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ADAPTABILITY OF TRITICUM DURUM DESF. ACCORDING TO PARAMETERS OF SELECTION VALUE AND HOMEOSTATICITY IN THE EASTERN FOREST STEPPE OF UKRAINE

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Goal*. To determine the adaptability of modern samples of Triticum durum Desf. according to the parameters of selection value and homeostatic weight of 1000 grains, and productivity, as well as source of high levels of their manifestation, adapted to the stressful conditions of the Eastern Forest Steppe of Ukraine.* **Methods***. General scientific (analysis and synthesis) — for differentiation and generalization of the obtained results; dispersive — to determine the levels of manifestation of the selection value and homeostaticity of the mass of 1000 grains and yield, to assess the reliability of experimental data.* **Results***. Three genotypes were identified, which were distinguished by the formation of a large mass of 1000 grains (over 46 g) — MIP Lakomka, Shliakhetnyi, and Koralovyi (Ukraine), and 11 sources of high yield manifestation (over 16% to the standard) — Prestyzhnyi, MIP Lakomka, Shliakhetnyi, Passat, Koralovyi (Ukraine), Hordeiforme 335 (Moldova), MV Hundur (Hungary), etc. The selection value of the best samples in terms of productivity was Sc=284.4–504.0, homeostaticity — Hom=1965.3–8543.1. It was established that the share of samples with the genotypic ability to form high homeostatic productivity was 26.7%, average — 40.0%, and low —*

33.3%. **Conclusions***. The most adapted genotypes of Trificum durum Desf. for cultivation in the stressful conditions of the Eastern Forest Steppe of Ukraine include the following varieties of domestic selection, which combine high selection value and homeostatic productivity: MIP Lakomka (Sc=504.0; Hom=6200.4), Passat (Sc=488.6; Hom=8543.1), Shliakhetnyi (Sc=477.6; Hom=6670.2), and Koralovyi (Sc=446.4; Hom=6103.6) — they form productivity at the level of more than 123% to the standard.*

Key words*: variability, homeostasis, reaction rate, weight of 1000 grains, productivity, stability, variety, source.*

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The agrarian sector effectiveness is determined by grain croppage and its stability, as increased croppage and stabilized grain production contribute to the grain market development and are strategic objectives of the Ukrainian economy [1]. However, biotic and abiotic stressors limit the yields and adaptability of food crops, posing significant obstacles on this path [2–4]. The successful introduction of competitive cultivars, including winter wheat (*Triticum durum* Desf.), into production requires considerable breeding efforts to increase yields and adaptive potentials in some agroecological zones [2, 5] and continuous research on improving cultivation technologies [6 –8]. Pre-selected sources with desirable expression of valuable economic traits under certain agroecological growing conditions help to breed up-and-coming cultivars.

Review of Recent Studies and Publications. Flour from *T. durum* Desf. grain is the best raw material for high-quality pasta production, because it contains Group II tight gluten, allowing for the production of pasta of proper quality, i.e. pasta of pleasant color, lemon-yellow or amber, which maintains shape and does not get sticky during cooking. *T. durum* Desf. is also often milled into semolina (coarsely milled durum wheat mainly used in making pasta) and semola (twice milled durum wheat, a special type of flour) of top quality for the bakery and groats industries [9]. Compared with *Triticum aestivum* L., *T. durum* Desf. grain is richer in protein; the protein content is 14-16%. The *T. durum* Desf. cultivation is mainly concentrated in Canada (4.4 million tons), Italy (4.0 million tons), and Turkey (3.0 million tons). Ukraine grows 1.5–2.3 million tons of *T. durum* Desf. [5, 10].

Among the factors that can increase and stabilize croppage, the cultivar is gaining more and more importance [11, 12]. The successful introduction of new cultivars into production is determined by their genetic potentials of yield, adaptability, and homeostaticity [13–15]. Advanced cultivation technologies are mandatory on this path [7]. It is known that, in general, the contribution of breeding to yield growth reaches 50% [12]. The breeding value and homeostaticity of yield and its major constituents, in particular thousand kernel weight, are the keys to genotypes' high and stable yielding under variable growing conditions [2].

