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FRENCH WINTER WHEAT VARIETIES UNDER UKRAINIAN NORTH STEPPE CONDITION

SUMMARY

The main purpose of research was to assess the variety material of bread winter wheat of the Western European ecotype (variety type), obtained from the Laboratory of Ecophysiology and Biodiversity of Cereals INRA (France). The parameters of evolution are winter resistance, grain quality, yield and its structure under the North Steppe of Ukraine conditions (at compare with the national standard and leading local variety) and make a phenological description of the material. In the context of climate change and more moderate winter conditions at the Steppe zone of Ukraine, the issue of priorities in estimation of new genotypes of winter wheat was of interest. Early maturity as a way to avoid early drought at key development stages was found to be no longer as a key priority. The advantage of some western varieties concerning local ones by grain production has been revealed, which is due to a fundamentally new approach to yield formation by individual components of the yield structure. The disadvantages (mainly by grain quality) for these samples are also shown. New sources of genetic material for breeding programs by grain quality in winter wheat have been identified. Structural differences in improving winter wheat as a crop between local and foreign approaches are characterized.

Key words: winter wheat, variety, grain productivity, quality.

INTRODUCTION

With an annual production of about 764.5million tons (2019) (USDA, 2020), bread wheat (*Triticum aestivum* L.) is one of the most important crops in the world. Winter wheat is the leading grain crop in terms of total yield and

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cultivation in the world and the most important, top one in Ukraine food grain crop. Bread wheat occupies 48% of the area under cereal crops and gives 38% of total grain production (Nazarenko and Bezus, 2018).

The territory of Ukraine is characterized by diversity on climatic zones and extremely unstable meteorological conditions by years and seasons. The presence of different natural-contrast zones leads to the creation of varieties genetically diverse by at least three main agroecotypes of winter wheat (Li *et al*., 2019). Varieties of semi-intensive and intensive winter wheat are characterized by high or above average tilling capacity, demands in precipitations during development critical phases, a fairly high frost and winter resistance. In the phase of full tilling, the plants tolerate well low negative temperatures up to -20°C, form large, well-grained spike with grains above than average or high quality (Mba *et al*., 2012; Nazarenko *et al*., 2019b).

Many years of breeding and genetic research have created a significant number of valuable hybrid populations. Tests of these materials in contrasting ecological zones contributed to the creation of adapted agroecotypes of high-yielding varieties of winter wheat. Over the last 15 years, new complex varieties of intensive winter wheat have been created and zoned, which are characterized by high yields, adaptability, disease resistance, as well as high grain quality parameters and fairly high winter resistance and drought resistance (Tuberosa and Salvi, 2006).

Agroclimatic steppe conditions are characterized by significant variability in weather conditions over the years, growing seasons, areas, which determine the existing size and variability of winter wheat yield in the region (Bhutta *et al*., 2005).

Along with the improvement of cultivation technology, an important role in increasing yields and reducing its variability by the years in the region belongs to the variety genotype. Regarding this, the key priority is to gain yield through breeding winter wheat varieties able to use environmental resources and peculiarities of the ecological zone most efficiently, to resist abiotic and biotic stressors (Andrusevich *et al*., 2018).

It is established that moisture supply above than average long-term level at critical stages of development ensures positive correlation of the yield with plant survival, with the number of plants per 1 m^2 before harvest, weight of 1000 grains, grain weight of main spike. Under highly intensive complex abiotic stress (freezing, drought), grain yield was positively correlated with winter resistance and grain nature. It is important to winter wheat breeding in the steppe to increase the resistance of varieties to abiotic stresses (drought, freezing, rotting) (Tester and Langridge, 2010).

The development of synthetic breeding for quality was less efficient than for yield, although better product quality is more important than just increased yield. For example, it is believed that increasing the protein content in the grain by 0.1% is equivalent to producing an additional 0.6-0.7 t ha^{-1} of grain (Bordes *et al.,* 2008; Bordes *et al*., 2011).

The main achievements in the breeding of wheat for grain quality belong to scientists in the southern regions, where there are appropriate agroclimatic conditions (temperature, moisture, soil fertility) (Mba *et al*., 2012).

