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4.1.1. Общее земледелие и растениеводство

4.1.1. General agriculture and crop production

**КОМПЛЕКСНАЯ ОЦЕНКА
ПРОДУКТИВНОСТИ, ЭКОЛОГИЧЕСКОЙ
ПЛАСТИЧНОСТИ И СТАБИЛЬНОСТИ НОВЫХ
ГЕНОТИПОВ ЯРОВОЙ МЯГКОЙ ПШЕНИЦЫ В
УСЛОВИЯХ ЦЕНТРАЛЬНОГО
НЕЧЕРНОЗЕМЬЯ**

**COMPREHENSIVE EVALUATION OF
PRODUCTIVITY, ECOLOGICAL
PLASTICITY AND STABILITY OF NEW
SPRING BREAD WHEAT GENOTYPES IN
THE CENTRAL NON-CHERNOZEM
CONDITIONS**

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Цель исследований - провести комплексную оценку продуктивности, экологической пластичности и стабильности девяти генотипов яровой мягкой пшеницы (*Triticum aestivum* L.) в условиях Центрального Нечерноземья при разных уровнях интенсификации. Полевые многофакторные эксперименты проводили в 2021-2023 гг. в двух контрастных почвенно-климатических локациях (Московская и Калужская области) по схеме расщепленных делянок. Изучали девять генотипов (семь перспективных линий и два районированных стандарта) на трех агрофонах минерального питания и трех уровнях химической защиты. Статистическая обработка включала дисперсионный анализ, расчет параметров стабильности по Эберхарту-Расселу, АММИ-анализ и вычисление индекса гомеостатичности по Хангильдину. Установлено, что доля влияния генотипа на урожайность составила 52,4 %, уровня минерального питания -21,9 %, системы защиты -14,1 %. Выявлена перспективная линия № 3, которая достоверно превысила стандарты по урожайности на 29-35 %, формируя в среднем 67,2 ц/га в Калужской области и 63,8 ц/га в Московской области. Линия № 3 характеризовалась высоким коэффициентом экологической пластичности ($b_i = 1,28$), минимальным отклонением от регрессии ($S^2d = 1,45$) и максимальным индексом гомеостатичности ($Hom = 18,4$). АММИ-анализ подтвердил универсальную адаптивность линии № 3 ($IPCA1 = +0,12$), в отличие от стандартов, показавших специализированную адаптацию к отдельным агроэкологическим условиям. Линия № 3 рекомендуется как высокоурожайный, стабильный и экологически пластичный генотип интенсивного типа для возделывания в условиях Центрального Нечерноземья на уровне минерального питания N90P90K90 и интегрированной системе защиты растений

Ключевые слова: ЯРОВАЯ МЯГКАЯ ПШЕНИЦА, ГЕНОТИП, ПРОДУКТИВНОСТЬ, ЭКОЛОГИЧЕСКАЯ ПЛАСТИЧНОСТЬ, СТАБИЛЬНОСТЬ, АММИ-АНАЛИЗ, НЕЧЕРНОЗЕМЬЕ

This study provides a comprehensive assessment of productivity, ecological plasticity, and stability in nine spring bread wheat genotypes (*Triticum aestivum* L.) grown under different intensification levels in the Central Non-Chernozem region of Russia. Field experiments were conducted during 2021–2023 at two contrasting soil-climatic locations (Moscow and Kaluga regions) using a split-plot design. The nine genotypes-seven promising breeding lines and two zoned check varieties-were evaluated across three mineral nutrition levels and three plant protection regimes. Statistical analysis included ANOVA, Eberhart–Russell stability parameters, AMMI analysis, and Khangildin's homeostaticity index. Genotype explained 52.4% of the total yield variation, followed by mineral nutrition (21.9%) and plant protection system (14.1%). Line No. 3 significantly outyielded the check varieties by 29–35%, producing 67.2 c/ha in Kaluga and 63.8 c/ha in Moscow. This line exhibited high plasticity ($b_i = 1.28$), minimal deviation from regression ($S^2d = 1.45$), and the highest homeostaticity index ($Hom = 18.4$). AMMI analysis confirmed its broad (universal) adaptability ($IPCA1 = +0.12$), in contrast to the check varieties, which showed specialized adaptation to specific environments. Based on these results, Line No. 3 is recommended as a high-yielding, stable, and ecologically plastic genotype of intensive type for cultivation in the Central Non-Chernozem region under N90P90K90 fertilization combined with an integrated plant protection system

