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INFLUENCE OF CHANGING CLIMATIC CONDITIONS ON THE QUALITY TRAITS OF COMMON WINTER WHEAT GROWN IN THE PAZARDZHIK REGION

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Abstract

The trial was conducted for a 5-year period (2019-2023) on the experimental field of irrigated agriculture experimental station Pazardzhik. In the period 2019-2023 in the field of irrigated agriculture experimental station Pazardzhik on cinnamon forest soil at humus 1.2-1.5% and pH 5.5-6 is set trial, which includes 9 varieties of common winter wheat selection of IPGR Sadovo. It was laid out using the long strip method in four replications with a harvest plot size of 10 m2. The sowing rate is 550 gs/m2. Fertilization was with phosphorus (20 kg/da), applied as triple superphosphate pre-sowing. The entire nitrogen fertilizer rate was applied as N12 (applied as ammonium nitrate). The quality parameters sedimentation value; grain vitreousness; fermentation number; crude protein; wet gluten content; gluten release, dry gluten; bread making strong index were monitored in the grain quality laboratory at IPGR, Sadovo. Gluten relaxation, baking stomg index and dry gluten were determined. ANOVA, Duncan test, cluster and correlation analysis were used for mathematical treatment of data.

Key words: *common winter wheat, grain quality, changing climatic conditions.*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the major crops closely linked to the nourishment and development of modern society. It is of strategic importance in solving food security problems, being used as a raw material for the production of various food products in many industries (Ekinci & Gökbulut, 2020; Belkina et al., 2018; Manukyan et al., 2023; Nosova et al., 2021). With population growth and urbanization, wheat grain consumption is also increasing (Hongjie et al., 2019; Li et al., 2019; Robles-Zazueta et al., 2024). The way to developing wheat varieties with maximum yield of quality wheat is extremely difficult. Wheat breeders are constantly challenged to develop new genotypes that respond to changing environmental conditions with high ecological plasticity (Dowla, et al., 2018; Gungor & Dumlupinar, 2019; Aydogan et al., 2020; Robles-Zazueta et al., 2024).

It has been suggested that changes in climatic conditions over time will cause further abiotic and biotic changes in grain production that are likely to lead to significant changes in wheat yield and quality (Fradgley et al., 2023).

The characteristics that affect the quality of wheat can be broadly grouped into two main groups. The first group of traits are heritable, those under genetic control. The second group includes properties that are influenced by environmental conditions and the specific factors of the growing area. Common winter wheat is a microclimate crop. It influences the expression of the genetic traits of a given genotype related to yield and grain quality. Intensely changing biotic and abiotic factors strongly influence a given variety that interacts with the environment in which it is grown (Moskalets & Rybalchenko, 2015; Harkness et al., 2020; Dennis et al., 2021). The quality of the harvested grain determines its nutritional value. It includes a complex of indicators determining its technological characteristic (Fradgley et al., 2023). The values of these indicators in each individual variety are genetically determined, but are also influenced by the agroecological conditions of a given growing region, climatic factors during the vegetation of the plants, the applied agrotechniques (Ivanova & Tsenov, 2009; Cifci & Yağdi, 2010; Delibaltova et al., 2014).

Therefore, research that is related to the cultivation of common winter wheat varieties in different regions has a certain scientific and practical importance. A number of our scientists are investigating the changing environmental conditions in different regions of Bulgaria and their impact on wheat productivity and quality (Tanchev, 2008; Stoeva & Ivanova, 2009; Ilieva, 2011; Kirchev & Delibaltova, 2016; Uhr & Samodova, 2020; Dragov & Samodova, 2020; Gubatov & Delibaltova, 2020; Tsenov et al., 2021; Angelova et al., 2023).

The varieties bred at IPGR Sadovo enable us to cover the wide range of quality requirements for different types of pasta production. Many years of research have shown that the varieties selected by IPGR have good ecological plasticity.

They retain good quality and quantity parameters regardless of the conditions of the growing region. The breeding of the Sadovo Institute has created some of the best quality wheat. The Pobeda variety is a national quality standard, Sashez is a new achievement in grain quality breeding, they are strong wheats with excellent dairy and baking qualities of the grain (gr. A - Executive agency for variety testing, approbation and seed control), which can serve as flour improvers.

