



Influence of Late Sowing Term on Forming of Selection-Valueble Characteristics of *Triticum Aestivum* L.

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ABSTRACT

To establish the influence of late sowing date of winter wheat on the formation of breeding-value traits and to identify varieties with high indicators of productivity, adaptability and grain quality. The material was domestic and Western European varieties and lines of winter wheat from the collection of the Institute of Plant Physiology and Genetics of the NAS of Ukraine, zoned for cultivation in the Forest-Steppe, Polissya and Steppe zones. Sowing was carried out at optimal times September 25-30, and late terms October 29. The influence of late sowing date on breeding-value traits of wheat was determined on varieties that occupy the largest sowing areas in Ukraine by distribution: Podolianka, Bohdana, Favoritka, Smuglyanka, Gospodarka 1. The Favoritka variety at the optimal and late sowing dates was characterized by a high plasticity index 3.8 and 3.0, respectively. A high level of homeostasis was established 40.0 in the Smuglyanka variety at the optimal date and 32.5 in the Gospodarka1 variety at the late sowing date. Late sowing time affects the indicators of productive tillering and grain mass per plant with a decrease of up to 50%, the number and mass of grain in the main spike by up to 24%, the number of productive spikelets and the mass of 1000 grains by up to 8.7%. According to the grain mass of 1 ear at the optimal and late sowing date, the variety Gospodarka1 was selected with a high index of stress resistance and adaptability and the variety Favoritka with plasticity.

Key words: late sowing term, *T. aestivum* L., selection-valuable characteristics, varieties, adaptability.

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INTRODUCTION

Climate changes significantly affect the conditions of plant growth, which ensure their growth, development, reproduction and distribution in different regions of the world [1]. Such changes make the external environment unpredictable and less predictable, when their yield variability increases with the regional and potential productivity of agricultural crops change [2].

Winter wheat (*Triticum aestivum* L.) is the main food crop of world agriculture. Climate change is making its own adjustments to the food process of crops. Therefore, scientists around the world: are developing models of the dynamic process of wheat seed germination using different sowing dates with effective use of soil heat/moisture supply [3]; are investigating the adaptive responses of vernalization and plant survival during mild and warm winter periods [4], which causes a loss of frost resistance [5]; by combining remote sensing methods (unmanned aerial vehicles) and integrated approaches to plant protection at different stages of wheat development [6], they are establishing the accuracy of nitrogen fertilizer use, which facilitates crop adaptation to stresses [7, 8]; establish a strong influence of the external environment on the relationship between different sowing dates and yield, grain quality and bread dough indicators [9]; use a combination of satellite images with machine learning and artificial intelligence algorithms in remote monitoring of winter wheat parameters [10].

To increase crop productivity and sustainable production of winter wheat, a reassessment of agricultural methods and techniques is necessary, as noted by scientists from the state of Nebraska, USA [11]. To successfully grow high yields of wheat, it is necessary to study the sowing date as an agronomic option, according to researchers from Australia [12].

Sowing crops at an early sowing date can optimize the use of precipitation and nutrients, and due to a late date, there is an increased probability of crop loss in the event of uncertainty in precipitation and temperature, as suggested by scientists in the UK [13]. A late sowing date, as researchers [14] have found,

improves resistance to lodging without loss of grain yield compared to an early one. In Germany, researchers [15] use different sowing dates on combined crops of winter wheat and soybeans, introducing them as a strategy for plant adaptation to climate change.

One of the most important tasks of the agrarian policy of Ukraine is a significant increase and stabilization of the production of high-yielding and high-quality food grains of soft winter wheat. One of the conditions for increasing its productivity is the use of varieties with a wide range of adaptability to adverse environmental conditions, which largely depends on the productivity and adaptability potential of the variety [16, 17].

Overwintering is among the important adaptive properties of plants that ensure stable production of high grain yields. In Ukraine, winter crops are often damaged by exposure to low temperatures, crushed ice, thawing, washing, getting wet, etc. The sowing terms, at which the maximum frost/winter resistance of plants is formed, do not always coincide in different years. The sowing term is dynamic and its definition for a new variety is individual for each growing zone. It is possible to achieve a high crop yield under the optimal soil and climatic conditions of the region with a correctly selected assortment of adaptive varieties and skillful regulation of sowing terms that [18]. Therefore, in adaptive breeding, the study of the reaction of plants of the most common and regional varieties of winter wheat to sowing terms as an influencing factor in the formation of valuable features of the adaptive ability of genotypes to such an important agricultural practice has significant scientific and practical significance and relevance.

