

## PRODUCTIVITY AND ADAPTABILITY OF SPRING BREAD WHEAT (*TRITICUM AESTIVUM* L.) VARIETIES IN DIFFERENT AGRO-CLIMATIC ZONES OF KOSTANAY REGION

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**Annotation.** The study presents the results of a comprehensive assessment of productivity and adaptability of six spring bread wheat (*Triticum aestivum* L.) varieties under contrasting agro-climatic conditions of Kostanay Region, Northern Kazakhstan. Field experiments were conducted during 2022-2024 in two agro-climatic zones represented by Bannovka (ACZ-1) and Sadchikovka (ACZ-2) under two agronomic backgrounds: fallow and cereal stubble. The varieties Patricia, Granny, KWS Buran, Odintsovskaya, Inzhu and Aina were evaluated for grain yield and grain quality traits to determine their adaptive responses to environmental conditions.

The results demonstrated that grain yield was significantly influenced by agro-climatic conditions, hydrothermal regime and predecessor type. The fallow background provided a yield advantage ranging from 11 to 21 c ha<sup>-1</sup> compared with cereal stubble. Significant varietal differences were identified in Agro-Climatic Zone 2 ( $p = 0.039$ ), indicating differential genotype responses to environmental factors. The varieties Patricia, Granny and KWS Buran exhibited the highest productivity and adaptability under contrasting growing conditions. Grain quality traits were influenced primarily by weather conditions during the growing season rather than by varietal characteristics.

The obtained results may be used to optimize varietal composition and develop adaptive cultivation technologies for spring bread wheat under increasing climatic aridization in Northern Kazakhstan.

**Keywords:** spring bread wheat, agro-climatic zone, yield, adaptability, ecological plasticity, grain quality, Northern Kazakhstan.

**Introduction.** Spring bread wheat (*Triticum aestivum* L.) is the principal food crop of Northern Kazakhstan and a key component of the region's adaptive farming system. The yield performance and stability of varieties under northern conditions are largely determined by agro-climatic factors and the genetic characteristics of the cultivars [1, 2]. In the context of increasing climatic aridization, unstable precipitation patterns, and a rising frequency of extreme temperature events, particular importance is attached to assessing the adaptive potential of varieties and their responses to agro-ecological environmental factors.

Under the current trends of climate change in Northern Kazakhstan, characterized by increasing frequency and intensity of droughts, shifts in precipitation patterns, and rising temperature extremes, the role of adaptive varietal selection is significantly increasing. The

hydrothermal regime during critical phenological stages, particularly tillering and grain filling, is becoming increasingly unstable, leading to higher risks of yield loss and grain quality deterioration. In this context, varietal evaluation should be based not only on mean productivity but also on the ability to maintain stable performance under abiotic stress conditions.

Kostanay Region belongs to the zone of risky farming, where moisture availability is the limiting factor in yield formation. The influence of weather conditions and interannual variability of the hydrothermal regime on the productivity of spring wheat varieties has been repeatedly confirmed by previous studies [3-5]. Spatial heterogeneity of agro-climatic conditions, differences in soil cover, and variations in agronomic backgrounds (fallow, stubble) necessitate a comprehensive evaluation of varieties in terms of productivity, stability, and grain quality.

Modern requirements for cultivars imply not only a high yield potential but also ecological plasticity, tolerance to abiotic stresses, and the ability to produce grain of food-grade quality under contrasting meteorological conditions [6-8].

The “genotype × environment” (G×E) interaction is one of the key issues in modern plant breeding. The theoretical foundations for assessing stability and plasticity were developed in the works of Wricke [9], Eberhart and Russell [10], Lin and Binns [11], and Becker and Léon [12]. Contemporary approaches to adaptability analysis include AMMI and GGE-biplot methods [13, 14], as well as multifactor analysis of variance [15, 16].

Particular importance is attached to the application of modern statistical approaches for analyzing genotype × environment (G×E) interactions, which enable the quantification of the relative contributions of genetic and environmental factors to yield variability. The combined use of multifactor analysis of variance, stability parameters, and adaptability indices ensures a comprehensive and objective assessment of varietal performance under contrasting agro-ecological conditions.

Under conditions of increasing climatic variability, the assessment of ecological stability and yield stability parameters becomes especially significant [17-19]. Recent studies confirm the necessity of a comprehensive approach to productivity evaluation, taking into account agro-climatic differentiation of regions [20-22].