Product quality parameters (protein, gluten, fat, sugars, vitamins, etc.), as a rule, positively correlate with the resistance of cultivated plants to abiotic and biotic stressors and negatively with high yields (Tribo *et al*., 2003). The greatest importance in the formation of high yield and grain quality has stability of weather conditions in the critical stages of growth and development of plants (Rangare *et al*., 2010).

The most important factors in increasing yield parameters are: collection, identification, conservation, and study of genetic diversity of plants for their wide inclusion of economic and valuable traits and adaptive reactions in the breeding process (Gepts and Hancock, 2006); selection of varieties that combine high potential yield and quality with resistance to toxic and negative environmental factors (Tester and Langridge, 2010); use of the main mechanism of stability of cultivated plant species – avoidance of the action of stressors in time and space due to adaptive macro-, meso- and micro-zoning of crops, as well as optimization of their species and varietal structure (Andrusevich *et al*., 2018); design of highly productive and ecologically sustainable agroecosystems and agrolandscapes based on the use of greater biological diversity of cultivated species and varieties (Nazarenko *et al*., 2018; Nazarenko *et al*., 2019a); the use of biologically active substances to optimize the growth and development of plants in accordance with the weather and other environmental conditions (Prabhu, 2019); more time- and space-differentiated (high-precision) use of natural, artificial, biological, labor, and other resources (Shewry *et al*., 2012); development of standards of parameters of fodder grain, requirements for technological and breeding aspects of its quality management (Oury and Godin, 2007); use of mechanisms and structures of potential productivity, ecological stability, and yield quality (Li *et al*., 2019); efficient use of anthropogenic energy (fertilizers, pesticides, irrigation, regulated microclimate, etc.) (Andrusevich *et al*., 2018; Datcu *et al*., 2020).

The bread-making qualities of wheat are determined by the content of some components of glutenins and gliadins. The start of the formation of the same components is depends on variety peculiarities. Twenty days after pollination, the rapid accumulation of glutenins begins, which peaks on the 28th-31st day after pollination, and the accumulation of high-molecular glutenins significantly prevents the accumulation of gliadins (Bordes *et al*., 2011).

One of the most multifunctional stress metabolites of plants is the concentration of soluble sugars. In free form, these compounds can exhibit a multifunctional biological effect, which is evident in the osmoregulatory and protective function. The stress-protective effect of sugars is their ability to interact with macromolecules directly or indirectly and thus contribute to the preservation of their native conformation. Undoubtedly, concentrations of soluble sugars are one of the components of the stress response. This is evidenced by their high rate of accumulation, as a corresponding effect on the action of extreme factors, and the relative non-specificity of a number of biological effects (Shah *et al*., 2018; Khalili *et al*., 2018).

MATERIAL AND METHODS

Experiments were conducted at the experimental fields of Dnipro State Agrarian and Economic University (DSAEU). The field`s geographic coordinates are: 48°50'N lat. and 35°25' E long. The experimental field is laid on 59 meters above the sea level. Weather conditions for hydrothermal indicators in the years of research (2017 – 2020) varied, which made possible to obtain objective results, but in general, they were typical. Air temperature during winter wheat growing season (September - July) is 7.4 °C, the average rainfall is 458 mm for the location of the research fields, air temperature during winter wheat growing season 2018 (September - July) was 10.5 °C, the average rainfall is about 543.8 mm; air temperature in season 2019 was 9.6 °C, the average rainfall is about 476.2 mm; air temperature in season 2020 was 10.9 °C, the average rainfall is about 552.3 mm.

The field station of DSAEU has been used for many years (start from 60th years of XX century) as a field for intensive agricultural farming and researches. It is located far away from the city Dnipro (about 28 km) which is enough to avoid industrial or town air pollution effects. The research fields occupy an area of 60 hectares. Special attention was paid to the differences on several agronomical-value traits (grain yield, yield structure, protein and main protein components content in grains).

We evaluated two varieties of national breeding – Podolyanka (national standard) and Komerciyna (DSAEU, the variety was created at and for the Steppe zone), 12 varieties of INRA breeding (Institute of National Studies in Agronomy, France) obtained from the Laboratory of Ecophysiology and Biodiversity of Cereals (Clermont-Ferrand, France) Courtiot, Flamenco, Gallixe, Geo, Ghayta, Gotik, Grapeli, Koreli, Lyrik, Musik, Renan and Skerzzo.

