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STUDY OF VARIABILITY OF WINTER WHEAT VARIETIES AND LINES IN TERMS OF WINTER HARDNESS AND DROUGHT RESISTANCE

Mykola NAZARENKO, OLeksandr IZHBOLDIN, Olena IZHBOLDINA

Dnipro State Agrarian and Economic University, 25 S. Efremova, Dnipro, Ukraine

Corresponding author email: nik_nazarenko@ukr.net

Abstract

The research objective was to identify the peculiarities of the emergence of resistance to adverse environmental factors (winter period and droughts), the assessment of local and foreign mutant lines and varieties for resistance by means of proven express tests. It has been confirmed that both traits are slightly variable under the effect of gamma irradiation. The lines and varieties with such traits have been identified, the relationship between the grain productivity in winter wheat has been described, the availability of these traits has been established, as well as the need to take them into account at creating an up-to-date variety model for the conditions of insufficient humidification with a harsh continental climate (North Steppe of Ukraine) in the conditions of climate change. It has been shown that drought resistance remains the key trait, but the possible mechanism for the realization of the genetically determined yield potential by a variety can also be the timing of ripeness, which may help avoiding the most critical periods (middle and early ripeness).

***Key words**: winter wheat, winter hardness, drought resistance, mutagenesis.*

INTRODUCTION

Winter wheat is the main grain crop not only in Ukraine, but across the world. It is the staple food in 48 countries with a population exceeding 2 billion people, providing part of the daily diet for about another 3 billion people. One of the main problems is the adaptive ability of existing winter wheat genotypes to a complex of adverse winter factors (Shah et al., 2018). This is a key problem for the Steppe region, since it limits the capabilities of modern varieties in the realization of their genetic potential in terms of quality and grain productivity, leading to increased plant death during the winter period and to the formation of impaired grains during droughts in critical periods of growth and development, which is not always possible to compensate for during further ontogenesis (Liu et al., 2017; Nazarenko et al., 2021a).

The territory of Ukraine is characterized by a variety of biomes and climatic zones and the extremely unstable meteorological conditions by years and seasons. Different natural and contrasting areas located in the latitudinal and vertical zonalities respectively stipulate the creation of genetically diverse varieties, at least three main agroecotypes of winter wheat (Essam et al., 2019; Kirova et al., 2021).

Varieties of semi-intensive and intensive types of winter wheat are distinguished by high and above average tilling capacity, thermal requirements, and are characterized by quite high frost and winter resistance (Prabhu, 2019). In the phase of full tillering, these varieties tolerate low negative temperatures up to -20°C quite well, and form large, well-grained ears with valuable and particularly valuable grain (Khalili et al., 2018; Harkness et al., 2020).

Over the past 15 years, new complex varieties of intensive winter wheat have been created and zoned, characterized by high yield, adaptability, disease resistance, as well as high grain quality and quite high winter and drought resistance (Kirova et al., 2021). Agro-climatic conditions of the Steppe are characterized by significant variability of the main resources by years, periods of vegetation, territories, which determines the existing value and variability of winter wheat yield in the region (Le Gouis et al., 2020; Polatovich et al., 2021).

Along with the improvement of cultivation technology, the variability also plays an important part in increasing yields and reducing its fluctuations by years in the region. In this regard, the key focus is breeding to increase the yield of winter wheat varieties, capable of maximizing the effective use of environmental resources and the features of the ecological zone, and resisting abiotic and biotic stressors (Reif et al., 2005; Polatovich et al., 2021).

The ability of plants to adapt and resist adverse environmental factors is one of the preconditions for their existence, which depends on the possibility of application of protective mechanisms (Hongjie et al., 2019). The implementation of the adaptation process can be roughly divided into two main stages: stress - response and specialized adaptation (Resende, 2016; Richardson at al., 2017). At the first stage, protective systems are actively mobilized or formed, ensuring the short-term survival of the body under the harmful effect of the stressor. During the second stage, adaptation mechanisms are formed, which are responsible for ontogenesis process under long-term exposure to the stressor factor (Daryanto et al., 2017). The plants can respond to the effect of stressors of different nature by changing the permeability and charge of cell membranes, ionic charge balance, metabolic rate, the differential gene expression (Pementel et al., 2014; Tengcong et al., 2020).