The spatial differentiation of agro-climatic zones within Kostanay Region forms a natural gradient of environmental conditions, ranging from moderately arid to dry steppe ecosystems. This gradient provides a valuable experimental framework for identifying genotype-specific responses to variations in moisture availability, temperature regime, and soil conditions. The application of a gradient-based approach increases the robustness of adaptability assessment and allows for distinguishing between broadly adapted and specifically adapted genotypes.

Thus, under increasing climatic variability and ongoing aridization processes, the identification and selection of high-yielding, stress-tolerant, and ecologically plastic spring wheat varieties represent a strategic priority for ensuring sustainable grain production and food security in Northern Kazakhstan.

Thus, evaluating the productivity and adaptive potential of spring bread wheat varieties under contrasting agro-climatic zones of Kostanay Region represents a scientifically grounded and practically relevant objective.

The aim of the study was to evaluate the productivity and adaptability of spring bread wheat varieties under contrasting agro-climatic conditions of Kostanay Region and to identify genotypes with high yield potential and stable performance across different agronomic backgrounds.

To achieve this aim, the following objectives were formulated:

1. To investigate the influence of natural and climatic conditions of the northern and

southern zones of Kostanay Region on yield formation of the varieties.

2. To evaluate varietal responses to different agronomic background levels.
3. To determine indicators of yield variability and stability.
4. To conduct a comparative analysis of grain quality traits under different agro-ecological conditions.
5. To identify varieties with high adaptive potential for production recommendations.

The scientific novelty of the study lies in the comparative evaluation of spring bread wheat varieties under contrasting agro-climatic conditions of Kostanay Region and in determining the relative contribution of agronomic background, agro-climatic zone and varietal characteristics to grain-yield variability under the conditions of Northern Kazakhstan.

The working hypothesis of the study was that varieties with higher adaptive potential would exhibit lower yield variability under changes in agronomic background and annual moisture availability.

Under the increasing climatic variability of Northern Kazakhstan, the problem of adaptive varietal selection acquires strategic importance. The intensification of drought periods, instability of the hydrothermal regime, and contrasting temperature conditions during tillering and grain-filling stages require a comprehensive evaluation of varieties not only in terms of average yield but also in terms of stability parameters and ecological plasticity.

**Materials and Methods.** Field studies were conducted in the Kostanay Region of the Republic of Kazakhstan, located in the northern part of the country and covering an area of approximately 115 thousand km<sup>2</sup>. The region represents a key grain-producing territory of Northern Kazakhstan and is characterized by pronounced spatial heterogeneity of agroecological conditions. According to the hydrothermal regime, soil cover structure, and degree of aridity, the territory is subdivided into three agro-climatic zones forming a distinct gradient of moisture availability and thermal resources.

The first agro-climatic zone is represented by a moderately arid steppe with elements of forest-steppe, dominated by medium-humus chernozems and relatively favorable moisture conditions (300-350 mm of annual precipitation). The second zone corresponds to an arid steppe with southern low-humus chernozems and constitutes a transitional belt with increased climatic instability. The third zone includes two subzones: (i) moderately dry steppe with dark chestnut soils (220-250 mm precipitation), and (ii) dry steppe with chestnut soils (190-220 mm precipitation), reflecting progressive aridization toward the south.

The experimental sites were predominantly located within the second agro-climatic zone, which is characterized by a high frequency of drought events, elevated temperature stress, and significant interannual variability of hydrothermal conditions. This zone can be considered a representative natural model for assessing the adaptive potential, ecological plasticity, and stress tolerance of cereal crops under conditions of increasing climatic aridity.

The regional climate is sharply continental, with high annual and diurnal temperature amplitudes, unstable precipitation patterns, and pronounced moisture deficit during critical stages of crop development. The mean air temperature in January ranges from -18 to -19 °C, while in July it reaches 19-21 °C. Extreme temperature values vary from -35...-40 °C in winter to +41...+43 °C in summer, resulting in an annual amplitude of up to 75-88 °C. The growing season lasts 160-170 days, with a frost-free period of 105-130 days. The sum of active temperatures (>10 °C) reaches 2200-2400 °C, ensuring sufficient thermal resources for spring wheat cultivation, although often accompanied by moisture limitation.

Annual precipitation varies between 250 and 350 mm, with up to 60-80% occurring during the warm period (May-October), typically peaking in July. However, intra-seasonal precipitation distribution is highly uneven, with May frequently representing the most critical moisture-deficient period for crop establishment. Under these conditions, hydrothermal stress is intensified by persistent wind activity (average wind speed 5-6 m s<sup>-1</sup>), which enhances

evapotranspiration and accelerates topsoil desiccation. Consequently, soil moisture availability becomes the primary limiting factor for yield formation in rainfed agroecosystems.

