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RESEARCH ARTICLE

Sowing qualities of winter wheat varieties depending on the intensification of cultivation technology

Volodymyr Orekhivskyi[1], Anna Kryvenko[2], Tetiana Marchenko[2]*, Volodymyr Vakulenko[1], Ruslan Solomonov[2]

[1]Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine, Vasylkivska St., 31/17, Kyiv, Ukraine
[2]Odesa State Agrarian University, Ukraine, Kanatnaia St., 13, Odesa, Ukraine

***Corresponding author:** Tetiana Marchenko, Odesa State Agrarian University, Kanatnaia St., 13, Odesa, 65039, Ukraine;
E-mail: tmarchenko74@ukr.net

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Abstract

The aim of the study is to develop agrobiological fundamentals for intensifying the cultivation of innovative varieties of winter wheat in the conditions of the Right-Bank Forest-Steppe of Ukraine, considering soil-climatic conditions and agrotechnical factors. The goal is to implement competitive innovative cultivation technologies for high-quality seed production of new environmentally adaptable soft winter wheat varieties with high genetic potential. Research methods include field evaluations of competitive winter wheat varieties, laboratory analysis to determine seed similarity and germination rates, and statistical data analysis. The variability of seed quality depends on various environmental factors and the complex of genetic traits of the variety. Decreased seed viability due to low temperatures, excessive rainfall during maturation, and non-compliance with technological elements can be explained by changes in the Nitrogen content of seeds, especially protein nitrogen, which disrupts metabolic processes in embryo cells. Intensive cultivation technologies have led to the highest seed and yield qualities of soft winter wheat.

Keywords: Winter wheat, Variety, Seed, Thousand-seed weight, Conditioned seed, Laboratory similarity

Introduction

Over the past decade, grain crop yields on a global scale have significantly increased primarily due to advances in selection and genetic improvement of crop resources, enhanced productivity potential of genotypes, adaptation to various climatic factors, and tolerance to biotic and abiotic stressors (Tester & Langridge, 2010). This underscores the importance of breeding and genetic developments, which according to research by leading scientists, contribute significantly to the yield and gross grain production gains in modern conditions (Lavrynenko et al., 2023). Ukraine possesses a robust scientific and production potential for developing new genotypes and producing grain crops, making it crucial in today's scientific support for food security to create winter wheat varieties with high stable yields and genetic resistance to environmental biotic and abiotic factors (Morgun, 2016).

Wheat is the most important food crop, and it is no coincidence that it is a staple food in 43 countries worldwide with populations exceeding 1 billion (Poole et al., 2021). Exceeding grain consumption over production has led to a significant decrease in transitional grain reserves globally (Grote et al., 2021). The productivity level of wheat is determined by the suitability of growing conditions to its genotypic characteristics, and the primary limiting factor

affecting potential productivity is climate (Iwańska et al., 2021). The degree and nature of climate change and fluctuations in weather conditions can significantly impact the productivity of winter wheat. Experts estimate that variability in abiotic environmental factors can lead to substantial (up to 40%–60%) fluctuations in the yield of this crop (Obembe et al., 2021).

Materials and Methods

Field experiments and evaluations of winter wheat varieties were conducted during 2021–2023 at the Research Agricultural Farm of the Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine, located in the Right-Bank Forest-Steppe of Ukraine. The winter wheat varieties were grown in crop rotation typical for the area, with the predecessor being fallow land. Field studies were carried out according to the methodology of the State Variety Testing of Agricultural Crops (Methodology, 2000). Different cultivation technologies for producing base seed of winter wheat varieties were compared based on the following schemes:

i) base cultivation technology included pre-sowing treatment of seeds with Vitavax 200 FF (3.0 L/ton), application of mineral fertilizers at a rate of N30P30K30 at sowing and stepwise nitrogen application N34 at the IV and VII stages of organogenesis, chemical protection against weeds, diseases, and pests: herbicides – Grodil Maxi (0.09–0.11 L/ha) + Zenkor Liquid (0.1 L/ha–0.4 L/ha), fungicide - Lamardor PRO (0.5 L/ha–0.6 L/ha), insecticide - Fastak (0.1 L/ha–0.25 L/ha);

ii) intensive cultivation was based on maximum concentration and intensive use of material-technical resources, including higher rates of mineral fertilizers N60P60K60 with stepwise nitrogen application and the application of pesticides: Grodil Maxi (0.09 L/ha–0.11 L/ha) + Zenkor Liquid (0.1 L/ha–0.4 L/ha) at the tillering phase; first sowing treatment with fungicide Rex Duo (0.6 L/ha at the tillering phase), second treatment with Karamba (1.25 L/ha at the booting phase), and insecticide Fastak (0.1 L/ha–0.25 L/ha).

