ABSTRACT

of the dissertation by Aidarbekova Toizhan Zhumagalievna on the topic «Ecological plasticity and homeostaticity of spring soft wheat lines on chernozem soils of Northern Kazakhstan» submitted for the degree of Doctor of Philosophy (PhD) in the educational program 8D08101 – «Agronomy».

Relevance of the topic. Under the conditions of Northern Kazakhstan, spring soft wheat occupies an important place in agricultural production, being one of the main grain crops that determine the economic stability of the region. Modern cultivation technologies require the development of new high-yielding and adaptive varieties capable of performing effectively under sharply continental climate conditions.

The main objective of breeding science is to develop varieties that combine high productivity, resistance to stress factors, diseases, pests, and lodging, as well as meet market requirements for grain quality and economic efficiency. However, the existing spring soft wheat varieties cultivated in the region do not fully meet these criteria and are characterized by reduced yield and stability under unstable environmental conditions.

Particular importance is given to the development of varieties possessing homeostatic and ecologically plastic properties, which ensure yield stability under conditions of global climate change. In this regard, the study of the response of initial genotypes to environmental variability and their role in the formation of adaptive traits becomes especially relevant.

In the steppe zone of Northern Kazakhstan, studies on the ecological plasticity and homeostaticity of soft wheat varieties remain insufficient. Therefore, investigating this issue is of great scientific and practical importance for improving the efficiency of spring soft wheat breeding in the region.

Objective of the research: to identify the most ecologically plastic and homeostatic lines of spring soft wheat on chernozem soils of Northern Kazakhstan under different levels of mineral nutrition.

Research Tasks:

1. To determine the most adapted lines of spring soft wheat based on a комплекс of morpho-physiological traits under different levels of mineral nutrition.
2. To assess ecological plasticity, homeostaticity, variability, and the correlation between grain yield and yield structure elements of spring soft wheat lines under different levels of mineral nutrition.
3. To study the ecological plasticity and homeostaticity of yield in spring soft wheat lines under different levels of mineral nutrition.
4. To evaluate the ecological plasticity and homeostaticity of technological grain quality traits of spring soft wheat lines under different levels of mineral nutrition.
5. To calculate the economic efficiency of using spring soft wheat lines in breeding under different levels of mineral nutrition.

Methods. The study was conducted in 2021–2023 at the experimental field of LLP “Kokshetau Experimental Production Farm” located in the Zerenda district of the Akmola region. The soils of the experimental site were ordinary carbonate

chernozem, heavy loam. Field experiments were established in accordance with the methodology of the State Variety Testing of Agricultural Crops of the Republic of Kazakhstan, with four replications and systematic plot arrangement.

The following parameters were determined in the experiment: humus content, nitrate nitrogen, available phosphorus, exchangeable potassium, and pH of the soil water suspension in the 0–40 cm layer. Agrometeorological conditions were assessed based on data from a meteorological station, and the hydrothermal coefficient was calculated. Phenological observations included emergence, tillering, stem elongation, heading, and milk and wax ripeness stages; plant density, field emergence, and plant survival were recorded.

Yield structure was analyzed based on key elements, including plant height, number of productive stems, number of grains per spike, grain weight per spike, and thousand kernel weight. Photosynthetic activity was evaluated through leaf area, photosynthetic potential, net photosynthetic productivity, and the coefficient of photosynthetically active radiation utilization. The dynamics of dry biomass accumulation and root system development were studied at different growth stages.

Technological grain quality traits were also assessed, including thousand kernel weight, test weight, gluten content and quality, and crude protein content. Indicators of ecological plasticity and homeostaticity were calculated. Statistical analysis of the results was performed using Microsoft Excel and AgStat (http://www.agstat.com/), with analysis of variance (ANOVA).

