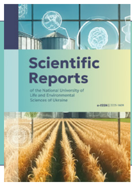
Received 09.10.2025 Revised 15.01.2026 Accepted 26.02.2026 Published: 04.03.2026

Vol. 22, No. 1
2026



Scientific Reports of the National University of Life and Environmental Sciences of Ukraine

Journal homepage: https://scireports.com.ua/en e-ISSN 2223-1609

UDC 633.11:631.559.2:631.53.01 DOI: 10.31548/dopovidi/1.2026.36

The influence of agrotechnical factors on the formation of indicators of seed productivity in winter bread wheat

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Abstract. Optimising sowing dates and selecting suitable preceding crops is crucial for realising the productive potential of modern winter wheat varieties under changing climate conditions. The aim of the study was to determine the effects of sowing dates and preceding crops on the formation of indicators of seed productivity in winter bread wheat varieties under the conditions of the Right-Bank Forest-Steppe of Ukraine. The research material included nine winter bread wheat varieties: 'AFK Stabiliti', 'AFK Lait Hrin', 'AFK Elit Hrein', 'AFK Fentezi', 'AFK Yunion', 'AFK Premium', 'MIP Feieriia', 'MIP Roksolana', and 'Podolianka'. It was established that sowing dates, preceding crops, and varietal characteristics significantly influenced seedling formation, morphological traits, and biological yield of winter bread wheat. The optimal sowing date was determined to be September 30, which provided the fastest germination (13 days), the highest tillering coefficient (1.57), the maximum number of productive stems (5.5-5.6 million/ha), and a biological yield of up to 6.3 t/ha. The most favourable preceding crops were pea and rapeseed, which ensured dense seedling stands (4.1-4.2 million/ha) and a high tillering coefficient (1.57-1.67). After sunflower, almost all studied indicators decreased due to soil nutrient depletion. The greatest ear length (up to 13.5 cm) was recorded in the 'AFK Lait Hrin' variety sown on September 30 after rapeseed, while the tallest plants were observed after pea (82.2 cm) and in the 'AFK Elit Hrein' variety (up to 89 cm). The highest biological yields were formed

Suggested Citation:
Bahatchenko, O., & Tsentylo, L. (2026). The influence of agrotechnical factors on the formation of indicators of seed productivity in winter bread wheat. *Scientific Reports of the National University of Life and Environmental Sciences of Ukraine*, 22(1), 36-53. doi: 10.31548/dopovidi/1.2026.36.

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by 'AFK Premium' (6.6-7.2 t/ha), 'AFK Elit Hrein' (6.3-6.8 t/ha), and 'AFK Fentezi' (5.8-6.4 t/ha). Analysis of variance revealed that varietal characteristics played the dominant role in determining productivity (up to 95% of variation), while preceding crops had the greatest influence on stand density, and sowing dates affected yield levels. The study demonstrated the effectiveness of applying different sowing dates after various preceding crops to differentiate winter wheat varieties by seed productivity indicators. The obtained results can be used in agricultural practice to improve the efficiency of winter wheat seed production across diverse soil and climatic conditions and to optimise crop rotation systems

Keywords: *Triticum aestivum* L.; variety; preceding crop; sowing date; germination stage

Introduction

The seed productivity of winter bread wheat plays a vital role in determining overall crop yield, influencing both the quantity and quality of seeds produced. This productivity is closely linked to a range of agronomic factors, including the timing of sowing, plant density, fertilisation practices, and pest management. As climate change continues to alter growing conditions, it becomes increasingly important to optimise sowing schedules and select appropriate preceding crops. These adjustments are necessary to ensure that modern winter wheat varieties can fully realise their productive potential under variable environmental conditions.

Winter bread wheat (*Triticum aestivum* L.) is one of the world's leading food crops. N. Rudavska *et al.* (2025) reported that in Ukraine the sown area of winter wheat in 2025 exceeded 5 million hectares. Considering global market trends, further growth in demand for wheat grain is expected, which can primarily be met by increasing yields. At the same time, climate change observed over the past decades significantly affects the state of agroecosystems and crop formation. Under these conditions, improving technological elements of cultivation that ensure crop adaptation to changing weather conditions and production stability becomes increasingly important.

Sowing date plays a key role, as it determines the growth and development rate of plants, their winter hardiness, and the realisation of the yield potential of winter wheat. O.A. Demidov *et al.* (2024) reported that the most favourable conditions for sowing occur when the average daily air temperature ranges from 14 to 17°C and sufficient productive soil moisture is available in the arable layer, ensuring seedling emergence within 6-8 days. U. Kumar *et al.* (2021), conversely, noted that excessively developed plants resulting from early sowing dates exhibit reduced resistance to adverse winter conditions, thereby increasing the risk of overwintering damage. J. Liu *et al.* (2023) investigated the effects of sowing date adjustment on winter wheat yield and established that the optimal sowing period ranged from 1 to 10 October, with no significant interannual variation.

High yields of winter wheat are mainly achieved when it follows the best preceding crops. I.M. Didur & G.V. Pantsyreva (2024) determined the productivity of winter wheat depending on the predecessors: meadow clover and white burkun. Authors noted that the choice of a preceding crop takes into account its harvest timing, ability to restore soil fertility, and the availability of soil moisture and mineral nutrients for subsequent crops. V.V. Polishchuk & Yu.M. Prytula (2025) determined the peculiarities of formation of yield and quality of winter wheat seeds depending on genotype and predecessors. Authors established that the germination energy, germination rate and weight of 1,000 seeds depended on the predecessors. Significantly lower germination energy was obtained when sowing after sunflower, and when sowing after winter rape and perennial grasses, it was the same. V. Hanhur & Y. Kotliar (2023) reported that the highest productivity of winter wheat was achieved when grown after grass pea and vetch-oat mixtures for green fodder. The least favourable preceding crops for winter wheat were sunflower and sugar beet. The authors concluded that the inclusion of leguminous crops in crop rotations serves an important ecological function by reducing the need for mineral nitrogen fertilisers and increasing the efficiency of soil nitrogen utilisation.

Achieving high and stable yields is possible only with adherence to optimal sowing dates and rational selection of preceding crops. This necessitates targeted research on the response of modern wheat varieties to variations in preceding crops and sowing time. O. Demydov *et al.* (2022) identified the features of the manifestation and variability of yield and grain quality indicators of winter wheat depending on the growing season, genotype, sowing date and preceding crop. They reported that the preceding crop had the greatest influence on yield, weight of 1,000 kernels, and protein content, whereas sowing date primarily affected yield. I. Sokolovska *et al.* (2024) reported that the preceding crop had the greatest influence on variations in yield parameters. The authors concluded that winter wheat should be sown around 15 September when following sunflower and between 15 and 30 September when following soybean. V.V. Kyrylenko *et al.* (2024) observed that the effects of preceding crops and sowing dates on germination energy and laboratory germination of winter wheat were less pronounced compared with their effect on seed sprouting activity.