The research objective was to show the possibility of creating winter- and drought-resistant lines based on local varieties using gamma irradiation, to compare the potential of these traits with international material (French varieties) (Nazarenko et al., 2021b), to carry out additional testing of previously proposed test systems for drought-resistance based on the photosynthetic potential data.

MATERIALS AND METHODS

The research was carried out on the experimental fields of the Educational and Scientific Center of the Dnipro State Agrarian and Economic University in 2015-2021. The experimental areas have a homogeneous cover, consisting of ordinary low-humus, leached, medium-loamy black soil on a loamy soil. The content of nitrogen (according to Tiurin (GOST, 1984)) during the years of research has not exceeded 3-5 mg, mobile phosphorus (according to Chyrykov (Belyaev, 2012) - 20-30 mg, exchange potassium (according to Chyrykov (Belyaev, 2012) - 20-35 mg per 100 g of dry soil.

The experimental field is located in the Dniprovskyi district of the Dnipropetrovsk region, which is the northern warm and insufficiently wet area. Its climatic resources are characterized by the following indices: hydrothermal coefficient is > 0.9, precipitation rare during the growing season - 250-280 mm, the annual amount of precipitation - 450-490 mm, temperature sum for the period with the temperatures above 10°C - about 2,900°C.

Dry seeds of local varieties Komertsiina and Spivanka were exposed to gamma irradiation of 100, 150, 200, 250 Gy at the gamma-ray unit of the Nuclear Research and Training Centre of the Department of FAO/IAEA Joint Division of Nuclear Techniques in Food and Agriculture (Austria, Freiburg), with gamma rays of the Co60 radioactive source, the capacity of the unit is 0.048 Gy/s.

The local mutant lines of the Komertsiina and Spivanka varieties (breeding by the Dnipro State Agrarian and Economic University) were used as a material for the study that fully corresponds to the conditions of the region (the Northern Steppe of Ukraine, 12 varieties of breeding by INRAE (National Research Institute for Agriculture, Food and Environment, France) obtained from the laboratory of ecophysiology and biodiversity of cereals (Clermont-Ferrand, France), Courtiot, Flamenko, Gallixe, Geo, Ghayta, Gotik, Grapeli, Koreli, Lyrik, Musik, Renan, Skerzzo. The area of the plots was 5-10 m^2 depending on the year of the experiment, the repetition was 1-2 times, the standard - every 20 numbers.

The assessment of winter resistance was carried out by the concentration of easily soluble sugars, and was measured by the contractual sample of the cultivar tillering nodes according to the generally accepted GOST 26176-91 (GOST, 1993).

Photosynthesis of plants was studied in a gasometric device developed in the laboratory of plant physiology and biochemistry on the basis of the manometric method of Warburg. Simazine (Sim) 10-4 (M) was used as an inhibitor of PS-II, which sharply inhibits the processes of oxygen release in the photosystem. The intended site of action of simazine is the ETL link between the primary PS-II acceptor (Q) and the inclusion of plastoquinone. Drought resistance of the lines was determined by the advantages in the activity of individual photosystems. According to the test system, dry-resistant lines were considered to be the ones, where the activity of the photosystem I prevailed (less energy- and moisture-consuming), that is, with a ratio of the activity of the PS-I + PSII/PS-I photosystems less than 1.

The obtained results were statistically processed using the discriminant analysis, the quality of the mean difference was assessed by factor analysis. The standard package of the Statistic 10.0 application was used.

RESULTS AND DISCUSSIONS

In the Komertsiina variety, total mutation rate ranged from 8.40% (gamma rays, 100 Gy) to 30.00% (gamma rays, 250 Gy) with a 1.20% control (spontaneous mutation rate) (Table 1). In the Spivanka variety, there were 6.40% (gamma rays, 100 Gy) to 31.67% (gamma ray, 250 Gy) at 0.80% of spontaneous mutations in the untreated reference group.

Individually identified mutations related to increased drought and winter resistance were referred to as rare. They reached significant values in the Komertsiina variety at a dose of 200 Gy amounting to 0.83% (winter hardness) and drought resistance in the same variety at a dose of 100 Gy amounting to 0.80%. That is, no more than 4 cases per 300 (200 Gy) and 500 (100-150 Gy) families. There are no corresponding mutations in the control group and at 250 Gy, and in the latter case, this can be explained by the destructive effect of this dose and a smaller sample size (40-60 families).