Sowing plots of winter wheat varieties were placed according to a randomized scheme with a plot area of 5 m^2 in 3 repetitions, and the seeding rate depended on the weight of a thousand grains. Yield assessment was performed by continuous threshing, yield structure was determined by standard parameters in triplicate, the sample was 25 - 30 plants including the marginal effects (plant height, parameters of the main ear, plant yield, thousand grains weight (TGW)).

During the growing season, phenological observations were made, germination and survival after the winter period was determined, crop conditions were visually evaluated, dates and character of main critical stages were determined.

Winter resistance was evaluated by the concentration of soluble sugars, determined at the tillering nods of varieties according to generally accepted GOST 26176-91 (GOST, 1993).

Agrochemical analysis of soils for content of nutrient elements was provided too ($N\text{-}NO_3$, mg kg^{-1} 18.7 – 32.8, P_2O_5 14.8 – 27.1, K_2O 134 – 235).

The protein content and contents of gliadin and glutenin were identified on device Spectran RT (for protein content) and RP-HPLS (for gliadins and glutenins).

Mathematical processing of the results was performed by the method of analysis of variance, the variability of the mean difference was evaluated by Student's t-test, factor analyses were conducted by module ANOVA, cluster analysis by module of multivariate statistic. In all cases standard tools of the program Statistica 8.0 were used.

RESULTS AND DISCUSSION

Table 1 presents the general characteristics of the main traits of the cultivated varieties of winter wheat obtained in the terms of phenological observations during the growing seasons of 2017 - 2020.

Table 1. General characteristic of winter wheat varieties phenotype

Variety	Plant height	Maturing (2018/2019)		Awns
		Date	Classification	
Podolyanka	high stem	22-23.05	medium	awnless
Komerciyna	high stem	20.05	early medium	awnless
Courtiot	semi-dwarf	17.05	early	awn
Flamenko	short stem	26.05	late	awn
Gallixe	short stem	26.05	late	awnless
Geo	short stem	26.05	late	awn
Ghayta	short stem	25-26.05	late	awn
Gotik	medium	26.05	late	awnless
Grapeli	medium	26.05	late	awnless
Koreli	medium	26-27.05	late	awn
Lyrik	short stem	26.05	late	awnless
Musik	short stem	26.05	late	awn
Renan	medium	26.05	late	awn
Skerzzo	medium	26-27.05	late	awn

The earliness as trait was previously considered as the key for Steppe zone. As we can see from the data, only one variety of French breeding was early-maturing, an early-medium variety of local breeding, the national standard was the medium by maturity; all other foreign varieties were at the late-maturing group. It is believed that such trait is negative for our zone because critical periods in the formation of grain yield with such development fall on periods with insufficient precipitation and higher air temperature. However, the study further proves this concept as outdated, which does not correspond to the late changes in the weather and climatic conditions of the North Steppe of Ukraine.

As for the traits that characterize the structure of the plant (plant height), the varieties of foreign breeding are shorter, with even one semi-dwarf. This is an absolute advantage in comparison with medium-height national varieties. Also, the varieties of French breeding have a higher economic suitability coefficient (defined as the ratio of grain mass to the total formed biomass) (0.27 - 0.31) (Nazarenko *et al.*, 2019b).

The work also considered such a trait as spike awns. It is believed that awnless plants are more resistant to pests. However, as we can see, both awn and awnless forms are equally present among foreign varieties. However, in the context of this study, this was not decisive.

Table 2 shows the results of an examination of winter wheat growth and development at winter period, starting from germination and until the resumption of vegetation after the period of low temperatures. As we can see, in general, domestic varieties have higher winter resistance in comparison with INRA varieties.