Keywords: SPRING BREAD WHEAT, GENOTYPE, PRODUCTIVITY, ECOLOGICAL PLASTICITY, STABILITY, AMMI ANALYSIS, NON-CHERNOZEM

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INTRODUCTION

Ensuring food security and achieving full technological sovereignty in breeding and seed production are strategic priorities for the development of the agricultural sector of the Russian Federation. For a long time, the production of high-quality food-grade spring wheat grain has been concentrated mainly in the

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southern and steppe regions of the country. In the Central Non-Chernozem zone, particularly in the Moscow and Kaluga regions, spring wheat has traditionally been considered an insurance crop, used primarily for replanting after winter crop failure [1]. However, modern climatic trends characterized by increasing hydrothermal instability, more frequent early summer droughts, and shifting temperature maxima necessitate a revision of varietal policy approaches in the Central Federal District. The emergence of new domestic short-stemmed genotypes of intensive type opens up the possibility of stable yields exceeding 60-70 c/ha of grain meeting the requirements for valuable and strong wheat. The fundamental foundations of crop productivity formation, theories of adaptability, ecological genetics, and mineral nutrition systems were established by prominent Russian and international scientists: N.I. Vavilov, E.D. Nettevich, B.I. Sandukhadze, A.A. Zhuchenko, S.A. Eberhart, W.A. Russell, H.G. Gauch and others [2, 3, 4, 5]. In the works of N.I. Vavilov [5], the theoretical foundations of the origin and variability of cultivated plants were laid, which to the present day serve as a methodological basis for breeding programs. E.D. Nettevich and A.I. Morgunov [1] developed the principles of spring wheat breeding for the Non-Chernozem zone, identifying key requirements for varieties: cold resistance, lodging and disease resistance, as well as high grain quality. A.A. Zhuchenko [4] developed the theory of ecological genetics, showing that the adaptive potential of a variety is determined not only by its genetic architecture but also by its ability for recombination under stress conditions. S.A. Eberhart and W.A. Russell [2] proposed a parametric approach to assessing genotype stability, which has become classical in world breeding practice. H.G. Gauch [3] developed multiplicative AMMI analysis, which makes it possible to effectively separate the effects of genotype, environment, and their interaction. Despite significant progress, under the changing climate of the Central Non-Chernozem region, issues of overcoming the negative correlation between yield and grain protein content in ultra-intensive varieties, as well as

precise assessment of their biotic and abiotic homeostasis using modern mathematical modeling methods (AMMI, Path-analysis), remain insufficiently studied. Furthermore, a comprehensive evaluation of new promising lines of spring bread wheat of domestic breeding in the contrasting soil and climatic conditions of the Moscow and Kaluga regions using these methods has not been previously conducted. This study comprehensively assesses of productivity, ecological plasticity and stability of promising spring wheat genotypes depending on the levels of mineral nutrition and intensification of plant protection in the Central Non-Chernozem conditions.

MATERIALS AND METHODS

Objects of research. The objects of research were nine genotypes of spring bread wheat (*Triticum aestivum* L.): promising breeding lines No. 1, No. 2, No. 3 (Leader), No. 4, No. 5, No. 6, No. 7; zoned standards Lisa (yield standard) and Ester (quality standard).

Experimental conditions. The experimental part of the work was carried out during the period from 2021 to 2023. Field multifactorial experiments were established simultaneously in two contrasting ecological and geographical locations of the Central Federal District: **Moscow region (Barybino)** - soil soddy-podzolic, medium loamy, with humus content of 2.1-2.3 %, pH_{water} 5.2-5.5, mobile phosphorus and exchangeable potassium content of 150-180 mg/kg of soil (according to Kirsanov) [6]; **Kaluga region (Experimental fields of the Kaluga Research Agriculture Institute)** - soil light gray forest, medium loamy, with humus content of 2.8-3.1 %, pH_{water} 5.6-5.8, mobile phosphorus and exchangeable potassium content of 200-220 mg/kg of soil [6].

Experiment design. The experimental design included three interrelated factors:

Factor A (Genotype): nine spring wheat varieties (seven lines + two standards).

Factor B (Agrobackground - mineral nutrition): B1 - Control (natural fertility, without mineral fertilizers); B2 - Moderate intensification level (N60P60K60); B3 - High intensification level (N90P90K90). The main fertilizer in the form of nitroammophoska was applied under pre-sowing cultivation, nitrogen top-dressings at tillering and stem elongation stages were applied in the form of ammonium nitrate.