A way of establishing the ability of varieties to resist various abiotic and biotic stresses is to test them in a variety of ecological zones. This enables us to select materials that efficiently use the resources of the surrounding environment and its features, which in turn enables the creation of ecologically plastic, high-yielding and high quality parameter varieties of common winter wheat (Kirchev & Delibaltova, 2016; Andrusevich et al., 2018; Öztürk et al., 2019; Uhr & Samodova, 2020; Tsenov et al., 2021; Güngör et al., 2022; Angelova et al., 2023).

The objective of the present study is to establish and monitor the grain quality of common winter wheat varieties, breeding by IRGR Sadovo, grown in the area of the Experimental Station of Irrigated Agriculture Pazardzhik.

MATERIALS AND METHODS

In the period 2019-2023 in the field of the Experimental Station of Irrigated Agriculture Pazardzhik on pseudopodzolic Cinnamon soil at humus 1.2-1.5% and pH 5.5-6 was carried out trial, which includes 9 varieties of common winter wheat selection of IPGR Sadovo. Plotted using the long strip method in four replications with a harvest plot size of 10 m^2. Sowing is with 550 germinating seeds/m^2. Fertilization with phosphorus (20 kg/da) was given pre-sowing in the form of triple superphosphate. The entire nitrogen fertilizer rate was applied as N_{12} (in the form of ammonium nitrate).

The laboratory tests for grain quality were carried out in the technological laboratory of IPGR - Sadovo. The following were analysed: VG - Grain vitreousness; SdV -Sedimentation value; FN-Fermentation number; Wet gluten content - WGC; Gluten release - RG; Dry gluten – DG; bread making strong index – BMSI.

Technological assessment for grain and bread-making quality

Vitreousness (VG), particularly for grain quality in durum wheat was determined according to BSS 13378:1976, BSS EN 15 585:2008 (https://bdsbg.org/bg/project/show/bds:proj:17689).

The Sedimentation Value (SdV) (Iced Acetic Acid Test – 2%, (Pumpyanskiy, 1971) test was used to provide information on the protein quality and baking properties of the wheat (Angelova et al., 2020; Galushko & Sokolenko, 2021; Uhr et al., 2023).

The Fermentation Number (FN) – Pelschenke test was used to assess the fermentation capacity of the wheat which is important for bread-making quality. The test is based on the retention of CO_2 gases released during dough fermentation. A 10 g sample of grain meal is mixed with a yeast solution (a biological product, representing a concentrated mass of yeast of the Saccharomyces cerevisiae species) in two replicates (Pelshenke et al., 1953). The experiment was carried out under controlled conditions (30ºC - water thermostat). The longer the retention time of the sample on the water surface, the better the quality of the gluten. (Angelova et al., 2020; Galushko and Sokolenko, 2021; Uhr et al., 2023).

Gluten Content and Quality (WGC) (BSS EN ISO 21 415-2:2008, BSS EN ISO 21415-1:2007) test was applied to determine gluten characteristics, which are critical for the end-use quality of wheat, gluten relaxation, mm (BDS 13375:1990/Amendment 1: 1993), (https://bds-bg.org/bg/project/show/bds:proj:17686).

Dry Gluten (DG) was done according to the ISO 21415-3:2006, BSS EN ISO 21415-4:2007 standards to further understand the protein quality of wheat samples (https://www.iso.org/standard/35864.html).

The mathematical processing of the data was performed by applying ANOVA, Duncan test, cluster and correlation analysis. SPSS 19 and Microsoft excel for Windows were used.

RESULTS AND DISCUSSIONS

The research was conducted in the experimental station of irrigated agriculture with Ivaylo, Pazardzhik on Pseudopodzolic Cinnamon soil. It belongs to the European-continental area and is referred to the transitional-continental sub-region in the region of the Upper Thracian Lowland. The field is situated on an old well-bedded terrace of the river Topolnitsa (Teoharov, 2019).

