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THE BEHAVIOR OF ROMANIAN WINTER WHEAT BREEDING LINES AND VARIETIES IN TRANSYLVANIAN PLAIN CONDITIONS

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Abstract

Genotype selection is a key requirement for high yields in wheat crop management; higher yields can only be realized with good genetic potential. The performance of different varieties is also influenced by the environment, and it is important to understand that no genotype is perfect in all growing areas. To assess the behavior of 24 winter wheat genotypes regarding their germination energy, germination capacity, thousand kernel weight, grain yield, grain protein content and test weight, a study was conducted over two consecutive growing seasons at ARDS Turda, under two different amount of nitrogen fertilizer applied, and it has been investigated whether there is any connection between each of these traits. The experimental factors and their interactions had a different influence on the studied traits. The growing season and the nitrogen fertilization had a highly significant effect on yield, protein content and test weight. The genotype had a highly significant effect on all the studied traits. Thousand kernel weight in comparison with the other traits studied was strongly influenced by the genotype and less by the growing season and nitrogen fertilization.

Key words: *germination, protein content, thousand kernel weight, winter wheat, yield.*

INTRODUCTION

Winter wheat is a vital crop that feeds billions of people worldwide and contributes to about 21% of global food production (Cao et al., 2024). According to Romanian National Institute of Statistics cereals were also the most important crop in the European Union in 2023, wheat represented 47.2% of the total area cultivated with cereals, with barley coming in second at 20.4% and maize in third, at 16.5% of the total. The importance of winter wheat in Romania's agriculture is given by the considerable percentage of 2023's total cereal production that went to wheat (46.3%), followed by maize (42.1%) and barley (9.6%). In 2023, Romania produced 9624.1 thousand tons of wheat, which was more than the 8684.2 thousand tons produced in 2022 (Brodeală et al., 2024; insse.ro).

The fundamental process by which plant species develop from a single seed into a plant is known as seed germination. It determines the effective use of water and fertilizer resources and affects crop quality as well as yield. (Xue et al., 2021). In agriculture the use of healthy, viable, and high-quality seeds is essential for maintaining a crop's ideal plant density. Indicators of seed vitality (germination energy and germination capacity) play a direct role in determining an optimal plant number per hectare, which is one of the three main components of yield (Mrđa et al., 2011). Germination comprises all the physiological and biochemical changes that take place in the seed during the transitions from dormant to active life. Germination evaluation in the laboratory indicates the embryo's capacity to develop into a normal plant when the field conditions are suitable. For this there are two factors needed to determine seed germination: germination energy and germination capacity. Germination energy (%) represents the speed at which the seeds placed under germination conditions initiates the germination process. Germination capacity (%) it is the ability of seeds to germinate in a limited number of days set for each species (winter wheat 8 days). The germination percentage (%) of the seed is a particularly important analysis for the seeds intended to be sown, given that the germination value is necessary for the Seed Rate calculation (Duda et al., 2003).

It is well known that nitrogen is an essential component for winter wheat to grow properly, it is one of the key elements to increase the yield and quality of winter wheat (Hamani et al., 2024). It is a crucial component of all proteins and amino acids, as well as hormones, enzymes, chlorophyll, and nucleic acids. In addition to having a significant impact on the protein content, a reasonable application of nitrogen fertilizer can promote the growth and development of winter wheat roots, stems, leaves, and other vegetative organs. Excessive application of chemical fertilizers on farmland will cause serious soil and groundwater pollution. The increase in the use of chemical fertilizers and the pollution caused by excessive use of chemical fertilizers to the soil and water sources has attracted more and more attention (Pacifico et al., 2024). Therefore, the application of fertilizers must be aimed at increasing crop yield, improving crop nutrient utilization efficiency, and reducing the impact on soil and environment (Kubar et al., 2021). Chemical fertilizers must be applied wisely in accordance with the crop growth and development requirements; they cannot be utilized excessively. Increases in nitrogen rates will result in higher crop yields when fertilization level fall within a certain range (Ju et al., 2009). Reasonable application of nitrogen fertilizer can promote the yield and quality of winter wheat. A suitable quantity of nitrogen can help winter wheat roots, stems, and leaves grow and development; increase the green area of plants; increase photosynthesis and nutrient accumulation; promote tillering; and support in the growth and development of reproductive organs (Kubar et al., 2021).