Factor C (Chemical Plant Protection System - CPPS): C1 - Control (no chemical application, except seed treatment); C2 - Basic scheme (seed treatment with fungicide based on fludioxonil + tebuconazole, single herbicide application at tillering based on tribenuron-methyl + florasulam); C3 - Intensive scheme (basic scheme + two-time foliar fungicide treatment: T1 at the end of tillering against leaf spots and T2 on flag-leaf/beginning of heading against rust and fusarium based on propiconazole + tebuconazole + insecticide protection with lambda-cyhalothrin against the complex of phytophages).

Field establishment. Field experiments were established using the split-plot method [7]. The total area of the first-order plot (Factor B) was 180 m², second-order plot (Factor C) - 60 m², accounting area of the third-order plot (Factor A) - 15 m². Replication in the experiment was fourfold. Arrangement of variants was systematic. Preceding crop in both locations - clean or occupied fallow (legumes). Sowing dates were tied to the moment of physical soil ripeness.

Phenological observations were carried out according to the international BBCH scale (Zadoks) [8]. Yield accounting was carried out by continuous threshing of accounting plots followed by recalculation to 14 % moisture content.

Statistical analysis. The mathematical apparatus included:

Analysis of variance of multifactorial field experiment (ANOVA) according to B.A. Dospekhov [7].

Calculation of stability parameters according to Eberhart and Russell (coefficient of ecological plasticity b_i and deviation from regression S^2_{di}) [2].

Multiplicative interaction analysis (AMMI model) according to Gauch [3].

Calculation of homeostaticity index according to V.V. Khangildin [9].

The choice of these methods is due to their wide approbation in world breeding practice. The Eberhart-Russell model is the most common parametric approach for assessing genotype stability due to its simplicity and interpretability [2]. AMMI analysis, in turn, makes it possible to decompose the complex genotype-environment interaction into principal components, which provides the opportunity to visualize the adaptive strategies of each genotype [3]. The homeostaticity index according to Khangildin [9] complements parametric methods by assessing the buffering capacity of the genotype to stress factors.

The hydrothermal coefficient (HTC) was calculated as the ratio of precipitation (mm) to the sum of active temperatures ($>10^\circ\text{C}$) multiplied by 0.1, according to G.T. Selyaninov. HTC values below 1.0 indicate moisture deficit, 1.0–1.5 indicate optimal moisture, and above 1.5 indicate excess moisture. Calculations were performed in STATISTICA 12.0 (StatSoft, Inc., Tulsa, OK, USA) and R 4.2.1 (R Core Team, 2022) software packages.

RESULTS

Agrometeorological conditions. The research period (2021-2023) was characterized by significant fluctuations in hydrothermal conditions, which

made it possible to evaluate the expression of genotypic traits of wheat in various agroclimatic conditions (Table 1). The hydrothermal coefficient (HTC) was calculated as the ratio of precipitation (mm) to the sum of active temperatures ($>10^{\circ}\text{C}$) multiplied by 0.1, according to G.T. Selyaninov. HTC values below 1.0 indicate moisture deficit, 1.0–1.5 indicate optimal moisture, and above 1.5 indicate excess moisture.

Table 1 - Hydrothermal conditions of growing seasons 2021–2023

Indicator	2021	2022	2023
HTC (June–July)	0,73	1,43	1,52
Sum of active temperatures ($>10^{\circ}\text{C}$), $^{\circ}\text{C}$	2150	1980	2040
Precipitation in June, mm	28	42	85
Precipitation in July, mm	42	58	120
Average temperature in June, $^{\circ}\text{C}$	$+22,4 \pm 1,8$	$+18,5 \pm 1,2$	$+19,2 \pm 1,5$
Average temperature in July, $^{\circ}\text{C}$	$+20,8 \pm 1,5$	$+19,4 \pm 1,1$	$+18,6 \pm 1,3$
Characteristic	Severely dry	Optimal	Excessively wet

Note: Values are presented as mean $\pm$ standard deviation. HTC - hydrothermal coefficient after G.T. Selyaninov.

2021 was characterized as severely dry (HTC = 0,73). 2022 was characterized by optimal distribution of moisture and heat (HTC = 1,43). 2023 was characterized as excessively wet (HTC = 1,52).

Phenological stages. The key phenological stages for each year and location are summarized in Table 2.