Table 1. The rate of winter wheat mutations due to the gamma irradiation effect

Variety	Gamma irradiation dose				
	controle	100 Gy	150 Gy	200 Gy	250 Gy
			Total rate		
Komertsiina	1.20±0.11	8.40±0.62[b]	13.56±1.05[c]	29.17±1.41[d]	30.00±1.69[d]
Spivanka	0.80±0.11[a]	6.40±0.53[b]	10.75±0.92[c]	19.00±1.14[d]	31.67±1.54[e]
			Winter hardness		
Komertsiina	0.00±0.04[a]	0.20±0.08[b]	0.44±0.08[c]	0.83±0.14[d]	0.00±0.11[a]
Spivanka	0.00±0.04[a]	0.60±0.09[b]	0.50±0.09[c]	0.50±0.11[c]	0.00±0.11[a]
			Drought resistance		
Komertsiina	0.00±0.04[a]	0.80±0.10[b]	0.67±0.09[b]	0.00±0.06[a]	0.00±0.11[a]
Spivanka	0.00±0.04[a]	0.40±0.08[b]	0.50±0.09b	0.00±0.06[a]	0.00±0.11[a]

Note: The difference is statistically significant at $P < 0.05$ taking into account the Bonferroni correction.

Factor analysis showed that in the case of winter resistance, the rate of mutations related to this trait did not depend on the genotype ($F = 0.05$; $F_{critical} = 7.71$; $P = 0.83$), however, there was a dependence on the dose of gamma irradiation ($F = 6.38$; $F_{critical} = 5.23$; $P = 0.05$). In the case of drought resistance, the same results were observed – genotype ($F = 2.07$; $F_{critical} = 7.71$; $P = 0.22$), dose ($F = 13.60$; $F_{critical} = 5.23$; $P < 0.01$).

That is, mutations related to abiotic stress tolerance of the original form were quite rare, mainly with moderate doses of gamma irradiation. However, as we will see, when analysing specifically varieties and lines by types of resistance, they are of considerable importance and, in fact, most of the drought resistance mutations are also successful in terms of high yields for our region (but not always - in terms of grain quality).

The second stage of research was to identify a set of indicators, both laboratory (germinating ability, sugar content in the root node by periods) and field ones (scoring of the state of crops before and after the overwintering period and survival of plants after the winter period) (Table 2).

It has been found that in all foreign varieties there was a low winter hardness, which was statistically significantly different from the national standard (Podolyanka variety) in terms of laboratory values. Such varieties were characterized by a fairly high resistance to a number of adverse factors of the winter period. As shown below, this indicator did not become a key one to determine the next yield of the varieties and some of them prevailed over the standard (Gallixe, Ghayta, Koreli). The assessment of the state of crops turned out to be an objective index.

According to the factor analysis, the readiness for overwintering was influenced by indices such as the genotype (F = 14.20; Fcritical = 5.04; P < 0.01) and a combination of climatic conditions during the year (F = 12.36; Fcritical = 5.11: P <0.01).

Table 2. Parameters of winter wheat varieties during winter (2017/2020 periods of vegetation dates) (n = 5)

N	Variety	G	BW	CS				S	AW
				11	02	03	04		
1	Podolyanka	98.3	5	32.2	26.3	20.2	19.9	97.9	5
3	Courtiot	93.4	4	22.1*	17.9*	16.9*	14.0*	92.8	4
4	Flamenko	90.6	4	20.2*	18.0*	14.8*	12.9*	89.9	4
5	Gallixe	91.2	3.5	16.4*	14.6*	12.1*	11.6*	90.1	3.5
6	Geo	92.3	4	23.0*	19.2*	16.8*	15.4*	90.1	4
7	Ghayta	89.2	3.5	15.9*	11.7*	10.2*	10.0*	85.1	3.5
8	Gotik	88.7	4	20.7*	17.2*	14.1*	13.2*	86.9	4
9	Grapeli	91.2	4	21.0*	19.1*	16.5*	13.4*	90.1	4
10	Koreli	90.7	4	22.3*	19.7*	14.9*	12.7*	88.9	4
11	Lyrik	90.2	4	18.6*	12.6*	11.1*	10.5*	86.1	4
12	Musik	88.4	3.5	13.4*	10.4*	10.1*	9.5*	85.0	3.5
13	Renan	92.3	4.5	21.0*	19.8*	14.9*	12.7*	90.8	4.5
14	Skerzzo	91.9	4	25.1*	23.1*	19.2*	18.0*	90.7	4

G - germination[%]; BW - evaluation before winter period [balls]; CS - content of sugars in tillering nod [%]; S - surviving of plants after winter period [%]; AW - evaluation after winter period [balls].
*indicate significant differences from standard at P < 0.05.