Field studies

According to literature data, the soil distinction is referred to as Izluzhena Cinnamon Forest soil (Penkov et al., 1992; Ivanov, 2019; Kirilov, 2022).

Ivanov (2019) made complete and detailed field investigations of the experimental station and found: that the mechanical composition is highly differentiated layer by layer. The humus horizon A1l (0-34 cm) has a light sandy-clay mechanical composition, is compacted with a sputtered structure and is poor in silt particles. A hard soil crust forms after more intense rain. In the humic podzolic horizon the silt content (<0.001) is 16.5% and physical clay content (<0.01) is 27.65%, respectively, while in the adjacent horizon 34-56 cm this content is 28.9% and 40.8%, respectively, i.e. about 2 times higher, this textural differentiation is characteristic of this soil differentiation (Dimitrov et al., 2016).

Teoharov (2019) reported that these soils are very poor in organic matter. The cultivated areas contain about 1-1.5% humus, mostly concentrated in the ploughsoil, which is mostly represented by the alluvial horizon. The composition of humus is dominated by fulvic acids. The amount of total nitrogen is usually very low and does not exceed 0.10-0.12%. These results are confirmed by Ivanov (2019), as he found a satisfactory content of total phosphorus, from 0.105 to 0.128%. As well as slightly acidic reaction pH 5.2 - 5.3 of the soil solution. No carbonates were detected on the profile. The humus content is low - from 1.09 to 2.13%.

The soil has a satisfactory content of absorbable forms of the main nutrient elements - nitrogen, phosphorus and potassium, which is the result of the use in previous years of the experimental area for breeding trials. The results obtained were confirmed by Kirilov (2022).

Meteriological studies

The Pazardzhik field belongs to the Transitional-Continental climatic sub-region in the Upper Thracian Lowland. The climate is temperate-continental, but is influenced by currents along the Topolnitsa and Maritsa rivers (Ivanov, 2019).

Climatically, the study years are very diverse.

Rainfall is unevenly distributed over time. Very often there is a strong lack of water in the wetter months, and in other cases there is waterlogging, reaching swamping and flooding. Temperatures below the multi-year values are recorded for 2019, 2020 and 2023, and for the other two years the values are aligned with the multi-year values.

The most important months for the formation of the quality of wheat are May and June, when we have the grain filling, its waxy and full maturity. Grain filling starts at the beginning of the milky stage and continues until the beginning of waxy maturity. Maturation is characterised by the complete anatomical separation of the grain from the mother plant and the cessation of the accumulation of reserve nutrients and enzymes. Full maturity occurs at the end of June.

In dry and warm climates, protein accumulation in grains is enhanced. Such conditions shorten grain formation and filling periods, accelerate ripening and consequently increase the proportional protein content of grain composition (Moayedi et al., 2021; Clauw et al., 2024; Chețan et al., 2024)

For the month of May, temperatures are reported to be 0.8 below multi-year values for 2022 to 4.1 for 2023. Reported precipitation for the period is well below normal with 17.4 for 2021 to 48.6 for 2022 unevenly distributed throughout the month. The month of June in terms of temperature is warmer than the perennial values highest temperature was recorded in 2019 at 22.4 and lowest in 2020 at 20.9. Precipitation below normal was recorded for 2020, 2022 and 2023 and above normal for 2019 and 2021. In all years they are unevenly distributed over the month (Table 1).

Table 1. Average monthly temperatures and rainfall totals for the months of March to June for the years 2019 to 2023

Months/Year	III	IV	V	VI
Average monthly temperatures in ^{0}C				
2019	9.8	11.7	17.2	22.4
2020	8.3	11.1	17.0	20.9
2021	5.5	12.1	16.9	21.1
2022	4.8	12.0	18.0	22.3
2023	7.9	11.3	14.7	21.4
for 70 years	6.2	12.0	18.8	20.6
Raifall, mm				
2019	3.5	59.8	33.6	128.9
2020	113.9	80.0	30.7	34.3
2021	35.6	75.2	45.3	74.0
2022	20.9	50.0	14.1	50.7
2023	33.4	55.3	43.1	41.9
for 70 years	37.9	45.2	62.7	56.4

The physical traits and chemical composition of wheat change under the influence of soil and climatic conditions (Delibaltova et al., 2014; Nekrasov et al., 2021; Uhr et al., 2022; Angelova et al., 2023).