Thus, numerous studies confirm the importance of an in-depth investigation of agrotechnical factors, particularly preceding crops and sowing dates, in the formation of seed productivity indicators of winter wheat under contemporary climatic conditions. At the same time, changes in the specialisation of agricultural production, a shift toward economically attractive crops, and climatic transformations necessitate their revision in modern intensive crop rotations. This substantiates the relevance of conducting the corresponding field studies.

The study aimed to evaluate the effects of different sowing dates and preceding crops on the formation of seed productivity parameters in winter bread wheat varieties grown in the Right-Bank Forest-Steppe zone of Ukraine.

Materials and Methods

The research was conducted under the conditions of "Agrofirma 'Kolos'", LLC (Pustovarivka village, Bila Tserkva district, Kyiv region), located in the Right-Bank Forest-Steppe zone of Ukraine, during 2022/23 and 2023/24. The study material included nine winter bread wheat (*Triticum aestivum* L.) varieties: 'AFK Stabiliti', 'AFK Lait Hrin', 'AFK Elit Hrein', 'AFK Fentezi', 'AFK Yunion', 'AFK Premium', 'MIP Feieriia', 'MIP Roksolana', and 'Podolianka'. The studied winter bread wheat varieties were chosen because they combine high yield potential with adaptive traits that ensure tolerance to unfavourable environmental factors, including climate variability. The above-mentioned varieties were studied under three sowing dates (I – September 20, II – September 30, III – October 10) and after four preceding crops (pea, soybean, sunflower, winter rapeseed). The study was conducted in accordance with ethical standards, adhering to the guidelines set forth by the Convention on Biological Diversity (1992), ensuring the responsible use of biological resources and respect for environmental sustainability throughout the research process.

The soil of the experimental field is a typical medium-humus, silty medium loam chernozem formed on loess. Humus content – 4.6-4.8% (by Tyurin method), easily hydrolysed nitrogen – 14.4 mg/100 g soil, available phosphorus – 9.6 mg/100 g soil, and exchangeable potassium – 15.2 mg/100 g soil. Bulk density – 1.24 g/cm^3, hydrolytic acidity – 1.14 meq/100 g soil, salt pH – 6.4. The soils are characterised by a moderate level of nutrient availability.

Crop cultivation technology followed the generally accepted practices for the Forest-Steppe zone (Poltoretskyi *et al.*, 2020; Demidov *et al.*, 2024). Sowing was carried out using a breeding seeder SN-10 at a depth of 3-4 cm with a seeding rate of 5 million viable seeds per hectare. The plots were arranged in a completely randomised design with four replications and a plot size of 10 m². Harvesting was performed using a "Sampo-130" combine harvester (Sampo-Rosenlew Ltd., Finland). Phenological observations, measurements, counts, and sample collections were conducted according to the V.V. Volkodav (2003) and other relevant methods (Tkachyk, 2016). Laboratory analysis of plants included the assessment of yield structure elements: tillering coefficient, plant density, number of productive stems, ear weight, grain yield per ear, ear length, plant height, and biological yield (Tsenov *et al.*, 2020; Demidov *et al.*, 2024). Statistical analysis of the obtained data was carried out using descriptive and variation statistics, as well as analysis of variance (ANOVA) with Fisher's Least Significant Difference (LSD) test, employing the software packages Statistica 10 and Microsoft Excel 2013. Differences between compared indicators were considered statistically significant at $p < 0.05$.

Results

The years of the study were characterised by contrasting hydrothermal conditions and uneven precipitation distribution throughout the year (Figs 1, 2). The average annual air temperature in 2022/23 and 2023/24 exceeded the long-term mean by 0.6°C and 2.5°C, respectively. The greatest fluctuations in monthly average temperatures were recorded mainly from September to February. Overall, the growing conditions in 2022/23 can be described as sufficiently moist, whereas the 2023/24 season was notably dry. The total annual precipitation amounted to 130% and 92% of the long-term norm in the respective years. A particularly pronounced precipitation deficit in 2023/24 was observed in August and September (46 mm and 47 mm below the norm), as well as in May and July (43 mm and 68 mm less than the long-term average).

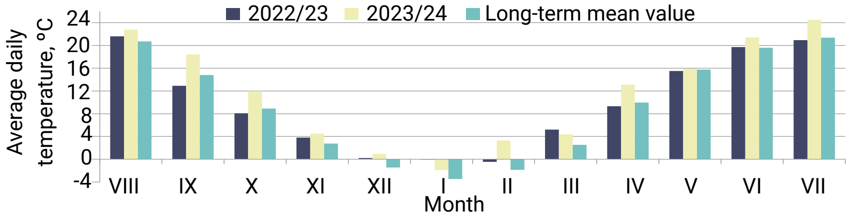

***Figure 1.** Mean daily air temperature in the study years compared to the long-term mean daily air temperature*

Source: constructed by the authors based on data from the Bila Tserkva Agrometeorological Station

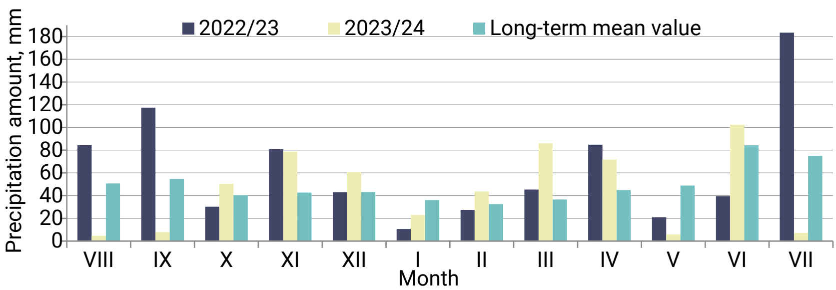

***Figure 2.** Monthly precipitation in the study years compared to the long-term mean value*

Source: constructed by the authors based on data from the Bila Tserkva Agrometeorological Station

Observations and experimental data obtained in the present study demonstrated that, at the full germination stage, the timing of seedling emergence of winter wheat varied considerably depending on the sowing date and preceding crop (Table 1).

