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ECOLOGY-AND GEOGRAPHY-RELATED FEATURES OF WINTER WHEAT VARIETIES FOR THE AREAS OF INSUFFICIENT HUMIDIFICATION

SUMMARY

The studies on the growth and development characteristics were carried out, as well on the peculiarities of phenophases and photosynthetic activity, yield features, its structure and grain quality of twenty bread winter wheat varieties, of which 11 genotypes represented the entire ecological and geographical diversity of the genetic material for all zones and all leading research institutions of Ukraine, one variety of CIS breeding, 8 varieties bred in various parts of the European Union. The varieties with a stable high yield have been identified, model features that have direct effect on its formation have been shown. The effect of photosynthetic activity on the yielding capacity formation has been revealed, its features have been shown. Grain quality indicators such as protein and gluten content, availability of reserve protein components have been studied. Varieties with high and satisfactory combinations of grain yielding capacity and quality have been identified, promising donors improving these features have been listed, key problems in the current compositions of components of reserve proteins in wheat grain have been described. It is planned to conduct studies in terms of the availability of individual useful micronutrient elements in these varieties.

Keywords: bread winter wheat; yield; yield structure; grain quality; photosynthetic activity; winter resistance.

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INTRODUCTION

Yield and cereal grain quality are the key challenges for the food security in any country in the world. A special place in the diet of the population of Ukraine (as well as of the most Eastern European countries) belongs to winter wheat with world gross yield of 740–780 million tons). However, in the steppe regions characterized by permanent lack of humidity (particularly in the critical phases of crop development) and with high peak temperatures (particularly during the grain ripening season), it is quite difficult to ensure stability in the yield of winter wheat agrocenosis (Daryanto *et al,* 2017).

Thus, the selection of stable and, at the same time, sufficiently plastic genotypes (cells) of this crop becomes not only a priority (Yakymchuk *et al,* 2021), but also a rather non-trivial task that requires continuous studies of both varieties of local (national) breeding and the varieties of world genetic resources (Hongjie *et al,* 2019; Essam *et al,* 2019). The set of samples of varieties of the Dnipro State Agrarian and Economic University, being one of the leading institutions for the subzone of the North of the Ukrainian Steppe (and for the Steppe of Ukraine as a whole), totals 406 constantly updated samples, mainly covering the varieties of the former USSR (from Awnless 1), national breeding varieties, modern varieties bred in the CIS countries and Western Europe. A particular focus is set on comparing the successes of national breeding and breeding of leading scientific institutions in Western Europe, both in terms of adaptability to local conditions and comparison in terms of yielding capacity and quality indicators (Bordes *et al,* 2011; Bondarenko and Nazarenko, 2020; Mangi *et al,* 2021).

Key attention is paid annually to the grain yielding capacity, its structure (identification of key components that provide superiority in yield), grain quality parameters (protein content, gluten content, individual units of high molecular weight glutenins and the availability of valuable components of gliadins) (Tokatlidis, 2017; Li *et al,* 2019). In addition, the study of drought resistance (using both visual assessment and laboratory methods), and winter resistance (the same way) is carried out, although in a more limited mode (Bordes *et al,* 2011; Lykhovyd, 2021).

The complex of a thorough and comprehensive assessment of winter wheat genotypes was commonly named an environmental test (Xu, 2016; Tengcong *et al,* 2020). Considering rather active climate changes (global warming) (Le Gouis *et al,* 2020; Avtaeva *et al,* 2021b) it should be noted that in general, for such semi-arid regions as the Steppe of Ukraine it has led to mostly positive consequences which were expressed in relaxing the wintering conditions, in the increase of not only the total amount of precipitation, but also the rates of precipitation during periods of heading and grain formation, which are critical for winter wheat. In general, the recorded changes are rather positive for winter crops (Liu *et al,* 2017; Horshchar and Nazarenko, 2022), but they also require correction to create the right energy balance in the variety model. Moreover, the problem of improving the quality of grain requires additional attention (Vesali *et* *al*, 2017). Although it is primarily related to the issues of compliance with the cultivation technology, it still remains incompletely solved from the point of view of the genetic component (variety) (Kozak *et al*, 2020). In this part of the study, a group of contrasting varieties (under the conditions of the Northern Steppe of Ukraine, i.e. the semi-arid zone) of different origin (20 varieties in total) has been assessed in terms of yielding capacity, grain quality and ecological plasticity.

MATERIAL AND METHODS

Field experiments have been carried out on the research field of the Dnipro State Agrarian and Economic University in 2021-2023. In total, 20 winter wheat (*Triticum aestivum* L.) varieties were tested, the area of the experimental plots was 5m^2, three replications, the variety Podolyanka was used as a reference, being the most stable variety in terms of characteristics presenting in the conditions of Ukraine. The following varieties were sown: Podolyanka, Samara 2, Perspektyva Odeska, Perlyna Podillia, Sonata Poltavska, Shpalivka, Zoreslav, Grom, Zoryanka, Poradnytsia, MIP Lada, Syla, Farell, Amandus, NE 12443, Retezat, Ronin, Patras, Seilor, Azano.

Weather conditions for hydrothermal indicators in the years of research (2021–2023) varied, which made possible to obtain objective results, for the location of the research fields: air temperature during winter wheat growing season 2022 (September–July) was 9.0°C, the average rainfall is about 611.7 mm; air temperature in season 2022 was 9.7°C, the average rainfall is about 573.4 mm; air temperature in season 2023 was 8.9°C, the average rainfall is about 562.0 mm). The following activities were carried out: phenological observations during the vegetation of winter wheat varieties, assessment of wintering, assessment of photosynthetic activity, assessment of yielding capacity, analysis of elements of the yield structure, analysis of grain quality (percentage of gluten and protein, availability of gliadins and glutenins).

Winter resistance was evaluated by the concentration of soluble sugars, determined at the tillering nods of varieties according to generally accepted GOST 26176-91. 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). There has been conducted the phlenological studies, assessed the overwintering of both visually and by determining the concentration of sugars in the node in meaningful period, determined the germination and survival of plants on the plots, conducted an assessment of photosynthetic activity during the earing period by the SPAD-502 appliance and an calculation to the concentration of chlorophyll (a+b) according to the generally accepted methodology by the formula Chl=10M^0.265, where M is the value of SPAD units (Vesali *et al*, 2017). Agrochemical analysis of soils for content of nutrient elements was provided too (N-NO3, mg kg-1 18.7–32.8, P2O5 14.8–27.1, K2O 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) (Bordes *et al*, 2011).

Statistical analysis of the results was conducted in Statistica 10.0. (TIBCO, Palo Alto, USA). Values in the tables are given as x±SD (mean ± standard deviation). The differences between the selections were determined using single-factor dispersion analysis (ANOVA) and were considered reliable at $P<0.05$. The normality of the data distribution was examined using the Shapiro–Wilk W-test. Differences between samples were assessed by Tukey HSD test.

