Breeding Improvement of the Drought Resistance of Winter Soft Wheat with Increased Climate Aridity of the Republic of Moldova

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Abstract
The possibility of breeding improvement of drought resistance for created winter wheat varieties against the climate aridity in the ecological conditions of the Republic of Moldova is discussed.
The analysis is based on the results of a 3-year competitive varieties test productivity for registered and promising varieties of winter wheat of local selection against a significant contrast in the hydrothermal regime of the weather conditions.
The study of winter wheat breeding material in such contrasting conditions allows to do a more targeted breeding of appropriate geno-plasm for the creation of more adapted varieties for this crop.

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Introduction

According to the dynamic variability of hydrothermal climate indicators in different years, and often within one year, the Republic of Moldova can quite objectively relate to the zone of risky agriculture. The periodic cycle of dry and wet years has traditionally been typical for this region. Dry periods of varying duration and depth of manifestation have especially intensified in the early 21st century [1].

The phenomenon of "drought" for the agricultural sector of the republic has its own specifics, but the criteria for determining the degree of its manifestation are generally accepted factors and indicators:

- a decrease in precipitation compared to the annual average, more than 30% characterize severe drought, and more than 50% - catastrophic. Such periods are usually accompanied by a combination of high air temperatures.
- reduction of the hydrothermal coefficient (HTC) below 0.8-0.85 (severe drought), and 0.7-0.75 (catastrophic drought).

The determination of this coefficient is of particular interest because it is an integrated factor of the interaction of precipitation and temperature over a certain period of time [9].

In some years, severe droughts cover almost the entire territory of the republic and last for a long time (up to 2 months in a row). In such years, drought causes a sharp decrease in yields of all field crops, including winter wheat. These have been the case in the republic over the past period of time. 2000, 2003, 2007, 2012, 2020, 2022 the years when the average yields of winter wheat in the country were several times lower in comparison with favorable years.

Combating the drought is complex and multifaceted in the selection of techniques and measures that reduce its negative effects. As it is known, droughts are divided into atmospheric, soil and mixed forms. Soil drought, as a rule, increases gradually, and plants manage to adapt to it (harden) to some extent, whereas atmospheric drought occurs suddenly (accelerated), causing significant damage to plants during critical phases of their growth and development, primarily during the laying and formation of the ear and grain filling in it [10], and as a result, the level of productivity.

If earlier such phenomena in the republic were most often manifested in the southern zone, now they are practically all over the territory. Moreover, drought can manifest itself in different periods of plant growth and development, and it can be classified as spring, summer and autumn.

Often, drought can be combined with hot dry winds of varying intensity, and, as a rule, they occur at sufficiently high humidity and air temperature, as well as with significant desiccation of the root-dwelling soil layer, which is often accompanied by abnormal development and premature ripening of grain.

But the phenomenon of drought is complex in its manifestation and therefore does not always fit exactly into the above schemes, often having intermediate manifestations. The manifestations of drought on the plants themselves are no less complex. The lack of water during the ear formation phase causes such profound changes that it is no longer possible to resume their normal development by further improving the moisture supply of plants.

Water deficiency significantly affects all of these functions of the plant organism, causing profound changes in the nitrogen metabolism of plants, which subsequently affects not only the yield level, but also the quality of products.

At the same time, in conditions of noticeable climate change, another negative factor is more pronounced, especially during the phase of earing and filling grain – high air temperatures [2].

Therefore, there is no doubt that it is necessary to strengthen breeding efforts to improve the level of drought and heat resistance for new varieties of winter wheat in this region.

One of the well-known and low-cost methods for the growth and stabilization of gross grain yields in the agricultural sector for the future, as a number of researchers believe, is the creation of adaptive varieties resistant to the negative effects of various abiotic stressors, including drought [2, 5, 7, 8].

Good adaptive drought-resistant varieties may have a slightly lower potential for their productivity, but they are more stable in terms of its level, especially under stressful conditions of cultivation of a variety, that is, they have a higher lower yield level.

This, in general, can contribute to more stable gross grain harvests.

The Institute has traditionally conducted and continues to conduct breeding work on a complex of biological caracters and properties for the created winter wheat varieties, which determine a relatively high level of their adaptability. The analysis presented in this article on the assessment of the Institute's zoned and promising breeding varieties proves this.

Material and Methodology

The material for the research has been some registered and promising varieties of winter soft wheat of two different ecotypes, created in the last period at this scientific center. These varieties have been studied in the Institute's competitive variety trials in comparison with Meleag and Kuyalnik varieties, which are among the national standards adopted by the GSI for this period of time in the Republic of Moldova.

The nursery was laid out on the area of 10м2 plots in a 4-fold repetition, according to the generally accepted methodology of the state variety testing. For sowing such an experiment, a SSFK-7 breeding seeder has been used, and a small-sized Sampo-130 combine harvester has been applied for individual harvesting of plots.

During the growing season of plants over the years of experiments (2022-2024), all necessary phenological observations and records have been conducted, and product quality analysis and plant morphoanalysis in laboratory conditions, have been performed.

The productivity results of the tested varieties have been statistically processed according to generally accepted methods of variance analysis [3].

Over the years, biometric indicators such as the coefficient of variation in productivity (CV%) and the drought resistance index (DRI) have been also evaluated and analyzed. It has been defined as the ratio of the productivity level of varieties in dry years to more favorable ones, expressed in % [6] and the environmental conditions index [4].

Research Results and their Discussion

There are many criteria for the reaction and resistance of winter soft wheat varieties to drought and high air temperatures. The main accumulating feature in the field is determined by the absolute value of yield and its structural features, as well as the degree of reduction in the productivity of the variety in drought conditions (the amplitude of productivity). This is also well evidenced by the coefficient of variation in productivity over the years of the experiment (Tab. 1).