Status of the study of the issue

Due to the aridization of the climate and global warming with the use of modern varieties and agricultural technologies in the forest-steppe zone of Ukraine, the trend of optimal sowing terms for winter wheat has changed. In the 1950s, the best time for sowing was on August 25, and in some years winter wheat produced a higher yield after early sowing than wheat that was sown after optimal terms. In the 1970 s, these dates shifted to September 10, and in the 1980 s, they were already optimal on September 10-15, where late sowing was more productive. In the 1990 s, the optimal sowing time was already on September 20. Intensification of drought in the last 20 years of the new millennium extended the terms of the autumn vegetation of plants, therefore significant corrections were made before their establishment. Today, the optimal sowing time falls on September 30 and largely depends on the genotype. The probability of obtaining a high yield of winter wheat after early sowing is 6%, after admissible early sowing — 24%, after optimal sowing — 61%, and after late sowing — 9% [19, 20].

In addition to the sowing terms, the adaptive characteristics of winter wheat are influenced by low-cost, highly effective and ecologically safe measures for the selection of suitable predecessors in crop rotation. This has a positive effect on the development of plants in the autumn period, the passage of stages of hardening with an increase in the general winter resistance of the crop and the preservation of the tendency to decrease the percentage of damage by diseases and pests from earlier to later terms of sowing [21, 22]. Postponement of sowing terms to later dates leads to a decrease in wheat yield by 0.97 and 0.62 t/ha after the previous crops of siderat and soybeans, respectively. The yield of wheat is most influenced by the hydrothermal conditions of the year (63%), by the interaction "predecessor × conditions of the year" (12%), and by the previous crop (11%). In the Right Bank Forest Steppe of Ukraine, the cultivation of winter wheat with sowing terms on September 15 and September 25 contributes to the most effective use of climatic conditions, an increase in the yield of grain per unit area and an improvement in the sowing qualities of the material [23].

Sowing terms in combination with stem density of winter wheat have a significant impact on productivity and its components. They are the main levers of adaptation systems of agriculture under conditions of climate change [24]. Sowing dates have a greater effect on the number of ears, grains in an ear, and the weight of 1000 grains with a decrease in selection traits until late sowing. High results can be achieved with a combination of three factors: productivity, sowing term and stem density [25, 26]. The winter wheat yield is significantly influenced by a combination of factors: the genotype of the variety, the term of sowing and the rate of sowing. Plants with a tillering coefficient of "3" form the largest share (20%) of the crop yield and are an important mechanism of its compensation [27]. The delay in sowing crops affects the yield and quality of wheat grain [28].

The aim of the research is to establish the influence of the late sowing date of winter wheat on the formation of breeding-value traits and to identify varieties with high productivity, adaptability and grain quality.

MATERIAL AND METHODS

The research was conducted during 2017-2022 in the Department of Plant Genetic Improvement of the Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine (IFRG) on the basis of the Research Agricultural Production Institute of the National Academy of Sciences of Ukraine (Glevakha village, Vasylkiv district, Kyiv region).

The material of the experiment was the collection of wheat varieties of the winter nursery of the Comparative testing. The set of varieties of the collection was divided into 3 groups: varieties of the growing zone of the Forest Steppe and Polissia, varieties of the Steppe zone and varieties of Western European selection (**table 1**).

The data in the table show that the largest number of 420 variety samples was studied in 2017/18 and the smallest number of 99 - in 2021/22. Over the past 5 years, the largest number in the collection, from 30.2% to 69.7% of winter wheat varieties cultivation of Forest Steppe and Polissia and from 24.2% to 59.3% of varieties of Western European selection, are undergoing comparative testing.

High-quality seed material of winter wheat varieties with appropriate biological characteristics and modern growing technology, namely, field preparation for sowing, fertilizers and proven plant protection products were used for sowing. Based on the soil and climatic features of the crop growing zone, crop rotation in the field and technical resources of the farm, the establishment of an experiment of collection samples and sowing was carried out at the optimal term on September 25-30 and at the late term on October 29. Sowing was carried out on plots in rows of 1.5 m long. Experiments were repeated 3 times. Harvesting, harvest accounting and morphological indicators of structural analysis of samples were carried out according to the methodology of examination of plant varieties of the cereal group for suitability for distribution in Ukraine [29].

