PARAMETRIC STABILITY ANALYSIS OF DURUM WHEAT YIELD (TRITICUM DURUM DESF)

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The **study purpose** was to assess the phenotypic stability of 23 durum wheat genotypes using different stability parameters to identify both high-yielding and stable genotypes.

Materials and methods. The study was carried out at 4 trial sites differing in soil and hydrothermal conditions in 2008/09 - 2009/10. To quantify the yield stability, 7 statistical parameters of the stability (bi, Pi, ASVi, CVi, S2di, S2i, and W2i) were calculated.

Results and discussion. The grain yields of all the genotypes were significantly affected by growing conditions, which accounted for 88.2% of the total variance of the yield, while the contributions of the genotype and genotype-environment interactions only amounted to 2.9% and 8.9%, respectively. There were significant positive correlations between the average yield of the genotypes under investigation and the regression coefficient (bi) and between the average yield of the genotypes and the environment variance (S2i). Correlation analysis also separated Pi, bi, and S2i approaches that correlated with the average yield and ASV, W2i, and S2di approaches that evaluate the phenotypic stability of the genotypes regardless of the yield.

Conclusions. The results show that the genotypes Bel, Amg, Miki, Bss and Msb were the most stable by the majority of the statistical models used. Miki, Amg and Msb were distinguished as the best genotypes combining high yield and high stability under various conditions.

***Key words**: durum wheat, yield, genotype, stability, correlation*

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ENVIRONMENTAL STABILITY AND PLASTICITY OF SPRING BARLEY CULTIVARS

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The yields of spring barley cultivars harvested in 2008–2015 with contrast conditions were compared to determine the strength and direction of a cultivar response to weather conditions. Cultivars bred at the Plant Production named after V.Ya. Yuriev of NAAS were taken as the test material: Parnas, Ahrarii, Modern, Alehro, Dyvohliad, Schedryi (Experiment 1) – in 2008–2011; Avhur, Balzam, Grin, Modern (Experiment 2) – in 2013–2015. The yield data were statistically processed by ANOVA. The informative and differentiating capacity of the environments (years), as well as the breeding value of the cultivars, were determined by GGE biplot.

The study found that barley cultivars Parnas and Avhur fully exploited their potential under the favorable conditions of cultivation. They are intensive cultivars. Cultivars Alehro, Parnas,

Avhur, and Balzam gave the most stable yields. The yields of cultivars Vziretz, Grin and awnless Modern were the most variable, i.e. these cultivars are plastic.

Thus, the Plant Production Institute named after V.Ya. Yuriev of NAAS created barley cultivars for different growing conditions: both for regions with optimal conditions and for arid and risky farming regions. This is relevant, given possible climate changes towards warming.

Key words: *barley, environmental stability and plasticity, differentiating capacity of the environment, ideal genotype, ranking, GGE biplot.*

Introduction. Climate changes will have significant implications for agricultural production, sometimes positive, but more often negative. For regions at high latitudes, changes may be positive, but for most regions, rising temperatures and reduced rainfall will decrease yields, especially of cereals. Producers will have to reconsider their sets of crops and technologies, to adapt crop rotations and management methods [1, 2]. Although production of new crops is agronomically possible for some regions, there is uncertainty as to the ability of producers to timely adapt technologies to these crops [3]. Therefore, agricultural producers should quickly develop new measures and systems of agriculture. The need for multidisciplinary research in collaboration between agronomists, bioclimatists, geneticists, and breeders arises.

Ukraine is one of the leading exporters of barley grain in the world, but significant variations in barley grain production over years, which are primarily due to high susceptibility of modern cultivars to weather fluctuations, are a serious obstacle in improving its position in the world market. According to the conclusions of Climate Change Assessment Report 4, Ukraine is not among the most vulnerable to the global warming regions of our planet. At the same time, an extension in the dry summer period was observed in the south of Ukraine, which has extremely negative effects on ecosystems and crop yields.

Analysis of literature, problem statement. Barley is highly tolerant to drought, salinity and other dehydration stresses. This is due to the simple structure of the genome (diploid chromosome set). Barley is very responsive to the genotype-environment (GxE) interaction, but, at the same time, easily adapts to environmental conditions, therefore, it is grown in a very wide areal.

Taking into account climate changes, at the present stage of breeding, it is important to create cultivars that combine high yields with tolerance to unfavorable environmental conditions. At the same time, it is most expedient to create cultivars adapted to specific agroecological conditions, since each cultivar has individual compensatory effects. The adaptive capacity of a cultivar is specific, hence, the breeding of cereals, including spring barley, should be closely related to the environmental conditions of an area where the cultivar was created [4, 5]. Not only high yield potential, but also the ability of a genotype to exploit this potential under unfavorable abiotic and biotic factors, i.e. in interaction with the environment, is of practical significance [6].