Table 2. Winter wheat samples parameters during winter period (2017/2020 periods of vegetation dates)

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	Komerciyna	98.9	5	28.4	22.1	19.8	19.0	98.4	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 standard made was especially developed due to its high ecological flexibility and adaptability (the ability to ensure a stable yield and satisfactory grain quality in a wide range of weather conditions). According to winter resistance, foreign varieties in terms of sugar content in the root node were seriously inferior to the standard. The content was especially low in Ghayta, Lyrik, and Musik. However, other varieties also did not reach the required level. Only domestic varieties scored 5 points in winter tolerance estimation, the visual evaluation of other genotypes was at the level of 3.5 - 4 points, except for one variety Renan. Their germination was lower. The best among INRA varieties in terms of sugar content (winter tolerance) was Geo.

Since 2016, winter has been getting significantly more moderate, for example, the winter wheat plant growth at winter season from 2017 did not stop until the end of December, and, in some years, it took place in early January. The periods with sharp reduction in temperature (down to -15 - -18°C) have significantly decreased by duration and at the winter period of 2019 - 2020 were practically absent, with the exception of a few days in February. Therefore, the lower winter tolerance of these samples did not lead to any negative consequences. That is, the idea of this property as a key one is somewhat outdated, and varieties of the Western European ecotype no longer suffer from our weather conditions as much as in the 1990s - 2000s.

Table 3 presents data on grain productivity. A three-year field test showed that, according to averaged data, such varieties as Komerciyna, Gallixe, Ghayta, and Koreli had overcome the standard. All the years of testing, Gallixe, Ghayta, and Koreli have been consistently surpassed the standard, the conditions of 2019/2020 (higher precipitation in late May - early June, less arid conditions) led to negative consequences for the Komerciyna local variety, which formed the yield at the standard level. However, this also had a positive effect on the overall yield of all genotypes.

Table 3. Grain productivity of winter wheat genotypes (2018-2020 years)

N	Variety	Yield, t ha^{-1}			Average	St. Dev
		2018	2019	2020		
1	Podolyanka	5.23	5.42	7.89	6.18	0.48
2	Komerciyna	6.61*	6.40*	7.27	6.76*	0.45
3	Courtiot	4.24	4.79	5.75	4.93	0.56
4	Flamenko	4.45	4.74	9.76*	6.32	0.59
5	Gallixe	7.33*	7.69*	9.36*	8.13*	0.08
6	Geo	4.00	4.10	7.06	5.05	0.54
7	Ghayta	7.12*	7.76*	9.58*	8.15*	0.48
8	Gotik	5.63	5.79	7.22	6.21	0.52
9	Grapeli	5.64	6.09*	7.47	6.40	0.56
10	Koreli	7.02*	6.79*	9.13*	7.65*	0.29
11	Lyrik	5.63	5.78	7.64	6.35	0.12
12	Musik	5.02	5.23	7.77	6.01	0.53
13	Renan	4.91	5.04	7.80	5.92	0.53
14	Skerzzo	5.26	5.59	7.87	6.24	0.42

* - difference is statistically significance from check at $P_{0.05}$

In some years, Grapeli (2019) and Flamenko (2020) also surpassed the standard by yield. In general, as we can see, late maturing only contributed to better productivity of foreign varieties. Low winter resistance did not have a significant effect.

Table 4 presents the results of the analysis of variance by factors variety and year (climatic conditions in a given period) for all genotypes. It was found that both factors influenced on grain productivity - the factor year was more powerful ($F = 64.59$; $F_{critical} = 3.36$; $p = 0.01$), the factor variety was less significant, but sufficient ($F = 7.44$; $F_{critical} = 2.11$; $p = 0.01$). Thus, the statistically significance of both factors that underlie the experiment was confirmed.

Table 4. Results of factor analysis

Source of variation	SS	df	MS	F	P-value	F critical
Variety	36,58848	13	2,814498	7,440355	8,06E-06	2,119166
Year	48,86606	2	24,43303	64,5907	8,2E-11	3,369016
Error	9,835143	26	0,378275			
Summary	95,28968	41				

The obtained material was classified according to grain productivity by cluster analysis (Fig. 1). It showed that the material was divided into six groups. The first group included varieties that consistently demonstrated the standard-level productivity, without significant variations. It consisted of Podolyanka, Skerzzo, Musik, Renan, Gotik, Grapeli, and Lyrik.