The varieties 'Podolyanka', 'Bohdana', 'Favorytka', 'Smuhlyanka', 'Hospodarka 1', which occupy the largest areas of sowing in Ukraine, were selected to establish the influence of the late sowing period on the breeding characteristics of winter wheat [30]. 25 typical undamaged plants were selected for structural analysis in the designated areas of the collection in the phase of waxy-full ripeness. The national standard 'Yednist' and the UK 065 line, which is a standard of productivity of IPPG, NAS of Ukraine, were used as the yield standard.

Agrometeorological actual and average long-term indicators of weather conditions were used according to the data of the weather archive from the website of the Borys Sreznevsky Central Geophysical Observatory [31].

The assessment of overwintering of breeding material of soft winter wheat for winter hardiness in field conditions was determined in percentages, which corresponds to the 9-point scale, where very low winter hardiness corresponds to the number of live plants <21% = 1 point, low winter hardiness with plant survival 21-30% = 2 points, winter hardiness below average with 31-40% of live plants = 3 points, average winter hardiness below average with survival of 41-50% = 4 points, average winter hardiness corresponds to 51-60% = 5 points, average above average winter hardiness - 61-70% = 6 points, winter hardiness above average - 71-80% = 7 points, increased winter hardiness corresponds to 81-90% of living plants = 8 points and high winter hardiness - 9 points with plant survival >90% [32].

Evaluation of the resistance of culture samples to damage by pathogens was carried out on a natural background according to the international scale which is based on a modified commonly used scoring scale [33]. Phytopathological assessment was carried out in the phase from the beginning of earing for powdery mildew to the early milky grain ripeness for septoriosus.

Technological indicators of winter wheat grain quality (protein and gluten content) were determined in the grain quality laboratory of the IPPG of the National Academy of Sciences of Ukraine using the Inframatic 8600 device which is specially designed and optimized for flour and grain analysis [34, 35, 36].

The statistical analysis of the results was carried out using the analysis of variance of a one-/two-factor experiment with an assessment of the difference between options and factors at the same level of 95% reliability according to the Fisher criterion, or the Least Significant Difference (LSD_{95}), using the analysis of the variation series, establishing the relationship and the reliability of the linear correlation coefficients according to Student's coefficient to the methods [37] and software for statistical data analysis [38]. Statistical processing of the data was carried out using the additional computer program Microsoft Excel 2007 and the software SPSS Statistics. Arithmetic averages of the studied quantitative traits (X) were determined. To interpret the coefficient of variation (V) we used the scale ($V \leq 10\%$) - weak variation, ($V = 10-20\%$) - medium and ($V \geq 20\%$) - strong variation. Adaptability indicators were calculated using the formulas of stress resistance ($X_{min}-X_{max}$), ecological plasticity ($X_{max}+X_{min}/2$) and homeostaticity $Hom = X^2/\sigma(X_{max}-X_{min})$, where σ is the mean square deviation [39].

The analysis of climatic conditions of 2017-2022 in the territory of Kyiv region showed that an elevated temperature regime with a tendency to insufficient moisture supply of crops is observed during the growing season of winter wheat every year. The average actual air temperature during the growing season exceeded the norm every year from +0.5 °C in 2021/22 to +1.6 °C in 2019/20 (**Figure. 1**).

The highest average actual air temperature of + 9.6 °C during the wheat growing season was observed in 2019/20, exceeding the norm (8.0°C) by + 1.6 °C, and this influenced the acceleration of all growth processes in the plant organism and led to the reduction of the harvest. At least it exceeded the average

multi-year norm by + 0.6 °C and + 0.5 °C in 2017/18 and 2021/22, respectively, and cold and long-lasting springs significantly improved the laying of the future crop at the initial stages of organogenesis of winter wheat.

During the last 5 years precipitation fell unevenly and was mostly local. According to calculations in accordance with the norm (562 mm), its number of winter wheat ranged from 708 mm or 126% of the norm during the vegetation cycle in 2017/18 with a decrease to 356 mm or 64% of the norm in 2021/22 (**Figure 2.**).