The climate warming-induced droughts are the main threat. In this regard, extensive studies on drought tolerance of crops, including barley [7, 8, 9, 10, 11], are conducted in the world. When highly adaptive cultivars are created, it is important to use the local gene pool, and numerous studies were devoted to this problem [12, 13]. One should have diverse genetic material to increase the stability of barley yields. In order to determine the barley response to changing weather conditions, Finnish researchers retrospectively analyzed a set of cultivars for a 40-year period and established optimal parameters of the conditions during development phases of barley plants [2].

To select genotypes combining drought tolerance with high performance, it is rather informative to assess breeding material for decrease in yields in dry years versus years with sufficient water availability. The Volga Research Institute of Breeding and Seed Production investigated the responses of local and Ukrainian spring barley cultivars in terms of yield drop (in % in an arid year related to favorable conditions). As a result, they found that locally bred cultivars showed the lowest reduction in their yields [11, 12, 14].

A lot of investigations have been devoted to evaluating the yields and stability of barley cultivars, where these parameters were determined using statistical parametric [15, 16] and non-parametric tests [17]. Recently, researchers have used modern approaches, in particular AMMI [18, 19, 20] and GGE biplot [21, 22, 23, 24] or their combination [25, 26, 27].

For many years, Myronivka Institute of Wheat has been studying the yields and stability of local and foreign cultivars. They identified cultivars with high homeostatsity, breeding value and yields. Hudzenko V.M. et al. conducted a systemic evaluation using a number of parametric and non-parametric statistical tests as well as AMMI and GGE biplot and found that cultivars differed in their responses to the contrast conditions of the study years, and, accordingly, they will complement one another in production, provided a proper selection of cultivars [28, 29, 30].

The Plant Production Institute named after V.Ya. Yuriev of NAAS obtained positive results in the determination of stability by testing cultivars in different zones. Solonechnyi P.M. et al. [31, 32, 33, 34, 35, 36, 37, 38] investigated domestic cultivars in the forest-steppe and steppe. The used GGE biplot and AMMI to analyze variations in the yield capacity, identified "ideal genotypes" as well as stable and plastic cultivars, and determined the degrees of influence of the genotype and the environment on fulfillment of the potential.

Materials and methods. The Plant Production Institute named after V.Ya. Yuriev of NAAS (PPI nd. a. V.Ya. Yuriev) compared the cultivar yields harvested in 2008–2015 in order to determine the strength and direction of the cultivar response to contrast weather conditions. The Laboratory of Barley Breeding and Genetics took the following cultivars bred at the PPI nd. a. V.Ya. Yuriev as the test material: Parnas, Ahrarii, Modern, Alehro, Dyvohliad, Schedryi (Experiment 1) – in 2008–2011; Avhur, Balzam, Grin, Modern (Experiment 2) – in 2013–2015. The standard was cultivar Vzirets.

The test material was studied in the research crop rotation fields of the Plant Production Institute named after V.Ya. Yuriev of NAAS, in the competitive trial nurseries in four replicates, with the plot area of 10 m^2. The cultivation technology was typical for the zone.

The yield data were statistically processed by ANOVA. Informative and differentiating ability of the environment (years) as well as the breeding value of cultivars were determined by GGE-biplot [39, 40].

The GGE-biplot graphs were constructed using the first two principal components (PC1 and PC2) obtained from data processing via singular value decomposition. The model only maintains two principal components, since it is better for detecting patterns and allows easy display of PC1 and PC2 on a two-dimensional biplot so that the interaction between each genotype and each environment can be visualized.

The basic model for the GGE biplot is as follows:

$$\boldsymbol{Y_{ij} - \mu - \beta_j = \lambda_1 \xi_{i1} \eta_{j1} + \lambda_2 \xi_{i2} \eta_{j2} + \varepsilon_{ij}} \qquad (1),$$

where Y_{ij} - mean yield of genotype *i* in environment *j*,

μ – grand mean,

β_j – mean yield of all the genotypes in environment *j*,

λ_1 and λ_2 – singular values (SVs) of the 1st and 2nd principal components (PC1 and PC2),

ξ_{i1} and ξ_{i2} – eigenvectors of genotype *i* for PCl and PC2, respectively,

η_{1j} and η_{2j} – eigenvectors of environment *j* for PCl and PC2, respectively,

ε_{il} – residual associated with genotype *i* in environment *j*.