Table 2 - Key phenological stages of spring wheat (2021–2023)

Year	Location	Sowing date	Tillering (BBCH 21–29)	Stem elongation (BBCH 30–37)	Heading (BBCH 51–59)	Full maturity (BBCH 87–89)	Harvest
2021	MO	25.04	18.05–05.06	06.06–20.06	21.06–05.07	25.07–05.08	10.08
2021	KO	28.04	20.05–08.06	09.06–22.06	23.06–08.07	28.07–08.08	12.08
2022	MO	27.04	19.05–06.06	07.06–21.06	22.06–06.07	26.07–06.08	11.08
2022	KO	30.04	22.05–09.06	10.06–24.06	25.06–09.07	29.07–09.08	13.08
2023	MO	29.04	20.05–08.06	09.06–23.06	24.06–08.07	28.07–08.08	12.08
2023	KO	02.05	24.05–12.06	13.06–27.06	28.06–12.07	01.08–12.08	16.08

Note: Phenological observations were conducted according to the BBCH scale (Zadoks et al., 1974). Dates represent the 50 % achievement stage for each phase. MO - Moscow region, KO - Kaluga region.

Analysis of variance. The results of analysis of variance (Table 3) confirmed the high statistical significance of the influence of all studied factors and their pairwise interactions on the resulting trait [7].

Table 3 - Results of analysis of variance (ANOVA) of wheat yield

Source of variation	df	SS	MS	Fcalculated	F05	Share of influence, %
Genotype (A)	8	9840,2	1230,0	45,2***	2,05	52,4
Agrobackground (B)	2	4120,5	2060,2	75,7***	3,09	21,9
Protection (C)	2	2640,1	1320,0	48,5***	3,09	14,1
Interaction A×B	16	1150,8	71,9	2,64***	1,75	6,1
Interaction A×C	16	450,2	28,1	1,03 ns	1,75	2,4
Error	24	652,8	27,2	---	---	3,1

*Note: *** - significant at $P \leq 0.001$; ** - significant at $P \leq 0.01$; * - significant at $P \leq 0.05$; ns - not significant*

The dominant vector of yield variability was genotype (52.4 %), which emphasizes the primary role of correct variety selection in the intensification of grain production. Mineral nutrition accounted for 21.9 %, and protection systems - 14.1 % of the variation. The small value of experimental error (3.1 %) indicates high precision of the field experiment. The Least Significant Difference (LSD05) between genotypes was 3.74 c/ha [7].

Genotype productivity. Analysis of yield (Table 4) showed that Line No. 3 significantly exceeded the standards in all experimental variants.

Table 4 - Yield of spring bread wheat (c/ha) by experimental variants (average for 2021–2023)

Genotype	Region	B1C1 (control)	B1C3 (protection)	B2C2 (moderate)	B3C1 (NPK)	B3C3 (max.)
Line No. 3	MO	38,2 ± 2,4	42,5 ± 2,1	55,4 ± 2,8	50,8 ± 2,5	63,8 ± 3,1
	KO	42,5 ± 2,6	46,8 ± 2,3	58,6 ± 2,9	54,2 ± 2,7	67,2 ± 3,4
Lisa (st)	MO	28,5 ± 1,8	34,2 ± 1,9	42,1 ± 2,1	35,4 ± 2,0	49,3 ± 2,5
	KO	31,0 ± 1,9	37,5 ± 2,0	44,8 ± 2,2	38,2 ± 2,1	51,7 ± 2,6
Ester (st)	MO	26,4 ± 1,7	31,8 ± 1,8	40,5 ± 2,0	32,8 ± 1,9	47,2 ± 2,4
	KO	29,5 ± 1,8	34,5 ± 1,9	42,4 ± 2,1	35,4 ± 2,0	49,8 ± 2,5
Line No. 6	MO	18,2 ± 1,4	24,5 ± 1,6	28,5 ± 1,7	20,4 ± 1,5	33,3 ± 1,9
	KO	19,8 ± 1,5	26,2 ± 1,7	30,2 ± 1,8	22,5 ± 1,6	35,2 ± 2,0
LSD05	---	2,8	3,2	4,1	3,5	3,74

Note: MO - Moscow region, KO - Kaluga region. Values are presented as mean $\pm$ standard deviation.

Under the intensive agrobbackground (B3C3), Line No. 3 produced a yield of 63.8 ± 3.1 c/ha in the Moscow region and 67.2 ± 3.4 c/ha in the Kaluga region, which exceeded the Lisa standard by 29.4 % and 30.0 %, respectively. Even on the control variant (without fertilizers and protection), Line No. 3 significantly exceeded the standards: 38.2 ± 2.4 c/ha against 28.5 ± 1.8 c/ha for Lisa in the Moscow region.

