diverse samples. Bioinformatics, Volume 23, Issue 19, Pages 2633–2635 https://doi.org/10.1093/bioinformatics/btm308
8. Bayer MM, Rapazote-Flores P, Ganal M, Hedley PE, Macaulay M, Plieske J. (2017) Development and evaluation of a barley 50k iSelect SNP array. Front. Plant Sci. 8:1792. https://doi.org/10.3389/ fpls.2017.01792 PMID: 29089957
9. P. Golinski, Z. Kacmarek, I. Kiccana, H. Wisniewska, P. Kaptur, M. Kostecki, J. Chelkowski (2002) Fusarium head blight of common Polish winter wheat

cultivars: Comparison of effects of Fusarium avenaceum and Fusarium culmorum on yield components. J Phytopathol, 150 (3), pp. 135-141 https://doi.org/10.1046/j.1439-0434.2002.00723.
10. S. Sanogo, X.B. Yang (2004) Overview of selected multivariate statistical methods and their use in phytopatholgical research Phytopathology, 94 (9), pp. 1004-1006 https://doi.org/10.1094/PHYTO.2004.94.9.1004
11. Karimizadeh R., Asghari A., Chinipardaz R., Sofalian O., Ghaffari A. (2016) Determining yield stability and model selection by ammi method in rain-fed durum wheat genotypes. Turk J Field Crops, 21(2), p. 174-183 https://doi.org/10.17557/tjfc.17390
12. Turuspekov, Y., Sariev, B., Chudinov, V., Sereda, G., Tokhetova, L., Ortaev, A. (2013). Genotype x environment interaction patterns for grain yield of spring barley in different regions of Kazakhstan. Genetika, 49(2), Pages 224–234. https://doi.org/10.7868/S0016675813020124
13. Almerekova, S., Sariev, B., Abugalieva, A., Chudinov, V., Sereda, G., Tokhetova, L., Turuspekov, Y. (2019). Association mapping for agronomic traits in six-rowed spring barley from the USA harvested in Kazakhstan. PLoS ONE, 14(8). https://doi.org/10.1371/journal.pone.0221064
14. Nayak P., Kumar A., Elssa M., Sharat P., Pradhan K. (2018). Application of Statistical Tools for Data Analysis and Interpretation in Rice Plant Pathology/ Rice Science, Volume 25, Issue 1, Pages 1-18 https://doi.org/10.1016/j.rsci.2017.07.001
15. Analysis of plants by growth indicators at the initial stages of ontogenesis // Methodological instructions of the All-Union Institute of Plant Production (N. I. Vavilov all-Russian institute of plant genetic resources), Leningrad, 1989 - 18 p.
16. Guidelines for the study of the world collection of barley and oats / VASHNIL, All-Russian Research Institute of Plant Production named after N. I. Vavilova; [Comp. M. V. Lukyanova and others.]. - 3rd ed., Recycled. - L.: VIR, 1981. - 31 p. https://search.rsl.ru/ru/record/01001053835
17. Mahalinga R. 2017. Phenotypic, physiological and malt quality analyses of US barley varieties subjected to short periods of heat and drought stress. Journal of Cereal Science, Volume 76, Pages 199-205 https://doi.org/10.1016/j.jcs.2017.06.007
18. Teunis J. Dijkman, Morten Birkved (2017) Environmental impacts of barley cultivation under current and future climatic conditions// Journal of Cleaner Production, Vol.140, P. 644-653 https://doi.org/10.1016/j.jclepro.2016.05.154
19. Wu D., Zhang G. (2016) Exploration and Utilization of salt-tolerant barley germplasm exploration// Identification and Utilization of Barley Germplasm, P. 75-113. https://doi.org/10.1016/B978-0-12-802922-0.00004-2
20. Tokhetova L.A., Tautenov I.A., Zelinski G.L. (2017) Demesinova A.A. Variability of main quantitative traits of the spring barley in different environmental conditions. Ecology, Environment and Conservation, Vol 23, Issue 2, Page 1093-1098 http://www.envirobiotechjournals.com/articl