The accounting plot area was 10 m2. Experimental plots were arranged randomly with three replications. The seeding rate was 5.5 million similar seeds per hectare.

The study used soft winter wheat varieties of high-intensity selection types developed by the Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine, including 'Borya', 'Astarta', 'Perlina Podillya' (base type), and 'Darinka Kyivska', 'Bohdana', 'Podolyanka' (intensive type).

Weather conditions in 2021 and 2023 were favorable for winter wheat cultivation, while conditions in 2022 were dry during the vegetative period.

Results and Discussion

In the studies conducted during the vegetative period of winter wheat cultivation from 2021 to 2023, it was observed that the 1000-seed weight varied depending on the variety and cultivation technology (Tab. 1). In 2021, under the intensive base technology, the 1000-seed weight for intensive-type varieties ranged from 40.8 g ('Bohdana' variety) to 41.4 g ('Podolyanka' variety). In 2022, this parameter was slightly lower, ranging from 36.4 g ('Darinka Kyivska' variety) to 39.5 g ('Podolyanka' variety).

Table 1. The 1000-seed weight of winter soft wheat varieties depending on the cultivation technology used, g, for the years 2021–2023

No.	Variety	Cultivation Technology					
		Base (Control)			Intensive		
		2021	2022	2023	2021	2022	2023
Varieties of intensive universal use							
1	Podolyanka (Control)	41.4	39.5	44.4	42.3	40.2	46.3
2	Bohdana	40.8	38.9	45.7	42.2	41.3	45.9
3	Darynka Kyivska	41	36.4	43.8	43.7	39.8	45.2
Avg		**41.1**	**38.3**	**44.6**	**42.7**	**40.4**	**45.8**

Varieties of thehigh-intensity type							
4	Astarta	43.8	36.4	46.4	46.2	42.1	47.5
5	Perlyna Podillia	42.4	37.3	45.8	47	42.8	46.3
6	Boria	43.2	37.8	44.9	47.1	41.9	46.5
Avg		**43.1**	**37.2**	**45.7**	**46.8**	**42.3**	**46.8**
LSD_{05}		**1.32**	**1.27**	**1.34**	**1.44**	**1.28**	**1.31**

In 2021, among high-intensity type varieties, the highest 1000-seed weight under the baseline technology was recorded in the 'Astarta' variety at 43.8 grams, while the lowest was in the 'Perlyna Podillia' variety at 42.4 grams. However, in 2022, the 1000-seed weight drastically decreased under baseline technology for high-intensity type varieties, with 'Astarta' at 36.4 grams and 'Boria' at 37.8 grams. In both 2021 and 2022, using energy-intensive technology resulted in higher 1000-seed weights across all varieties compared to the baseline.

The highest 1000-seed weight among universal type varieties was achieved by the 'Darynka Kyivska' variety at 43.7 grams, and the lowest was in the 'Bohdana' variety at 42.2 grams in 2021. However, in 2022, the highest was achieved by the 'Bohdana' variety at 41.3 grams, and the lowest was the 'Darynka Kyivska' variety at 39.8 grams. For high-intensity type varieties, this metric ranged from 46.2 grams ('Astarta') to 47.1 grams ('Boria') in 2021, and from 41.9 grams ('Boria') to 42.8 grams ('Perlyna Podillia') in 2022.

In 2023, under favorable weather conditions, the 1000-seed weight of winter wheat varieties was significantly higher compared to previous years. Under the baseline cultivation technology, universal type varieties achieved 1000-seed weight indicators of 43.8 grams ('Darynka Kyivska') and 45.7 grams ('Podolyanka'). High-intensity type varieties achieved 1000-seed weight indicators of 44.9 grams ('Boria') and 46.4 grams ('Astarta') under baseline technology. Under intensive technology, this metric slightly increased and ranged between 45.2 grams–46.3 grams for universal type varieties and 46.3 grams–47.5 grams for high-intensity type varieties.