Parameters of ecological plasticity and stability. Calculation of linear regression on the environment index [2] allowed differentiating nine genotypes by types of their adaptive strategy (Table 5).

Table 5 - Parameters of adaptability and homeostasis of genotypes (2021–2023)

Genotype	Mean yield, c/ha	Plasticity coefficient (bi)	Residual variance (S ² d)	Homeostaticity index (Hom) [9]	IPCA1 [3]
Line No. 3	65,5 $\pm$ 3,2	1,28 $\pm$ 0,08	1,45	18,4	+0,12
Line No. 1	54,1 $\pm$ 2,8	1,15 $\pm$ 0,07	2,10	11,2	-0,38
Line No. 2	52,1 $\pm$ 2,6	1,08 $\pm$ 0,06	2,45	9,8	-0,25
Lisa (st)	50,5 $\pm$ 2,5	1,02 $\pm$ 0,05	4,20	6,4	+0,45
Ester (st)	48,5 $\pm$ 2,4	0,92 $\pm$ 0,05	2,10	5,2	+0,22
Line No. 4	40,8 $\pm$ 2,0	0,88 $\pm$ 0,04	3,50	2,8	-0,55
Line No. 5	39,0 $\pm$ 1,9	0,85 $\pm$ 0,04	3,80	2,2	-0,62
Line No. 6	34,2 $\pm$ 1,7	0,65 $\pm$ 0,03	8,50	1,4	-0,95
Line No. 7	33,3 $\pm$ 1,6	0,62 $\pm$ 0,03	9,10	1,1	-0,98

Note: Values for mean yield and plasticity coefficient are presented as mean $\pm$ standard deviation ($n = 4$ replicates $\times$ 3 years $\times$ 3 agrofons = 36 observations). Homeostaticity index (Hom) and IPCA1 values are point estimates derived from the Eberhart-Russell and AMMI models, respectively; confidence intervals for these parameters are not provided as they are not directly calculable from the ANOVA structures used in the original models.

The data in Table 5 reveal clear differentiation among genotypes. Line No. 3 shows the highest mean yield and plasticity coefficient, alongside the lowest residual variance and highest homeostaticity index.

AMMI analysis. Multiplicative AMMI analysis [3] allowed deeper revelation of the $G \times E$ interaction structure. The first interaction principal component IPCA1 explained 74.5 % of the variation of the residual sum of squares (Table 6).

Table 6 - Results of AMMI analysis [3]

Component	Eigenvalue (λ)	Proportion of explained variance, %	Cumulative variance, %	Significance
IPCA1	8,42	74,5	74,5	***
IPCA2	2,06	18,2	92,7	**
IPCA3	0,52	4,6	97,3	ns
Remainder	0,31	2,7	100,0	---

*Note: *** - significant at $P \leq 0.001$; ** - significant at $P \leq 0.01$; ns - not significant.*

The IPCA1 value for Line No. 3 was only +0.12 (Table 5), which positions this genotype in close proximity to the x-axis, indicating minimal interaction with environmental conditions.

DISCUSSION

The results obtained in this study provide a comprehensive understanding of the performance and adaptive strategies of the nine spring wheat genotypes evaluated under contrasting agroecological conditions of the Central Non-Chernozem region.

The dominant role of genotype in yield determination. The ANOVA results revealed that genotype was the primary source of yield variability, accounting for 52.4 % of the total variation. This finding is consistent with the reports of Dospekhov [7] and Zhuchenko [4], who emphasized that genetic

potential is the cornerstone of productivity in intensive cropping systems. The relatively high contribution of mineral nutrition (21.9 %) and chemical protection (14.1 %) confirms that the full expression of genetic potential requires an optimized agrotechnical background, aligning with the principles of adaptive breeding outlined by Nettevich and Morgunov [1].

Superior performance and stability of Line No. 3. The identification of Line No. 3 as the top-performing genotype across all environments is a significant outcome. Its average yield of 67.2 c/ha in the Kaluga region represents a 30 % increase over the standard variety Lisa. This superiority can be attributed to its intensive-type genetic architecture, characterized by high responsiveness to improved conditions, as evidenced by its plasticity coefficient ($b_i = 1.28$). According to the Eberhart-Russell model [2], genotypes with $b_i > 1.0$ are considered responsive to environmental improvements, making them ideal for high-input farming systems.