The fulfillment of the genetic potentials of yield and adaptability by cultivars is limited by different biotic and abiotic environmental stressors [2]. Of the biotic factors, fungal diseases are the most damaging ones, as they can reduce yields by 15–20% or even by 60% in the case of epiphytotics [16]. Of the abiotic factors, the water deficit issues caused by elevated temperatures and decreased precipitation (as commonly predicted in the context of climate changes) are gaining more and more importance [3, 17]. The effects of environmental stressors on genotypes are determined by their homeostaticity, which is understood as the genotype's ability to minimize the impact of environmental stressors [18]. It was established that the higher homeostaticity (Hom) and breeding value (Sc) were, the more stable and valuable for breeding the genotype was under variable growing conditions [19]. Determination of breeding value and homeostaticity of yield and its constituents in the genetic diversity of current *T. durum* Desf. cultivars is a necessary and relevant stage on the way to creating promising cultivars adapted to certain agroecological growing conditions.

Purpose - to assess the adaptability of current *T. durum* Desf. cultivars by breeding value and homeostaticity for thousand kernel weight and yield and to select sources of strong expression of these features, which would be adapted to the conditions of the Eastern Forest-Steppe of Ukraine.

Materials and Methods. Fifteen *T. durum* Desf. accessions from five countries were studied: seven accessions from Ukraine, three from Moldova, three from Hungary, one from Austria, and one from France (Table 1). The study was carried out in the Laboratory of Genetic Resources of Cereals of the National Center for Plant Genetic Resources of Ukraine at the Yuriev Plant Production Institute of NAAS (Kharkivskyi District, Kharkivska Oblast, Eastern Forest-Steppe of Ukraine) in 2018-2021. The experiments were designed per the requirements of field experimentation in breeding [Dospekhov B.O., 1985]. Seeds were sown in plots of 2 m^2 with a SSFK-7 seeder at a seeding rate of 4.5 million seeds/ha in three replications after bare fallow within the optimal timeframe. Cv. 'Kontynent' was taken as the check cultivar and sown every 20 accessions. The accessions were investigated by conventional methods [Merezhko A.F. et al., 1999].

Breeding value Sc and homeostaticity Hom were determined by V.V. Khangildin's method [18]. Data were statistically processed, as recommended in [Dospekhov B.O., 1985].

The following research approaches were used: general scientific (analysis and synthesis) - for differentiation and generalization of the obtained results; ANOVA - for determination of the breeding value and homeostaticity of thousand kernel weight and yield and assessment of significance of experimental data.

Table 1. Breeding value and homeostaticity of thousand kernel weight in the best T. durum Desf. accessions, 2019 - 2022

Accession	Country of origin	Thousand kernel weight, g					
		max	*min*	$\bar{X}$	Sc	CV, %	Hom
Kontynent, check cultivar	Ukraine	44.5	38.5	41.6	36.1	7.2	576.0
MIP Lakomka	Ukraine	49.5	43.5	46.8	41.2	6.5	717.9
Shliakhetnyi	Ukraine	48.5	44.0	46.6	42.3	5.1	921.7
Koralovyi	Ukraine	48.5	43.5	46.5	41.7	5.7	817.3
Prestyzhnyi	Ukraine	47.5	42.0	44.5	39.4	6.3	711.3
Passat	Ukraine	44.5	40.5	42.8	38.9	4.9	881.4
Prozoryi	Ukraine	45.5	38.0	42.2	35.2	9.1	465.6
Nadiinyi	Ukraine	45.5	39.5	42.0	36.5	7.4	564.9
Hordeiforme 340	Moldova	45.5	36.5	42.0	33.7	11.5	365.8
Hordeiforme 335	Moldova	46.5	36.5	41.2	32.3	12.2	336.7
Hordeiforme 333	Moldova	41.5	35.0	37.8	31.9	8.8	429.9
MV Hundur	Hungary	44.5	39.0	42.0	36.8	6.6	633.7
GK Betadur	Hungary	44.0	37.5	40.2	34.2	8.5	474.4
MV Pennedur	Hungary	43.5	36.5	39.7	33.3	8.9	443.6
Lupidur	Austria	42.5	33.5	38.8	30.6	12.2	319.1
XE 9710	France	46.5	35.0	40.3	30.4	14.4	280.7
$LSD_{0.05}$		–	–	0.9	–	–	–
min		41.5	33.5	37.8	30.4	4.9	280.7
max		49.5	44.0	46.8	42.3	14.4	921.7
mean		45.5	38.7	42.2	35.9	8.5	558.8