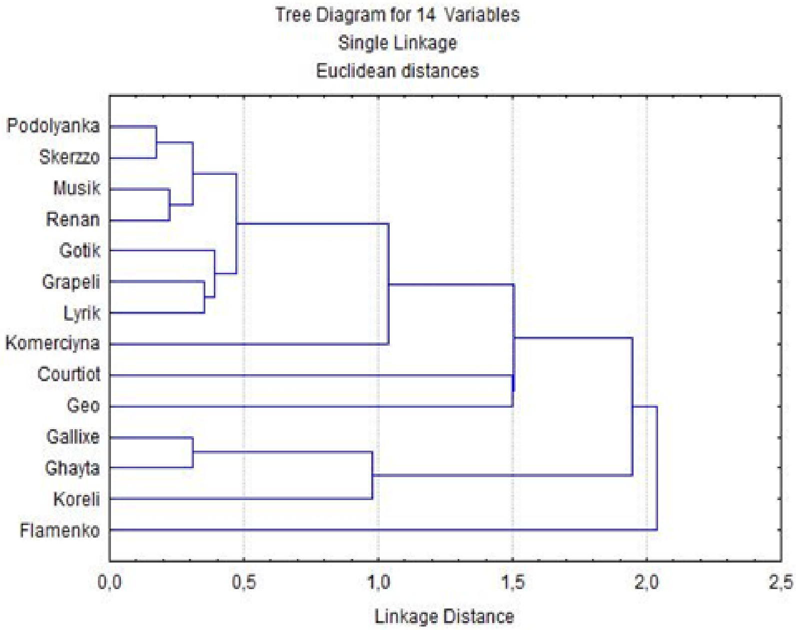

Figure 1. Cluster analysis of genotypes grain production

In the second group, the variety Komerciyna surpassed the standard in general, but in 2020 came less of yield. In the third group only one variety, Courtiot, the only semi-dwarf and at the same time earlyness variety in the experiment, showed yields consistently below the standard in all the years of the study.

The fourth group consists of one Geo variety, which for two years showed yields consistently below the standard variety, but in the last year, which was more favorable in terms of hydrothermal conditions, form yield at the standard level.

The fifth group contains several foreign varieties – Gallixe, Ghayta, and Koreli. These are the most perspective varieties for grain productivity, which definitely exceeded the standard in any conditions and formed a high yield under any conditions during the experiment period. The last group is represented by the only variety – Flamenko, which for two years gave yields below the standard. However, in the last year, it exceeded it.

Thus, as the cluster analysis shows, drought in the 2nd-3rd decade of May - the 1st decade of June is still important for Steppe conditions. Less drought-susceptible varieties produce consistently high yields that are above or at the standard level. These are the first (Podolyanka, Skerzzo, Musik, Renan, Gotik, Grapeli, Lyrik), the second (Komerciyna), and especially the fifth (Gallixe, Ghayta, Koreli) groups. The main part of the varieties of the Western European ecotype is quite suitable for North Steppe conditions (which, apparently, are increasingly shifting towards the conditions of the region of creation). The cluster analysis has significantly underlined the results of the initial grain yield analysis.

The appropriate analysis to establish the influence of the yield structure parameters of (Table 5) on total grain productivity. The higher-yielding varieties exceeded the standard in terms of such parameters as the weight of a thousand grains (and they were the only ones who exceeded the standard in this parameter), and for two out of three cases, superiority was observed in grain weight per plant (all other genotypes did not show it either) and in the same two cases exceeded the standard in terms of grain weight per main spike. The number of grains per spike parameter is rather contradictory. Thus, the key parameters were the thousand grains weight and the weight of the grain from the main spike and plant.

That is if previously noted that the investigated form high yields on the basis of good productive tillering, then in the case of French varieties, both the high productive grain content of the main spike and good productive tillering affect the synthesis.

Our early researches showed that varieties are usually focused on one of two parameters, and cases when it was possible to effectively achieve their combination haven't been observed. This is a qualitatively new fact in our long-term studies of various genotypes of winter wheat.

However, modern agriculture practice demands on the quality and nutritional value of food in a higher priority than the total grain production. Therefore, the investigation cannot be considered complete without an analysis of quality parameters.

Table 6 presents the results for such parameters as the content of protein, gluten, glutenins (high and low molecular weight and total), and gliadins.