The same parameters were used to assess the mutant lines of winter wheat. Those were compared with parental forms, one of which, Spivanka, was more winter-resistant, the other, Komertsiina, was less winter-resistant than the standard (Table 3).

Table 3. Parameters of winter wheat mutant lines and parent varieties during winter period (2017/2020 vegetation dates) (n = 5)

N	Variety	G	BW	CS				S	AW
				11	02	03	04		
1	Podolyanka	98.3	5	32.2	26.3	20.2	19.9	97.9	5
2	Spivanka	99.1	5	33.4	29.7	22.4.	20.9	99.1	5
3	26	99.2	5	32.6	27.7*	21.0*	19.5	99.2	5
4	45	99.4	5	32.0	24.2*	19.7*	17.9*	99.1	4.75
5	123	99.2	5	34.3	28.9	25.6*	23.7*	99.2	5
6	152	99.2	5	30.1*	22.3*	19.0*	16.1*	99.0	4.75
7	178	99.4	5	33.2	28.1	21.0	20.2	99.4	5
8	179	99.2	5	32.8	28.4	21.7	20.1	99.2	5
9	Komertsiina	98.9	5	28.4	22.1	19.8	19.0	98.4	4.75
10	181	99.7	5	26.1*	20.0*	17.4*	14.1*	98.2	4.5
11	203	99.2	5	30.6*	26.9*	24.0*	22.3*	99.2	5
12	213	99.4	5	26.6	19.9*	17.6*	15.5*	97.6	4.5
13	214	99.3	5	28.0	21.5	20.3	18.6	99.2	5
14	262	99.9	5	28.1	22.7	18.4	18.1	99.2	4.75

G - germination[%]; BW - evaluation before winter period [balls]; CS - content of sugars in tillering nod [%]; S - surviving of plants after winter period [%]; AW - evaluation after winter period [balls].
*indicate significant differences from standard at P < 0.05.

It turned out that varieties such as 123 (Spivanka variety), 203 (Komertsiina variety) had statistically reliable advantages over the parent form, while lines 45, 152 (Spivanka variety), 181, 213 (Komertsiina variety) had certain unsatisfactory results (a reduced winter resistance). It should be noted that the regression of a trait is more likely than its enhancement. However, all the lines given in the table by yield outperformed both the standard and the original forms. That is, it cannot be stated that this trait was decisive for the yield of a certain variety even in our conditions.

Based on the factor analysis results, factors such as the genotype (F = 7.16; Fcritical =

4.11; P = 0.02) and a number of climatic conditions during the year (F = 22.17; Fcritical = 4.11: P< 0.01) influenced the readiness for overwintering.

As it can be seen, the significance of winter hardness for both varietal and linear material was not high in view of the future yield. At the same time, the local material had reliable advantages over foreign forms in terms of higher adaptability.

At the next stage, the assessment was carried out by the ratio in the photosystem activities (Tables 4 and 5).

Table 4. Quality of photosynthesis of winter wheat of foreign varieties under study (x ± SD, n = 5)

Variety	Intensity of photosynthesis, mcL/hour		PS-I+ PS II/ PS-I	PS
	Check (H_2O)	Simasin		
Podolyanka	6,112 ±68	4,817±34	1.27	II
Courtiot	6,234±78	4,544±55	1.37	II
Flamenko	6,565±112	4,786±70	1.37	II
Gallixe	7,134±56	7,020±65	1.02	I-II
Geo	6,711±76	4,534±64	1.48	I
Ghayta	7,655±43	7,542±23	1.01	I-II
Gotik	3,330±67	2,526±43	1.32	II
Grapeli	5,412±89	5,388±71	1.00	I II
Koreli	7,611±54	7,543±28	1.01	I-II
Lyrik	4,111±78	3,234±91	1.27	II
Musik	4,344±90	2,980±93	1.46	II
Renan	6,767±45	4,890±54	1.38	II
Skerzzo	7,476±76	5,611±63	1.33	II

Given the lower drought resistance of those genotypes where the activity of the photosystem II prevails.