To generate a biplot, the aforecited model was transformed as (2):

$$\boldsymbol{Y_{ij} - \mu - \beta_j = g_{i1} e_{1j} + g_{i2} e_{2j} + \varepsilon_{ij}} \qquad (2),$$

where $g_{i1} e_{1j}$ and $g_{i2} e_{2j}$ - PCl and PC2 scores for genotype *i* and environment *j*, respectively.

In a biplot, genotype *i* is displayed as a point defined by all g_i values, and environment *j* is displayed as a point defined by all e_j values.

To construct a GGE biplot, we used Genstat12 software.

Results and discussion. Analysis of the weather in 2008–2015, in particular the average daily temperature, the sum of effective temperatures and the precipitation amount at the study location, gave the results summarized in Table 1.

Table 1.

Hydrothermal conditions during the study years

Year	Emergence-tillering			Tillering – earing			Earing – grain filling			Grain filling – ripening			HTC Emergence-ripening
	$\sum t°ef$	$\sum precip$	HTC	$\sum t°ef$	$\sum precip$	HTC	$\sum t°ef$	$\sum precip$	HTC	$\sum t°ef$	$\sum precip$	HTC	
2008	293	121.0	**4.13**	247	31.0	**1.26**	227	22.0	0.97	323	45.0	**1.39**	**2.01**
2009	160	24.0	**1.50**	365	29.0	0.79	348	36.0	**1.03**	380	25.0	0.66	**1.15**
2010	324	56.5	**1.74**	279	23.6	0.85	168	14.6	0.87	383	32.9	0.86	1.07
2011	304	32.7	**1.08**	315	15.2	0.48	301	194.3	**6.46**	351	48.2	**1.33**	**2.28**
2013	393	27.0	0.69	311	17.0	0.55	185	12.0	0.65	367	52.0	**1.42**	0.86
2014	218	37.0	**1.70**	330	32.0	**0.97**	167	54.0	**3.23**	583	99.0	**1.70**	**1.71**
2015	291	46.4	**1.59**	162	7.0	0.43	350	30.0	0.86	665	117.1	**1.76**	**1.14**

2008 and 2014 were the most favorable for barley: the precipitation amount was above the average; temperatures were not high during the crucial phases of the development of barley plants (earing – grain filling). In 2009, 2011 and 2015, the air temperature was moderate during the growing season; droughts alternated with rains, resulting in the medium yields of barley cultivars. 2010 and 2013 were the most unfavorable for barley: in these years precipitation generally was uneven and showery during the growing season, and, therefore, could not sufficiently provide barley plants with water, especially at high temperatures.

We observed in a decline in the yields in all the genotypes under the unfavorable conditions (drought) (Table 2).

In experiment 1, the most drastic decrease in the yields was recorded in standard Vzirets (66%), while Ahrarii, Schedryi and Alehro showed a relatively small decline in the yields (54–55%). In experiment 2, cultivar Hrin was the most responsive (60%) to the growing conditions (see Table 2), while Modern was the least responsive (47%). Basing on these data, it is difficult to assess the stability of the cultivar yields; therefore, we used the GGE biplot analysis.

Table 2.

Changes in the yields of barley cultivars, depending on the cultivation conditions, 2008–2015.

Genotype index	Cultivar	Yield, t/ha			Decline in the yield, %
		max	min	mean	
Experiment 1, 2008–2011 (indices of environments E1, E2, E3, E4)					
G1	Vzirets (standard)	6,77	2,30	4,59	66
G2	Parnas	7,41	2,98	4,92*	60
G3	Ahrarii	7,18	3,30	5,02*	54
G4	Modern	6,29	2,66	4,36	58
G5	Alehro	7,13	3,18	4,84*	55
G6	Dyvohliad	6,80	2,78	4,51	59
G7	Schedryi	5,81	2,65	4,27	54
	LSD_{05}			0,11	
Experiment2, 2013–2015 (indices of environments E1, E2, E3)					
G1	Vzirets (standard)	7,23	2,02	4,85	72
G2	Modern	6,95	2,22	4,68	68
G3	Grin	7,61	2,57	5,37*	66
G4	Balzam	6,85	2,38	4,38	65
G5	Avhur	7,86	2,85	5,12*	64
	LSD_{05}			0,08	

* – the yield is significantly higher than the standard

The GGE biplot analysis allows visual assessment of the discriminating and representative capacity of the environment as a tester for assessing genotypes. The principal components PC1 and RS2 (for the genotype and year conditions) account for 87.02% and 96.10% of the total variability caused by the genotype-environment interaction in experiments 1 and 2, respectively (Fig. 1–4).