Main Provisions Submitted for Defense:

1. Adapted lines of spring bread wheat identified by a complex of morphophysiological traits under different levels of mineral nutrition.
2. Ecological plasticity, homeostaticity, variability, and the correlation between grain yield and yield structure elements of spring bread wheat lines under different levels of mineral nutrition.
3. Ecological plasticity and homeostaticity of the yield of spring bread wheat lines under different levels of mineral nutrition.
4. Ecological plasticity and homeostaticity of the technological grain quality traits of spring bread wheat lines under different levels of mineral nutrition.
5. Economic efficiency of the use of spring bread wheat lines in breeding under different levels of mineral nutrition.

The main provisions submitted for defense:

1. Adapted lines of spring soft wheat identified based on a комплекс of morpho-physiological traits under different levels of mineral nutrition.
2. Ecological plasticity, homeostaticity, variability, and the correlation between grain yield and yield structure elements of spring soft wheat lines under different levels of mineral nutrition.
3. Ecological plasticity and homeostaticity of grain yield in spring soft wheat lines under different levels of mineral nutrition.
4. Ecological plasticity and homeostaticity of technological grain quality traits of spring soft wheat lines under different levels of mineral nutrition.
5. Economic efficiency of using spring soft wheat lines in breeding under different levels of mineral nutrition.

Object: spring soft wheat lines of mid-season and mid-early maturity groups.

Description of the main research results.

Based on the results of three-year studies (2021-2023), the following was established:

The morpho-physiological traits of spring soft wheat lines varied depending on genotype and mineral nutrition level. The duration of the growing season averaged 84 days for mid-season lines and 75 days for mid-early lines, which was 2 days shorter than the standard varieties. Mineral nutrition levels did not significantly affect phenological development stages. In mid-early lines, fertilizer application increased plant survival by 2.7% under the ½ dose and by 4.4% under the full dose; in mid-season lines, an increase of 4.5% was observed under the full dose. Among the mid-early group, Lutescens 1148 sp2/09 and Lutescens 715 sp2/04 were distinguished, while in the mid-season group, Lutescens 371/06 (Taymas) and Line 33/93-01-15 showed the best performance. Thus, the response of lines to fertilizers was genotype-dependent.

The highest number of nodal roots under all mineral nutrition levels in the mid-early group was observed in Lutescens 715 sp2/04, Lutescens 857 sp2/05, Lutescens 783 sp2/07, Lutescens 1148 sp2/09, and Erythrospermum 738 sp2/09; in the mid-season group, in Line 12/93-01-10 and Lutescens 371/06 (Taymas). Mineral nutrition levels contributed to an increase in the number of nodal roots and an increase in dry biomass in both maturity groups.

In terms of flag leaf area, total leaf area, photosynthetic potential, net photosynthetic productivity, and the coefficient of photosynthetically active radiation utilization, the best lines in the mid-early group were Lutescens 1148 sp2/09, Lutescens 857 sp2/05, and Lutescens 715 sp2/04; in the mid-season group, Line 12/93-01-10, Lutescens 371/06 (Taymas), and Line 55/94-01. It was established that mineral fertilizers improved the efficiency of solar radiation utilization.

In the mid-early group, the best lines based on the main yield structure elements across all backgrounds were Lutescens 1148 sp2/09, Lutescens 715 sp2/04, Erythrospermum 738 sp2/09, and Lutescens 1143 sp2/09. In the mid-season group, Line 12/93-01-10, Lutescens 371/06, and Line 55/94-01 were distinguished. Mineral nutrition levels had a significant effect on yield structure formation in spring wheat.

The highest grain yield in the mid-early group across all backgrounds was obtained from Lutescens 715 sp2/04: 2.33 t/ha without fertilizers, 2.63 t/ha at the ½ dose, and 2.71 t/ha at the full dose, with yield increases of 56.4%, 49.4%, and 39.69%, respectively. The most responsive lines to fertilizers were Lutescens 814 sp2/09, Erythrospermum 738 sp2/09, Lutescens 857 sp2/05, and Lutescens 783 sp2/07.

Under the interaction of factors (line × fertilizer), the highest grain yield in the mid-early group was obtained from Lutescens 715 sp2/04 (2.71 t/ha), and in the mid-season group from Line 12/93-01-10, indicating their high adaptability, responsiveness to fertilizers, and перспективность for further breeding and production use.