Table 1. *Time of seedling emergence in winter bread wheat varieties depending on sowing dates and preceding crops, days*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Pea	21	21	20	21	21	21	21	21	21	21
	Soybean	22	22	21	22	22	22	22	22	22	22
	Sunflower	24	24	23	24	24	24	24	24	24	24
	Rapeseed	21	21	20	21	21	21	21	21	21	21
	Average	22	22	21	22	22	22	22	22	22	22
30.09	Pea	12	13	11	13	13	13	13	13	12	13
	Soybean	13	14	12	14	14	14	14	14	13	14
	Sunflower	13	14	12	14	14	14	14	14	13	14
	Rapeseed	13	14	12	14	14	14	14	14	13	14
	Average	13	14	12	14	14	14	14	14	13	13
10.10	Pea	14	15	13	15	15	15	15	15	14	15
	Soybean	15	16	14	16	16	16	16	16	15	16
	Sunflower	15	16	14	16	16	16	16	16	15	16
	Rapeseed	15	16	14	16	16	16	16	16	15	16
	Average	15	16	14	16	16	16	16	16	15	15

Source: developed by the authors

Under early sowing (September 20), the emergence period averaged 22 days. The fastest emergence was observed under the September 30 sowing date, averaging 13 days. In the case of late sowing (October 10), seedling emergence lasted 15 days, which can be explained by lower temperatures and slower physiological processes in the seeds. A significant effect of the preceding crop on the emergence rate was revealed. The shortest period from sowing to emergence was observed after pea – 21, 13, and 15 days for the three sowing dates, respectively. After soybean and sunflower, emergence occurred 1-2 days later. Rapeseed as a preceding crop provided similar indicators to pea, indicating its favourable influence on the early growth of wheat plants. Differences among varieties were minor (within 1-2 days), suggesting the predominance of agronomic factors (sowing date and preceding crop) over genetic variation. Slightly faster emergence was noted for the varieties 'AFK Elit Hrein' and 'Podolianka', which exhibited higher germination energy. Thus, results of the current study confirm that the sowing date significantly affects the duration of seedling emergence, as different sowing periods create variable environmental conditions for the growth and development of winter wheat plants.

One of the key criteria for yield formation is the optimal plant density per unit area. On average, the plant density in the experiment ranged from 3.9 to 4.3 million plants per hectare (Table 2). It is noteworthy that the sowing date had no significant effect on this indicator.

Table 2. *Seedling density of winter bread wheat varieties depending on sowing dates and preceding crops, million plants/ha*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Pea	4.1	4.2	4.3	4.3	4.3	4.3	4.2	4.2	4.2	4.2
	Soybean	3.9	4.0	4.1	4.1	4.1	4.1	4.0	4.0	4.0	4.0
	Sunflower	3.9	3.9	4.1	4.0	4.0	4.0	3.9	3.9	3.9	4.0
	Rapeseed	4.0	4.1	4.2	4.2	4.2	4.1	4.1	4.1	4.0	4.1
	Average	4.0	4.1	4.2	4.2	4.2	4.1	4.1	4.1	4.0	4.1
30.09	Pea	4.2	4.2	4.3	4.3	4.3	4.3	4.2	4.2	4.2	4.2
	Soybean	3.9	4.0	4.1	4.1	4.1	4.1	4.0	4.0	4.0	4.0
	Sunflower	3.9	4.0	4.0	4.0	4.1	4.0	3.9	4.0	3.9	4.0
	Rapeseed	4.0	4.1	4.2	4.2	4.2	4.2	4.1	4.1	4.1	4.1
	Average	4.0	4.1	4.2	4.2	4.2	4.2	4.1	4.1	4.1	4.1
10.10	Pea	4.1	4.2	4.3	4.3	4.3	4.3	4.2	4.2	4.2	4.2
	Soybean	3.9	4.0	4.0	4.0	4.1	4.0	3.9	4.0	3.9	4.0
	Sunflower	3.8	3.9	4.0	4.0	4.0	4.0	3.9	3.9	3.9	3.9
	Rapeseed	4.0	4.1	4.1	4.1	4.1	4.1	4.0	4.1	4.0	4.1
	Average	4.0	4.1	4.1	4.1	4.1	4.1	4.0	4.1	4.0	4.1
LSD 0.95		0.07									

Source: developed by the authors

Regarding preceding crops, the highest stand density was formed after pea and rapeseed – within 4.1-4.2 million plants/ha – whereas after soybean and sunflower it was lower (3.9-4.0 million plants/ha). Differences among varieties were minor (within 0.1-0.2 million plants/ha) and did not exceed the least significant difference (LSD 0.95 = 0.07), indicating no substantial genotype effect on stand density under uniform growing conditions. Slightly higher densities were recorded for the varieties 'AFK Elit Hrein', 'AFK Fentezi', and 'AFK Yunion', likely due to their greater germination energy and field emergence. Thus, the most favourable conditions for achieving optimal stand density of winter bread wheat were ensured by sowing on September 20 or 30 after pea or rapeseed, when the average plant density reached 4.2 million plants/ha. This confirms the importance of adhering to these sowing dates and selecting suitable preceding crops to ensure uniform plant development during the early stages of vegetation. The highest tillering coefficient was observed for the September 30 sowing date, with an average value of 1.57, which exceeded those of the early (September 20 – 1.52) and late (October 10 – 1.47) sowings (Table 3).

Table 3. *Tillering coefficient in winter bread wheat varieties depending on sowing dates and preceding crops*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Pea	1.70	1.59	1.80	1.59	1.59	1.69	1.49	1.59	1.54	1.62
	Soybean	1.59	1.49	1.69	1.49	1.49	1.59	1.39	1.49	1.49	1.52
	Sunflower	1.49	1.39	1.59	1.39	1.39	1.49	1.29	1.39	1.39	1.42

Table 3. *Continued*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Rapeseed	1.59	1.49	1.69	1.49	1.49	1.59	1.39	1.49	1.49	1.52
	Average	1.59	1.49	1.69	1.49	1.49	1.59	1.39	1.49	1.48	1.52
30.09	Pea	1.75	1.64	1.85	1.64	1.64	1.74	1.54	1.64	1.59	1.67
	Soybean	1.64	1.54	1.74	1.54	1.54	1.64	1.44	1.54	1.54	1.57
	Sunflower	1.54	1.44	1.64	1.44	1.44	1.54	1.34	1.44	1.44	1.47
	Rapeseed	1.64	1.54	1.74	1.54	1.54	1.64	1.44	1.54	1.54	1.57
	Average	1.64	1.54	1.74	1.54	1.54	1.64	1.44	1.54	1.53	1.57
10.10	Pea	1.65	1.54	1.75	1.54	1.54	1.64	1.44	1.54	1.49	1.57
	Soybean	1.54	1.44	1.64	1.44	1.44	1.54	1.34	1.44	1.44	1.47
	Sunflower	1.44	1.34	1.54	1.34	1.34	1.44	1.24	1.34	1.34	1.37
	Rapeseed	1.54	1.44	1.64	1.44	1.44	1.54	1.34	1.44	1.44	1.47
	Average	1.54	1.44	1.64	1.44	1.44	1.54	1.34	1.44	1.43	1.47
LSD 0.95		0.05									