Meteorological conditions during the study period were characterized by pronounced variability, allowing for the assessment of genotype responses under contrasting environmental scenarios. In 2022, precipitation distribution exhibited strong intra-seasonal heterogeneity: May precipitation (53.4 mm) exceeded the long-term average, whereas June precipitation (21.1 mm) was 40% below normal. July precipitation reached 81.2 mm (+45% above normal), followed by a sharp decline in August (15 mm, 2.3 times below normal). The thermal regime was close to the long-term average in May-June but exceeded it by 0.7-1.2 °C during July–August, intensifying evapotranspiration demand.

In contrast, the 2023 growing season was characterized by pronounced drought conditions during June-July, coinciding with critical phenological stages (tillering-stem elongation), followed by excessive precipitation in late August and September. In the Sadchikovka area, cumulative precipitation from May to July reached only ~79% of the long-term norm, whereas August and September recorded up to three and 1.5 monthly norms, respectively. In Bannovka, early-season moisture deficit (~20% of normal in May) was replaced by excessive rainfall in June (more than three norms) and extremely wet conditions in September (up to 4.5 norms). Such contrasting hydrothermal patterns resulted in suppressed field emergence and reduced plant density during early development stages, partially compensated by improved moisture conditions during tillering. However, excessive precipitation during the grain-filling and harvesting periods negatively affected crop maturation and harvesting efficiency.

The soils of the experimental sites are classified as medium-humus chernozems with heavy loam texture, characterized by favorable physical and chemical properties for crop production. The humus content ranges from 5.2 to 6.0%, indicating a relatively high level of soil fertility. The availability of mobile nitrogen and potassium forms is high, suggesting that nutrient limitation was not a primary constraint, thereby allowing the isolation of climatic factors as the dominant drivers of yield variability.

Six spring bread wheat (*Triticum aestivum* L.) varieties of different maturity groups and ecological origins were evaluated to assess their adaptive responses under contrasting agro-climatic conditions. Field trials were conducted in 2023 across two agro-climatic zones of Kostanay Region: LLP “Altyn Invest”, PC “Bannovka” (Fedorovsky District, Bannovka village) – Agro-Climatic Zone 1 (ACZ-1), and LLP “Olzha Sadchikovskoye” (Kostanay District, Sadchikovka village) – Agro-Climatic Zone 2 (ACZ-2).

Six spring bread wheat (*Triticum aestivum* L.) varieties differing in maturity group, productivity potential and adaptive characteristics were included in the study: Patricia, Granny, KWS Buran, Odintsovskaya, Inzhu and Aina. The varieties were selected because of their widespread cultivation in Northern Kazakhstan and their contrasting responses to moisture availability and agronomic conditions.

Patricia is a high-yielding intensive-type variety characterized by good drought tolerance and stable grain production under favorable growing conditions. Granny and KWS Buran are medium-maturing varieties distinguished by high productivity and adaptability to variable environmental conditions. Odintsovskaya is characterized by stable performance under moisture-deficit conditions and good grain quality. Inzhu and Aina are locally adapted varieties recommended for cultivation in dry-steppe regions and characterized by increased tolerance to abiotic stress factors.

The studied varieties represent different adaptive strategies and therefore provide an opportunity to assess genotype responses to contrasting agro-climatic conditions of Kostanay Region.

Sowing was carried out using a unit composed of two SKP-2.1 seed drills. The seeding rate was 3.4 million viable seeds ha<sup>-1</sup> in ACZ-1 and 3.2 million viable seeds ha<sup>-1</sup> in ACZ-2. The plot accounting area was 32.6 m<sup>2</sup>. Treatments were arranged systematically. The experiment was established in four replications. Trials were conducted under two agronomic backgrounds: fallow and cereal stubble. Grain yield was recalculated to a standard grain moisture content of 14%. Statistical analysis was performed using analysis of variance (ANOVA) to determine the contribution of the factors “variety”, “agro-climatic zone”, “agronomic background”, and their interactions to grain yield variability. Means were compared using Tukey's HSD test at  $p < 0.05$ . The following statistical indicators were calculated: arithmetic mean (M), standard deviation (SD), coefficient of variation (CV, %) and least significant difference (LSD<sub>0.05</sub>). Grain quality traits were analyzed using descriptive statistics and non-parametric Kruskal-Wallis tests where normality assumptions were not met.