Table 5. Parameters of main components of yield structure (at average)

Variety	PH	Per main spike		WGP	TGW
		GN	GW		
Podolyanka	103.0±2.0	36.5±3.6	1.9±0.5	4.3±0.7	51.2±6.8
Komerciyna	103.8±1.7	33.0±4.8	1.5±0.3	4.4±0.8	43.5±5.8
Courtiot	60.2±1.7*	35.8±2.9	1.5±0.2	3.1±0.2	41.7±2.8
Flamenko	78.0±2.3*	31.6±3.0	1.1±0.1	3.8±0.3	35.0±2.0
Gallixe	74.4±1.9*	42.2±7.4*	2.5±0.2*	5.2±0.3*	54.1±2.9*
Geo	75.2±1.5*	37.5±5.4	1.6±0.2	4.2±0.2	41.5±2.1
Ghayta	77.8±0.4*	48.8±2.7*	2.4±0.3*	5.7±0.4*	53.6±2.3*
Gotik	88.0±0.6*	48.2±3.7*	1.9±0.3	3.7±0.3	39.2±2.0
Grapeli	85.2±2.8*	49.3±11.0*	1.4±0.3	3.8±0.3	30.3±2.3
Koreli	94.2±1.2*	44.0±9.7*	1.3±0.2	4.6±0.3	54.7±2.0*
Lyrik	74.8±1.2*	35.6±5.5	1.3±0.2	3.0±0.2	36.3±2.1
Musik	68.6±6.4*	42.3±4.1*	1.6±0.3	3.2±0.3	38.5±2.6
Renan	82.2±3.4*	28.3±3.9	1.1±0.1	3.4±02	39.6±2.9
Skerzzo	85.2±1.9*	44.3±8.6*	1.8±0.2	3.5±0.3	40.5±2.9

PH – plant height[cm]; GN – grain number[piece]; GW – grain weight[g]; TGW – thousand grain weight [g]; WGP – weight of grain per plant [g]
* indicate significant differences from standard at $P < 0.05$

Table 6. Grain quality parameters (at average)

Variety	PC	GC	Glutenins			Gliadins
			HMW	LMW	Total	
Podolyanka	13.99	25.59	0,16003	0,46485	0,62890	0,4598
Komerciyna	13.48	24.98	0,18522	0,54343	0,73268*	0,4248
Courtiot	14.55*	27.14*	0,19321*	0,54839	0,74160*	0,4352
Flamenko	10.92	17.51	0,15465	0,71101*	0,86566*	0,4564
Gallixe	11.46	20.21	0,15736	0,65789*	0,81525*	0,4894*
Geo	14.57*	27.69*	0,20483*	0,43901	0,64384	0,3345
Ghayta	13.42	24.72	0,22938*	0,58478*	0,81416*	0,4001
Gotik	11.02	18.33	0,17022	0,64633*	0,81655*	0,4325
Grapeli	11.71	19.85	0,16660	0,64457*	0,81117*	0,4536
Koreli	12.66	22.14	0,15337	0,70987*	0,86324*	0,4234
Lyrik	12.11	19.02	0,17446	0,66748*	0,84194*	0,4326
Musik	12.46	21.78	0,16747	0,70093*	0,86840*	0,4445
Renan	14.41*	26.01	0,23984*	0,45888	0,69872	0,3909
Skerzzo	13.94	26.81	0,16094	0,54091	0,70185	0,4385
Average	12.90	22.98	0,17982	0,59416*	0,77456*	0,4297
St.D, %	0.40	1.01	0,02763	0,09600	0,08228	0,0368

PC – protein content [%]; GC – gluten content [%]; HMW – high molecular weight clutenins [%]; LMW – low molecular weight clutenins [%].
* indicate significant differences from standard at $P < 0.05$

The results reaffirmed that high quality still does poorly and sometimes contradicts increased yields. Although it will receive a genotype with an acceptable level of this trait and higher yield is quite common. Protein levels at or above standard level, content of high-molecular-weight glutenins above standard, high content of gliadins is acceptable.