Source: developed by the authors

This indicates an optimal combination of temperature and moisture conditions during late September, when uniform seedling development and more intensive tillering were observed. The present results also showed that tillering intensity depended on the preceding crop. The highest tillering coefficients across all sowing dates were recorded after pea (1.57-1.67), confirming the beneficial effect of this predecessor on the growth and development of wheat plants. Slightly lower but comparable values were observed after rapeseed. After soybean, the coefficient decreased on average by 0.1, while the lowest values were recorded after sunflower, which can be explained by soil nutrient depletion following this crop and a reduction in available nutrients. The tillering intensity was also influenced by the biological characteristics of the varieties. The highest coefficients were recorded for 'AFK Elit Hrein' (1.80), 'AFK Stabiliti' (1.75), and 'AFK Premium' (1.74), whereas the varieties 'MIP Feieriia' and 'Podolianka' exhibited lower tillering activity. These results confirm the effectiveness of using leguminous preceding crops and maintaining a medium sowing date to ensure intensive autumn tillering in winter bread wheat. The number of productive stems is an important component of winter bread wheat yield structure because it directly reflects the realisation of the plant's tillering potential. The present research demonstrated a significant dependence of this indicator on sowing date, preceding crop, and variety characteristics (Table 4).

Table 4. *Number of productive stems in winter bread wheat varieties depending on sowing dates and preceding crops, million/ha*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Pea	5.0	4.9	5.6	5.0	4.9	5.2	4.6	4.8	4.6	5.0
	Soybean	4.6	4.4	5.1	4.4	4.4	4.7	4.1	4.3	4.3	4.5
	Sunflower	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2

***Table 4.** Continued*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Rapeseed	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	Average	4.6	4.6	4.9	4.6	4.6	4.7	4.4	4.5	4.5	4.6
30.09	Pea	5.7	5.4	6.2	5.6	5.5	5.9	5.1	5.5	5.2	5.6
	Soybean	5.1	4.9	5.6	4.9	5.0	5.2	4.6	4.8	4.8	5.0
	Sunflower	4.8	4.6	5.1	4.6	4.6	4.9	4.1	4.5	4.5	4.6
	Rapeseed	5.2	4.9	5.7	5.1	5.1	5.3	4.6	5.0	4.9	5.1
	Average	5.2	5.0	5.7	5.1	5.1	5.3	4.6	5.0	4.9	5.1
10.10	Pea	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
	Soybean	4.9	4.7	5.4	4.7	4.8	5.1	4.4	4.7	4.6	4.8
	Sunflower	4.6	4.3	5.0	4.4	4.4	4.7	4.0	4.3	4.3	4.4
	Rapeseed	5.1	4.8	5.5	4.9	4.9	5.1	4.4	4.8	4.8	4.9
	Average	5.0	4.8	5.4	4.9	4.9	5.1	4.6	4.8	4.8	4.9
LSD 0.95		0.15									

Source: developed by the authors

The highest number of productive stems on average across the experiment was recorded for the September 30 sowing date – 5.1 million stems/ha, exceeding the values for early sowing (September 20 – 4.6 million stems/ha) and late sowing (October 10 – 4.9 million stems/ha). This indicates that the medium sowing date provided optimal conditions for autumn tillering, promoting the formation of a greater number of productive shoots. For early sowing, excessive vegetative growth could weaken some shoots, whereas late sowing shortened the autumn vegetation period, limiting stem development. Across all sowing dates, the highest number of productive stems was observed after pea – ranging from 5.0 to 5.6 million stems/ha, highlighting the significant role of this preceding crop in improving nitrogen nutrition and soil structure. After rapeseed, the values were slightly lower (4.7-5.1 million stems/ha) The lowest values were observed after sunflower (4.2-4.6 million stems/ha), which can be attributed to soil nutrient depletion and reduced availability of essential elements following this crop. Among varieties, the highest numbers of productive stems were recorded for 'AFK Elit Hrein' (4.9-5.7 million stems/ha) and 'AFK Premium' (4.7-5.3 million stems/ha).

The present study showed that spike mass in winter bread wheat varieties depended more on preceding crops and variety traits, while no significant differences were observed between sowing dates for this trait (Table 5). The highest spike mass, regardless of sowing date, was recorded after soybean, sunflower, and rapeseed (1.5-1.6 g), whereas after pea this value was lower (1.2-1.4 g). The varieties 'AFK Premium', 'MIP Roksolana', and 'AFK Fentezi' produced the largest spike mass (up to 1.6-1.7 g), indicating their high potential productivity. Thus, the most favourable conditions for achieving high spike mass were provided by the preceding crops soybean, sunflower, and rapeseed. Among the studied varieties, the best results were obtained by 'AFK Premium', 'MIP Roksolana', and 'AFK Fentezi'. Grain weight per spike ranged from 83.0 to 92.3%, depending on sowing date, preceding crop, and variety characteristics (Table 6). On average, the highest values were recorded for the October 10 sowing date – 87.8%, exceeding the values for earlier sowings (86.9% for September 20 and 86.0% for September 30).

***Table 5.** Ear weight in winter bread wheat varieties depending on sowing dates and preceding crops, g*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Pea	1.2	1.3	1.2	1.4	1.3	1.4	1.4	1.4	1.3	1.3
	Soybean	1.4	1.5	1.4	1.6	1.5	1.7	1.6	1.6	1.4	1.5
	Sunflower	1.4	1.5	1.4	1.6	1.5	1.6	1.5	1.6	1.4	1.5
	Rapeseed	1.4	1.5	1.4	1.6	1.5	1.6	1.5	1.6	1.4	1.5
	Average	1.4	1.5	1.4	1.6	1.5	1.6	1.5	1.6	1.4	1.5
30.09	Pea	1.2	1.3	1.2	1.3	1.2	1.4	1.3	1.4	1.3	1.3
	Soybean	1.4	1.5	1.4	1.6	1.5	1.7	1.6	1.6	1.5	1.5
	Sunflower	1.4	1.5	1.4	1.6	1.5	1.6	1.5	1.6	1.5	1.5
	Rapeseed	1.4	1.5	1.4	1.6	1.5	1.6	1.5	1.6	1.5	1.5
	Average	1.4	1.5	1.4	1.5	1.4	1.6	1.5	1.6	1.5	1.5
10.10	Pea	1.2	1.3	1.2	1.3	1.3	1.4	1.3	1.4	1.3	1.3
	Soybean	1.4	1.5	1.4	1.6	1.5	1.7	1.6	1.6	1.5	1.5
	Sunflower	1.4	1.5	1.4	1.6	1.5	1.6	1.5	1.6	1.5	1.5
	Rapeseed	1.4	1.5	1.4	1.6	1.5	1.6	1.5	1.6	1.4	1.5
	Average	1.4	1.5	1.4	1.5	1.5	1.6	1.5	1.6	1.4	1.5
LSD 0.95		0.05									