Environmental conditions have a considerable effect on protein content and yield, with both being managed through N application rates and timing (Burton et al., 2024). Wheat yield is also strongly influenced by the agronomic methods, and different wheat varieties used (Chen W. et al., 2024).

Protein is the main component of wheat grains, and its content is closely related to wheat quality (Shewry & Hey, 2015). Protein is the most essential component of the wheat grain and influences its nutritional value as well as its baking attributes (Muntean et al., 2014). Frequently the protein content is use to determine the baking quality, although protein composition is genetically determined, their proportion is strongly influenced by agronomic conditions (Peigné et al., 2014). Protein synthesis in wheat grains is regulated by the nitrogenous substances stored in the reproductive organs before flowering, as well as by nitrogen absorption and redistribution capacity after flowering. Additionally, the nitrogen compounds stored in the stem sheath and leaves before flowering are transported to the grains after flowering (Cao et al., 2024). Aside from protein content, test weight (TW) and thousand kernel weight (TKW) serve as fundamental quality attributes for baking and milling. These grain attributes are crucial indicators of the quality of wheat (Ingver et al., 2024). Wheat genotypes seeds with test weight values above 80 kg hl^{-1} show very good grain filling capacities and indicates their high quality (Tabără et al., 2008).

MATERIALS AND METHODS

This study was conducted to assess the behaviour of 24 winter wheat genotypes regarding germination energy (GE), germination (G), grain yield (GY), thousand kernel weight (TKW) grain protein content (GPC) and test weight (TW) over two consecutive growing seasons (2022-2023 and 2023-2024) under two different amount of nitrogen fertilizer applied, and it has been investigated whether there is any connection between each of these traits.

The genotypes chosen for this experiment were developed at NARDI Fundulea (12), ARDS Lovrin (1), ARDS Turda (10), and an old Russian genotype with very good quality that was mainly used as a quality control.

Field experiments were carried out at the Agricultural Research and Development Station Turda (46°35’ N; 23°47’E) which is located in the Transylvanian Plain, Romania and the experimental design consists in randomized blocks in six replications. The experiment was established on a typical clay Chernozem soil, typical for the forest steppe encountered over half of the Transylvanian Plain. The agrochemical indexes for this soil type had the following average values: the soil reaction is neutral (pH 6.81-6.84) and the humus content is 3.36-3.73% in the arable layer. The supply soil is good in nitrogen (0.177-0.205%) and rich in potassium content (220-320 ppm), and poor in mobile phosphorus (11-35 ppm).

The climate of the area is continental with 4 distinct seasons. Monthly meteorological variables were recorded from a weather station placed on site. Normal long-period average climatic data, were compared with the two-year trial data. The monthly air temperature and rainfall throughout the two growing seasons and long term are presented in Figure 1. Temperatures during the two years of the experiment were higher than the 65 years average, especially in October 2023, February, April, June and July 2024. The temperature was lower during 2022-2023 growing season, in comparison with 2023-2024 growing seasons, except for January 2023. From all two seasons 2023-2024 was the warmest. Regarding the amount of rainfall, the two experimental years were very different, 2022-2023 vegetation period was mostly rainy, the rainiest month was June, the total amount of rainfall during this period was 457.5 mm. On the other hand, 2023-2024 was mostly dry, the total amount of rainfall during this growing season was 317.6 mm.

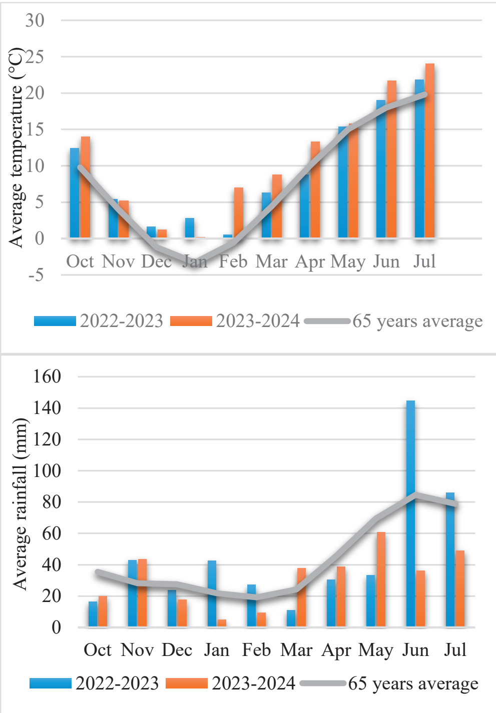

Figure 1. Weather conditions during winter wheat growing season (Oct 1st to July 31st) in Turda, Romania

The 24 winter wheat genotypes including both cultivars and breeding lines were tested over two consecutive growing seasons (2022-2023 and 2023-2024). Winter wheat was sown after pea in a three years crop rotation maize – pea - winter wheat.