The most important grain quality traits by which varieties are evaluated for quality are vitreousness, gluten quantity and quality, and sedimentation value.

Table 2 presents the mean values of the studied traits and their corresponding evidences according to Duncan's multiple comparison test between genotypes.

Vitreousness is very important in determining the quality of the grain, it is a varietal characteristic. This indicator reflects the structural features of the grain endosperm. It is closely related to the protein content and technological properties of the wheat. There is information that vitreous grain justifies higher milling quality (Egorov, 2002; Filipov, 2004; Ionova et al., 2017; Galushko et al., 2019). Galushko et al. (2021) found a positive relationship between grain virtuousness and bread volume in winter wheat (r = 0.57).

The results of the study showed that the mean values over the period by genotypes ranged from 49.200 Fermer to 64.200 for Pobeda (Table 2). The highest values for the indicator were recorded in the 2022 crop year, the environmental conditions were favorable and the varieties formed trait values above Executive agency for variety testing, approbation and seed control requirements (50%) for quality group A. The coefficient of variation was 12.62% (average) (Dimova & Marinkov, 1999).

While the physical parameters of the grain are primarily important for the milling quality of the wheat and for the potential flour yield, its chemical composition and mainly the gluten complex are crucial for the baking characteristics of the varieties.

Table 2. Average values of quality traits in winter wheat varieties for the period 2019-2023

Variety	Grain vitreousness	Sedimantation value	Fermentation number	Wet gluten yield	Gluten release	Bread making strong index	Dry gluten
Sadovo 1	55.400 ab	52.600 ab	59.800 a	29.432 ae	13.100 a	50.000 a	9.538 de
Pobeda	64.200 b	62.000 cd	100.400 cd	31.656 abc	12.300 a	52.200 a	10.400 abc
Boryana	54.000 ab	58.000 abcd	67.800 ab	30.020 ab	11.600 a	50.800 a	9.736 ad
Nadita	56.400 ab	60.600 bcd	71.400 ab	32.676 bc	12.700 a	50.800 a	10.554 bc
Gizda	56.400 ab	55.600 abcd	72.000 ab	32.256 abc	11.700 a	51.800 a	10.444 abc
Geya1	39.000 c	42.600 e	36.000 e	25.816 d	11.400 a	45.600 b	8.068 f
Nikibo	52.800 ab	49.400 ab	60.000 a	26.724 de	10.800 a	48.600 ab	8.850 e
Fermer	49.200 ac	54.400 abc	88.400 bc	31.824 abc	12.200 a	51.000 a	10.040 abc
Sashets	53.800 ab	64.000 d	111.600 d	34.608 c	13.300 a	50.400 a	11.182 c
Mean	53.47	55.47	74.16	30.56	12.12	50.13	9.87
Minimum	39.00	42.60	36.00	25.82	10.80	45.60	8.07
Maximum	64.20	64.00	111.60	34.61	13.30	52.20	11.18
Std. Error	2.25	2.24	7.65	0.95	0.27	0.66	0.32
Std. Dev.	6.75	6.71	22.94	2.86	0.82	1.99	0.95
CV, %	12.62	12.09	30.93	9.35	6.80	3.97	9.64

The sedimentation value (cm^3) is a method of examining the settling of flour in 2% acetic acid, which accurately indicates the quality of gluten and dough.

Sedimentation value has been found to correlate with gluten content, gluten quality, and bread volume as a function of protein content (Boyadjieva & Mangova, 2007; Pshenichnaya & Dorokhov, 2017; Galushko et al., 2021).

Therefore, measuring this value is extremely useful for grain quality. Sediment value has also been found to be influenced by heritability (58.6%) and is mostly determined by genotype, but environmental factors (24.9%) are also significant (Lorenzo & Kronstad, 1987; Grausgruber et al., 2000; Hruskova and Famera, 2003; Kibkalo, 2022).