RESULTS AND DISCUSSION

The studied varieties were selected in such a way as to, on the one hand, reflect the biodiversity used in domestic breeding to the fullest, and on the other hand, to provide enough data for comparison on the varieties bred in the countries, the resources of which are actively used in the sub-zone of the Northern Steppe of Ukraine in the maximum diversity of phenology (Table 1). A total of 20 genotypes have been presented – Podolyanka as a reference, being the most stable genotype in terms of growing in the widest range of conditions, and varieties Samara 2, Perspektyva Odeska, Perlyna Podillia, Sonata Poltavska, Shpalivka, Zoreslav, Grom, Zoryanka, Poradnytsia, MIP Lada (bred in Ukraine, various centres from Polissia to the South of Steppe), Syla (Russian Federation), Farell, Amandus, Retezat, Ronin, Patras, Seilor, Azano (EU breeding), NE 1244 (CYMMIT).

Table 1. General characteristic of winter wheat varieties phenotype

Variety	CoG	Awns	PH	Maturing	Type	Days
Podolyanka	Ukr	awnless	m	m	semiintensive	272
Samara 2	Ukr	awn	m	e-m	intensive	269
Perspektyva Odeska	Ukr	awn	m	m	intensive	271
Perlyna Podillia	Ukr	awnless	m	m	semiintensive	273
Sonata Poltavska	Ukr	awn	m	m	intensive	272
Shpalivka	Ukr	awn	s	m	intensive	274
Zoreslav	Ukr	awn	s	m	intensive	274
Grom	Ukr	awnless	s	l	intensive	280
Zoryanka	Ukr	awnless	m	m	intensive	271
Poradnytsia	Ukr	awn	m	e-m	intensive	269
MIP Lada	Ukr	awnless	h	m	semiintensive	274
Syla	Rus	awnless	sd	m-l	intensive	276
Farell	Ca	awnless	m	l	intensive	281
Amandus	Au	awn	m	m	intensive	274
NE 12443	Me	awn	h	m	semiintensive	273
Retezat	Ro	awn	s	l	intensive	281
Ronin	Deu	awnless	s	m-l	intensive	275
Patras	Deu	awnless	sd	l	intensive	283
Seilor	Fr	awn	m	l	intensive	284
Azano	Swe	awnless	sd	l	intensive	286

Note: CoG – country of origing; Ukr – Ukraine; Rus – Russian Federation; Ca – Canada; Me – Mexica; Ro – Romania; Swe – Sweden; Fra – France; Deu – Deutschland; PH – plant height; h – high-stem; m – medium; s – short-stem; sd – semidwarf; e-m – early-medium; m-l – medium-late; l – late.

Among the varieties, both awnless (potentially more resistant to entopests) and awned forms are equally represented, and it can be noted that there is no focus here. Mostly varieties of domestic breeding are medium-grown, although there are three short-stalked varieties. The varieties of foreign breeding are mainly of a more intensive type, there is a significant number of semidwarfs, which cannot be found among domestic varieties. As for the maturity period (according to the data regarding the heading stage), the domestic varieties are predominantly midseason maturing and early maturing, while foreign varieties tend to be late maturing, which on the one hand allows to better fulfil the yield potential, however, does not help to avoid droughts during the critical period of grain formation in our region from mid-May to early June. However, due to climate change, the situation has slightly changed in the last five years. No early maturing varieties have been observed, which makes different combinations of geno-types slightly more vulnerable (it is still advisable to use at least 10% of early maturing forms when sowing).

The varieties are mainly referred to intensive forms (in terms of the tuft form, the peculiarities of growth and development, the requirements for technology), but among the domestic forms, almost a third are semiintensive. Among foreigners, only the collection sample is considered intensive, which is mainly used as a source material and a reference form due to its properties. The number of days to full maturity and harvesting shows that the EU breeding is still focused on forms with a longer growing season, and it is sufficient to record the date of spiking in order to identify the peculiarities of development, and there has not been done anything particular in terms of the duration of individual phases (attempts to create the forms, would be photosynthesizing for a longer period after ear formation, which would allow more effective use of the plant's potential with the outflow of nutrients for grain formation).

One of the key parameters for the region is winter resistance (Table 2), which has been studied both through visual evaluation and measuring of sugars in the tillering node depending on the period (three measurements). In general, the visual assessment correlates quite well with the obtained laboratory data, the trait was conditioned both by the genotype of the variety ($F=9.27$; $F_{0.05}=6.01$; $P=3.8*10^{-7}$) and by the year of cultivation ($F=11.46$; $F_{0.05}=3.88$; $P<0.01$). The general tendency to develop winter resistance allows us to say that the more successful forms in this regard include varieties of domestic breeding and the Russian variety ($F=24.92$; $F_{0.05}=4.12$; $P=2.1*10^{-16}$), while foreign varieties are generally worse in terms of the concentration of sugars and outcomes of visual assessment. The following genotypes were distinguished by winter resistance: Podolyanka ($F=26.44$; $F_{0.05}=4.12$; $P=1.2*10^{-14}$), Sonata Poltavska ($F=18.16$; $F_{0.05}=4.12$; $P=5.1*10^{-12}$), MIP Lada ($F=27.49$; $F_{0.05}=4.12$; $P=1.9*10^{-13}$), Syla ($F=31.22$; $F_{0.05}=4.12$; $P=1.7*10^{-15}$) and only one foreign variety Azano ($F=17.01$; $F_{0.05}=4.12$; $P=4.0*10^{-9}$), apparently as a representative of the Scandinavian breeding, where this feature is much more important than for the rest of the EU.

It is also worth noting that worse ability to accumulate the necessary sugars at the first stage of preparing for wintering is not an indication of worse winter resistance. The situation may also change due to the lower consumption for life support, like in the Sonata Poltavska variety, which is obviously more interesting for further research in this area.

Table 2. Winter wheat varieties parameters during winter period (2021/2022 periods of vegetation dates) (x±SD, n=5).