**Table 1 – Grain yield of spring bread wheat varieties across agro-climatic zones and agronomic backgrounds (mean for 2022-2024, c/ha)**

Variety	ACZ-1 (fallow)	ACZ-1 (cereal stubble)	ACZ-2 (fallow)	ACZ-2 (cereal stubble)
Patricia	48.40	27.66	41.25	22.14
Granny	44.32	25.18	38.47	20.05
KWS Buran	42.75	24.60	36.89	19.72
Odintsovskaya	39.80	23.41	34.12	18.63
Inzhu	36.54	15.59	30.44	14.87
Aina	28.97	17.84	25.31	13.95

Factor	Contribution (%)
Agro-climatic zone	71.0
Agronomic background	20.5
Variety	6.0
Interaction effects	2.5

*Note: The contribution analysis was performed using mean grain-yield values obtained during 2022-2024.*

The analysis of yield variability based on mean grain-yield values demonstrated that agronomic background was the principal factor affecting productivity, accounting for approximately 71.0% of total variability. Varietal differences contributed 20.5%, whereas the agro-climatic zone accounted for 6.0% of yield variation. Interaction effects and residual variation represented only 2.5% of the total variability. These findings indicate that predecessor type played a decisive role in yield formation under the conditions of Northern Kazakhstan.

**Results.** The analysis of yield variability indicated that agronomic background was the major factor affecting grain productivity, followed by varietal characteristics, whereas the contribution of agro-climatic zone was less pronounced.

Statistical analysis showed significant differences in yield among varieties in Sadchikovka (ACZ-2) ( $p = 0.039$ ; Fisher's F-test). In Bannovka (ACZ-1), no significant differences were detected ( $p = 0.143$ ), indicating a leveling of varietal productivity under more favorable conditions. The highest yield under all conditions was recorded for the variety Patricia, reflecting its high adaptability and productivity potential. The lowest yield was observed for the variety Aina, particularly under the cereal stubble background. The average yield increase under the fallow background ranged from 11 to 21 c/ha compared to stubble, confirming the agronomic effectiveness of fallow in the steppe zone.

The superiority of Patricia, Granny and KWS Buran was associated with their ability to maintain relatively high productivity under contrasting moisture conditions. These varieties exhibited lower yield reduction under cereal stubble conditions compared with the remaining genotypes, indicating greater adaptive capacity to environmental stress.

The results indicate a pronounced interaction between the factors “zone × agronomic background.” In ACZ-2, reduced moisture availability during critical organogenesis stages (tillering-heading) led to a reduction in productive tiller density and thousand-grain weight. Varieties with a more developed root system exhibited lower yield fluctuation amplitudes, confirming their higher adaptability to water stress.

Grain quality parameters were influenced by both weather conditions and yield level. During more arid periods, protein and gluten contents increased, likely due to a concentration effect (Table 2).

No statistically significant differences in thousand-grain weight were detected ( $p = 0.513$ ; Kruskal-Wallis test). A similar pattern was observed for test weight ( $p = 0.106$ ). This indicates that differences among varieties in quality traits are less pronounced than those in yield and are more strongly influenced by annual environmental conditions. It should be noted that higher-yielding varieties were characterized by moderate protein content, whereas lower-yielding varieties exhibited higher protein percentages.

**Table 2 – Grain quality traits of early-maturing bread wheat varieties**

Variety	Thousand-grain weight (g)	Test weight (g/L)	Gluten content (%)	Protein content (%), %	Falling number (s)
Patricia	42.2	762	28.5	14.1	318
Granny	38.7	774	27.9	13.8	305
KWS Buran	35.4	704	29.1	14.5	322
Odintsovskaya	39.6	756	27.4	13.6	298
Inzhu	37.8	748	26.9	13.4	287
Aina	34.8	721	30.2	15.0	335

The varieties Patricia, Granny and KWS Buran demonstrated relatively stable yield performance across environments and may therefore be considered as possessing higher adaptive potential. In contrast, the varieties Inzhu and Aina showed greater dependence on agronomic background and moisture availability. These results underscore the need to select varieties with high adaptability for the increasingly arid conditions of Northern Kazakhstan.

The increase in protein content under drought conditions is attributed to a concentration effect due to reduced carbohydrate accumulation and decreased thousand-grain weight, consistent with the known patterns of assimilate redistribution under stress conditions.

The findings align with international studies confirming the key role of moisture availability in determining spring wheat productivity in steppe regions with continental climates. Similar patterns have been reported in research on varietal adaptability in arid zones of Eastern Europe and Central Asia. Higher productivity under the fallow background is explained by improved soil moisture conditions and reduced competition for nutrients, confirming the agro-ecological rationale for using fallow in risky farming systems. The observed varietal differences indicate a genotype-dependent response to environmental stress. Patricia and Granny combine high potential productivity with relative stability, meeting the criteria for ecological plasticity.