Results. Analyzing the weather during the growing periods in 2019-2022, we concluded that varying hydrothermal coefficient (HTC) enabled us to differentiate the winter *T. durum* Desf. accessions by thousand kernel weight and yield.

2021 had the driest autumn (HTC = 0.36); the autumn was also very dry in 2020 (HTC = 0.46); it was rather wet in 2019 (HTC = 1.46). The meteorological conditions of the vegetational spring-summer periods of the study differed significantly in available moisture and temperature. Spring months were dry in 2022 (HTC = 0.59), fairly wet in 2021 (HTC = 1.46), and water-logged in 2020 (HTC = 2.05). The summer months were quite wet in 2020 (HTC = 1.27) and 2022 (HTC = 1.17), but dry in 2021 (HTC = 0.64). 2020 was the most favorable year for *T. durum* Desf. to have a large weight of one thousand kernels and yield a lot. In 2019 and 2021, these parameters were mostly lower. The water deficit and high temperature in July 2021 (HTC = 0.09) resulted in shrunken grain, which most negatively affected the thousand kernel weight and yield compared to the other years of our research.

Therefore, the weather during the growing periods enabled us to differentiate the current *T. durum* Desf. cultivars by breeding value and homeostaticity of thousand kernel weight and yield and to identify sources of strong expression of these features adapted to the conditions of the Eastern Forest-Steppe of Ukraine.

Based on the multi-year study, three genotypes were distinguished by large weights of one thousand kernels (>46 g) in comparison with the check cultivar, 'Kontynent' (UKR) (41.6 g): domestic cvs. 'MIP Lakomka', 'Shliakhetnyi', and 'Koralovyi' (UKR) (see Table 1).

It was found that, in current *T. durum* Desf. cultivars and lines, the breeding value for thousand kernel weight (Sc) was 30.4–42.3 and the homeostaticity (Hom) was 280.7–921.7.

Having evaluated the breeding value for thousand kernel weight in *T. durum* Desf., we identified sources with above-average breeding values (Sc = 35.9). The following cultivars stood out by this parameter: cv. 'Shliakhetnyi' (Sc = 42.3), cv. 'Koralovyi' (Sc = 41.7), cv. 'MIP Lakomka' (Sc = 41.2), cv.

'Prestyzhnyi' (Sc = 39.4), cv. 'Passat' (Sc = 38, 9), cv. 'Nadiinyi' (Sc = 36.5), cv. 'MV Hundur' (Sc = 36.8), and cv. 'Kontynent' (check cultivar; Sc = 36.1).

Low variability of a trait is a criterion for the genotype's homeostaticity. Stability of a trait under changing environmental conditions clearly reflects the close relationship between homeostaticity (Hom) and coefficient of variation (CV).

Genotypes with high homeostaticity and low variability (CB ≤10.0%) of thousand kernel weight included the following cultivars and lines: cv. 'Shliakhetnyi' (Hom = 921.7), cv. 'Passat' (Hom = 881.4), cv. 'Koralovyi' (Hom = 817.3), cv. 'MIP Lakomka' (Hom = 717.9), cv. 'Prestyzhnyi' (Hom = 711.3), cv. 'Nadiinyi' (Hom = 564.9), cv. 'Prozoryi' (Hom = 465.6), line 'Hordeiforme 333' (Hom = 429.9), cv. 'MV Hundur' (Hom = 633.7), cv. 'GK Betadur' (Hom = 474.4), and cv. 'MV Pennedur' (Hom = 443.6). Their share was 73.3%.