Variety	G	BW	Content of sugars in tillering nod, %			AW
			11	02	03	
Podolyanka	5.0	5.0	34.0 ± 0.3[a]	26.9 ± 0.4[a]	21.7 ± 0.3[a]	5.0
Samara 2	5.0	5.0	32.9 ± 0.3[b]	25.8 ± 0.3[b]	21.5 ± 0.4[a]	5.0
Perspektyva Odeska	5.0	5.0	33.0 ± 0.3[b]	26.0 ± 0.4[b]	21.4 ± 0.3[a]	5.0
Perlyna Podillia	4.8	4.8	31.9 ± 0.4[c]	25.0 ± 0.4[c]	20.7 ± 0.3[b]	4.5
Sonata Poltavska	5.0	5.0	33.1 ± 0.3[b]	26.2 ± 0.4[ab]	21.8 ± 0.3[a]	4.8
Shpalivka	4.8	4.8	31.7 ± 0.4[c]	24.9 ± 0.4[c]	20.6 ± 0.3[b]	4.5
Zoreslav	4.8	4.8	31.8 ± 0.3[c]	24.8 ± 0.4[c]	20.5 ± 0.4[b]	4.3
Grom	4.8	4.8	31.9 ± 0.3[c]	25.0 ± 0.3[c]	20.8 ± 0.4[b]	4.3
Zoryanka	4.8	4.8	31.5 ± 0.5[c]	24.7 ± 0.4[c]	20.5 ± 0.4[b]	4.5
Poradnytsia	4.8	4.8	31.6 ± 0.5[c]	24.8 ± 0.4[c]	20.6 ± 0.3[b]	4.3
MIP Lada	5.0	5.0	34.2 ± 0.3[a]	27.1 ± 0.4[a]	21.8 ± 0.4[a]	5.0
Syla	5.0	5.0	34.4 ± 0.4[a]	27.2 ± 0.3[a]	22.2 ± 0.4[a]	5.0
Farell	4.8	4.8	33.0 ± 0.4[b]	26.0 ± 0.4[b]	21.0 ± 0.3[b]	4.8
Amandus	4.3	4.3	29.5 ± 0.4[d]	23.8 ± 0.5[d]	19.0 ± 0.4[c]	4.0
NE 12443	4.0	4.0	25.1 ± 0.5[e]	21.4 ± 0.5[e]	18.0 ± 0.3[d]	3.5
Retezat	4.3	4.3	29.6 ± 0.4[d]	23.9 ± 0.4[d]	19.1 ± 0.4[c]	4.0
Ronin	4.3	4.3	29.0 ± 0.5[d]	23.3 ± 0.5[d]	19.4 ± 0.4[c]	4.0
Patras	4.3	4.3	29.1 ± 0.5[d]	23.7 ± 0.4[d]	19.3 ± 0.4[c]	4.0
Seilor	4.3	4.3	28.2 ± 0.6[d]	23.5 ± 0.5[d]	19.2 ± 0.4[c]	4.0
Azano	5.0	5.0	33.9 ± 0.3[a]	27.0 ± 0.5[a]	21.6 ± 0.4[a]	5.0

Note: G – germination, BW – evaluation before winter period [balls]; AW – evaluation after winter period [balls]; significant differences at P < 0.05 by factor analyze.

It can be said that for the first time we observe some variability of domestic material in terms of the mechanism of formation of the complex trait. Variety NE 12443 was distinguished for its low winter resistance, which in this case was used as an additional reference point in terms of the lower rates ($F=13.99$; $F_{0.05}=4.12$; $P=6.7*10^{-10}$). In general, varieties Podolyanka, Sonata Poltavska, MIP Lada, Syla and Azano are advantageous for growing in the region taking into account the more severe wintering conditions. However, the increasing tendency to ease winter conditions should be taken into account. The final check of the material using the Tukey's test confirmed all the conclusions made.

The yielding capacity of this set of varieties was being studied for three years (with a more favourable year in 2021) (Table 3), and the grain share in the total biological productivity of wheat was also taken into account. This number depends most on the characteristics of the plant architecture and increases significantly for shorter and more intensive forms, which is demonstrated by a higher value of this feature in shorter varieties of foreign breeding. Variety Patras is particularly distinguished in this regard, but this in itself does not provide any increase in yields.

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Samara 2	5.0	5.0	32.9 ± 0.3^{b}	25.8 ± 0.3^{b}	21.5 ± 0.4^{a}	5.0
Perspektyva Odeska	5.0	5.0	33.0 ± 0.3^{b}	26.0 ± 0.4^{b}	21.4 ± 0.3^{a}	5.0
Perlyna Podillia	4.8	4.8	31.9 ± 0.4^{c}	25.0 ± 0.4^{c}	20.7 ± 0.3^{b}	4.5
Sonata Poltavska	5.0	5.0	33.1 ± 0.3^{b}	26.2 ± 0.4^{ab}	21.8 ± 0.3^{a}	4.8
Shpalivka	4.8	4.8	31.7 ± 0.4^{c}	24.9 ± 0.4^{c}	20.6 ± 0.3^{b}	4.5
Zoreslav	4.8	4.8	31.8 ± 0.3^{c}	24.8 ± 0.4^{c}	20.5 ± 0.4^{b}	4.3
Grom	4.8	4.8	31.9 ± 0.3^{c}	25.0 ± 0.3^{c}	20.8 ± 0.4^{b}	4.3
Zoryanka	4.8	4.8	31.5 ± 0.5^{c}	24.7 ± 0.4^{c}	20.5 ± 0.4^{b}	4.5
Poradnytsia	4.8	4.8	31.6 ± 0.5^{c}	24.8 ± 0.4^{c}	20.6 ± 0.3^{b}	4.3
MIP Lada	5.0	5.0	34.2 ± 0.3^{a}	27.1 ± 0.4^{a}	21.8 ± 0.4^{a}	5.0
Syla	5.0	5.0	34.4 ± 0.4^{a}	27.2 ± 0.3^{a}	22.2 ± 0.4^{a}	5.0
Farell	4.8	4.8	33.0 ± 0.4^{b}	26.0 ± 0.4^{b}	21.0 ± 0.3^{b}	4.8
Amandus	4.3	4.3	29.5 ± 0.4^{d}	23.8 ± 0.5^{d}	19.0 ± 0.4^{c}	4.0
NE 12443	4.0	4.0	25.1 ± 0.5^{e}	21.4 ± 0.5^{e}	18.0 ± 0.3^{d}	3.5
Retezat	4.3	4.3	29.6 ± 0.4^{d}	23.9 ± 0.4^{d}	19.1 ± 0.4^{c}	4.0
Ronin	4.3	4.3	29.0 ± 0.5^{d}	23.3 ± 0.5^{d}	19.4 ± 0.4^{c}	4.0
Patras	4.3	4.3	29.1 ± 0.5^{d}	23.7 ± 0.4^{d}	19.3 ± 0.4^{c}	4.0
Seilor	4.3	4.3	28.2 ± 0.6^{d}	23.5 ± 0.5^{d}	19.2 ± 0.4^{c}	4.0
Azano	5.0	5.0	33.9 ± 0.3^{a}	27.0 ± 0.5^{a}	21.6 ± 0.4^{a}	5.0

Note: G – germination, BW – evaluation before winter period [balls]; AW – evaluation after winter period [balls]; significant differences at P < 0.05 by factor analyze.