Source: developed by the authors

***Table 6.** Grain yield per ear in winter bread wheat varieties depending on sowing dates and preceding crops, %*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Pea	90.4	85.4	91.4	86.4	88.4	87.4	86.4	86.4	87.4	87.7
	Soybean	88.9	83.9	89.9	84.9	86.9	85.9	84.9	84.9	85.9	86.2
	Sunflower	89.4	84.4	90.4	85.4	87.4	86.4	85.4	85.4	86.4	86.7
	Rapeseed	89.7	84.7	90.7	85.7	87.7	86.7	85.7	85.7	86.7	87.0
	Average	89.6	84.6	90.6	85.6	87.6	86.6	85.6	85.6	86.6	86.9
30.09	Pea	89.5	84.5	90.5	85.5	87.5	86.5	85.5	85.5	86.5	86.8
	Soybean	88.0	83.0	89.0	84.0	86.0	85.0	84.0	84.0	85.0	85.3
	Sunflower	88.5	83.5	89.5	84.5	86.5	85.5	84.5	84.5	85.5	85.8
	Rapeseed	88.8	83.8	89.8	84.8	86.8	85.8	84.8	84.8	85.8	86.1
	Average	88.7	83.7	89.7	84.7	86.7	85.7	84.7	84.7	85.7	86.0
10.10	Pea	91.3	86.3	92.3	87.3	89.3	88.3	87.3	87.3	88.3	88.6
	Soybean	89.8	84.8	90.8	85.8	87.8	86.8	85.8	85.8	86.8	87.1
	Sunflower	90.3	85.3	91.3	86.3	88.3	87.3	86.3	86.3	87.3	87.6
	Rapeseed	90.6	85.6	91.6	86.6	88.6	87.6	86.6	86.6	87.6	87.9
	Average	90.5	85.5	91.5	86.5	88.5	87.5	86.5	86.5	87.5	87.8
LSD 0.95		1.61									

Source: developed by the authors

Among preceding crops, the highest grain weight per spike was observed after pea (87.7-88.6%), whereas slightly lower values were recorded after soybean, sunflower, and rapeseed

(85.3-87.9%). In terms of genotypic characteristics, the varieties 'AFK Elit Hrein' (90.5-92.3%), 'AFK Stabiliti' (89.5-91.3%), and 'AFK Fentezi' (85.5-87.3%) demonstrated the highest grain weight per spike, indicating their stable ability to produce well-filled spikes. The differences among treatments were statistically significant (LSD 0.95 = 1.61%), confirming the influence of sowing date, preceding crop, and variety on grain weight per spike. On average, the best results were obtained under late sowing (October 10) after pea, with values ranging from 86.3 to 91.3%.

Spike length varied from 8.1 to 13.5 cm, depending on sowing date, preceding crop, and variety (Table 7). On average, the highest spike length was recorded for the September 30 sowing date – 9.7 cm, exceeding values for early (September 20 – 9.4 cm) and late (October 10 – 9.2 cm) sowings. This suggests that optimal conditions for growth and development during the stem elongation stage were provided by the medium sowing date, positively influencing the formation of generative organs.

Table 7. *Ear length in winter bread wheat varieties depending on sowing dates and preceding crops, cm*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Pea	8.9	12.5	9.1	9.5	9.1	9.7	9.0	9.2	8.5	9.5
	Soybean	8.8	12.3	9.0	9.3	9.0	9.6	8.9	9.0	8.4	9.4
	Sunflower	8.7	12.2	8.9	9.2	8.8	9.5	8.8	8.9	8.3	9.3
	Rapeseed	8.8	13.0	9.0	9.3	9.6	9.6	8.9	9.7	8.4	9.6
	Average	8.8	12.5	9.0	9.3	9.1	9.6	8.9	9.2	8.4	9.4
30.09	Pea	9.1	13.0	9.6	9.6	9.1	9.7	9.1	9.4	9.1	9.7
	Soybean	9.0	12.9	9.5	9.5	8.9	9.6	8.9	9.3	9.0	9.6
	Sunflower	8.8	12.7	9.4	9.4	8.8	9.5	8.8	9.1	8.9	9.5
	Rapeseed	8.9	13.5	9.5	9.5	9.6	9.6	8.9	9.9	9.0	9.8
	Average	9.0	13.0	9.5	9.5	9.1	9.6	8.9	9.4	9.0	9.7
10.10	Pea	8.7	12.2	8.9	9.2	8.8	9.5	8.8	8.9	8.3	9.3
	Soybean	8.6	12.0	8.8	9.1	8.7	9.4	8.7	8.7	8.2	9.1
	Sunflower	8.5	11.9	8.7	9.0	8.5	9.3	8.6	8.6	8.1	9.0
	Rapeseed	8.6	12.7	8.8	9.1	9.3	9.4	8.7	9.4	8.2	9.4
	Average	8.6	12.2	8.8	9.1	8.8	9.4	8.7	8.9	8.2	9.2
LSD 0.95		0.32									

Source: developed by the authors

Among preceding crops, the longest average spikes were observed after rapeseed (9.6-9.8 cm), while the shortest spikes occurred after sunflower (9.0-9.5 cm). By variety, the longest spikes were consistently formed by 'AFK Lait Hrin' (12.0-13.5 cm) across all sowing dates and preceding crops, indicating its genetically determined advantage in spike formation. Slightly shorter but relatively stable values were observed in 'AFK Premium' (9.3-9.7 cm), 'AFK Elit Hrein' (8.8-9.6 cm), and 'AFK Fentezi' (9.0-9.6 cm), while the shortest spikes were recorded in 'Podolianka' and 'MIP Feieriia' (8.2-8.9 cm). The effects of sowing date and preceding crop on spike length were statistically significant (LSD 0.95 = 0.32 cm), emphasising the importance of these factors in shaping spike morphology. The optimal combination – sowing on September 30 after rapeseed – produced the highest spike length (up to 13.5 cm) in 'AFK Lait Hrin'. Plant height was significantly influenced by sowing date, preceding crop, and variety. The tallest plants were recorded for the September 30 sowing date, averaging 80.7 cm, which exceeded the heights for early (September 20 – 78.7 cm) and late (October 10 – 79.7 cm) sowings (Table 8).