The environment eigenvectors are proportional to the standard deviation of the genotype yields in the corresponding environment. Accordingly, the environments with long eigenvector are highly discriminatory, but if the marker of a tester environment is close to the biplot center, i.e. the environment's eigenvector is short, all the genotypes in the biplot are close to one another, thus, this environment is non-informative. In experiment 1, arid 2010 was non-informative: the genotypes were unable to exploit their potentials under such conditions. The favorable 2008, on the contrary, had a very high discriminating capacity (Fig. 1a). In experiment 2, all the years were equally informative (Fig. 1b).

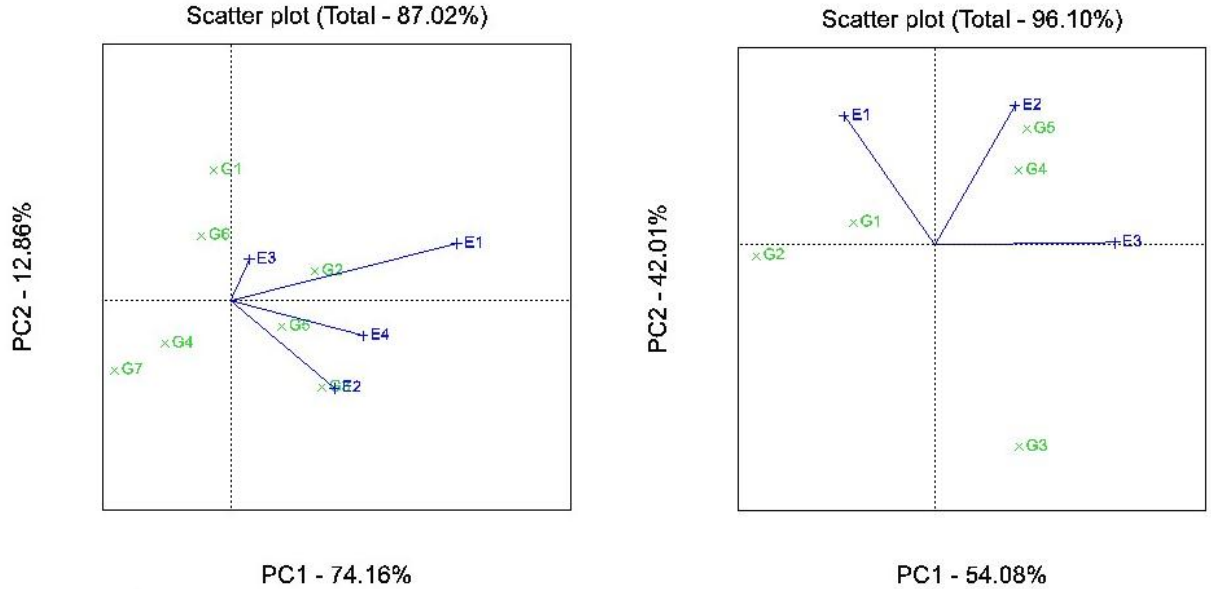

Figure 1a. Experiment 1, 2008–2011 Figure 1b. Experiment 2, 2013–2015

Figure 1. **GGE biplot of the discriminating capacity of the environments.**

The smaller the angle between the environments' eigenvectors is, the greater the correlation between them is. Accordingly, in experiment 1 there is a close correlation between 2009 and 2011, while in experiment 2 the correlation is weak (see Fig. 1).

The "what-won-where" polygon view of the GGE biplot (showing where which of the genotypes wins) visualizes the patterns of the genotype-environment interaction (Figure 2). The polygon vertices are the markers of the genotypes that are as maximally removed from the biplot center, while the markers of the other genotypes are inside the polygon. The lines dividing the bipolt into sectors are a set of hypothetical environments. The genotype that is at the polygon vertex is most productive in the environments inside this sector. Another important feature of biplots is a possibility of grouping environments into a mega-environment. Thus, in experiment 1, the mega-environment is formed by E2 (2009) and E4 (2011), between which there is a close correlation. Cultivar Ahrarii (G3) fell in this meg-environment's sector (Fig. 2a). This means that the conditions of these years were optimal for this cultivar. Parnas (G2) exploited its potential under the favorable conditions in 2008 (E1). For cultivar Vzirets (G1), 2010 was the best (E3), despite the aridity of this year, and for awnless cultivar Schedryi (G7), the conditions in 2008-2011 were not favorable (see Fig. 2a).

In experiment 2, the mega-environment consists of E2 (2014) and E3 (2015), which had favorable for barley conditions. Cultivar Avhur (G5) was in this mega-environment's sector (Fig. 2b). Cultivar Modern (G2) fulfilled its potential under the dry conditions of 2013 (E1), and for cultivar Grin (G3), the conditions in 2013–2015 were not favorable (see Fig. 2b).