It can be said that for the first time we observe some variability of domestic material in terms of the mechanism of formation of the complex trait. Variety NE 12443 was distinguished for its low winter resistance, which in this case was used as an additional reference point in terms of the lower rates ($F=13.99$; $F_{0.05}=4.12$; $P=6.7*10^{-10}$). In general, varieties Podolyanka, Sonata Poltavska, MIP Lada, Syla and Azano are advantageous for growing in the region taking into account the more severe wintering conditions. However, the increasing tendency to ease winter conditions should be taken into account. The final check of the material using the Tukey's test confirmed all the conclusions made.

The yielding capacity of this set of varieties was being studied for three years (with a more favourable year in 2021) (Table 3), and the grain share in the total biological productivity of wheat was also taken into account. This number depends most on the characteristics of the plant architecture and increases significantly for shorter and more intensive forms, which is demonstrated by a higher value of this feature in shorter varieties of foreign breeding. Variety Patras is particularly distinguished in this regard, but this in itself does not provide any increase in yields.

Table 3. Grain productivity of winter wheat genotypes (2021-2023 years).

Variety	Percent of grains in total productivity, %	Yield, t ha^{-1}			Average
		2021	2022	2023	
Podolyanka	41.20 ±1.12^{a}	7.64 ± 0.11^{a}	6.82 ± 0.09^{a}	6.49 ± 0.18^{a}	6.98 ± 0.21^{a}
Samara 2	40.80 ± 1.22^{a}	7.45 ± 0.23^{a}	6.63 ± 0.19^{a}	6.22 ± 0.19^{a}	6.77 ± 0.23^{a}
Perspektyva Odeska	42.40 ± 1.17^{a}	6.65 ± 0.19^{b}	6.23 ± 0.07^{b}	6.01 ± 0.13^{b}	6.30 ± 0.33^{b}
Perlyna Podillia	40.10 ± 1.19^{a}	6.53 ± 0.15^{b}	6.11 ± 0.17^{b}	5.56 ± 0.10^{c}	6.07 ± 0.29^{b}
Sonata Poltavska	44.20 ± 1.22^{b}	8.12 ± 0.16^{c}	7.42 ± 0.23^{c}	7.26 ± 0.11^{d}	7.60 ± 0.26^{c}
Shpalivka	43.20 ± 1.23^{ab}	7.51 ± 0.21^{a}	6.73 ± 0.20^{a}	6.55 ± 010^{a}	6.93 ± 0.21^{a}
Zoreslav	45.10 ± 1.32^{bc}	7.65 ± 0.19^{a}	6.23 ± 0.15^{b}	7.25 ± 0.22^{d}	7.04 ± 0.23^{a}
Grom	44.70 ± 1.19^{b}	8.71 ± 0.17^{c}	6.84 ± 0.17^{a}	7.65 ± 0.10^{d}	7.73 ± 0.24^{c}
Zoryanka	42.00 ± 1.34^{a}	7.01 ± 0.23^{b}	7.17 ± 0.10^{a}	6.12 ± 0.19^{b}	6.77 ± 0.27^{a}
Poradnytsia	41.00 ± 1.43^{a}	6.95 ± 0.21^{b}	6.77 ± 0.18^{a}	6.00 ± 0.17^{c}	6.57 ± 0.20^{a}
MIP Lada	40.50 ± 1.23^{a}	7.52 ± 0.14^{a}	7.01 ± 0.12^{a}	6.52 ± 0.18^{a}	7.02 ± 0.20^{a}
Syla	48.10 ± 1.39^{d}	8.45 ± 0.14^{c}	7.39 ± 0.21^{c}	7.46 ± 0.22^{d}	7.77 ± 0.29^{c}
Farell	48.70 ± 1.32^{d}	8.01 ± 0.11^{c}	7.17 ± 0.20^{c}	7.42 ± 0.16^{d}	7.53 ± 0.19^{c}
Amandus	49.00 ± 0.98^{d}	6.96 ± 0.09^{b}	6.44 ± 0.12^{b}	6.37 ± 0.11^{a}	6.59 ± 0.32^{a}
NE 12443	40.10 ± 1.53^{a}	6.01 ± 0.15^{d}	5.09 ± 0.22^{d}	5.07 ± 0.16^{e}	5.39 ± 0.24^{b}
Retezat	49.60 ± 1.17^{d}	8.16 ± 0.11^{c}	7.09 ± 0.13^{a}	7.17 ± 0.14^{d}	7.47 ± 0.30^{a}
Ronin	48.50 ± 1.34^{d}	7.99 ± 0.14^{c}	7.81 ± 0.21^{c}	6.67 ± 0.13^{a}	7.49 ± 0.22^{c}
Patras	52.10 ± 0.75^{e}	6.92 ± 0.22^{b}	6.47 ± 0.14^{b}	6.32 ± 0.19^{ab}	6.57 ± 0.31^{a}
Seilor	47.90 ± 1.12^{d}	7.98 ± 0.19^{a}	7.19 ± 0.21^{c}	6.94 ± 0.15^{d}	7.37 ± 0.24^{c}
Azano	48.90 ± 1.49^{d}	7.92 ± 0.20^{a}	7.35 ± 0.23^{c}	7.32 ± 0.19^{d}	7.53 ± 0.24^{c}

Note: significant differences at P < 0.05 by factor analyze

The yields characteristics depended both on the genotype of the variety ($F=7.11$; $F_{0.05}=6.01$; $P=0.02$) and on the year of cultivation ($F=14.62$; $F_{0.05}=3.88$; $P=1.4*10^{-11}$).When we analysed the characteristics by individual varieties, we found that the following genotypes were positively distinguished by this feature: Sonata Poltavska ($F=11.16$; $F_{0.05}=3.55$; $P=3.2*10^{-10}$), Grom ($F=9.07$; $F_{0.05}=3.55$; $P=4.7*10^{-6}$), Syla ($F=13.17$; $F_{0.05}=3.55$; $P=9.0*10^{-9}$), Farell ($F=9.08$; $F_{0.05}=3.55$; $P=5.1*10^{-9}$), Ronin ($F=10.33$; $F_{0.05}=3.55$; $P=1.7*10^{-8}$), Seilor ($F=6.19$; $F_{0.05}=3.55$; $P=0.03$), Azano ($F=11.49$; $F_{0.05}=3.55$; $P=2.6*10^{-10}$), which, according to the results of three years of testing, exceled the Podolyanka variety as a yield standard for the region. However, two of the last-named varieties were at the reference variety level in the most favourable year 2020, which was confirmed during the Tukey's test. For a more accurate classification of varieties depending on variability by years, a cluster analysis was carried out (Fig.1), which allowed distinguishing 7 groups of varieties by yielding capacity depending on variability by years and genotypes, among which there were 4 minor ones (represented by one variety).