According to the sedimentation number, the varieties Pobeda, Sashets, Nadita, for the whole period of the study show values above the requirements for group A ($50cm^3$), in the case of the rest of the studied materials we observe a slight decrease of the indicator over the years depending on the conditions of the year. The reported average value for the period is 55.47 (above the requirements for group A). The coefficient of variation of the attribute is average (12.09%).

The joint consideration of the Pelshenke fermentation number (min) trait (Pelshenke et al., 1953) together with the sedimentation number allows us to assess the interdependence between the quality and quantity of gluten by the magnitude of their values (Hermuth, 2019; Angelova et al., 2020; Galushko & Sokolenko, 2021; Uhr et al., 2023).

The results obtained in the present study show high values of this trait in the first (2019) and third (2021) years in the high quality wheats Pobeda and Sashez. For the remaining varieties, the values are below 100 minutes. On average for the study period for the trait lower results were obtained (74.16 min) The coefficient of variation was high 30.93. Our previous studies confirm the high variation of the trait (Angelova et al., 2023).

Asseng et al. (2019) assessed the impact of climate change on wheat protein from a global perspective, concluding that climate change may affect wheat quality by impacting wheat protein synthesis and accumulation (Yuan et al., 2024).

The yield of wet gluten in the grain ensures the appropriate amount of gluten in the flours and gives us an idea of the protein content and nutritional value. Gluten is highly dependent on wheat type and variety, soil and climatic conditions, fertilization, etc. The baking strength number provides the level of bread quality - volumetric yield of bread with good formability (Abduazimov, 2018; Nekrasov et al., 2021; Juraev et al., 2023).

Wet gluten is an extremely important trait for grain processing products- flour, dough, bread, etc. (Dimitrova-Doneva et al., 2002; Dochev 2011). The unique ability of gluten proteins to form a complex called gluten predetermines the leading role of wheat among all cereals (Podgorny et al., 2020). Research by Popa et al.

(2014) proves that the best predictor of bread quality is not the gluten index parameter as such, but the amount of wet gluten at the time of determining this parameter. It also correlated significantly with bread volume (r = 0.79***) and h/d ratio (r = 0.73 ***).

Our results show that the varieties grown in the soil-climatic conditions of the Ivaylo Experimental Station area showed, on average, a high retention of wet gluten content (30.56%) over the study period. The average values for the varieties, with the exception of variety Geya 1 (25.8%) and variety Nikibo (26.7%), were above the quality requirements for group A. The best results were obtained in the 2022 crop year, during which the indicator values were above IACAS requirements (28%). Reported wet gluten yields ranged from 30.64% for Sadovo 1 to 40.06% for Sashez (data not tabulated). The coefficient of variation is low (CV, 9.35%).

For gluten relaxation, we observed values ranging from 8 to 13.5 mm during the first three years of the study (2019-2021). There is an increase in the trait values in the following two years from 11.5 mm to 18 mm. On average over the five year period the result is 12.12 mm, with the lowest being in Nikibo 10.8 mm, and the highest in Sashez 13.3 mm. The coefficient of variation for this trait is low (CV, 6.8%). For the BMSI, the variation is low (CV, 3.97%), and the values obtained for the trait depend on gluten relaxation. The highest values are in 2019 and 2021, during which a lower gluten relaxation is reported. For dry gluten, the average values for the period ranged from 8.07% for variety Geya 1 to 11.18 for Sashez. The average for the period was 9.87%. The variation for the trait is low (CV, 9.64%).

Microclimate has a strong influence on the expression of genetic traits of the varieties related to productivity and grain quality.

The variety, as a genotype or a combination of close genotypes, exists and interacts with the given environment, encountering biotic and abiotic factors that change intensively, indicating its strong influence (Uhr & Samodova, 2020; Dennis et al., 2021; Uhr et al., 2022).

The varieties monitored in the study cover the three wheat quality groups Group A - "strong wheat" - Pobeda and Sashets.

Group B - "medium wheats with increased strength"- Sadovo 1, Nikibo, Boriana and Farmer.

Group W - "medium strength wheats"- Geya-1, Gizda and Nadita.