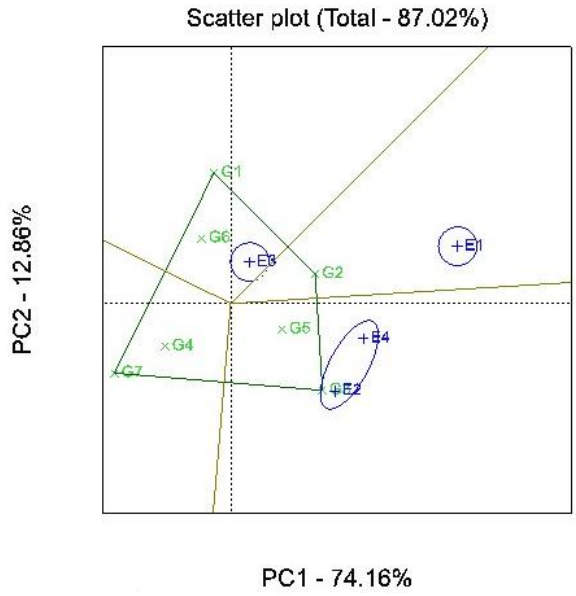

Figure 2a. Experiment 1, 2008–2011

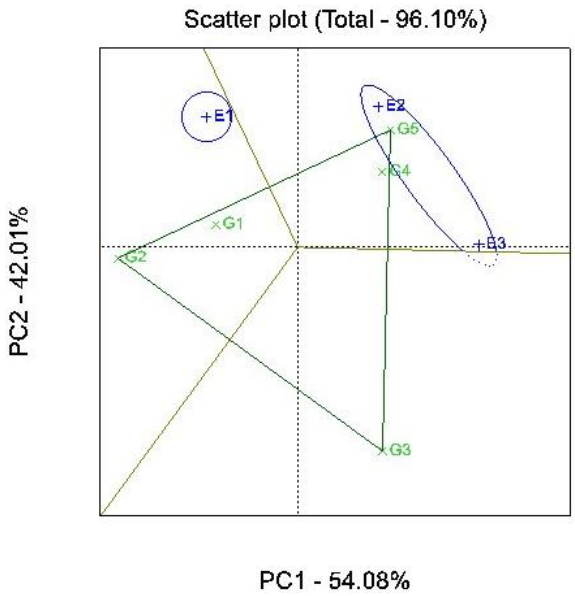

Figure 2b. Experiment 2, 2013–2015

Figure 2. **The "which-won-where" polygon GGE biplot for genotypes and environments**

GGE biplotting allows one to rank genotypes by average yields and stability in different environments (Fig. 3). The average environmental coordinate (AEC) (axis X) or the yield line is drawn through the origin of coordinates as an arrow indicating its positive end and ranks the genotypes by yield. The AEC Y axis, or the stability axis, is drawn through the origin of coordinates perpendicularly to the AEC X axis. The average yields of the genotypes are estimated by projecting their markers on the AEC X axis. In experiment 1, cultivars Ahrarii (G3), Parnas (G2) and Alehro (G5) had the highest average yields, and cultivar Schedryi (G7) – the lowest. The yield of cultivar Vzirets (G1) was the most variable, while cultivars Alehro (G5), Parnas (G2) and Modern (G4) were highly stable (Fig. 3a).

In experiment 2, cultivars Avhur (G5) and Balzam (G4) combined the highest yields with the greatest stability, while Grin (G3) and Modern (G2) were the least yielding, and moreover, the least stable ones (Fig. 3b).