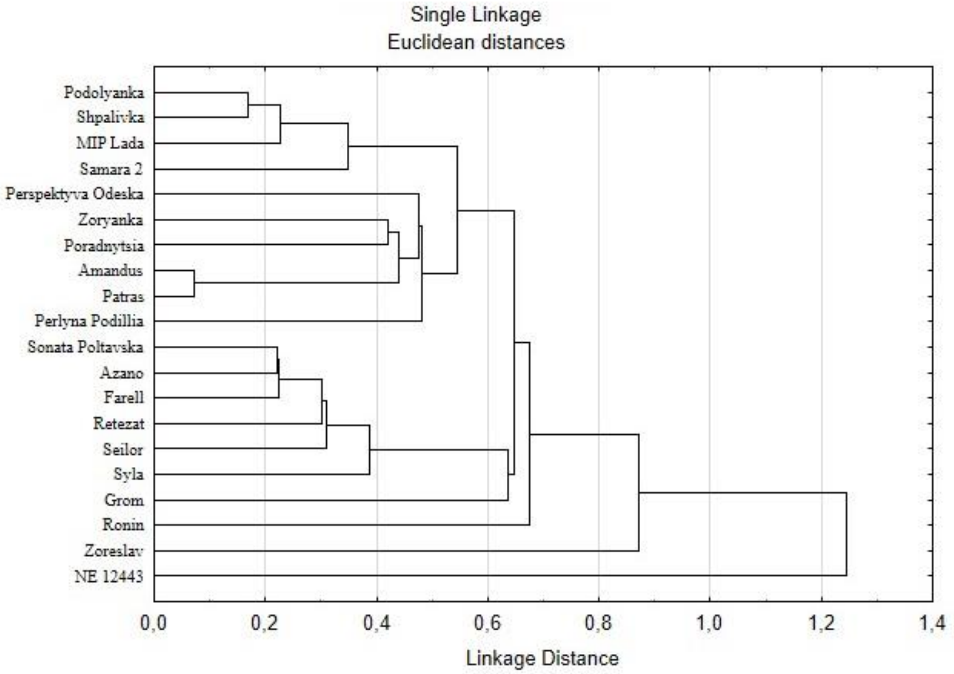

Figure 1. Resaults of cluster analysis by grain productivity.

Shpalivka, and MIP Lada genotypes. A high stability of this feature is expected with a significant mitigation of the impact of the conditions during the year of growing (high ecological plasticity). The second group is represented by varieties Perspektyva Odeska, Zoryanka, Poradnytsia, Patras, Amandus, and Perlyna Podillia. In general, these varieties are significantly inferior to the standard, but in some years, they can show yields close to it. The third group includes Sonata Poltavska, Azano, Syla, Farell, Retezat, Seilor – the varieties are significantly superior to the standard in all years of testing without variants. These varieties are most promising for the Northern Steppe of Ukraine. The fourth minor group includes the Grom variety, which is generally superior to the reference variety. However, it did not differ statistically significantly from the reference in the most favourable year. The variety is quite promising in terms of yielding capacity, but it is not very stable. The fifth group, which includes variety Ronin showed lower yields, but in the conditions of an unfavourable year was at the level of the standard variety. The sixth group, variety Zoreslav, is unstable in terms of growing conditions, it can both excel the standard or be at the same level, and be inferior to it, but on average it is at the level of the standard variety. The seventh group, variety NE 12443, is significantly inferior to both the standard and the least yielding group, without variations. In general, the varieties of the third and fourth minor groups are definitely better, based on the yielding capacity figures.

In order to determine the mechanism of yield formation, a structural analysis was carried out (Table 4) in terms of the parameters as follows: plant height, number and weight of grain in the main ear, weight of grain of the plant, thousand grain weight (hereinafter referred to as TGW). When it comes to the plant height, the structural analysis confirmed previous visual characteristic of wheat varieties. In general, foreign varieties are characterized by short height or semi-dwarfism with an advantage in terms of the plant architecture of a long grained spike. It can also form additional full ears with a high nitrogen content. The main ear grain quantity indicator is extremely variable and it can perhaps be noted that not only high-yielding, but also low-yielding varieties can have a significant advantage of this parameter over the reference ones, and only a high combination of this feature with the grain quality can be of significance, which the second characteristics show – the weight of grain in the main ear, by which such varieties as Sonata Poltavska, Farell, Ronin, and partially varieties Seilor and Azano were significantly distinguished – that is, only those varieties that significantly excelled in terms of productivity as well ($F=8.17$; $F_{0.05}=6.01$; $P=0.03$). Obviously, for these varieties, the formation of yield as an integrative feature (in terms of structure) is precisely due to the well-grained main ear of high quality. Also, for the variety NE 12443 ($F=12.64$; $F_{0.05}=3.55$; $P=4.1*10^{-14}$), the low level of this feature has also become a significant problem of low yielding capacity.

Table 4. Parameters of main components of yield structure (at average) (x±SD, n=25).