21. Abera, Kiflu Tarekegn (2009) Agronomic evaluation of Ethiopian barley (Hordeum vulgare L.) landrace populations under drought stress conditions in low-rainfall areas of Ethiopia. Second cycle, A2E. Uppsala: SLU, Swedish Biodiversity Centre http://urn.kb.se/resolve?urn=urn:nbn:se:slu:epsilon-8-315
22. Szulczewski W., Żyromski A., Biniak-Pieróg M., Machowczyk A. (2010) Modelling of the effect of dry periods on yielding of spring barley. Agricultural Water Management, Volume 97, Issue 5, Pages 587-595 https://doi.org/10.1016/j.agwat.2009.12.004

ӘР ТҮРЛІ ЭКОЛОГИЯЛЫҚ ЖАҒДАЙЛАРҒА БЕЙІМДЕЛУ ҮШІН ЖАЗДЫҚ АРПАНЫҢ СЕЛЕКЦИЯСЫНДА КӨП ӨЛШЕМДІ ФАКТОРЛЫҚ ТАЛДАУДЫ ҚОЛДАНУ

Тохетова Л. А., а-ш.ғ.д, доцент
Ахмедова Г. Б., докторант
Ақжүніс Р.А. магистрант
КЕАҚ «Қорқыт Ата атындағы Қызылорда университеті»,
120014, Қызылорда қаласы, Әйтеке би көшесі 29а,
E-mail: lauramarat_777@mail.ru

Түйін

Әр түрлі экологиялық және географиялық тегі бойынша шыққан арпаның 155 үлгісінің (Hordeum vulgare L.) сандық және морфо-биологиялық сипаттамаларын көп факторлы дисперсиялық талдау арқылы құнды белгілер анықталды, оларға тұздану кезіндегі өну қарқындылығы, 14 күндік көшеттердің жалпы массасы, ұрық тамырларының саны мен ұзындығы жатады. Өнімділік белгілерінің ішінде масақтың дәндер саны, масақтың дән массасы, ақуыз мөлшері және ерте пісуі қасиеті маңызды болып табылады. Статистикалық талдаулар арқылы зерттелген сортүлгілерде масақтағы дәндер саны және масақтағы дән салмағы арасында тұрақты жоғары оң корреляциялық байланысы анықталды. Осыған байланысты Қазақстандық Арал өңірінің қолайсыз экожүйелерінде «масақтағы дәндер саны» белгісін өнімділікті арттырудың маңызды факторы ретінде пайдалануға болады.

Кілттік сөздер: арпа, өзгергіштік, тұздану, құрғақшылық, таңдау, бейімделу параметрлері, корреляция.

ПРИМЕНЕНИЕ МНОГОМЕРНОГО ФАКТОРНОГО АНАЛИЗА В СЕЛЕКЦИИ ЯРОВОГО ЯЧМЕНЯ НА АДАПТИВНОСТЬ К РАЗЛИЧНЫМ УСЛОВИЯМ СРЕДЫ

Тохетова Л.А., доцент
Ахмедова Г.Б., докторант
Акжунусова Р.А.магистрант
НАО «Кызылординский университет им.Коркыт Ата»,
120014, г.Кызылорда, ул.Айтеке би 29А,
E-mail: lauramarat_777@mail.ru

Резюме

Многофакторный дисперсионный анализ количественных и морфо-биологических признаков 155 образцов ячменя (Hordeum vulgare L.) различного эколого-географического происхождения позволил выделить наиболее адаптивно ценные признаки, к которым относятся интенсивность прорастания в условиях засоления, общая масса 14-суточных проростков, число и длина зародышевых корней. Из признаков продуктивности значимы число зерен в колосе, масса зерна с колоса и содержание белка в сочетании со скороспелостью. Статистический анализ данных показал, что у изучаемых сортообразцов по признакам число зерен в колосе и масса зерна с колоса проявляется стабильно высокая положительная корреляционная связь независимо от годов исследования и зон их возделывания. В связи с этим, признак «число зерен в колосе" можно использовать в качестве основного фактора повышения урожайности в неблагоприятных экосистемах Казахстанского Приаралья.

Ключевые слова: ячмень, вариабельность, засоление, засуха, отбор, параметры адаптивности, корреляция.