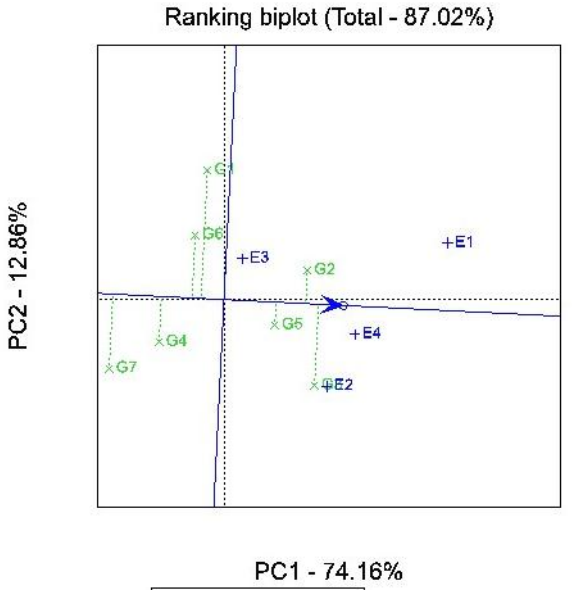

Figure 3a. Experiment 1, 2008–2011

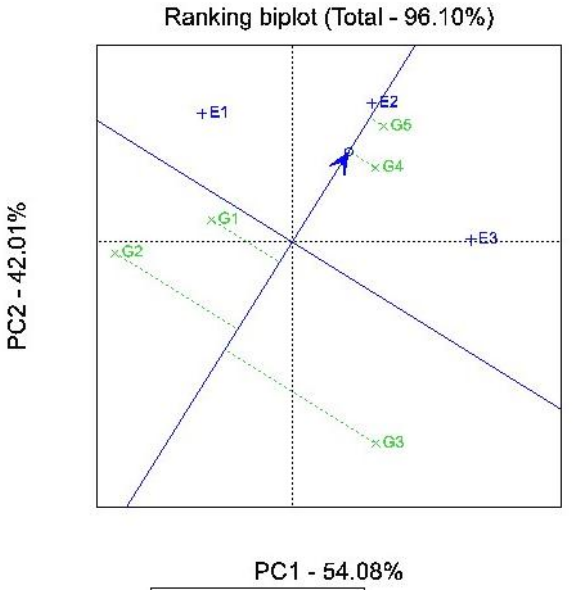

Figure 3b. Experiment 2, 2013–2015

Figure 3. **GGE biplot of the average performance and stability of the genotypes**

GGE biplotting allows one to rank genotypes by “breeding value.” The center of concentric circles is the "ideal" genotype’s position. The closer genotype to the "ideal" is, the more valuable it is (Fig. 4).

In experiment 1, cultivars Ahrarii (G3) and Parnas (G2) are the closest to the center, hence, they are "ideal" in terms of combining yield and stability compared to the other genotypes. Cultivar Alehro (G5) localized in the next circle is also valuable by these parameters (Fig. 4a). In experiment 2, cultivar Avhur (G5) is in the center of the circles, and, therefore, it can be considered as an "ideal" genotype. Cultivar Balzam (G4), which is closest to the center, is also valuable (Fig. 4b).

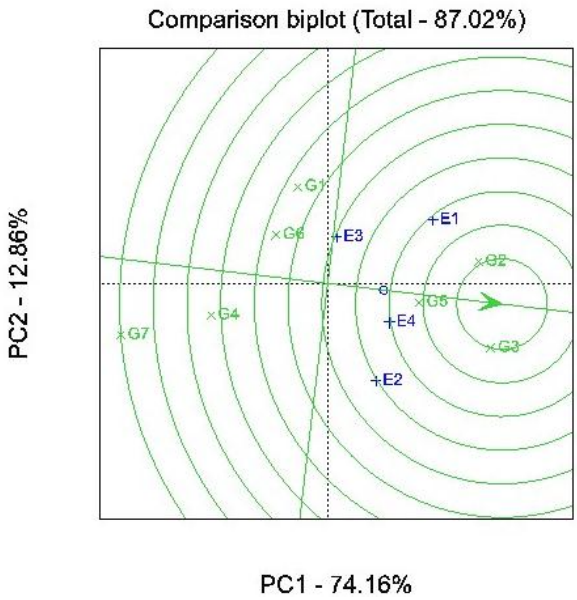

Figure 4a. Experiment 1, 2008–2011

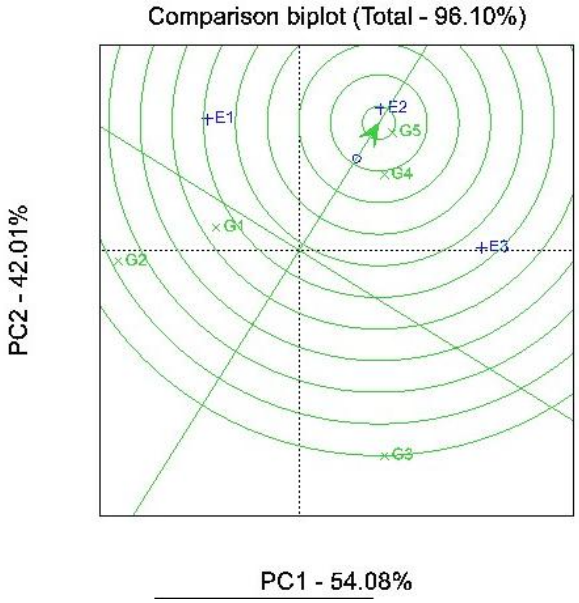

Figure 4b. Experiment 2, 2013–2015

Figure 4. **GGE biplot comparison of the genotypes with the "ideal" genotypes**

Conclusions. As a result of the cultivar trials using GGE biplot in the years with various conditions, barley cultivars Parnas and Avhur were identified as fully exploiting their potentials under the favorable conditions of cultivation; they are intensive cultivars. Cultivars Alehro, Parnas, Avgur, and Balzam gave the most stable yields. The yields of cultivars Vzirets, Grin and awnless Modern were the most variable, i.e. these varieties are plastic. At the same time, Vzirets can exploit its potential even under arid conditions