Knowledge of the influence of G × E (genotype × environment) can be used to adapt crops to specific environmental conditions or to select broadly adaptive varieties that are resistant to variable environments. The environment is rarely fully conducive to expressing the full potential of the varieties sown. Grain quality traits expressed by the studied parameters are largely under genetic control, but are also influenced by growing environment conditions (Atanasova et al., 2010; Eagles et al., 2002; Laidig et al., 2017; Podgorny et al., 2020).

The ANOVA results (Table 3) show that both location and cultivar and the interaction between these two factors have the largest contribution to the strength of factor influence on the quality parameters studied. The influence of year and environmental conditions had the greatest contribution on quality parameters such as grain vitreousness (63.9%), gluten relaxation (59.7%), sedimentation value (58.6%) and wet gluten content (43.4%). Results close to ours were obtained by Szafranska et al. (2024).

Genotype had the strongest influence in dry gluten yield (46.2%) and FN (37.3%) although, in FN, the year of cultivation also had an influence (31.6%).

The influence of G*E was strong in BMSI (46.9%), RG (31.4%) and FN (30.9%). When studying the genotype*environment interaction in common winter wheat cultivars and its quality Tsenov et al. 2004 obtained results similar to ours. The values obtained by Stoeva & Penchev (1999, 2005) are largely analogous, demonstrating the determining role of year in expressing wheat quality potential.

Table 3. Analysis of variance for the studied traits ANOVA, determination of influence of the factor strength η, %

Grain vitreousness	SS	DF	MS	F	P	η, %	SIG
YEAR	21427.6	4	5356.9	6343.7	0.00	63.9	***
GENOTYPE	5467.2	8	683.4	809.3	0.00	16.3	***
GxE	6546.8	32	204.6	242.3	0.00	19.5	***
Error	76.0	90	0.8			0.2	
						100	
Fermentation number	SS	DF	MS	F	P	η,%	SIG
YEAR	53415.1	4	13353.8	3196.4	0.00	31.6	***
GENOTYPE	63130.5	8	7891.3	1888.9	0.00	37.3	***
GxE	52216.1	32	1631.8	390.6	0.00	30.9	***
Error	376.0	90	4.2			0.2	
						100	
Gluten release	SS	DF	MS	F	P	η, %	SIG
YEAR	732.23	4	183.06	578.08	0.00	59.7	***
GENOTYPE	81.53	8	10.19	32.18	0.00	6.6	***
GxE	384.97	32	12.03	37.99	0.00	31.4	***
Error	28.50	90	0.32			2.3	
						100	
Sedimantation value	SS	DF	MS	F	P	η, %	SIG
YEAR	12720.9	4	3180.2	3577.8	0.00	58.6	***
GENOTYPE	5400.0	8	675.0	759.4	0.00	24.9	***
GxE	3518.7	32	110.0	123.7	0.00	16.2	***
Error	80.0	90	0.9			0.4	
						100	
Wet gluten content	SS	DF	MS	F	P	η,%	SIG
YEAR	1256.6	4	314.2	32484	0.00	43.4	***
GENOTYPE	979.9	8	122.5	12665	0.00	33.8	***
GxE	660.9	32	20.7	2136	0.00	22.8	***
Error	0.9	90	0.0			0.0	
						100	
Bread making strong	SS	DF	MS	F	P	η, %	SIG
YEAR	1113.6	4	278.4	348.0	0.00	35.6	***
GENOTYPE	475.2	8	59.4	74.2	0.00	15.2	***
GxE	1468.8	32	45.9	57.4	0.00	46.9	***
Error	72.0	90	0.8			2.3	
						100	
Dry gluten	SS	DF	MS	F	P	η,%	SIG
YEAR	67.04	4	16.76	2423	0.00	28.5	***
GENOTYPE	108.66	8	13.58	1964	0.00	46.2	***
GxE	59.04	32	1.85	267	0.00	25.1	***
Error	0.62	90	0.01			0.3	
						100	

Correlation analysis (Table 4) was performed to assess the relationships among the qualitative indices under study, and the results showed that there was a strong positive correlation of DG with SdV (0. 941**), FN (0.866**), WGC (0.985**) and BMSI (0.838**) at 0.01 level of evidence and significant at 0.05 level of evidence with VG (0.684*) and GR (0.669*).