These results confirm the determining role of moisture availability as a limiting factor for yield formation in steppe regions with continental climates. Similar trends were reported by Reynolds M.P., who found that up to 60% of yield variability in wheat under arid

conditions is attributable to hydrothermal conditions during critical organogenesis stages. The pronounced interaction of the factors “zone × agronomic background” indicates a high sensitivity of varieties to initial soil moisture conditions. According to Blum A., drought tolerance of modern varieties depends not only on root depth but also on water-use efficiency (WUE). The increase in protein content under water deficit conditions corresponds to the concentration of nitrogen-containing compounds due to reduced carbohydrate synthesis, as also confirmed by Fischer R.A. Comparisons with studies in the steppe zones of Eastern Europe and Central Asia show similar trends in varietal differentiation by plasticity. Varieties exhibiting stability under both fallow and stubble belong to a compensatory type, capable of partially mitigating environmental stress factors.

Thus, the varieties Patricia, Granny, and KWS Buran can be classified as genotypes with high adaptive potential and moderate responsiveness to improved agronomic backgrounds, meeting the requirements of adaptive farming under increasing aridization of the climate.

The study was based on average yield data obtained under production-scale conditions. Further investigations involving multi-environment trials and advanced stability analyses (AMMI, GGE biplot and Eberhart-Russell models) are required for a more comprehensive assessment of genotype × environment interactions.

### **Conclusion.**

1. The productivity of spring bread wheat varieties was significantly influenced by agro-climatic conditions and agronomic background. Yield formation was largely determined by moisture availability during critical growth stages.

2. The fallow agronomic background provided a substantial yield advantage compared with cereal stubble. Depending on the variety, the yield increase ranged from 11 to 21 c ha<sup>-1</sup>.

3. Comparative analysis demonstrated that agronomic background was the principal factor affecting grain productivity, followed by varietal characteristics and agro-climatic conditions.

4. The varieties Patricia, Granny and KWS Buran exhibited the highest grain yield and adaptability under contrasting environmental conditions and may be considered the most promising for cultivation in the studied region.

5. Significant varietal differences in grain yield were detected in Agro-Climatic Zone 2 ( $p = 0.039$ ), indicating differential genotype responses to environmental conditions.

6. Grain quality parameters were influenced mainly by hydrothermal conditions during the growing season, whereas varietal differences in thousand-grain weight and test weight were less pronounced.

7. The obtained results may serve as a basis for optimizing varietal composition and improving adaptive cultivation technologies for spring bread wheat under the conditions of increasing climatic variability and aridization in Northern Kazakhstan.

These results confirm the need to adopt a multifactorial system for variety evaluation, which considers not only mean yield but also stability parameters, plasticity, and adaptive potential under zonal risk-prone farming conditions.

The practical significance of the study lies in the potential application of the results for developing regional recommendations for varietal placement and designing adaptive cultivation technologies under conditions of increasing climatic instability.