Thus, the Plant Production Institute named after V.Ya. Yuriev of NAAS created barley cultivars for different growing conditions: both for regions with optimal conditions and for arid and risky farming regions. This is relevant, given possible climate changes towards warming.

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ЕКОЛОГІЧНА СТАБІЛЬНІСТЬ ТА ПЛАСТИЧНІСТЬ СОРТІВ ЯЧМЕНЮ ЯРОГО

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Мета дослідження. Виділити стабільні та пластичні сорти в контрастних погодних умовах східної частини Лісостепу України, оцінити погодні умови років дослідження як середовища з інформаційною та диференціюючою здатністю.

Матеріали та методи. Урожай ярого ячменю, зібраний в 2008–2015 роках з контрастними умовами, порівнювали для визначення сили та спрямованості реакції сорту на погодні умови. Сорти селекції Інституту рослинництва ім. В.Я. Юр'єва НААН було взято в якості тестового матеріалу: Парнас, Аграрій, Модерн, Алегро, Дивогляд, Щедрий (експеримент 1) – у 2008–2011 роках; нові сорти Авгур, Бальзам, Грін, (експеримент 2) – у 2013–2015 роках. Стандартом був сорт Взірець.

Дослідження проводили на дослідних полях Інституту рослинництва ім. В.Я. Юр'єва НААН у розсадниках конкурсного сортовипробування у чотирьох повтореннях, з площею ділянки 10 м^2. Дані про врожайність були статистично оброблено за допомогою ANOVA. Інформаційна та диференціююча здатність середовищ (років), а також селекційна цінність сортів визначалися GGE-biplot аналізом.

Обговорення результатів. У результаті порівняння рівня врожайності сортів установлено, що 2008 та 2014 роки були сприятливими; 2010 та 2013 роки – несприятливими. Випадання опадів було нерівномірним, носило зливовий характер, а отже, не могло задовольнити потребу рослин ячменю у зволоженні, особливо при високій температурі повітря. Всі сорти знизили врожайність при несприятливих умовах (посуха), а рівень зниження врожайності залежав від генотипу.

Дослідження виявило, що сорти ячменю Парнас та Авгур повністю використовували свій потенціал за сприятливих умов вирощування, їх урожайність досягала 4,92 т/га та 5,12 т/га відповідно. Вони є інтенсивними сортами. Найбільш стабільну врожайність дали сорти Алегро, Парнас, Авгур та Бальзам. Зниження врожайності в цих сортів при несприятливих погодних умовах складало 55–65 %. Урожайність сортів Взірець, Грін та безостий Модерн була найбільш мінливою, зниження врожайності – 66–72 %, тобто ці сорти є пластичними. У той же час Взірець може реалізувати свій потенціал навіть у посушливих умовах.

Висновки. Таким чином, в Інституті рослинництва ім. В.Я. Юр'єва НААН створено сорти ячменю для різних умов вирощування: як для регіонів з оптимальними умовами, так і для посушливих та ризикованих районів ведення сільського господарства. Це є актуальним, враховуючи можливі зміни клімату в напрямку потепління.

Ключові слова:*ячмінь, екологічна пластичність та стабільність, диференціюючи здатність середовища, ідеальний генотип, ранжування, GGE-biplot*

ЭКОЛОГИЧЕСКАЯ СТАБИЛЬНОСТЬ И ПЛАСТИЧНОСТЬ СОРТОВ ЯЧМЕНЯ ЯРОВОГО

Васько Н.И., Солонечный П.Н., Козаченко М.Р., Важенина О.Е., Солонечная О.В., Наумов А.Г., Зимогляд А.В.
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Цель исследования. Выделить стабильные и пластичные сорта в контрастных погодных условиях восточной части Лесостепи Украины, оценить погодные условия годов исследования как среды с информационной и дифференцирующей способностью.

Материалы и методы. Урожай ярового ячменя, собранный в 2008–2015 годах с контрастными условиями, сравнивали для определения силы и направленности реакции сорта на погодные условия. Сорта селекции Института растениеводства им. В.Я. Юрьева НААН были взяты в качестве тестового материала: Парнас, Аграрій, Модерн, Алегро, Дивогляд, Щедрий (эксперимент 1) – в 2008–2011 годах; новые сорта Авгур, Бальзам, Грін, (эксперимент 2) – в 2013–2015 годах. Стандартом был сорт Взірець.