There was a noticeable trend towards a decrease in moisture supply during the growing season of winter wheat during 2017-2022. In 2021/22, dry conditions and absence of the rain in some places were already observed after sowing and in early spring. It should be noted that the lack of precipitation during grain pouring, which was noted almost every year, had a negative impact on the formation of the grain and the wheat harvest in general.

RESULT AND DISCUSSION

Academician V. V. Morgun notes [30] that the varieties 'Smuhlyanka', 'Zolotokolosa' and 'Favorytka' produced record yields of 124.0-131.8 t/ha for the first time in the history of Ukraine. Varieties, genetic yield potential of which is realized on average by 75-80%, are added to the Register of Plant Varieties of Ukraine every year [40]. It is very difficult to combine high productivity with resistance to abiotic and biotic stress factors due to the existence of negative relationships between these traits [41].

Research in recent years in Ukraine has shown that the highest winter resistance is formed at optimal and admissibly late sowing terms. Negative overwintering conditions are one of the main stressors that determine the yield of winter wheat grain [42]. The assessment of varieties for winter hardiness of the late sowing date was not much different from the optimal one, therefore, overwintering was determined on the plots of variety samples that were sown at the optimal sowing dates.

As a result of mild and warm winter periods during 2017-2022, winter wheat overwintered well. The plants of all three distribution groups of collection samples mostly kept their viability (**Table 2**).

The obtained data indicate that, according to estimates of overwintering in 2017-2022, the highest plant survival is 97.6% (9 points) in winter wheat varieties zoned for the Forest Steppe and Polissia zones. The percentage of survival of varieties of Western European selection differs significantly from the assessment of overwintering of this group of varieties according to $LSD_{95}=6.2$. Growing them in this zone is risky, since in the spring of 2021/22 the number of live plants averaged 70.4%, which corresponds to 6 points of overwintering.

Evaluation of plants for diseases of powdery mildew and septoriosiis was carried out during the flowering of the ear and during the grain pouring period. The least damage to the leaf surface of plants by septoriosiis was 5-10% during the flowering of wheat in most varieties of the collection. This disease weakened the immunity of plants in a pyramidal growth together with powdery mildew, which was already observed on the leaves by 15-50%. But timely treatment of plants with chemical protection restrained the spread of these diseases.

The weight of grain from 1 ear of winter wheat variety samples is an integrated indicator of winter wheat adaptability. It is a marker in breeding when creating high-yield varieties [43, 44]. Depending on the climatic conditions of the year, only highly productive cultivars, which are the most regionalized and widespread in Ukraine, have high adaptability indicators and stably maintain high harvest indicators [45]. 10 ears at the stage of wax maturity were selected, threshed and weighed and the grain weight of 1 ear was calculated among the collection samples of winter wheat of the 2018-2022 harvest. Calculations were made depending on the set of varieties of the Forest Steppe and Polissia zones, varieties of the Steppe and varieties of Western European selection (**Figure 3**).

The data in the Fig. 3 show that varieties of Western European selection had the highest average weight of grain from 1 ear of 3.5 g and 4.6 g under favorable weather conditions in 2018 and 2022, respectively. Varieties of the Forest Steppe and Polissia zones exceeded this indicator of Western European varieties under difficult climatic conditions in 2019 and 2021, which indicates their high adaptability. According to statistical analysis, the grain weight of 1 ear of Western European varieties is significantly different from the varieties of the forest-steppe and Polissia zones at $HIP_{95}=0.60$. 'Darynka Kyivska' variety with the weight of an ear of 4.8 g and the lines of the new varieties UK 1517/14, UK 2074/19, and UK 175/20 were isolated by this marker of 4.8 g and included for use in selection programs of the creation of new source material.

To determine the influence of the late sowing period on the selection-valuable characteristics of winter wheat, the results of the structural analysis, which are given in **Table 3**.

Thus, from a set of winter wheat varieties, the late sowing date on October 29 strongly reduces the $r = 0.7-0.9$ average indicator of general/productive tillering and the weight of grain from a plant to 50.5%, and the

weight of the main spike, the number and weight of grain - to 24% with a decrease in the number of productive ears and the weight of 1000 grains to 8.7%. According to the Student's criterion $t_{95} = 0.437 > t_{\tau} = 0.250$ (table), the correlation coefficients differ reliably.