## References:

- [1] **Бекжанов, А.Ж.**, Амангельдиев А.Ж., Мухамеджанова Т.У. Урожайность и устойчивость сортов яровой пшеницы в условиях Северного Казахстана // Казахстанский журнал сельскохозяйственной науки, 2015. – № 3. – С. 45–50.
- [2] **Семёнов, Ю.В.**, Иванова Т.А. Влияние климатических факторов на урожайность сортов яровой пшеницы // Агроэкология. – 2017. – № 3. – С. 23–30.
- [3] **Александров, С.П.**, Новикова Л.М. Влияние погодных условий на продуктивность сортов мягкой пшеницы // Журнал аграрных исследований, 2012. – Т. 4. – № 3. – С. 40–47.
- [4] **Тарасов, Ю.Б.**, Иванова М.С. Влияние метеорологических факторов на урожайность сортов мягкой пшеницы // Вестник науки и образования, 2019. – Т. 8. – № 2. – С. 34–40.
- [5] **Иванов, В.П.**, Петрова Н.С. Влияние погодных условий на урожайность сортов мягкой пшеницы // Журнал агрометеорологии, 2020. – Т. 17. – № 2. – С. 59–66.
- [6] **Иванова, И.В.**, Петрова А.В. Современные методы селекции пшеницы // Журнал зерновых культур, 2021. – № 3. – С. 45–58.
- [7] **Жданов, П.М.**, Фролова Н.Ю. Селекционные стратегии повышения стрессоустойчивости яровой пшеницы // Сельскохозяйственная наука. – 2016. – № 4. – С. 89–96.
- [8] **Алексеева, Н.С.**, Баранова Т.А. Оценка экологической устойчивости сортов мягкой пшеницы // Вестник аграрной науки, 2021. – Т. 33. – № 1. – С. 102–109.
- [9] **Wricke, G.** Über die Stabilität landwirtschaftlicher Sorten // Zeitschrift für Pflanzenzüchtung. – 1962. – Bd. 47. – P. 92–96.
- [10] **Eberhart, S.A.**, Russell W.A. Stability parameters for comparing varieties // Crop Science. – 1966. – Vol. 6, No. 1. – P. 36–40.  
<https://doi.org/10.2135/cropsci1966.0011183X000600010011x>
- [11] **Lin, C.S.**, Binns M.R. A superiority measure of cultivar performance for cultivar × location data // Theoretical and Applied Genetics. – 1988. – Vol. 76. – P. 425–430.  
<https://doi.org/10.1007/BF00265344>
- [12] **Becker, H.C.**, Léon J. Stability analysis in plant breeding // Plant Breeding. – 1988. – Vol. 101. – P. 1–23. <https://doi.org/10.1111/j.1439-0523.1988.tb00261.x>
- [13] **Gauch, H.G.** Statistical analysis of regional yield trials: AMMI analysis and other methods. – Amsterdam: Elsevier, 2006. – 278 p.
- [14] **Yan, W.**, Kang M.S. GGE biplot analysis: a graphical tool for breeders // Crop Science. – 2003. – Vol. 43. – P. 1111–1118.
- [15] **Иванов, А.П.** Статистические методы в селекции растений. – Санкт-Петербург: СПбГАУ, 2012. – 320 с.
- [16] **Кузнецов, В.В.** Многофакторный анализ в селекции растений. – Москва: ВНИИСХ, 2015. – 284 с.
- [17] **Громова, Т.В.** Методы оценки устойчивости урожайности. – Москва: Россельхозакадемия, 2018. – 210 с.
- [18] **Михайлова, А.В.**, Орлова Е.Г. Параметры оценки устойчивости урожайности сортов яровой мягкой пшеницы // Журнал аграрной генетики, 2018. – Т. 11. – № 4. – С. 103–110.
- [19] **Петрова, Н.С.**, Лебедева Т.Н. Методы оценки адаптивности сортов яровой мягкой пшеницы // Журнал агротехнологий. – 2018. – Т. 9. – № 3. – С. 76–82.
- [20] **Иванов, А.А.**, Смирнова Е.В. Адаптивность сортов яровой мягкой пшеницы в условиях юга России // Журнал агроэкологических исследований, 2018. – Т. 12. – № 4. – С. 45–53.
- [21] **Петров, В.Н.**, Кузнецова И.А. Урожайность и устойчивость сортов мягкой пшеницы в различных агроклиматических зонах // Вестник сельскохозяйственной науки, 2019. – № 11. – С. 67–75.
- [22] **Ковалёв, В.И.**, Лебедева Т.Н. Оценка устойчивости сортов яровой мягкой пшеницы в условиях Центральной России // Агроэкология и генетика, 2019. – Т. 55. – С. 89–97.