Analysis of our data shows that there is positive correlation in SdV with FN (0.864**), WGC (0.897**), BMSI (0.826**), DG (0.941**) at 0.01 level of evidence. It is also significant for FN and SdV (0.864**). A strong positive correlation was also observed for the WGC parameters with SdV (0.897**) and FN (0.846**). A strong correlation was also found for BMSI with VG (0.857**), SdV (0.826**). Moderate correlation relationships between VG, SdV and WGC were obtained close to our results in Grain Quality study of new winter wheat genotypes (Galushko et al., 2021). A positively significant correlation over the years of study between sedimentation value and wet gluten content (r = 0.63) was also obtained by Sokolenko et al., 2021. Correlation analysis performed by Podgorny et al. 2020 revealed a relationship between yields and quality traits. As in our previous studies (Table 4).

Table 4. Correlations between the qualitative traits studied

Correlations							
	Grain vitreousness	Sedimantation value	Fermentation number	Wet gluten yield	Gluten release	Bread making strong index	Dry gluten
Grain vitreousness	1						
Sedimantation value	0.770*	1					
Fermentation number	0.605	0.864**	1				
Wet gluten yield	0.568	0.897**	0.846**	1			
Gluten release	0.345	0.615	0.56	0.703*	1		
Bread making strong	0.857**	0.826**	0.722*	0.788*	0.4	1	
Dry gluten	0.684*	0.941**	0.866**	0.985**	0.669*	0.838**	1
*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed)							

Cluster analysis was performed to determine the genetic similarity among the varieties studied. The results are presented in a dendrogram (Figure 1) The figure shows that according to the quality traits studied, the varieties are divided into three main cluster groups. Genetically the most similar varieties are Nadita and Gizda (corresponding to quality group W), followed by Sadovo 1 and Nikibbo (corresponding to quality group B) they form the first cluster group with two subclusters. The second cluster is formed by the high quality Group A wheats. Genetically the most distant in quality are the varieties Geya 1 and Sashez, followed by Geya 1 and Pobeda. This analysis gives us a good idea of the genetic closeness and remoteness of the varieties depending on their quality parameters.

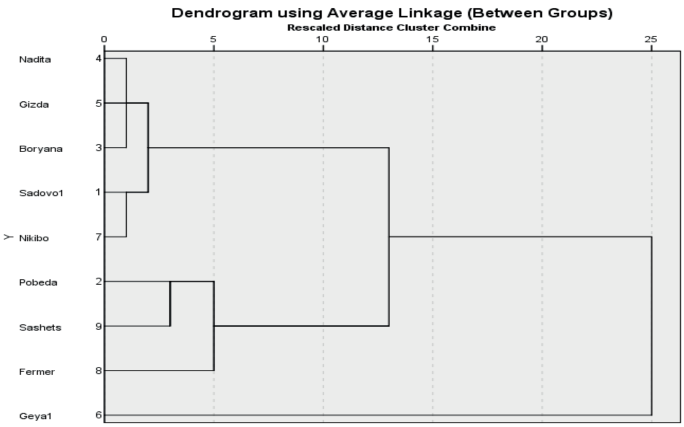

Figure 1. Dendrogram of cluster analysis

CONCLUSIONS

Each of the quality traits examined provides information on part of the "grain quality" complex. It is therefore important to follow the level of varieties as a whole, as well as their performance under environmental variables. The varieties Pobeda and Sashez are high quality varieties in terms of the indices which are tracked correspond to the quality of wheat Group A - "strong wheat".

The varieties Sadovo 1, Boriana and Fermer meet and exceed the quality requirements of Group B - "medium wheat with increased strength". Only in the case of Nikibo, there is an underestimation of the values of individual indicators in individual years. The conditions in the growing area have affected the outbred genotypes differently.

In the case of Group W wheats - 'medium strength wheats' - Gizda and Nadita have shown excellent results over the five-year period,

exceeding the requirements for Group W. In the case of variety Geya-1, lower results were observed, but they covered the requirements for the group in which the variety was classified.
The conditions in the Pazardzhik area are suitable for growing quality grain.

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