The grain weight of 1 ear was calculated at the optimal and late sowing period in the same variety samples during 5 years of research. The obtained results are presented in **Figure 4**.

The data obtained over 5 years of research on the set of varieties, according to the characteristic of grain weight of 1 ear, show that 'Bohdana' variety responds the least to the terms of sowing and has the lowest average indicators at the optimal and late sowing terms - 2.7 and 2.6 g, respectively. The maximum grain weight per 1 ear of 3.7 g at the optimal sowing term and 3.0 g at the late term is produced by 'Favorytka' variety.

The variety, as a genetic system, specifically reacts to the climatic conditions of the year. A distinctive feature of any variety is a set of properties that determine its suitability for one or another growing area. Therefore, in this set of varieties, the indicators of adaptability: stress resistance, plasticity, coefficient of variation, and homeostaticity were calculated based on the indicator of the selection trait, and the weight of the grain per 1 ear (**Table 4**).

The given data show that in the last 5 years of winter wheat cultivation, 'Hospodarka 1' variety was selected for both sowing terms, and 'Smuhlyanka' variety was selected for the optimal term at the lowest rate of 0.8 from a set of varieties with high stress resistance. 'Favorytka' variety has a high index of plasticity (stress/non-stress conditions) of 3.8 for the optimal sowing term and of 3.0 for the late sowing term. 'Smuhlyanka' variety at the optimal term at high homeostasis $Hom=40.0$ in combination with the smallest coefficient of variation $V=9.7$ and 'Hospodarka 1' variety even at the late sowing term at $Hom=32.5$ and $V=10.5$ maintain the most stable weight of 1 ear of grain.

The varieties 'Kyivska 17', 'Horodnytsia 3' were selected based on the weight of grain from 1 ear of 4.0 g, and 'Blahovishchenska' variety - on the weight of grain of 4,8 g. Selected varieties have a high realization of the productive and adaptive potential of the ear.

Grain quality is an integral and valuable selection feature of winter wheat when obtaining high yields [44]. Therefore, technological indicators of grain quality (protein, gluten) were determined in the grain of the researched variety samples of optimal and late sowing periods after structural analysis. The impact of the late sowing period on individual technological indicators of grain quality of the variety samples is presented in **Table 5**.

The data show that the protein content in the grain of a set of varieties decreases from the optimal period until late sowing by an average of 7.3% and gluten by 7.6%. According to the statistical data of the correlation coefficients of protein $r = 0.89$ and gluten $r = 0.86$, there is a close connection of these indicators in the direction of decrease until late sowing. 'Favorytka' variety reduces these grain quality indicators by at least 1.9%.

Table 1. The number of variety samples that were studied in the Comparative testing collection during 2017-2022

Year	% of variety samples from the total number by cultivation zones			Pieces per year
	Forest steppe and Polissia	Steppe	Western European selection	
2017/18	43.8	13.8	32.4	420
2018/19	30.2	10.5	59.3	199
2019/20	59.9	9.8	30.3	162
2020/21	53.8	6.0	40.2	199
2021/22	69.7	6.1	24.2	99

Table 2. Results of assessment of overwintering of collection varieties of winter wheat in 2017-2022.

Variety samples	The number of live plants on the site, % (overwintering point)					Average % (point)	± to forest steppe and polissia zones
	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022		
Fopest Steppe and Polissia zones	95.0 (9)	95.4 (9)	99.6 (9)	99.3 (9)	98.9 (9)	97.6 (9)	-
Steppe zone	92.0 (9)	95.0 (9)	99.6 (9)	100.0 (9)	99.3 (9)	97.2 (9)	-0.4
Western European	92.0 (9)	93.4 (9)	99.1 (9)	99.1 (9)	70.4 (6)	90.8 (9)	-6.8

LSD₉₅ = 3.2

Table 3. The influence of the late sowing terms on the parameters of the breeding characteristics of winter wheat, harvest of 2022.