Table 8. *Plant height in winter bread wheat varieties depending on sowing dates and preceding crops, cm*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Pea	83.5	78.5	88.5	83.5	83.5	58.5	78.5	78.5	88.5	80.2
	Soybean	81.5	76.5	86.5	81.5	81.5	56.5	76.5	76.5	86.5	78.2
	Sunflower	80.5	75.5	85.5	80.5	80.5	55.5	75.5	75.5	85.5	77.2
	Rapeseed	82.5	77.5	87.5	82.5	82.5	57.5	77.5	77.5	87.5	79.2
	Average	82.0	77.0	87.0	82.0	82.0	57.0	77.0	77.0	87.0	78.7
30.09	Pea	85.5	80.5	90.5	85.5	85.5	60.5	80.5	80.5	90.5	82.2
	Soybean	83.5	78.5	88.5	83.5	83.5	58.5	78.5	78.5	88.5	80.2
	Sunflower	82.5	77.5	87.5	82.5	82.5	57.5	77.5	77.5	87.5	79.2
	Rapeseed	84.5	79.5	89.5	84.5	84.5	59.5	79.5	79.5	89.5	81.2
	Average	84.0	79.0	89.0	84.0	84.0	59.0	79.0	79.0	89.0	80.7
10.10	Pea	84.5	79.5	89.5	84.5	84.5	59.5	79.5	79.5	89.5	81.2
	Soybean	82.5	77.5	87.5	82.5	82.5	57.5	77.5	77.5	87.5	79.2
	Sunflower	81.5	76.5	86.5	81.5	81.5	56.5	76.5	76.5	86.5	78.2
	Rapeseed	83.5	78.5	88.5	83.5	83.5	58.5	78.5	78.5	88.5	80.2
	Average	83.0	78.0	88.0	83.0	83.0	58.0	78.0	78.0	88.0	79.7
LSD 0.95		2.79									

Source: developed by the authors

Among preceding crops, pea provided the tallest plants, with an average height of 82.2 cm, whereas after soybean and rapeseed heights were 80.2 and 81.2 cm, respectively. The shortest plants were recorded after sunflower (79.2 cm). By genotype, the tallest plants were observed in 'AFK Elit Hrein' (88-89 cm), indicating an intensive growth type. Heights of 82-84 cm were recorded for 'AFK Fentezi', 'AFK Yunion', and 'Podolianka', whereas 'AFK Premium' exhibited a shorter-stemmed habit (57-59 cm).

Analysis of the obtained data showed that the formation of biological yield in winter wheat was significantly influenced by sowing date, preceding crop, and variety (Table 9). The highest yield was obtained for the September 30 sowing date – averaging 6.3 t/ha, exceeding the results for early sowing (September 20 – 5.7 t/ha) and late sowing (October 10 – 6.2 t/ha). Thus, the optimal sowing period fell in the third decade of September, when weather conditions favoured better crop development and a greater number of productive stems.

Table 9. *Biological yield in winter bread wheat varieties depending on sowing dates and preceding crops, t/ha*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
20.09	Pea	5.4	5.4	6.3	5.9	5.6	6.6	5.4	6.0	5.3	5.8
	Soybean	5.8	5.5	6.4	5.9	5.7	6.7	5.5	6.0	5.4	5.9
	Sunflower	5.4	5.1	5.9	5.5	5.3	6.3	4.9	5.5	4.9	5.4
	Rapeseed	6.0	5.5	6.4	6.0	5.8	6.7	5.4	6.1	5.4	5.9
	Average	5.7	5.4	6.3	5.8	5.6	6.6	5.3	5.9	5.3	5.7

Table 9. *Continued*

Sowing date	Preceding crop	'AFK Stabiliti'	'AFK Lait Hrin'	'AFK Elit Hrein'	'AFK Fentezi'	'AFK Yunion'	'AFK Premium'	'MIP Feieriia'	'MIP Roksolana'	'Podolianka'	Average
30.09	Pea	6.2	5.8	6.7	6.4	6.1	7.1	5.8	6.4	5.8	6.3
	Soybean	6.4	6.0	7.0	6.5	6.3	7.4	6.0	6.6	6.1	6.5
	Sunflower	6.0	5.7	6.4	6.1	5.9	6.9	5.4	6.2	5.6	6.0
	Rapeseed	6.6	6.1	7.1	6.7	6.5	7.5	6.0	6.8	6.2	6.6
	Average	6.3	5.9	6.8	6.4	6.2	7.2	5.8	6.5	5.9	6.3
10.10	Pea	6.1	5.8	6.7	6.3	6.0	7.1	5.7	6.4	5.7	6.2
	Soybean	6.4	6.0	6.9	6.4	6.3	7.3	5.9	6.5	5.9	6.4
	Sunflower	5.8	5.5	6.4	6.0	5.7	6.8	5.3	6.0	5.5	5.9
	Rapeseed	6.5	6.0	7.0	6.6	6.4	7.4	5.9	6.5	5.9	6.5
	Average	6.2	5.8	6.8	6.3	6.1	7.2	5.7	6.4	5.8	6.2
LSD 0.95		0.23									

Source: developed by the authors

Among preceding crops, rapeseed provided the highest average yield (6.6 t/ha), surpassing values after pea (6.3 t/ha), soybean (6.5 t/ha), and especially sunflower (6.0 t/ha). Regarding variety characteristics, the highest biological yield was recorded for 'AFK Premium' (6.6-7.2 t/ha across sowing dates), which showed stable productivity in all experimental variants. High yields were also observed in 'AFK Elit Hrein' (6.3-6.8 t/ha) and 'AFK Fentezi' (5.8-6.4 t/ha). The results indicate that the best growth, development, and yield of winter wheat were achieved through a combination of optimal sowing date (September 30), suitable preceding crop (rapeseed or pea), and use of high-yielding varieties ('AFK Premium', 'AFK Elit Hrein', and 'AFK Fentezi'). This approach promoted the formation of well-developed plants and ensured stable yields under the climatic conditions of the study region.