According to the available criteria, the following potentially drought-resistant varieties were identified: Gallixe, Geo, Ghayta, Koreli. Interestingly, three of these varieties further showed yields above the standard, and the Geo variety yielding capacity exceeded the standard values in certain adverse years.

It can be stated that the drought resistance trait under climate change in our region has proved to be more significant than the tolerance to the winter period, being previously the key trait, since although the period of droughts has not become as critical with regard to the phases of development of wheat plants as before, but still a particular threat is posed for late-ripening varieties, which include all studied French varieties (Nazarenko et al., 2021b).

Factor analysis firstly showed a statistically significantly blocking effect of the applied processing method (F = 13.60; Fcritical = 2.68; P = 0.02) and secondly showed that the trait is conditioned by the genotype of the variety (F = 24.07; Fcritical = 4.74; P < 0.01)

The assessment of photosynthetic activity of mutant lines showed not only greater homogeneity of the selection, but also the trait variability (Table 5).

Both parental forms are classified as drought-resistant, but we can see that the identified lines 26 (Spivanka) and 213 (Komertsiina) are classified as less drought-resistant. At the same time, while the activity of photosystems in the original Komertsiina variety is at about the same level, only line 203 has the same characteristics. In all other cases, there have been changes in the line.

Table 5. Quality of photosynthesis of winter wheat mutant lines under study (x ± SD, n = 5)

Variety	Intensity of photosynthesis, mcL/hour		PS-I+ PS II/ PS-I	PS
	Check (H_2O)	Simasin		
Podolyanka	5,867±70	4,564±83	1.29	II
Spivanka	4,330±56	5,522±55	0.78	I
26	4,980±67	5,679±67	0.88	II
45	4,540±65	5,413±40	0.84	I
123	4,211±87	5,100±68	0.83	I
152	4,545±56	4,677±65	0.97	I-II
178	4,314±45	5,766±80	0.75	I
179	4,892±40	6,034±65	0.81	I
Komertsiina	5,311±67	5,217±50	1.02	I-II
181	5,435±87	6,147±88	0.88	I
203	5,600±91	5,711±74	0.98	I-II
213	5,049±90	4,312±78	1.17	II
214	5,433±39	6,454±75	0.84	I
262	5,767±47	5,100±72	1.29	II

Considering that out of 11 lines under study 9 are classified as drought-resistant according to the test, it can be considered that this trait is sufficiently significant.

The two lines with a worse indicator refer to medium-early ones, that avoid drought in the conditions of the Northern Steppe of Ukraine and have an intense epicuticular wax accumulation, which is also typical of drought-resistant forms.

Thus, such a test system allows to objectively detect the forms with potentially high productivity among the material under study in the early stages, although, obviously, this position should be tested (in terms of genetic diversity) using a greater number of genotypes.

Factor analysis again showed a statistically significantly blocking effect of the applied treatment method (F = 5.17; Fcritical = 2.68; P= 0.04) and revealed that the trait was conditioned by the line genotype, although the material was significantly more homogeneous (F = 6.12; Fcritical = 4.74; P= 0.05).

Accordingly, to confirm the obtained data, a comprehensive factorial and discriminant analysis was carried out, which showed (Table 6) relevant static evaluation criteria.

When it comes to the winter hardness, this trait has not been included in the discriminant analysis model and had no significant effect in terms of the factor analysis, the classification ability is insignificant by canonical roots and only 30-40% of objects can be identified by such a trait as high-yielding, which is clearly not a very good result. That is, for the cultivation of winter wheat varieties in the Northern Steppe zone of Ukraine, mean values of this trait are enough. The conditions for winter survival are significantly mitigated due to the climate change, so this parameter ceases to be limiting and critical.

Table 6. Results of factorial (Varimax raw) and discriminate analysis of the relationship of the obtained traits with grain productivity

Parameter	Winter hardness		Drought resistance	
	varieties	lines	varieties	lines
Act of factor	0.11	0.23	**0.60**	**0.76**
λ	0.09	0.13	**0.24**	**0.29**
F	3.22	4.03	**11.13**	**22.67**
$F_{critical}$	5.51	5.51	4.67	4.67
p-level <	0.01	0.01	0.01	0.01
By canonical root (%)	38.46	42.85	76.92	85.71

Note: significant differences from control at P < 0.05 in bold.