Average indicator		30.09	29.10	± to 29.10	Decrease %	Correlation coefficient <i>r</i>	
Height to the top of the main ear (without spines), sm		81.4	76.2	-5.2	6.4	0.9	
Total bushiness, pcs.		7.1	4.0	-3.1	43.7	0.5	
Product. bushiness, pcs.		5.9	3.1	-2.8	47.5	0.4	
The main spike	Length, sm	10.1	9.1	-1.0	9.9	0.9	
	Weight, g	3.0	2.4	-0.6	20.0	0.9	
	Number	productive spikelets, pcs.	18.3	16.7	-1.6	8.7	0.7
		non-productive spikelets, pcs.	1.1	1.3	+0.2	18.2	0.9
		зерен, шт. grains, pcs.	49.5	43.0	-6.5	13.1	0.9
Weight of grain, g		2.5	1.9	-0.6	24.0	0.6	
Weight of grain from a plant, g		9.3	4.6	-4.7	50.5	0.7	
Weight of 1000 grains, g		44.9	41.6	-3.3	7.3	0.6	

Remark: by Student's criterion $t_{95} = 0.437 > t_m = 0.250$, number of degrees of freedom $v=62$

Table 4. Adaptability of winter wheat varieties by grain weight of 1 ear after optimal and late sowing terms, 2017-2022.

Name of variety	Parameters of adaptability							
	$X_{min} - X_{max}$		$X_{max} + X_{min}/2$		V, %		Hom	
	30.09	29.10	30.09	29.10	30.09	29.10	30.09	29.10
UK 065 (standard)	-1.7	-1.5	3.4	2.8	19.5	16.9	16.3	18.9
Podolyanka	-1.1	-1.6	3.1	2.0	16.6	27.6	17.1	5.45
Bohdana	-1.6	-1.5	2.8	2.6	21.9	21.5	7.7	8.1
Favorytka	-1.5	-1.5	3.8	3.0	18.4	14.2	13.4	11.5
Smuhlyanka	-0.8	-1.4	3.2	2.3	9.7	22.3	40.0	8.0
Hospodarka 1	-0.8	-0.8	3.4	2.8	11.6	10.5	37.1	32.5

Table 5: Technological indicators of grain quality of winter wheat varieties depending on the sowing terms, harvest of 2022

Variety	Protein, %		Gluten, %		Grain moisture, %
	30.09	29.10	30.09	29.10	
UK 065 (standard)	13.5±1.3	12.4±0.9	28.6±3.3	25.9±2.5	14.2±1.5
Podolyanka	14.1±1.5	12.5±1.0	30.0±3.6	26.2±3.0	14.4±1.7
Bohdana	13.2±1.3	12.9±1.1	27.8±3.1	27.2±2.8	14.6±2.0
Favorytka	14.7±1.6	14.4±1.5	31.2±3.7	30.6±3.3	14.4±1.7
Smuhlyanka	12.4±0.9	10.7±0.5	26.0±3.0	22.2±2.0	14.3±1.5
Hospodarka 1	14.0±1.5	13.1±1.3	29.0±3.4	27.5±2.3	14.4±1.7
Average	13.7±1.4	12.7±1.1	28.8±3.4	26.6±2.7	14.4±1.7

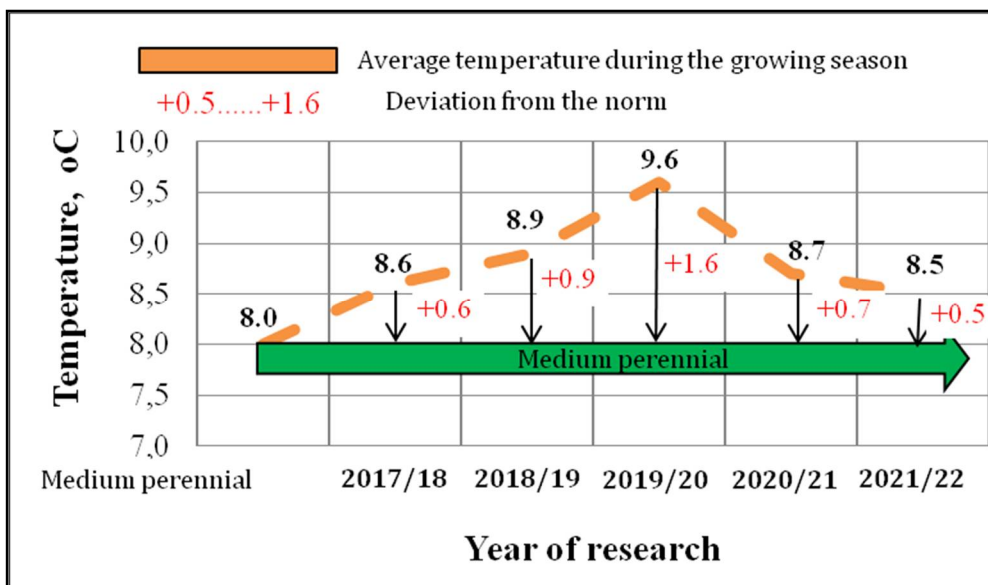


Figure 1. Average air temperature for the growing cycle of winter wheat during 2017-2022.