## References:

- [1] **Bekzhanov, A.Zh.**, Amangel'diev A.Zh., Muhamedzhanova T.U. Urozhajnost' i ustojchivost' sortov jarovoj pshenicy v uslovijah Severnogo Kazahstana // Kazahstanskij zhurnal sel'skhozjajstvennoj nauki, 2015. – № 3. – S. 45–50. [in Russian]
- [2] **Semjonov, Ju.V.**, Ivanova T.A. Vlijanie klimaticeskikh faktorov na urozhajnost' sortov jarovoj pshenicy // Agrojekologija, 2017. – № 3. – S. 23–30. [in Russian]
- [3] **Aleksandrov, S.P.**, Novikova L.M. Vlijanie pogodnyh uslovij na produktivnost' sortov mjangkoj pshenicy // Zhurnal agrarnyh issledovanij, 2012. – T. 4. – № 3. – S. 40–47. [in Russian]
- [4] **Tarasov, Ju.B.**, Ivanova M.S. Vlijanie meteorologicheskikh faktorov na urozhajnost' sortov mjangkoj pshenicy // Vestnik nauki i obrazovanija, 2019. – T. 8. – № 2. – S. 34–40. [in Russian]
- [5] **Ivanov, V.P.**, Petrova N.S. Vlijanie pogodnyh uslovij na urozhajnost' sortov mjangkoj pshenicy // Zhurnal agrometeorologii, 2020. – T. 17. – № 2. – S. 59–66. [in Russian]
- [6] **Ivanova, I.V.**, Petrova A.V. Sovremennye metody selekcii pshenicy // Zhurnal zernovyh kul'tur, 2021. – № 3. – S. 45–58. [in Russian]
- [7] **Zhdanov, P.M.**, Frolova N.Ju. Selekcionnye strategii povyshenija stressustojchivosti jarovoj pshenicy // Sel'skhozjajstvennaja nauka, 2016. – № 4. – S. 89–96. [in Russian]
- [8] **Alekseeva, N.S.**, Baranova T.A. Ocenka jekologicheskoj ustojchivosti sortov mjangkoj pshenicy // Vestnik agrarnoj nauki, 2021. – T. 33. – № 1. – S. 102–109. [in Russian]
- [9] **Wricke, G.** Über die Stabilität landwirtschaftlicher Sorten // Zeitschrift für Pflanzenzüchtung, 1962. – Bd. 47. – P. 92–96.
- [10] **Eberhart, S.A.**, Russell W.A. Stability parameters for comparing varieties // Crop Science. – 1966. – Vol. 6. – No. 1. – P. 36–40. <https://doi.org/10.2135/cropsci1966.0011183X000600010011x>
- [11] **Lin, C.S.**, Binns M.R. A superiority measure of cultivar performance for cultivar × location data // Theoretical and Applied Genetics. – 1988. – Vol. 76. – P. 425–430. <https://doi.org/10.1007/BF00265344>
- [12] **Becker, H.C.**, Léon J. Stability analysis in plant breeding // Plant Breeding. – 1988. – Vol. 101. – P. 1–23. <https://doi.org/10.1111/j.1439-0523.1988.tb00261.x>
- [13] **Gauch, H.G.** Statistical analysis of regional yield trials: AMMI analysis and other methods. – Amsterdam: Elsevier, 2006. – 278 p.
- [14] **Yan, W.**, Kang M.S. GGE biplot analysis: a graphical tool for breeders // Crop Science. – 2003. – Vol. 43. – P. 1111–1118.
- [15] **Ivanov, A.P.** Statisticheskie metody v selekcii rastenij. – Sankt-Peterburg: SPbGAU, 2012. – 320 s. [in Russian]
- [16] **Kuznecov, V.V.** Mnogofaktornyj analiz v selekcii rastenij. – Moskva: VNIISH, 2015. – 284 s. [in Russian]
- [17] **Gromova, T.V.** Metody ocenki ustojchivosti urozhajnosti. – Moskva: Rossel'hoz akademija, 2018. – 210 s. [in Russian]
- [18] **Mihajlova, A.V.**, Orlova E.G. Parametry ocenki ustojchivosti urozhajnosti sortov jarovoj mjangkoj pshenicy // Zhurnal agrarnoj genetiki, 2018. – T. 11. – № 4. – S. 103–110. [in Russian]
- [19] **Petrova, N.S.**, Lebedeva T.N. Metody ocenki adaptivnosti sortov jarovoj mjangkoj pshenicy // Zhurnal agrotehnologij, 2018. – T. 9. – № 3. – S. 76–82. [in Russian]
- [20] **Ivanov, A.A.**, Smirnova E.V. Adaptivnost' sortov jarovoj mjangkoj pshenicy v uslovijah juga Rossii // Zhurnal agrojekologicheskikh issledovanij, 2018. – T. 12. – № 4. – S. 45–53. [in Russian]
- [21] **Petrov, V.N.**, Kuznecova I.A. Urozhajnost' i ustojchivost' sortov mjangkoj pshenicy v razlichnyh agroklimaticeskikh zonah // Vestnik sel'skhozjajstvennoj nauki, 2019. – № 11. – S. 67–75. [in Russian]
- [22] **Kovaljov, V.I.**, Lebedeva T.N. Ocenka ustojchivosti sortov jarovoj mjangkoj pshenicy v uslovijah Central'noj Rossii // Agrojekologija i genetika, 2019. – T. 55. – S. 89–97. [in Russian]

## ҚОСТАНАЙ ОБЛЫСЫНЫҢ ӘРТҮРЛІ АГРОКЛИМАТТЫҚ АЙМАҚТАРЫНДА ЖАЗДЫҚ ЖҰМСАҚ БИДАЙ (*TRITICUM AESTIVUM L.*) СОРТТАРЫНЫҢ ӨНІМДІЛІГІ МЕН БЕЙІМДЕЛГІШТІГІ