Variety	PH	Per main spike		WGP	TGW
		GN	GW		
Podolyanka	101.0 ± 1.3^{a}	35.5 ± 3.7^{a}	1.7 ± 0.2^{a}	4.0 ± 0.4^{a}	50.0 ± 3.2^{a}
Samara 2	99.8 ± 1.7^{a}	34.0 ± 4.8^{a}	1.5 ± 0.3^{a}	4.4 ± 0.4^{a}	45.5 ± 2.8^{a}
Perspektyva Odeska	92.2 ± 1.7^{b}	32.8 ± 2.9^{a}	1.4 ± 0.2^{a}	3.2 ± 0.3^{b}	42.7 ± 2.2^{ab}
Perlyna Podillia	89.0 ± 2.3^{b}	36.6 ± 3.0^{a}	1.4 ± 0.1^{a}	3.8 ± 0.3^{a}	42.0 ± 2.1^{b}
Sonata Poltavska	93.4 ± 1.9^{b}	41.2 ± 7.4^{b}	2.2 ± 0.2^{b}	4.9 ± 0.3^{c}	55.5 ± 2.3^{d}
Shpalivka	99.2 ± 1.5^{a}	37.5 ± 5.4^{a}	1.6 ± 0.2^{a}	4.2 ± 0.2^{a}	46.5 ± 2.1^{a}
Zoreslav	77.0 ± 1.4^{c}	47.8 ± 2.7^{b}	1.7 ± 0.2^{a}	4.7 ± 0.4^{a}	45.6 ± 2.3^{a}
Grom	76.0 ± 1.6^{c}	47.2 ± 3.7^{b}	1.9 ± 0.3^{a}	5.1 ± 0.3^{c}	56.2 ± 2.0^{d}
Zoryanka	95.4 ± 2.8^{a}	48.3 ± 4.0^{b}	1.4 ± 0.2^{a}	3.8 ± 0.3^{a}	39.3 ± 2.3^{b}
Poradnytsia	97.3 ± 1.2^{a}	45.0 ± 9.7^{b}	1.3 ± 0.2^{a}	4.5 ± 0.3^{a}	44.7 ± 2.0^{a}
MIP Lada	112.3 ± 2.9^{d}	39.6 ± 5.5^{a}	1.5 ± 0.2^{a}	3.9 ± 0.2^{a}	46.9 ± 2.1^{a}
Syla	57.6 ± 2.4^{e}	43.3 ± 4.1^{b}	2.1 ± 0.2^{a}	5.2 ± 0.3^{c}	55.9 ± 2.5^{d}
Farell	93.1 ± 1.4^{b}	32.3 ± 3.9^{a}	2.2 ± 0.1^{b}	5.0 ± 02^{c}	55.6 ± 2.1^{d}
Amandus	89.2 ± 1.7^{b}	43.3 ± 5.6^{b}	1.8 ± 0.2^{b}	3.5 ± 0.3^{b}	39.5 ± 1.9^{b}
NE 12443	112.4 ± 2.3^{d}	41.3 ± 4.6^{b}	1.2 ± 0.2^{c}	3.4 ± 0.3^{b}	38.2 ± 2.9^{bc}
Retezat	78.5 ± 1.4^{c}	39.3 ± 4.1^{a}	1.8 ± 0.1^{a}	4.1 ± 0.3^{a}	48.5 ± 2.1^{a}
Ronin	76.5 ± 1.1^{c}	46.1 ± 3.9^{b}	2.2 ± 0.2^{b}	4.7 ± 0.3^{ac}	51.5 ± 1.9^{ae}
Patras	77.0 ± 1.4^{c}	40.4 ± 4.2^{a}	1.8 ± 0.1^{a}	4.0 ± 0.3^{a}	40.0 ± 2.5^{b}
Seilor	88.6 ± 1.3^{b}	48.2 ± 5.1^{b}	1.9 ± 0.2^{ab}	4.9 ± 0.5^{ac}	55.7 ± 2.0^{d}
Azano	58.3 ± 1.7^{e}	42.3 ± 4.3^{b}	1.9 ± 0.2^{ab}	4.6 ± 0.3^{a}	56.5 ± 1.8^{d}

Note: PH – plant height[cm]; GN – grain number[piece]; GW – grain weight[g]; TGW – thousand grain weight [g]; WGP – weight of grain per plant [g], significant differences at P < 0.05 by factor analyze.

The following indicator of grain weight per plant has already become significant for advantageous yield for Sonata Poltavska, Grom, Syla, Farell, Azano, partially Ronin and Seilor ($F=14.83$; $F_{0.05}=4.88$; $P=1.6*10^{-12}$), which allows us to conclude that for Grom and Syla varieties, the formation of a greater number of well-grained ears is of greater importance than that of the main ears, and for Seilor and Azano varieties a mixed option is possible, when both the main ear and additional ears are of great importance, which offers numerous opportunities of combining the elements of growing technology. The following TGW indicator expressly exceeded the standard for all high-yielding varieties: Sonata Poltavska, Grom, Syla, Farell, Azano, Ronin and Seilor, which indicates the key role of grain quality in yield formation. Thus, in varieties Sonata Poltavska, Farell, and Ronin, the formation of high yield depends on the main ear, the Grom and Syla varieties have high-performance tilling capacity, while in Seilor and Azano varieties have a mixed mechanism.

A study of photosynthetic activity (Table 5), in turn, showed that the higher yielding varieties were also significantly superior in terms of this parameter in the heading stage ($F=11.483$; $F_{0.05}=6.01$; $P=1.2*10^{-11}$). Only one more variety Shpalivka was added, which had a yielding capacity at the reference level. This gives us the opportunity to talk about the relationship between yielding capacity and high photosynthetic activity during the heading stage. However, less productive varieties do not necessarily have lower photosynthetic activity. The same results were obtained by pairwise comparison using Tukey's test.

Table 5. Parameters of photosynthetic activity. First group (x±SD, n=5).

Variant	Soil Plant Analysis Development (SPAD)	Chl, μmol/m^2
Podolyanka	50.39 ± 1.45[a]	669.37 ± 12.69
Samara 2	49.11 ± 1.63[a]	640.42 ± 13.75
Perspektyva Odeska	49.50 ± 1.36[a]	649.17 ± 13.34
Perlyna Podillia	45.07 ± 1.51[b]	553.79 ± 13.04
Sonata Poltavska	55.11 ± 0.60[c]	782.56 ± 7.47
Shpalivka	55.98 ± 0.68[c]	804.55 ± 8.00
Zoreslav	50.11 ± 0.64[ac]	662.98 ± 7.73
Grom	58.12 ± 0.46[c]	860.17 ± 6.52
Zoryanka	49.18 ± 0.39[a]	641.99 ± 6.01
Poradnytsia	47.16 ± 1.20[b]	597.72 ± 11.21
MIP Lada	50.94 ± 1.44[b]	681.34 ± 12.63
Syla	52.44 ± 0.89[c]	717.28 ± 9.32
Farell	54.91 ± 0.99[c]	777.55 ± 9.94
Amandus	49.74 ± 1.15[a]	654.58 ± 10.91
NE 12443	48.14 ± 1.42[a]	618.97 ± 12.51
Retezat	51.40 ± 1.12[a]	692.74 ± 10.73
Ronin	55.17 ± 1.13[a]	784.06 ± 10.79
Patras	49.42 ± 2.45[a]	647.37 ± 18.54
Seilor	53.49 ± 1.00[c]	742.56 ± 10.00
Azano	54.12 ± 1.12[c]	757.97 ± 10.73

Note: significant differences at P < 0.05 by factor analyse

To measure the weight of each trait and its model value, a factorial and discriminant analysis were carried out, respectively, in order to identify both key traits affecting the formation of grain productivity and the possibilities for their classification for each genotype (Table 6, 7). As a result, it was found that the most frequent models were the parameters of sugar concentration at the beginning and at the end of winter, grain weight per plant, TGW, and photosynthetic activity. Essentially more parameters were valid for the genotype (variety). In this case, such parameters as the height of the plants and the weight of grains of the main ear were important.