Lutescens 715 sp2/04 showed the highest homeostaticity (Hom) in the mid-early group under all fertilizer levels and was characterized by a medium level of ecological plasticity (bi = 1.0). In the mid-season group, the most stable genotypes were Astana 2 and Line 55/94-01 across all backgrounds.

The most favorable conditions in terms of the combination of yield, ecological plasticity, and homeostaticity were observed at the ½ calculated fertilizer dose, which can be considered optimal for the realization of ecological plasticity in both maturity groups. The full fertilizer dose increased productivity but was accompanied by higher yield variability, especially in mid-early lines.

In terms of technological grain quality, the highest adaptive potential was observed in the mid-early group in Lutescens 1148 sp2/09, Lutescens 715 sp2/04, Lutescens 814 sp2/09, and Erythrospermum 738 sp2/09; in the mid-season group in Line 12/93-01-10 and Astana 2. These lines can be recommended as genotypes with stable grain quality under different levels of mineral nutrition. Overall, mineral nutrition had a positive effect on grain technological quality in both maturity groups.

The highest economic efficiency under the combined effect of genotype and fertilizers was achieved at the ½ calculated fertilizer dose: in the mid-early group for Lutescens 715 sp2/04 and in the mid-season group for Line 12/93-01-10.

Justification of the novelty and significance of the results.

Under the conditions of the steppe zone of Northern Kazakhstan, the features of yield formation and grain quality of spring soft wheat lines of mid-early and mid-season maturity groups were studied for the first time on ordinary chernozem under different levels of mineral nutrition. The duration of the growing season and interphase periods, dynamics of root system development, photosynthetic activity of the leaf surface, and dry biomass accumulation were determined. Ecological plasticity, homeostaticity, variability, and the correlation between grain yield and the main yield structure elements were established. In addition, ecological plasticity and homeostaticity of grain yield and technological grain quality were evaluated. Grain yield and technological characteristics were assessed, and the economic efficiency of cultivating spring soft wheat lines under different levels of mineral nutrition was calculated.

The study identified ecologically plastic and homeostatic spring soft wheat lines in terms of yield and technological grain quality. The highest yield in the mid-early group was obtained from Lutescens 715 sp2/04, while Lutescens 1148 sp2/09 also showed high productivity. In the mid-season group, the best-performing lines were Line 12/93-01-10, Line 55/94-01, and Lutescens 371/06 (Taymas), with yield increases of 39.69%, 31.55%, and 31.01% compared to the control.

These lines demonstrated high adaptive potential in terms of technological grain quality and can be recommended as genotypes with stable yield and grain quality formation under different levels of mineral nutrition. Mineral nutrition had a positive effect on both yield and technological grain quality.

Compliance with the directions of scientific development and state programs.

The dissertation topic is aligned with the Decrees of the Government of the Republic of Kazakhstan: No. 960 dated December 30, 2021, “On the Concept for

the Development of the Agro-Industrial Complex of the Republic of Kazakhstan for 2021–2030," and No. 427 dated May 30, 2024, "On the Comprehensive Plan for the Development of Plant Breeding and Seed Production of Agricultural Crops in the Republic of Kazakhstan for 2024–2028."

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Contribution of the doctoral student to each publication.

The main results of the dissertation have been published in 4 scientific papers, including 3 articles in journals recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan: *"Ғылым және Білім"* (GBJ), Vol. 2, Issue 2 (71), pp. 186–194, June 2023. DOI: https://doi.org/10.52578/2305-9397-2023-2-2-186-194; *"Ғылым және Білім"* (GBJ), Vol. 2, Issue 3 (76), pp. 97–110, September 2024. DOI: https://doi.org/10.52578/2305-9397-2024-3-2-97-110; *"Ғылым және Білім"* (GBJ), Vol. 2, Issue 4 (79), pp. 54–66, 2025. DOI: https://doi.org/10.52578/2305-9397-2025-2-4-54-66.

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