In the present experiment later sowing (September 30) did not reduce productivity, which may be attributed to the regional climatic specifics (a longer warm autumn and sufficient soil moisture) and the use of modern varieties with increased adaptability to later sowing. Additionally, rapeseed and pea as preceding crops provided favourable nutrition and moisture accumulation, compensating for any potential negative effects of delayed sowing. Thus, differences in optimal sowing dates reported by various authors can be explained not only by regional cultivation conditions but also by differences in variety composition, preceding crops, and weather conditions of specific years. This emphasises the need for regional adaptation of technological recommendations and consideration of the genetic potential of varieties when planning sowing dates. Analysis of variance showed that the formation of the main elements of winter wheat seed productivity is largely determined by variety genetics, while the role of sowing date and preceding crop varied depending on the specific trait (Table 10). The greatest variety effect was observed for plant height (95.2%) and spike length (92.4%), highlighting the leading role of genetic factors in determining morphological parameters. A similar trend was observed for grain weight per spike (72.6%) and biological yield (59.7%), where variety characteristics accounted for the majority of trait variation. Meanwhile, the effect of the preceding crop was significant for plant density (66.4%), spike weight (53.1%), and number of productive stems (43.0%), indicating that preceding crops substantially influence the formation of productive tillers, particularly stand density. The sowing date had a comparatively smaller but still noticeable impact on certain traits, notably productive stems (21.4%) and biological yield (21.3%), underscoring the importance of adhering to optimal sowing dates to ensure harmonious plant development during critical organogenesis phases. Interactions among factors contributed minimally to overall variation (up to 3%), indicating stable variety responses and a minor synergistic effect of agronomic combinations. The proportion of unexplained factors ranged from 1.7 to 10.3%, confirming the high accuracy of the experiment. Thus, the study results demonstrated that variety characteristics play a decisive role in determining seed productivity of winter wheat, while agronomic factors (sowing dates and preceding crops) modulate trait expression, particularly through their effects on stand density, number of productive stems, tillering, and spike weight.

Table 10. *Contribution of factors to the formation of seed productivity indicators in winter bread wheat varieties, %*

Indicator of seed productivity	Sowing date	Preceding crop	Variety	Sowing date× Preceding crop	Sowing date × Variety	Preceding crop × Variety	Sowing date× Preceding crop × Variety	Unexplained factors
Tillering coefficient	11.8	34.3	49.0	0.0	0.0	0.4	0.0	4.4
Seedling density	2.0	66.4	20.2	0.6	0.6	0.6	2.9	6.6
Number of productive stems	21.4	43.0	31.7	0.2	0.1	0.8	0.2	2.6
Ear weight	0.0	53.1	38.0	0.4	1.0	2.9	0.9	3.6
Grain yield per ear	11.0	6.1	72.6	0.0	0.0	0.0	0.0	10.3
Ear length	2.7	1.1	92.4	0.0	0.8	1.3	0.0	1.7
Plant height	0.9	1.6	95.2	0.0	0.0	0.0	0.0	2.3
Biological yield	21.3	14.3	59.7	0.3	0.2	0.6	0.4	3.2

Source: developed by the authors

Discussion

Summarising the results of the conducted studies, it was established that crop predecessors and sowing dates are key agronomic factors that significantly affect yield formation and seed productivity indicators of winter bread wheat. Scientists from Ukraine and other countries have conducted a series of studies addressing this issue. I.I. Yarchuk & T.V. Melnyk (2018) showed that shifting sowing to later dates resulted in a reduction of all plant growth parameters. At the same time, the number of newly formed nodal roots after a stubble preceding crop was lower under both early and late sowing dates. The authors found that by the time of cessation of autumn vegetation, winter bread wheat plants reached the highest level of development when sown early (3 September) after a fallow preceding crop. At the same time, maximum yield after a fallow preceding crop was formed under a high level of mineral nutrition when sowing was carried out on 17 September, whereas after a stubble preceding crop the highest yield was obtained when sowing on 10 September. These results are consistent with the findings of I.V. Pravdziva *et al.* (2020), who noted the effectiveness of using contrasting sowing dates after different preceding crops for the evaluation of winter bread wheat genotypes. The authors established that the growing year conditions accounted for 66.2% of the variation in yield, preceding crops for 12.5%, sowing dates for 6.1%, and genotype for 1.7%. A statistically significant difference in genotype responses to sowing dates after different preceding crops was observed, with a tendency toward a decrease in mean yield when sowing dates were shifted from 26 September to 16 October, whereas for some genotypes the optimal sowing date was 5 October.

Yu.M. Priadko (2014) reported similar patterns in a study investigating the effects of preceding crops, sowing dates, and mineral fertiliser rates on the growth and development of winter wheat during the autumn growing period. The author emphasised the substantial influence of sowing dates on the growth processes of winter wheat in autumn. At the same time, under favourable hydrothermal conditions, the differences between early and optimal sowing dates decreased. However, a strong relationship was identified between sowing dates, field germination of seeds, and plant stand density of winter wheat. It was established that under an adequate level of mineral nutrition and optimal sowing dates (the third ten-day period of September), the tillering coefficient at the time of cessation of autumn vegetation ranged from 2.6 to 3.6 across all preceding crops (rapeseed, mustard, vetch, and fallow). A. Siroshtan *et al.* (2021) reported that the thousand-kernel weight of winter wheat cultivars following a green manure preceding crop was significantly higher compared with that after soybean as a preceding crop. The influence of preceding crops and sowing dates on germination energy and laboratory seed germination was insignificant. The authors concluded that in the Right-Bank Forest-Steppe zone of Ukraine, green manure is the best preceding crop for seed production, especially for the cultivation of pre-basic seed, while the optimal sowing dates were identified as 15 and 25 September. For soybean as a preceding crop, the highest yield was observed when sowing was carried out on 25 September and 5 October compared with 15 October. The researchers noted that placing winter wheat seed production fields after the best preceding crops in crop rotations and at optimal sowing dates promotes more efficient use of natural-climatic and anthropogenic factors, increases gross grain yields, and improves seed sowing quality. A.D. Gyrka *et al.* (2017) indicated that the most favourable combination of yield structure components was observed at the optimal sowing date of 20 September. Delaying sowing until 30 September or 10 October had a negative effect on plant stand density, productive tillering, spike fertility, and grain weight. This confirms that even slight shifts in sowing dates can substantially alter the morphological and yield-related traits of plants.