Table 6. Factor Loadings (Unrotated) and Discriminant Function

Parameter	Year	Genotype	Wilks' - Lambda	F_{remove} (6.12)	p-value
CS 11	-0.848*	0.892*	0.018	9.64	< 0.01
CS 02	-0.654	0.404	0.011	4.11	0.09
CS 03	0.748*	0.861*	0.018	8.95	0.04
PH	0.532	0.792*	0.017	8.16	0.04
GN	0.311	0.317	0.010	3.23	0.12
GW	-0.611	0.788*	0.017	7.98	0.10
WGP	0.812*	0.912*	0.021	14.12	< 0.01
TGW	0.748*	0.943*	0.028	18.92	< 0.01
SPAD	0.850*	-0.893*	0.020	11.43	< 0.01
Explenation variants	2.162	1.976	–	–	–
Non-explanation	0.893	0.198	–	–	–

Table 7. Resaults of classification for genotypes (part of objects by parameters from previous table in model for such genotype)

Genotype	Objects in model, %
Podolyanka	100.0
Samara 2	100.0
Perspektyva Odeska	71.4
Perlyna Podillia	57.1
Sonata Poltavska	85.7
Shpalivka	71.4
Zoreslav	85.7
Grom	100.0
Zoryanka	71.4
Poradnytsia	57.1
MIP Lada	85.7
Syla	71.4
Farell	85.7
Amandus	71.4
NE 12443	57.1
Retezat	71.4
Ronin	100.0
Patras	71.4
Seilor	85.7
Azano	100.0

In turn, the results of discriminant analysis clearly show that the concentration of sugars at the beginning and at the end of winter, the weight of grain of the main ear and per plant, TGW, and photosynthetic activity are of primary importance for modelling the future yield in terms of varietal response for specific environmental conditions. The successful classification of individual genotypes shows that at least four parameters from the set are always significant, although the set itself varies significantly depending on the specific genotype. At the same time, for higher-yielding varieties, no more than one parameter can be insignificant – i.e., the integrative attribute of yielding capacity is the result of interaction and mutual influence of at least six model parameters. While for the less yielding varieties the number decreases.

The analysis of grain quality was carried out for the following characteristics: protein content in the grain, gluten content in the grain, availability of high and low molecular weight glutenins in proteins and the total content of gliadins (Table 8). The first parameter is of key importance, as the protein content of 14% on average shows it can be referred to the class of strong wheat, which is of key significance for the baking industry. Thus, this class of materials includes varieties Podolyanka, Perlyna Podillia, Shpalivka, Zoryanka, Syla, Farell, NE 12443, Retezat, Ronin, Seilor, and Azano ($F=13.62$; $F_{0.05}=4.88$; $P=2.2*10^{-15}$). Of which, varieties Syla, Farell, Ronin, Seilor, and Azano, in turn, are more productive, therefore they can be recommended for growing, considering the combination of flour strength and high grain productivity. Podolyanka, Shpalivka, and Retezat have both productivity and quality at the standard level, and therefore, in general, are at the reference level for the region. While Perlyna Podillia, Zoryanka, and NE 12443 varieties are generally low-yielding and can be used, particularly the latter, exclusively as a source of material for breeding. Syla and NE 12443 were significantly positively distinguished as carriers of high quality and as potentially strong wheat ($F=8.17$; $F_{0.05}=3.55$; $P=0.01$).

In terms of gluten content, the pattern is about the same, since this indicator strongly correlates with the indicator of protein content. In general, it makes no sense to consider it separately. With regard to the compositions of protein components, high levels of high molecular weight glutenins and high content of gliadins should be attributed to positive qualities, while a high rate of low molecular weight glutenins is negative. Shpalivka, Zoreslav, Syla, Farell, NE 12443, Retezat, and Seilor ($F=8.34$; $F_{0.05}=5.11$; $P=0.01$) were significantly positively distinguished by the first feature, while Perlyna Podillia, Sonata Poltavska, Zoreslav, Syla, Farell, NE 12443, and Seilor ($F=7.16$; $F_{0.05}=4.55$; $P=0.03$) were negatively distinguished by the second attribute. It is known that this feature became noticeable in the negative aspect relatively recently and the necessary adjustments are being made to grain quality breeding programs. Moreover, this aspect influences nutritional value and possible allergic reactions rather than baking qualities. As for the indicator of the gliadines content, it is quite high in Sonata Poltavska, NE 12443, and Retezat, that is, it is extremely rare. All of the features, except for the low-variable content of gliadins are considered to be average, which is more favourable for sampling by these parameters. The pairwise comparison using Tukey's test confirmed these results. Thus, varieties Syla, Farell, Ronin, Seilor, and Azano were distinguished primarily by the combination of increased yielding capacity with advanced baking characteristics. Varieties Podolyanka, Shpalivka, and Retezat have yielding capacity and quality at an acceptable level, when taking into account the negative parameter of a high content of low molecular weight glutenins – varieties Ronin and Azano are preferable. However, they have lower gliadines content than other varieties. Thus, it is impossible to distinguish at least one variety that would excel others in terms of all parameters.

Table 8. Grain quality parameters (at average)