Lines 'Hordeiforme 340' (Hom = 365.8) and 'Hordeiforme 335' (Hom = 336.7), cvs. 'Lupidur' (Hom = 319.1) and 'XE 9710 (Hom = 280.7)' were characterized by medium homeostaticity and variability (Hom = 280.7) (in the check cultivar, 'Kontynent' Hom = 576.0). The share of accessions with medium homeostaticity of thousand kernel weight was 26.7%. In the studied sample, there were no accessions with low homeostaticity of thousand kernel weight.

Thus, cvs. 'Shliakhetnyi', 'Koralovyi', 'MIP Lakomka', 'Prestyzhnyi', 'Passat', 'Nadiinyi', and cv. 'MV Hundur' are genotypes with high breeding value and homeostaticity of thousand kernel weight. These accessions are valuable starting materials to create new breeding-valuable and stable genotypes with large weights of one thousand kernels.

In 2019-2022, sources of high yield capacity (+16% to the check cultivar) were selected from the current *T. durum* Desf. accessions. These accessions included cvs. 'Prestyzhnyi', 'MIP Lakomka', 'Nadiinyi', 'Prozoryi', 'Shliakhetnyi', 'Passat', 'Koralovyi', 'MV Hundur', and 'Lupidur' as well as lines 'Hordeiforme 335' and 'XE 9710'. Cv. 'Kontynent' (check cultivar) yielded 422 g/m^2. The breeding value Sc for yield varied from 284.4 to 504.0; the homeostaticity Hom - from 1,965.3 to 8,543.1 (Table 2).

Table 2. Breeding value and homeostaticity of yield in the best T. durum Desf. accessions, 2019 - 2022

Accession	Yield, g/m^2					
	max	*min*	$\bar{x}$	Sc	CV, %	Hom
Kontynent, check cultivar	450	375	422	351.4	9.7	4,366.2
Prestyzhnyi	688	525	631	481.5	14.6	4,333.2
MIP Lakomka	676	554	615	504.0	9.9	6,200.4
Nadiinyi	664	503	582	440.6	13.9	4,199.7
Prozoryi	665	500	563	423.6	15.8	3,568.5
Shliakhetnyi	611	523	558	477.6	8.4	6,670.2
Passat	585	515	555	488.6	6.5	8,543.1
Koralovyi	573	490	522	446.4	8.6	6,103.6
Hordeiforme 335	617	382	496	307.1	23.7	2,090.9
Hordeiforme 333	534	371	456	317.3	17.9	2,548.9
Hordeiforme 340	556	353	448	284.4	22.8	1,965.3
MV Hundur	685	504	611	449.8	15.6	3,930.7
MV Pennedur	572	392	477	326.9	18.9	2,516.5
GK Betadur	556	353	454	288.2	22.4	2,030.6
Lupidur	567	363	493	315.6	22.9	2,151.9
XE 9710	633	382	531	320.5	24.9	2,137.1
$LSD_{0.05}$	–	–	23.0	–	–	–
min	534	353	448	284.4	6.5	1,965.3
max	688	554	631	504.0	24.9	8,543.1
mean	602	443	526	389.0	16.0	3,959.8

Having assessed the breeding value of *T. durum* Desf., we identified eight sources in which Sc exceeded the experimental mean (Sc = 389.0): cvs. 'MIP Lakomka' (Sc = 504.0), 'Passat' (Sc = 488.6), 'Prestyzhnyi' (Sc = 481 .5), 'Shliakhetnyi' (Sc = 477.6), 'Koralovyi' (Sc = 446.4), 'Nadiinyi' (Sc = 440.6), 'Prozoryi' (Sc = 423,6), and 'MV Hundur' (Sc = 449.8); Sc of the check cultivar ('Kontynent) was 351.4.