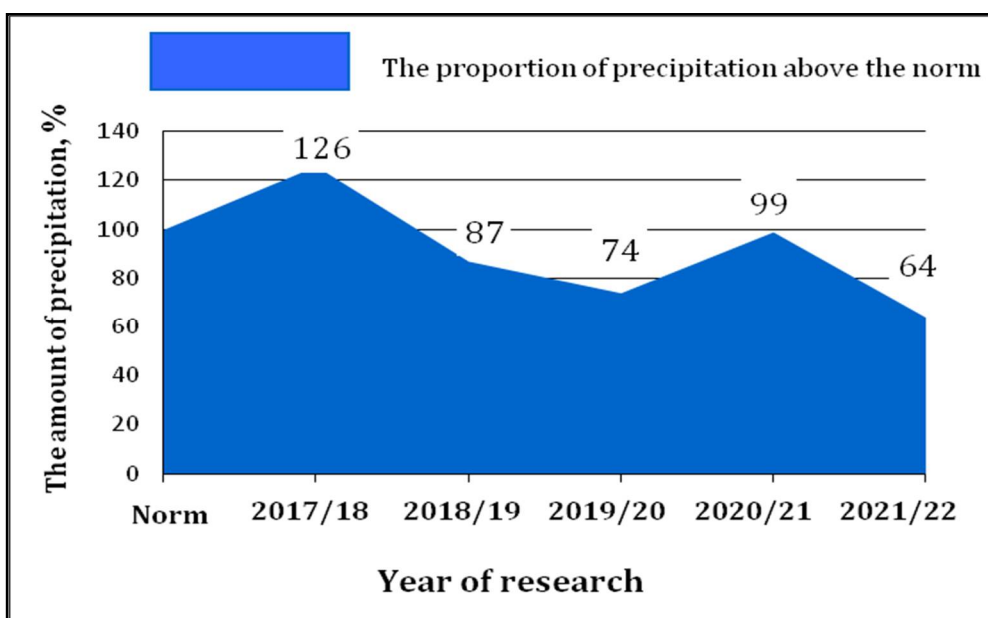


Figure 2. The amount of precipitation that fell during the growing cycle of winter wheat in 2017-2022.