Variety	PC	GC	Glutenins		Gliadins
			HMW	LMW	
Podolyanka	13.97 ± 0.24[a]	25.44 ± 0.34[a]	0.16 ± 0.01[a]	0.46 ± 0.01[a]	0.44 ± 0.02[a]
Samara 2	13.48 ± 0.32[a]	22.98 ± 0.32[b]	0.18 ± 0.01[a]	0.54 ± 0.02[a]	0.42 ± 0.01[a]
Perspektyva Odeska	12.55 ± 0.27[b]	20.40 ± 0.29[c]	0.19 ± 0.01[a]	0.54 ± 0.02[a]	0.43 ± 0.02[a]
Perlyna Podillia	13.92 ± 0.22[a]	21.51 ± 0.22[b]	0.15 ± 0.02[a]	0.71 ± 0.02[b]	0.45 ± 0.01[a]
Sonata Poltavska	13.46 ± 0.16[a]	22.21 ± 0.28[b]	0.15 ± 0.01[a]	0.65 ± 0.01[c]	0.48 ± 0.01[b]
Shpalivka	14.14 ± 0.29[a]	26.69 ± 0.27[d]	0.20 ± 0.01[ab]	0.43 ± 0.02[a]	0.36 ± 0.02[c]
Zoreslav	13.42 ± 0.19[b]	24.72 ± 0.29[a]	0.22 ± 0.01[b]	0.58 ± 0.01[b]	0.40 ± 0.01[ac]
Grom	13.02 ± 0.31[b]	24.33 ± 0.31[a]	0.17 ± 0.01[a]	0.64 ± 0.01[c]	0.43 ± 0.01[a]
Zoryanka	13.71 ± 0.19[a]	19.85 ± 0.21[c]	0.16 ± 0.01[a]	0.64 ± 0.01[c]	0.45 ± 0.01[a]
Poradnytsia	13.66 ± 0.15[a]	22.14 ± 0.22[b]	0.15 ± 0.02[a]	0.70 ± 0.02[bc]	0.42 ± 0.01[a]
MIP Lada	13.11 ± 0.14[b]	23.02 ± 0.17[b]	0.17 ± 0.01[a]	0.66 ± 0.01[c]	0.43 ± 0.01[a]
Syla	14.46 ± 0.11[c]	25.78 ± 0.29[a]	0.23 ± 0.01[b]	0.70 ± 0.02[bc]	0.44 ± 0.01[a]
Farell	14.01 ± 0.26[a]	25.01 ± 0.32[a]	0.20 ± 0.01[ab]	0.45 ± 0.02[d]	0.39 ± 0.02[c]
Amandus	13.17 ± 0.24[b]	24.81 ± 0.27[a]	0.16 ± 0.01[a]	0.54 ± 0.02[a]	0.43 ± 0.01[a]
NE 12443	14.90 ± 0.23[c]	27.98 ± 0.25[d]	0.25 ± 0.01[b]	0.59 ± 0.02[b]	0.52 ± 0.03[b]
Retezat	14.18 ± 0.15[a]	26.19 ± 0.24[d]	0.24 ± 0.01[b]	0.47 ± 0.01[a]	0.48 ± 0.01[b]
Ronin	13.99 ± 0.19[a]	25.13 ± 0.23[a]	0.16 ± 0.01[a]	0.49 ± 0.01[a]	0.34 ± 0.03[c]
Patras	13.24 ± 0.20[b]	24.22 ± 0.24[a]	0.17 ± 0.01[a]	0.46 ± 0.01[a]	0.45 ± 0.01[a]
Seilor	14.11 ± 0.23[a]	24.09 ± 0.31[ab]	0.23 ± 0.01[b]	0.51 ± 0.01[a]	0.39 ± 0.01[c]
Azano	13.89 ± 0.22[a]	26.11 ± 0.26[d]	0.21 ± 0.01[a]	0.49 ± 0.01[a]	0.34 ± 0.02[cd]
Average	13.72	23.83	0.19	0.56	0.42
C.v, %	5.75	11.71	5.02	7.16	4.95

Note: PC – protein content [%]; GC – gluten content [%]; HMW – high molecular weight clutenins [%]; LMW – low molecular weight clutenins [%], significant differences at P<0.05 by factor analyze.

It should be noted that the selected varieties are referred to the genotypes of foreign breeding. The key problem for the Ukrainian varieties is the balance of reserve protein components, which never meets all the requirements in full. In general, however, the same varieties are technologically feasible. There is a significant negative correlation of high yielding capacity and improved quality, which cannot be found in foreign varieties. How-ever, promising donors have been identified by individual parameters, which makes it possible to obtain a breeding material with the necessary com-positions.

A key point for creating an efficient agrocenosis of any crop is the varietal component. The correct selection of varieties/combination of varieties in the production sowing ensures up to 30% of success (Tsenov *et al*, 2015). At the same time, the main point is not only the successful fulfilment of the genetically determined potential in terms of yield and quality, but also the stability in the manifestation of all the characteristics determining this potential throughout ontogenesis (Nuttall *et al,* 2017). Obtaining stable, predictable values is sometimes better than a problematic increase in the total grain amount or its baking qualities, its dietary value (Žofajová *et al*, 2017).

Characteristics that determine resistance to abiotic stress (in our case, winter resistance and drought resistance are the key ones) (Vesali *et al,* 2017; Avtaeva *et al,* 2021a; Pirych *et al,* 2021) should not only be stable, but also be effective in the required critical phases of development, that is the periods from January to February for winter varieties, requiring winter resistance, and from May to June (Masliev *et al,* 2020), for which drought resistance is essential (Wang et al, 2017). Finding new mechanisms to ensure efficiency of these features (such as a decrease in the consumption of accumulated sugars in the winter or high rates of photosynthetic activity during the heading stage) (Cann *et al,* 2022) allows to significantly stabilize and correlate over time the implementation of these properties, when the impact of an undesirable factor is most intensive (Quintero *et al*, 2018; Nazarenko *et al*, 2021).

Another option is to avoid this critical period through ontogenesis regulation (Nazarenko *et al,* 2022), however, within the studied set of varieties, the use of this mechanism has not been observed and, apparently, its role due to partial adverse effects time transfer due to global climate change has not been observed (Nuttall *et al,* 2017; Miroshnychenko *et al*, 2021). However, this does not mean a refusal of the cultivation of early maturing winter wheat varieties (Nazarenko *et al*, 2019), and additional research with a wider set of genotypes is needed, which in the past has shown that this method remains very significant (Wang *et al,* 2017; Beiko and Nazarenko, 2022b).

Modern varieties ensure stable increase in grain productivity at the appropriate level (Amram *et al,* 2015; Nazarenko and Izhboldin, 2017), however, it is quite often impossible to focus on this parameter only (Quintero et al, 2018). The materials presented indicate a number of shortcomings in terms of the grain quality, which still need to be eliminated, for which the necessary source material has already been allocated (Richardson *et al*, 2017).

Three possible ways to fulfil the yield potential have been identified: through the formation of a well-grained main ear with high-quality grain, which is quite common for contemporary breeding, due to the formation of additional quality ears (which is promising, although it provides for additional requirements for nitrogen nutrition of plants), and the third mixed possibility involves a particular ratio of blending both of the above mechanisms. It is also potentially possible to intensify this attribute due to the extension of the period of photosynthetic activity (Richardson *et al,* 2017; Beiko and Nazarenko, 2022a). However, this has not been observed yet during the phases (Jaradat, 2018). Potentially, the domestic varieties provide a sufficient degree of solving the problem of increasing the productivity of the agro-industrial complex in terms of a combination of productivity and quality (Hans *et al,* 2019; Miroshnychenko *et al,* 2021). Also, in general, a fairly large share of foreign varieties has been found, which, having been created for slightly different conditions, fully meets the needs of the zone of insufficient humidification (Harkness *et al*, 2020).

CONCLUSIONS

The use of various winter wheat genotypes (varieties) together allows, with a correctly selected combination, to cover the maximum possible changes in climatic conditions, which in principle has become important in recent years. The selection of specific varieties allows for the ecological test of the variety. And also helps to solve the problem of variety changing for the farms in the region. Despite the general mitigation of abiotic stresses, the work to increase the adaptive capacities of the source material still remains very relevant. At the same time, it is essential to study the peculiarities of the most critical phases in plants' development. In the future, it is planned not only to conduct research on other sets of soft winter wheat varieties, but also to detail the parameters of studying drought resistance by recording changes in photosynthetic activity, studying the nature of mechanisms of grain quality formation due to various combinations of alleles conditioning protein compositions and microelement composition.

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