Among the most perspective high-yielding varieties, Ghayta was the only to show an acceptable level of quality by all traits (acceptable protein content, high content of high molecular weight glutenins and gliadins). The rest of the high-yielding varieties generally performed poorly. In the first group (Skerzzo, Musik, Renan, Gotik, Grapeli, Lyrik), the Renan variety deserves attention in terms of protein and high-molecular-weight glutenins, gliadins at the standard level. Komerciyna does not differ statistically from the standard in terms of quality.

In general, Courtiot, Geo, and Renan are donors of the protein content trait; Courtiot, Geo, Renan, and Ghayta – the content of high-molecular-weight glutenins; Gallixe – the content of gliadins. In a complex, varieties Courtiot, Geo, and Renan are the most perspective.

French varieties have a common problem in terms of the high content of low-molecular-weight glutenins. Also, only one genotype had high gliadin content.

Generally, the period investigations were characterized by moderate weather conditions than those obtained as a result of long-term observations (table 1-3). However, recent global climate changes have led to significantly more moderate conditions in region. First of all, this refers to an increase in temperature in winter, shifts in periods with insufficient precipitation, and an increase in the average monthly and decades precipitation rate at critical phases for winter wheat growth and development (Chope *et al.*, 2014; Shah *et al.*, 2018).

This led to the fact that the Varieties of Western European breeding, previously less adapted to North Steppe conditions, began not only to explicitly compete with local varieties but also - as shown in these studies - significantly surpass in yield parameters both the standard and the newest local variety, which is no longer well suited to local conditions and starts to lose (Essam *et al.*, 2019; Hongjie *et al.*, 2019). At the same time, the lower winter resistance of French varieties has no longer become a key problem. Despite the significantly lower sugar content, overwintering as a whole can be considered quite successful for the subsequent formation of grain productivity at and above than the standard level (Nazarenko and Bezus, 2018; Shah *et al.*, 2018).

The earliness (previously, earlier maturing forms had been considered as advantageous) also can no longer be considered a key point for obtaining a competitive advantage (Tsenov *et al.*, 2015; Nazarenko *et al.*, 2019b). Moreover, apparently, the French samples have a significantly higher ability to use the increase in precipitations just at later stages of development, which local varieties do not have. As for the parameters of the yield structure, the weight of a thousand grains became key as in previous studies (Essam *et al.*, 2019). However, the local varieties showed to form a higher yield with a significantly lower this parameter. All this makes the research data somewhat contradictory (Nazarenko *et al.*, 2019a; Li *et al.*, 2019).

As for quality, several more perspective forms with a high content of both protein and high-molecular-weight glutenins among foreign varieties were identified. At the same time, local varieties also demonstrated enough grain quality. Thus, although the level of the local sources in terms of grain quality should be recognized as satisfactory, the use of European forms for its improvement is not only quite promising but also necessary both as components in crossing systems and directly - since local forms now lack the previously observed advantage such as higher adaptability (Bordes *et al.*, 2008; Katyal *et al.*, 2016; Li *et al.*, 2019).

Both local genetic resources and the widespread use (both as varieties for cultivation or sources for breeding) of the variety sources of the EU countries provide new opportunities to increase the yield and quality of grain (Žofajová *et al.*, 2017).

CONCLUSIONS

Thus, as a result of a complex of investigations of winter resistance, grain productivity and quality, it was possible not only to identify perspective genotypes by each trait but also to show the possibilities of genotypes with a set of such traits that even surpass the already used under Steppe conditions winter wheat varieties. The combination of climatic factors and critical stages of development has become more favorable for the use of varieties of intensive (western-europe) ecotype and allows less focus on local varietal resources. The key parameters for the existing mechanism of yield formation and the possibility of combining high yield with the equally high-quality grain were showed. The cultivation of varieties of Western European breeding for the agriculture of the region should be recognized as possible and desirable, as well as the fact of the growing lag of local varieties, which is no longer compensated by the less favorable conditions for growing winter wheat under local conditions. This cannot be considered as a positive trend, and local breeding of crops requires a substantial increase in efforts. The more perspective varieties for the conditions of the region were identified. Further research will focus on key parameters such as drought tolerance, photosynthetic activity, peculiarities in nutrient elements utilization and accumulation for the investigated varieties to confirm the parameters that ensure the revealed superiority in terms of grain yield and quality parameters.

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