These years are generally characterized by aridity, but 2022 wos especially different. Following the generally accepted classification according to HTC values, it belongs to the group of very dry years (Tab. 2). This clearly affected the productivity level of winter wheat shown in the table.

The varieties used in the experiment behaved differently. The Tiras variety showed a comparatively good level of productivity in conditions of drought and thermal stress, as well as the more short-season variety – Zborul, which to a certain extent “escaped” from the peak of drought and heat.

The same group includes Acord, Numitor, Simbol, Rândunica (intensive ecotype) and Meleag, Aport, Odor, Fluieras (semi-intensive ecotype) varieties.

As already mentioned, the Institute permanently conducts breeding work with winter wheat in combination with other caracters of drought resistance.

However, a noticeable increase in the pressure of hydrothermal climate indicators towards drought and increased heat during such critical phases of growth and development of winter wheat plants as ear laying and grain filling in this region necessitates the creation of new varieties that combine the necessary level of their adaptability, primarily to drought and high air temperatures.

Table 1: Results of trials for rezistered of zoned and promising winter soft wheat varieties created at NCRSP (competitive variety trials predecessor – mixture of spring vetch outss as siderate)

№	Variety	Productivity, t/ha				Deviation from the standard		The amplitude of productivity	CV, %	DRI, %	Weight of grain per ear, g	Number of ears per 1м², pcs
		2022	2023	2024	average	t/ha	%					
Intensive ecotype varieties												
1	Kuialnic-st.	2,81	5,93	6,48	5,07		100	3,67	39	43	1,49	504
2	Acord	3,68	5,73	6,68	5,36	+0,29	106	3,00	29	55	1,43	589
3	Nuvitor	3,76	5,60	6,58	5,31	+0,24	105	2,82	27	57	1,55	568
4	Simbol	3,73	5,68	6,25	5,22	+0,15	103	2,52	25	55	1,51	640
5	Zborul	3,87	5,58	6,08	5,18	+0,11	102	2,21	22	64	1,47	624
6	Rândunica	3,65	6,28	6,50	5,48	+0,41	108	2,85	29	56	1,39	582
	average	3,58	5,80	6,43	5,27	+0,20	104	2,85	28,5	55	1,47	584
Semi-intensive ecotype varieties												
1	Meleag-st.	3,73	6,05	6,73	5,50	-	100	3,00	29	55	1,40	580
2	Vestitor	3,48	5,43	6,33	5,08	-0,42	92	2,85	29	55	1,62	550
3	Savant	3,16	4,90	6,10	4,72	-0,78	86	2,94	31	52	1,32	716
4	Aport	3,76	5,90	6,80	5,49	-0,01	99,8	3,04	28	55	1,81	596
5	Tiras	3,89	6,08	6,45	5,47	-0,03	99	2,56	25	60	1,50	582
6	Odor	3,60	6,48	6,60	5,56	+0,06	101	3,00	31	55	1,69	516
7	Fluieraș	3,57	5,88	6,83	5,43	-0,07	98	3,26	31	52	1,52	634
	average	3,60	5,82	6,55	5,32	-0,18	97	2,95	29,1	55	1,55	596
	$Dl_{0,5}$ (t/ha)	0,30	0,60	0,48	0,45							

Table 2: Degree of aridity of the climate for 2022-2024 years in the northern region of the Republic of Moldova

Agricultural years	Index indicators	
	Hydrothermal coefficient (HTC)	Environmental conditions index
21/22	0,62	-1,71
22/23	0,76	+0,51
23/24	0,80	+1,16

The hydrothermal conditions of wheat cultivation in this region are becoming more contrasting and harsher, often covering the autumn period, which is important for the germination and initial growth of winter wheat plants of this crop. This is also evident from the analysis of the environmental conditions index, which, even during the three-year period of this experiment, ranged from -1,71 to +1,16.

In such unstable conditions of wheat cultivation, gross grain harvests in the republic can be stabilized to a certain extent by further improving its cultivation technology, creating and selecting new adaptive arid varieties.

The Institute has a fairly good working genetic collection of about 600 samples from 17 countries, which makes it possible to purposefully selection the appropriate parental forms for hybridization followed by selection the necessary recombinants under stressful conditions of drought and high air temperatures. Subsequently, they undergo a step-by-step assessment and study in various breeding nurseries with additional selection of appropriate useful breeding lines.

Candidates (the best breeding lines) receive the final assessment for transfer to the state variety trials in the competitive variety trials at the Institute, in comparison with national standards – Meleag and Kuyalnik varieties.

A visual assessment of plants in the field such as the reaction to twisting and wilting of leaves, especially flag leaves, the presence of wax plaque, slowing down the aging of plants and their longer preservation in green form was conducted.

When selecting drought-resistant genotypes, the parameters of the flag leaf and the length of the last internode, the size of the ear and the productive tilling capacity of plants were taken into account.

In addition to simple crosses during hibridization, a one-time saturation with a third appropriately selected parent form was also applied in the form of intermittent and continuous incomplete crosses.

As a result of the application of this scheme for the development and processing of initial breeding material for winter soft wheat, new varieties characterized by a favorable combination of productivity and adaptability, including drought resistance, have been developed. These include registered and promising varieties such as Meleag, Talisman, Aport, Tiras, Odor, Zborul and Rândunica.

Conclusions

1. Climate change towards aridity in all regions of the Republic of Moldova has become a reality.
2. This issue requires a comprehensive study and assessment of drought and high-temperature resistance indicators for winter wheat varieties developed under specific environmental growing conditions.
3. Such an approach will enable the targeted selection of appropriate parental forms for hybridization, as well as the evaluation and selection of valuable varieties under conditions of increased climate aridity.

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