Four domestic cultivars (26.7%) were noticeable for high homeostaticity and low variability (CV ≤10.0%) of yield, viz. cv. 'Passat' (Hom = 8,543.1), 'Shliakhetnyi' (Hom = 6,670.2), 'Koralovyi' (Hom = 6,103.6), and 'MIP Lakomka' (Hom = 6200,4); Hom of the check cultivar ('Kontynent) was 4,366.2.

Six accessions were characterized by medium homeostaticity and variability; their share was 40.0%. They were cvs. 'Prestyzhnyi' (Hom = 4,333.2), 'Nadiinyi' (Hom = 4,199.7), 'Prozoryi' (Hom = 3,568.5), 'MV Hundur' (Hom = 3,930.7), and 'MV Pennedur' (Hom = 2,516.5) as well as line 'Hordeiforme 333' (Hom = 2,548.9).

Low homeostaticity of yield was detected in five accessions, viz. line 'Hordeiforme 340' (Hom = 1,965.3), line 'Hordeiforme 335' (Hom = 2,090.9), cv. 'GK Betadur' (Hom = 2'030.6), cv. 'Lupidur' (Hom = 2,151.9), and line 'XE 9710' (Hom = 2,137.1); their share was 33.3%.

So, the most promising genotypes, which combined high breeding value and homeostaticity of yield, included cvs. 'MIP Lakomka', 'Passat', 'Shliakhetnyi', and 'Koralovyi'. Genotypes with high breeding value and homeostaticity of thousand kernel weight and yield selected in this study are valuable starting materials to create up-and-coming *T. durum* Desf. cultivars adapted to stressful growing conditions in the Eastern Forest-Steppe of Ukraine.

Conclusions

Among the current *T. durum* Desf. cultivars and lines, three genotypes with large weights of one thousand kernels (□46 g), viz. cvs. 'MIP Lakomka', 'Shliakhetnyi', and 'Koralovyi', and 11 sources of high yield (+16% to the check cultivar), viz. 'Prestyzhnyi', 'MIP Lakomka', 'Nadiinyi', 'Prozoryi', 'Shliakhetnyi', 'Passat', 'Koralovyi', V Hundur', and 'Lupidur' as well as lines 'Hordeiforme 335' and 'XE 9710' were identified.

The breeding value Sc for thousand kernel weight was 30.4 to 42.3; the homeostaticity Hom was 280.7 to 921.7. Cvs. 'Shliakhetnyi' (Sc = 42.3; Hom = 921.7), 'Koralovyi' (Sc = 41.7; Hom = 817.3), 'MIP Lakomka' (Sc = 41.2; Hom = 717.9), 'Prestyzhnyi' (Sc = 39.4; Hom = 711.3), 'Passat' (Sc = 38.9; Hom = 881.4), 'Nadiinyi' (Sc = 36.5; Hom = 564.9), and 'MV Hundur' (Sc = 36.8 ; Hom = 633.7) are valuable genotypes distinguished due to high breeding value and homeostaticity of thousand kernel weight.

It was found that the share of accessions with the genotypic ability to show high homeostaticity of yield was 26.7%; the share of accessions with medium homeostaticity was 40.0%; and the share of accessions with low homeostaticity was 33.3%. The breeding value Sc for yield was 284.4 - 504.0; the homeostaticity Hom was 1,965.3 - 8,543.1. The most promising *T. durum* Desf. genotypes combining high breeding value and homeostaticity of yield include domestic cvs. 'MIP Lakomka' (Sc = 504.0; Hom = 6,200.4), 'Passat' (Sc = 488.6; Hom = 8'543.1), 'Shliakhetnyi' (Sc = 477.6; Hom = 6,670.2), and 'Koralovyi' (Sc = 446.4; Hom = 6,103.6), which yielded over 123% related to the check cultivar.

Genotypes with high adaptive potentials identified in this study are valuable starting materials to create promising *T. durum* Desf. cultivars adapted to stressful growing conditions in the Eastern Forest-Steppe of Ukraine.

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