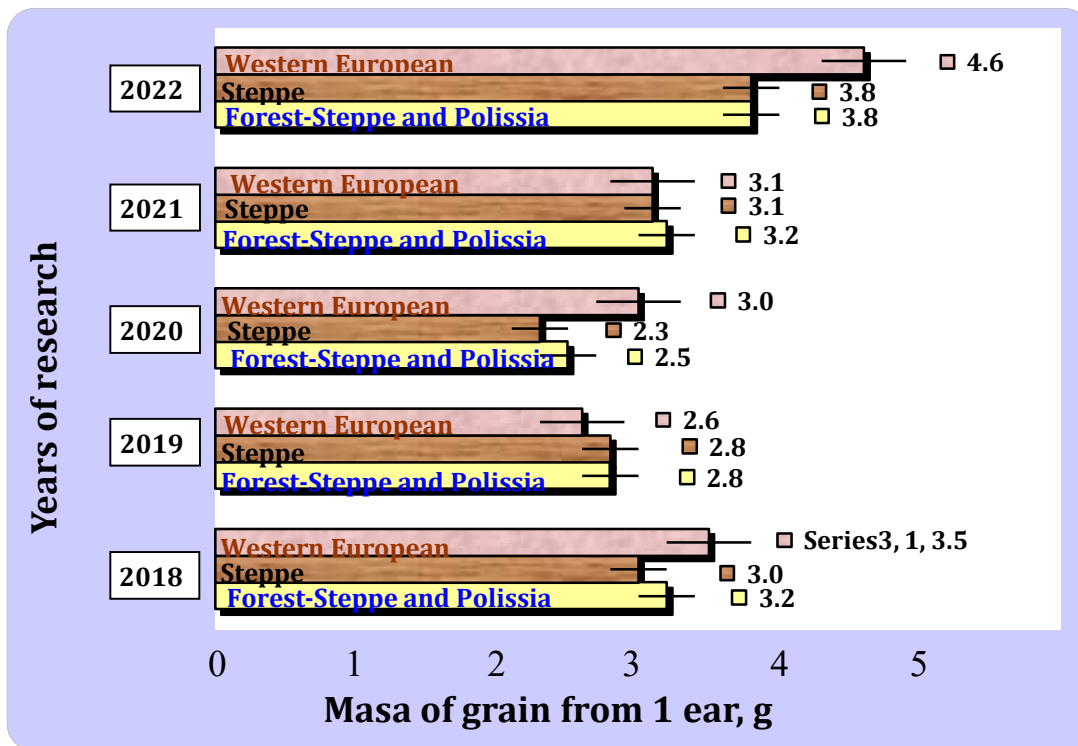


Figure 3. The average grain weight of 1 ear of winter wheat of collection varieties, harvest of 2018-2022.

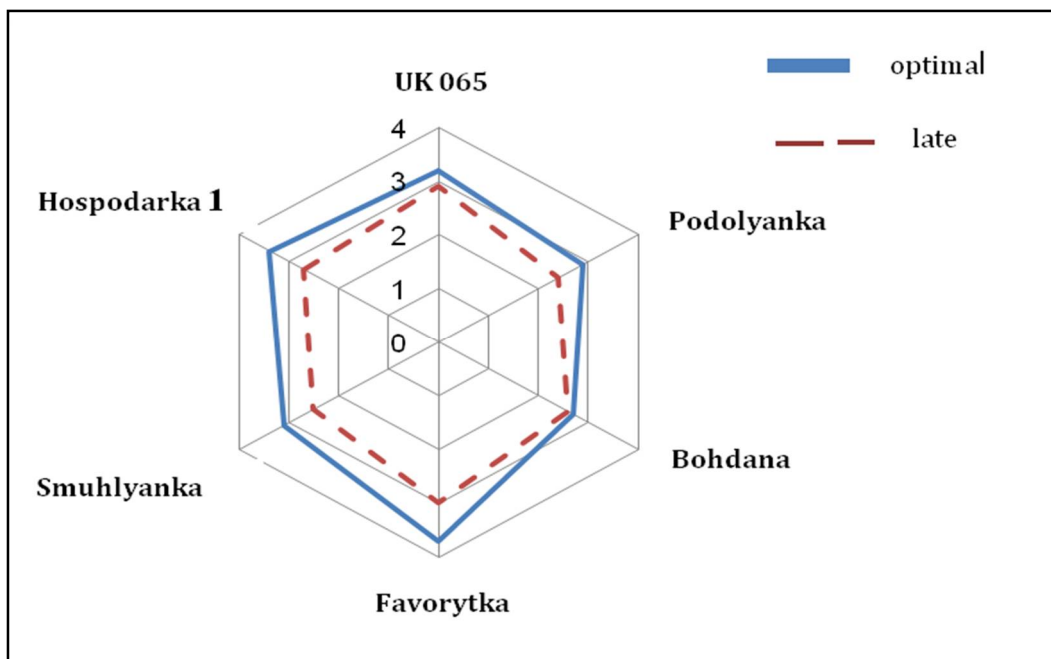


Figure 4. Average grain weight of 1 ear of winter wheat varieties of the 2018-2022 harvest depending on the time of sowing, g

CONCLUSIONS

It was found that when forming breeding traits in varieties that occupy the largest sowing areas in Ukraine by distribution, Podolyanka, Bogdana, Favoritka, Smuglyanka, Gospodarka 1, the late sowing date reduces: the indicator of general/productive tillering and the mass of grain per plant to 50.5%; the mass of the main spike, the number and mass of grain from it to 24%; the number of productive spikelets of the main spike and the mass of 1000 grains to 8.7%.

During 2017-2022, among the varieties studied by the characteristic of the mass of grain in 1 spike at the optimal and late sowing date, the Gospodarka 1 variety and the Favoritka variety with a high index of stress resistance and adaptability were selected.

It was found that in the studied varieties there is a close relationship between the decrease in technological indicators of grain quality of protein and gluten towards the late sowing date, on average up to 7.6%.

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