Studies by M. Babulicová (2014) emphasised the importance of preceding crops in crop rotation: winter wheat grown in rotations with 80% cereals produced a statistically higher yield after pea compared with winter barley, while the yield increase of 1.9 t/ha was attributed to the choice of an appropriate preceding crop and combined fertilisation. This trend is further supported by the research of M. Groeneveld *et al.* (2024), who conducted field experiments in Northern Germany. The authors found that winter wheat productivity strongly depends on the interaction between the preceding crop and sowing date. Under later sowing dates, crop yield increased following sugar beet, silage maize, and winter wheat, whereas after winter oilseed rape the effect of sowing date was negligible. Overall, sugar beet and winter oilseed rape were identified as the most favourable preceding crops; however, the need for further long-term field studies to clarify the interactions among agronomic factors was emphasised. O.L. Ulich (2018) noted that due to increasing drought intensity and the prolongation of the autumn growing period, a tendency toward a shift of optimal sowing dates to later periods has been observed. Over recent decades, sowing dates of winter wheat have shifted from early to intermediate and moderately late periods: by approximately 30 days compared with the 1950s, 20 days compared with the 1970s, 15-20 days compared with the 1980s, and about 10 days compared with the 1990s. At present, optimal sowing dates predominantly fall around 30 September and largely depend on genotype. S. Poltoretskyi *et al.* (2020) confirmed that consensus on optimal agronomic parameters has not yet been achieved, and a shift in sowing dates from early to intermediate and moderately late has been observed, accompanied by changes in cultivar choice, seeding rate, and sowing method.

Thus, an analysis of the literature and experimental data indicates that the effective formation of yield and seed productivity of winter bread wheat is largely determined by the interaction between preceding crops and sowing dates. The differences in the assessment of the effects of these agronomic factors reported by various researchers can be explained not only by regional growing conditions but also by cultivar differences and year-to-year weather variability. This highlights the need for regional adaptation of technological recommendations and for considering the genetic potential of cultivars when optimising sowing dates. Overall, the selection of agronomic practices should be based on an integrated consideration of climatic conditions, crop genotype, and the specific characteristics of preceding crops, which ensures the realisation of productive potential and high seed quality.

Conclusions

It was established that sowing dates, preceding crops, and variety characteristics significantly influenced the formation of seedlings, morphological traits, and biological yield of winter bread wheat. The optimal sowing date was determined to be September 30, which provided the fastest germination (13 days), the highest tillering coefficient (1.57), the maximum number of productive stems (5.5-5.6 million stems/ha), and the highest biological yield (6.3 t/ha). The most favourable preceding crops were pea and rapeseed, which promoted optimal stand density (4.1-4.2 million plants/ha), high tillering coefficient (1.57-1.67), and the largest number of productive stems (up to 5.6 million stems/ha). Values were reduced after sunflower due to soil nutrient depletion. Spike mass depended mainly on the preceding crop and ranged from 1.5-1.6 g after soybean, sunflower, and rapeseed.

The highest grain weight per spike (up to 91.3%) was recorded for late sowing (October 10) after pea. The maximum spike length (up to 13. cm) was observed in the 'AFK Lait Hrin' variety sown on September 30 after rapeseed. Regarding plant height, the advantage was observed for crops sown on September 30 after pea (82.2 cm), with 'AFK Elit Hrein' standing out among varieties (up to 89 cm). The highest biological yields were recorded for 'AFK Premium' (6.6-7.2 t/ha), 'AFK Elit Hrein' (6.3-6.8 t/ha), and 'AFK Fentezi' (5.8-6.4 t/ha) under September 30 sowing after rapeseed. Variance analysis showed that variety characteristics played a leading role in determining productivity, accounting for more than 50% of the variation in most traits (up to 95% for plant height and 92% for spike length). The influence of the preceding crop was most significant for stand density (66.4%) and spike mass (53.1%), while the contribution of sowing date to the variation in biological yield was about 21%.

These results indicate that a comprehensive combination of optimal sowing date (September 30), appropriate preceding crop selection (rapeseed or pea), and the use of high-yielding varieties ('AFK Premium', 'AFK Elit Hrein', 'AFK Fentezi') provides the best conditions for achieving key indicators of seed productivity in winter bread wheat under the studied regional conditions. Future research could focus on exploring additional agronomic factors, long-term climate effects, and the resilience of wheat varieties to extreme weather conditions to further enhance seed productivity under changing environmental conditions.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Вплив агротехнічних чинників на формування показників насіннєвої продуктивності пшениці м'якої озимої

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Анотація. Оптимізація строків сівби та добору попередників є важливою для реалізації продуктивного потенціалу сучасних сортів пшениці озимої в умовах змін клімату. Мета дослідження полягала у встановленні впливу строків сівби та попередників на формування показників насіннєвої продуктивності сортів пшениці м'якої озимої в умовах Правобережного Лісостепу України. Матеріалом дослідження були дев'ять сортів пшениці м'якої озимої: 'АФК Стабіліті', 'АФК Лайт Грін', 'АФК Еліт Грейн', 'АФК Фентезі', 'АФК Юніон', 'АФК Преміум', 'МІП Феєрія', 'МІП Роксолана' та 'Подолянка'. Встановлено, що строки сівби, попередники та сортові особливості суттєво впливали на формування сходів, морфологічні показники й біологічну врожайність пшениці м'якої озимої. Оптимальним визначено строк сівби 30 вересня, за якого відзначено найшвидше проростання (13 діб), найвищий коефіцієнт кущення (1,57), максимальну кількість продуктивних стебел (5,5-5,6 млн шт./га) та біологічну врожайність до 6,3 т/га. Найсприятливішими попередниками були горох і ріпак, що забезпечували формування густих сходів (4,1-4,2 млн шт./га) та високий коефіцієнт кущення (1,57-1,67). Після соняшнику майже всі досліджувані показники знижувалися через виснаження ґрунту. Найвищу довжину колоса (до 13,5 см) відмічено у сорту 'АФК Лайт Грін' за сівби 30 вересня після ріпаку, а за висотою рослин перевагу мали посіви після гороху (82,2 см) і сорт 'АФК Еліт Грейн' (до 89 см). Найвищу біологічну врожайність формували сорти 'АФК Преміум' (6,6-7,2 т/га), 'АФК Еліт Грейн' (6,3-6,8 т/га) та 'АФК Фентезі' (5,8-6,4 т/га). Дисперсійний аналіз засвідчив, що провідну роль у формуванні продуктивності відіграють сортові особливості (до 95 % варіації), тоді як попередники найбільше впливали на густоту посівів, а строки сівби – на рівень врожайності. Виявлено ефективність застосування різних строків сівби після різних попередників для диференціації сортів пшениці м'якої озимої за показниками насіннєвої продуктивності. Результати можуть бути використані у виробничій практиці для підвищення ефективності вирощування насіння пшениці м'якої озимої в різних ґрунтово-кліматичних умовах та оптимізації системи сівозмін

Ключові слова: *Triticum aestivum* L.; сорт; попередник; строк сівби; стадія проростання