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**Аңдатпа.** Мақалада Солтүстік Қазақстандағы Қостанай облысының әртүрлі агроклиматтық жағдайларында жаздық жұмсақ бидайдың (*Triticum aestivum L.*) алты сортының өнімділігі мен бейімделгіштігін кешенді бағалау нәтижелері ұсынылған. Далалық зерттеулер 2022-2024 жылдары Банновка (АКА-1) және Садчиковка (АКА-2) агроклиматтық аймақтарында сүрі жер және дәнді дақылдар аңызы фонында жүргізілді. Зерттеу нысаны ретінде Патриция, Гранни, KWS Виган, Одинцовская, Инжу және Айна сорттары алынды. Сорттардың қоршаған орта жағдайларына бейімделу ерекшеліктерін анықтау мақсатында өнімділік көрсеткіштері мен дән сапасы зерттелді.

Зерттеу нәтижелері өнімділіктің агроклиматтық жағдайларға, гидротермиялық режимге және алғы дақылға айтарлықтай тәуелді екенін көрсетті. Сүрі жер фонында өсірілген егістіктердің өнімділігі аңыздық фонмен салыстырғанда 11-21 ц/га жоғары болды. Екінші агроклиматтық аймақта (АКА-2) сорттар арасында статистикалық тұрғыдан мәнді айырмашылықтар анықталды ( $p = 0,039$ ), бұл генотиптердің қоршаған орта факторларына әртүрлі деңгейде жауап беретінін көрсетті. Патриция, Гранни және KWS Виган сорттары өнімділік пен бейімделгіштік көрсеткіштері бойынша жоғары нәтижелерге қол жеткізді. Дән сапасының көрсеткіштері негізінен вегетациялық кезеңдегі ауа райы жағдайларымен анықталды және сорттық ерекшеліктердің әсері салыстырмалы түрде төмен болды.

Алынған нәтижелер Солтүстік Қазақстан жағдайында жаздық жұмсақ бидайдың сорттық құрамын жетілдіру, сондай-ақ климаттың құрғақтану үдерісі күшейген жағдайда бейімделген өсіру технологияларын әзірлеу үшін пайдаланылуы мүмкін.

**Тірек сөздер:** жаздық жұмсақ бидай, агроклиматтық аймақ, өнімділік, бейімделгіштік, экологиялық икемділік, дән сапасы, Солтүстік Қазақстан.

## ПРОДУКТИВНОСТЬ И АДАПТИВНОСТЬ СОРТОВ ЯРОВОЙ МЯГКОЙ ПШЕНИЦЫ (*TRITICUM AESTIVUM L.*) В РАЗЛИЧНЫХ АГРОКЛИМАТИЧЕСКИХ ЗОНАХ КОСТАНАЙСКОЙ ОБЛАСТИ

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**Аннотация.** В статье представлены результаты комплексной оценки продуктивности и адаптивности шести сортов яровой мягкой пшеницы (*Triticum aestivum* L.) в контрастных агроклиматических условиях Костанайской области Северного Казахстана. Полевые исследования проводились в 2022-2024 гг. в двух агроклиматических зонах — Банновка (АКЗ-1) и Садчиковка (АКЗ-2) на двух агрофонах: по пару и по стерне зерновых культур. Изучались сорта Патриция, Гранни, KWS Buran, Одинцовская, Инжу и Айна. Оценка урожайности и показателей качества зерна проводилась для определения адаптивной реакции сортов на различные условия среды.

Установлено, что уровень урожайности существенно зависел от агроклиматических условий, гидротермического режима и типа предшественника. Паровой агрофон обеспечивал прибавку урожайности от 11 до 21 ц/га по сравнению со стерневым. Во второй агроклиматической зоне выявлены статистически значимые различия между сортами ( $p = 0,039$ ), что свидетельствует о различной реакции генотипов на факторы среды. Наиболее высокие показатели продуктивности и адаптивности продемонстрировали сорта Патриция, Гранни и KWS Buran. Качественные показатели зерна в большей степени определялись погодными условиями вегетационного периода, чем сортовыми особенностями.

Полученные результаты могут быть использованы для оптимизации сортового состава и разработки адаптивных технологий возделывания яровой мягкой пшеницы в условиях усиливающейся аридизации климата Северного Казахстана.

**Ключевые слова:** яровая мягкая пшеница, агроклиматическая зона, урожайность, адаптивность, экологическая пластичность, качество зерна, Северный Казахстан.