Crucially, Line No. 3 combined this high responsiveness with exceptional stability, reflected in the minimal deviation from regression ($S^2_d = 1.45$). This combination is rare and highly desirable, as it ensures that the genotype not only performs well under optimal conditions but also maintains predictable yields under stress. The high homeostaticity index ($H_{om} = 18.4$) calculated according to Khangildin's method [9] further corroborates its buffering capacity against environmental fluctuations, a trait essential for the variable climate of the Non-Chernozem zone.

Ecological adaptability revealed by AMMI analysis. The AMMI biplot analysis [3] provided deeper insights into the $G \times E$ interaction patterns. The positioning of Line No. 3 near the origin of the IPCA1 axis ($IPCA1 = +0.12$) confirms its wide or universal adaptability. In contrast, the standard Lisa ($IPCA1 = +0.45$) exhibited a specific adaptation to the soddy-podzolic soils of the Moscow region, while Line No. 1 ($IPCA1 = -0.38$) showed a tendency for the

light gray forest soils of Kaluga. This specialization explains why these genotypes performed well in specific locations but failed to match the consistent performance of Line No. 3 across the entire range of environments. This finding aligns with the theoretical framework of Gauch [3], which suggests that genotypes with IPCA1 values near zero are less sensitive to environmental changes, making them more reliable for broad recommendation.

Implications for breeding and production. The results have clear implications for both breeding programs and agricultural practice. For breeders, Line No. 3 represents a valuable genetic resource for developing new varieties that combine high yield potential with stability. Its short-stemmed morphotype and intensive response to fertilizers make it an excellent candidate for crossing programs aimed at improving lodging resistance and nitrogen use efficiency. For producers in the Central Non-Chernozem region, the recommendation of Line No. 3 for cultivation under the intensive agrobbackground (N90P90K90 with integrated protection) offers a pathway to achieving stable, high-quality grain yields, thereby enhancing the economic viability of spring wheat production in the region.

Limitations and future research. While this study covered three growing seasons and two locations, expanding the trial network to include more diverse environments across the Central Federal District would further validate the adaptability of Line No. 3. Additionally, future research should focus on the physiological and molecular mechanisms underlying its stress tolerance and high nitrogen use efficiency, which could be elucidated through transcriptomic or metabolomic approaches. Investigating the genetic basis of the superior stability and plasticity of Line No. 3 through molecular marker analysis and genome-wide association studies (GWAS) would provide valuable insights for breeding programs. Furthermore, long-term studies assessing the performance of Line No. 3 under different crop rotation systems and its interaction with soil

microbiota would contribute to the development of sustainable agricultural practices in the region.

CONCLUSION

As a result of the conducted research, it was established that **genotype** is the dominant factor determining the yield of spring bread wheat in the Central Non-Chernozem conditions, with a share of influence of **52.4 %**, which significantly exceeds the contribution of the mineral nutrition level (21.9 %) and the plant protection system (14.1 %).

A promising **Line No. 3 (Leader)** was identified, which significantly exceeded the zoned standards Lisa and Ester in yield by **29–35 %** in all agroecological conditions, forming an average of **67.2 ± 3.4 c/ha** in the Kaluga region under the intensive agrobbackground (N90P90K90 + integrated protection).

Based on the assessment of ecological plasticity and stability parameters according to Eberhart-Russell [2], Line No. 3 is classified as an **intensive type** ($b_i = 1.28 \pm 0.08$) with **high stability** ($S^2_d = 1.45$) and **maximum homeostaticity index** ($Hom = 18.4$) according to Khangildin [9], which indicates its high responsiveness to improved cultivation conditions and yield predictability.

AMMI analysis [3] confirmed the **universal ecological adaptability** of Line No. 3 ($IPCA1 = +0.12$), in contrast to the standards that showed specialized adaptation to specific soil and climatic conditions.

Line No. 3 is recommended as a **high-yielding, stable and ecologically plastic genotype of intensive type** for cultivation in the Central Non-Chernozem conditions at the level of mineral nutrition N90P90K90 and an integrated plant protection system.

The obtained results can be used in breeding programs for creating adaptive high-yielding varieties of spring bread wheat, as well as in the system of recommendations for agricultural producers of the Central Federal District.

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CONFLICT OF INTEREST STATEMENT

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTHORS' CONTRIBUTION

F. Duksi - conducting field research, data collection and processing, writing the text of the article.

V.A. Burlutskiy - scientific supervision, development of research concept, analysis of results, editing the text.

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