As for drought resistance, the situation is quite different. Factor analysis showed a significant relationship between the effect of this trait on crop formation in our conditions, that is, this trait is essential for the variety that is planned for cultivation in our region. The trait is available in the model according to the discriminatory analysis and the classification capacity amounts to 70-80% - that is, such a share of varieties and lines with high yields had this feature at a high level. This makes it possible to relate the express test for photosynthetic activity not only with drought resistance, but also with the mandatory future high yield of the identified genotype. That is, this trait remains critical despite the climate change. Although, according to the material studied, it is possible to compensate for the negative impact of drought on account of other traits that affect the timing of critical phases (terms of ripening) (Bondarenko and Nazarenko, 2020; Nazarenko et al., 2021b).

Thus, in accordance with the material already studied (Nazarenko, 2016; Nazarenko et al., 2020; Nazarenko et al., 2021a), it was drought resistance that was of great importance for the relation of grain productivity traits and the tolerance to adverse abiotic stress, while winter hardness was not significant for both varieties and lines (Mickelbart et al., 2015).

It should be noted that the greater classification capacity for mutant lines is undoubtedly due to the much greater genetic uniformity of the lines obtained from the two varieties than the groups of varieties with substantially higher variability in genotypes. But as we can see, when it comes to the drought resistance, even for varieties, the canonical roots are sufficient to identify drought-resistant genotypes as more productive ones using the test for photosynthetic activity.

For local varieties, given the tasks that have always been set for the genetic improvement of winter wheat in the steppe zone, tolerance to adverse winter conditions and drought resistance have always been the key features that required additional compensation, primarily on account of yield and quality (Li et al., 2019). Obviously, a balanced approach allows creating genotypes of high resistance to adverse abiotic stress, and at the same time of high grain productivity and satisfactory technological quality of grain (Xu, 2016). However, mitigating requirement related to these needs can significantly expand the framework of used biodiversity, allow the use of new varieties and save effort significantly (Nazarenko, 2016b; Nazarenko, 2017; Lykhovyd, 2021).

Global climate change offers not only new challenges, but also new opportunities. In this regard, it is important to quickly respond to changes in environmental conditions and formulate an appropriate strategy at the level of programs for genetic improvement of crops, and not only at the technological level (Dai et al., 2015; Jaradat, 2018). Given that the creation of new material requires significantly higher costs, time and qualification costs than the change of individual elements of the cultivation technology, this will have a qualitatively better economic effect. The efficiency of investments in the initial stages of the breeding process is the highest across the agricultural production (Halford et al., 2014; Cann et al., 2022; Keser et al., 2022).

The formation of resistance to adverse abiotic stress is not always associated with an increased ability of the plant to respond to negative effects at the physiological or morphological level, forming new traits, but is also quite often associated with the ability to partially or completely avoid undesirable factors in the time space (Serpolay et al., 2011; Nazarenko, 2016a; Tokatlidis, 2017). In the conditions of our zone, such a development trait is early or middle ripeness. It is possible to form high-yielding genotypes both with an advantage of functioning of photosystem I and medium-early ripeness genotypes, genotypes with intense wax accumulation. Typically, a high-yielding variety exhibits the combination of any two traits (Tsenov et al., 2015).

If in the new conditions winter hardness is no longer a limiting trait, as it has been recently, then the need to form a high potential drought resistance in winter wheat plants remains a precondition for high yielding capacity and should be a mandatory component of the variety for the conditions of the insufficient humidity zones, in our research - of the Northern Steppe of Ukraine (Mba et al., 2012; Nazarenko et al., 2021b, Lykhovyd, 2021). Varieties in which the level of this complex feature is insufficient cannot consistently provide high grain productivity.

CONCLUSIONS

Resistance to abiotic stressors has always been a key desirable trait for winter wheat varieties, especially for the regions with harsh wintering conditions and insufficient humidity during the growing season. The droughts are particularly dangerous during the critical phases of winter wheat plant development, that is during stem elongation and ear formation. But in the context of climate change, the importance of certain traits can be significantly adjusted. Moreover, the required level of certain parameters can be ensured by other methods. In the future, it is planned to significantly expand the set of genotypes for which research is carried out using express methods for assessment of the winter resistance with sugars available in the tillering node, to assess winter resistance and photosynthetic activity, to assess drought resistance in order to accurately establish the limits of variability of these traits, their relationship with productivity for areas with lack of humidity, to identify possible new features in the mechanism of formation of these traits, to test new mutagenic substances in order to increase the variability of the original material.

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