Исследования проводили на опытных полях Института растениеводства им. В.Я. Юрьева НААН в питомниках конкурсного сортоиспытания в четырех повторениях, с площадью делянки 10 м^2. Данные об урожайности были статистически обработаны с помощью ANOVA. Информативная и дифференцирующая способность среды (годов), а также селекционная ценность сортов определены GGE-biplot анализом.

Обсуждение результатов. В результате сравнения уровня урожайности сортов установлено, что 2008 и 2014 годы были благоприятными; 2010 и 2013 годы – неблагоприятными. Выпадение осадков было неравномерным, носило ливневый характер, то есть не могло удовлетворить потребность растений ячменя в обеспечении влагой, особенно при высокой температуре воздуха. Все сорта снизили урожайность при неблагоприятных условиях (засуха), а уровень снижения урожайности зависел от генотипа.

Исследование выявило, что сорта ячменя Парнас и Авгур полностью использовали свой потенциал при благоприятных условиях выращивания, их урожайность достигала 4,92 т/га и 5,12 т/га соответственно. Они являются интенсивными сортами. Наиболее стабильную урожайность дали сорта Алегро, Парнас, Авгур и Бальзам. Снижение урожайности у этих сортов при неблагоприятных условиях составляло 55–65 %. Урожайность сортов Взірець, Грін и безостый Модерн была наиболее изменчивой, снижение урожайности – 66–72 %, то есть эти сорта являются пластичными. В то же время Взірець может реализовать свой потенциал даже в засушливых условиях.

Выводы. Таким образом, в Институте растениеводства им. В.Я. Юрьева НААН созданы сорта ячменя для разных условий выращивания: как для регионов с оптимальными условиями, так и для засушливых и рискованных районов ведения сельского хозяйства. Это является актуальным, учитывая возможные изменения климата в сторону потепления.

Ключевые слова: *ячмень, экологическая пластичность и стабильность, дифференцирующая способность среды, идеальный генотип, ранжирование, GGE biplot*

ENVIRONMENTAL STABILITY AND PLASTICITY OF SPRING BARLEY CULTIVARS

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Purpose and onjectives. To distinguish stable and plastic varieties under contrast weather conditions of the eastern forest-steppe of Ukraine, to evaluate the weather conditions of the study years as environments with informative and differentiative capacity.

Material and methods. The yields of spring barley cultivars harvested in 2008–2015 with contrast conditions were compared to determine the strength and direction of a cultivar response to weather conditions. Cultivars bred at the Plant Production named after V.Ya. Yuriev of NAAS were taken as the test material: Parnas, Ahrarii, Modern, Alehro, Dyvohliad, Schedryi (Experiment 1) – in 2008–2011; Avhur, Balzam, Grin, Modern (Experiment 2) – in 2013–2015. The standard was cultivar Vzirets.

The study was conducted in the research crop rotation fields of the Plant Production Institute named after V.Ya. Yuriev of NAAS, in the competitive trial nurseries in four replicates, with the plot area of 10 m^2. The yield data were statistically processed by ANOVA. The informative and differentiating capacity of the environments (years), as well as the breeding value of the cultivars, were determined by GGE biplot.

Results and discussion. 2008 and 2014 were favorable; 2010 and 2013 – unfavorable. The precipitation was uneven and showery, and, therefore, could not meet the barley plants' need for water, especially at high temperatures. All the cultivars lowered their yields under the unfavorable conditions (drought), and the yield drop depended on the genotype.

The study found that barley varieties Parnas and Avhur fully utilized their potential under favorable growing conditions, as their yields reached 4.92 t/ha and 5.12 t/ha, respectively. They are intense varieties. The most stable yields were given by varieties Alehro, Parnas, Avhur, and Balzam. The decrease in the yields of these varieties under unfavorable weather conditions was 55–65%. The yields of varieties Vzitets, Hrin and awnless variety Modern were the most variable, with a decrease in their yields of 66–72%, i.e. these varieties are plastic. At the same time, Vzirets can reach its potential even in arid conditions.

Conclusions. Thus, the Plant Production Institute named after V.Ya. Yuriev of NAAS created barley cultivars for different growing conditions: both for regions with optimal conditions and for arid and risky farming regions. This is relevant, given possible climate changes towards warming.

Key words: *barley, environmental stability and plasticity, differentiating capacity of the environment, ideal genotype, ranking, GGE biplot.*