On average, under the baseline technology, the 1000-seed weight indicator for universal use varieties was 40.0 grams and 38.2 grams, and for high-intensity type varieties, it was 43.1 grams and 37.1 grams in 2021 and 2022 respectively. In the favorable weather conditions of 2021 under intensive technology, high-intensity type varieties significantly outperformed universal type varieties in 1000-seed weight. The highest indicator of 47.1 grams was achieved by the 'Boria' variety, while the lowest was 'Astarta' at 46.2 grams, substantially exceeding the metrics of universal type varieties – 42.2 grams ('Bohdana') and 43.7 grams ('Darynka Kyivska').

Analyzing the impact of variety technology on the formation of genetically inherent traits in the variety, we observed a significant alteration. Compared to the baseline technology serving as our control, under an intensive regime (with higher mineral fertilizer application rates and more frequent chemical treatments), this trait increased by an average of 3.15 grams and 3.65 grams in 2021 and 2022 respectively.

Under favorable vegetation conditions in 2021, the intensive cultivation technology resulted in a substantial increase in the 1000-seed weight indicator for high-intensity type varieties. However, in 2022, due to less favorable weather conditions, high-intensity type varieties experienced a sharp decline in the 1000-seed weight indicator compared to universal type varieties.

Considering the significant change in the 1000-seed weight indicator, there was a fundamental shift in seed yield, which is an extremely important quality and financial metric in seed production (Tab. 2). In 2021, using the baseline cultivation technology, seed yields ranged from 70% for the 'Darynka Kyivska' variety to 74% for the 'Bohdana' and 'Astarta' varieties. It's noteworthy that high-intensity type varieties achieved this metric practically at the level of intensive type varieties.

Table 2. The yield of conditioned seeds of soft winter wheat varieties depending on the cultivation technology, %, 2021–2023

No.	Variety	Cultivation Technology					
		Base (Control)			Intensive		
		2021	2022	2023	2021	2022	2023
Varieties of intensive universal use							
1	Podolyanka (Control)	73	78	83	79	85	81
2	Bohdana	74	82	84	83	83	83
3	Darynka Kyivska	70	79	80	81	84	79
Avg		**72.3**	**79.7**	**82.3**	**81**	**84**	**81**
Varieties of thehigh-intensity type							
4	Astarta	74	75	85	85	79	85
5	Perlyna Podillia	73	74	80	83	83	81
6	Boria	72	74	78	83	84	78
Avg		**73**	**74.3**	**81**	**83.7**	**82**	**81.3**
LSD_{05}		**1.01**	**1.19**	**1.17**	**1.25**	**1.11**	**1.15**

In 2022, the seed quality of all varieties was higher due to lower plant density and more developed main spikes. Under the base cultivation technology, the highest conditioning seed output was achieved by the variety 'Bohdana' at 82%, while the lowest was observed in 'Darinka Kyivska' at 78%. Varieties of the high-intensity type had significantly lower conditioning seed output, ranging from 74% ('Perlyna Podillia', 'Boria') to 75% ('Astarta'). With intensive cultivation technology, even under challenging weather conditions in 2022, universal-use types achieved high conditioning seed output ranging from 83% to 85% ('Bohdana', 'Podolyanka'), while high-intensity types provided conditioning seed output ranging from 79% to 84% ('Astarta', 'Boria').

The lowest laboratory seed similarity was noted in 'Darinka Kyivska' at 93.0%, while the highest was in 'Bohdana' at 96.0%. High-intensity types showed a slight decrease, with laboratory seed similarity dropping to around 92%. With the application of intensive technology, most varieties demonstrated an increase in laboratory seed similarity to 95%–96%, except for 'Darinka' Kyivska', where this metric decreased to 93%.

Conclusions

It has been determined that under intensive cultivation technology, the highest seeding qualities and crop properties of soft winter wheat varieties were achieved. Over the years of the study, the highest 1000-seed weight was recorded for the following varieties: 'Podolyanka', a universal-use intensive type, with an average of 46.3g, and 'Astarta, a high-intensity type, with an average of 47.5g. Under the base cultivation technology, these figures decreased to 44.4g and 46.4g, respectively. The highest percentage of laboratory seed similarity was noted in the following varieties under intensive cultivation technology: 'Bohdana' and Darinka Kyivska' (universal-use intensive types) at 96%, 'Astarta' (high-intensity type) at 98%, and 'Perlyna Podillia' at 99%.

A balanced nutrient regime under intensive cultivation technology contributed to the formation of a higher 1000-seed weight (by 1.1g) in the 'Astarta' high-intensity type compared to the base technology. This resulted in the highest output of large seed fractions (2.5 mm – 2.8 mm) at 68.7% and medium seed fractions (2.2mm – 2.5mm) at 29.3%.

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