The fertilizer amount was 50 kg ha^{-1} active substance of nitrogen applied in autumn before sowing (F1) in all six replications, and another 50 kg ha^{-1} was applied during vegetation at boot stage (F2) in the first three replications.

Winter wheat was sown with the experimental machine, at 2-4 cm depth, at density of 550 grains m^{-2} during the second decade of October. The plot surface area was 6.25 m^{-2}. Herbicides were always applied to the whole experiment during initial wheat growth and were chosen according to the dominant weed species. Glyphosate was applied before crop seeding, because of a very high weed pressure. Fungicide-dressed seeds were used to control seedborne diseases and insecticide were also used according to integrated crop protection principles. The plots were harvested mechanically at maturity independently for each plot, and grain yield GY (kg ha^{-1}) was expressed on a 14% grain moisture basis.

The quantity of seed harvested from each plot was weighed and the production per hectare was calculated for each experimental plot. Sample was taken from the seed harvested and using the Inframatic 9500 Near Infrared grain analyser. In the laboratory TW and TKW was determined.

In order to determine GE and G was carried out in Petri dishes at an ambient temperature of 20-22°C, by placing uniformly 100 seeds in 3 replications for 8 days. On the 4^{th} day GE was determined. On the 8^{th} day G was determined. Both GE and G were determined by counting (Duda et al., 2003).

Analysis of variance (ANOVA) was used to estimate the effects of genotype, year (climatic conditions) and nitrogen fertilization, and their interactions on grain yield and other tested traits. The results were also statistically treated using MS Excel 2012 tools. Correlation was assessed using the Pearson correlation coefficient.

RESULTS AND DISCUSSIONS

The results of ANOVA showed that the experimental factors and their interactions had a

different influence on the studied traits (Table 1). The growing season had a highly significant effect on GE, also significantly influenced GY, GPC and TW. Nitrogen fertilization had a highly significant effect on GY, GPC and TW. The genotype had a highly significant effect on all the studied traits. G and TKW in comparison with the other traits studied were strongly influenced by the genotype and less by the growing season and nitrogen fertilization.
As shown in Figure 2 the statistical analysis according to the Duncan test classification, indicates that the 24 genotypes from this study differ from each other regarding GE, and does not demonstrate a significant difference between the genotypes studied regarding G, all the genotypes registered very good G, over 98%, mostly because the experiment's seeds came from the 2022 and 2023 yield. Voinic and Dacic had the best G from all the genotypes, on the other hand Ursita, Pitar and FDL Consecvent had the lowest G from this study. Bezostaia, Andrada and Dacic had the best GE from all the genotypes. Genotypes with good GE were Semnal, Andrada, Cezara, Luminiţa, T 28-19. Genotypes with low GE but good G were Glosa, FLD Miranda, FDL Abund, FDL Columna, FDL Evident, Codru, T 75-16. The only genotypes with low GE were Ursita, FDL Consecvent and FDL Emisar. It is reasonable to assume that a low GE does not always indicate a low G.

Table 1. Analysis of variance (ANOVA) of the effects of growing season (GS), nitrogen fertilization (F) and genotype (G), and their interaction for all studied traits

Experimental factors	**DF**	**GE**	**G**	**GY**	**TKW**	**GPC**	**TW**
Growing season (GS)	1	424.360***	2.619ns	160.471**	20.436*	102.382**	151.579**
Nitrogen fertilization (F)	1	248.669**	5.255ns	296.737***	21.865*	2033.491***	877.669***
Genotype (G)	23	6.494**	3.294**	75.336***	59.429***	54.692***	99.452***
GSxF	1	165.024**	0.455ns	23.424*	0.090ns	272.744***	34.368*
GSxG	23	1.312ns	3.936**	16.023***	4.457**	10.971**	4.959**
FxG	23	3.661ns	3.192ns	2.482ns	3.516ns	4.127ns	4.071ns
GSxFxG	23	3.254**	3.443**	2.257**	1.761*	1.599ns	3.555**

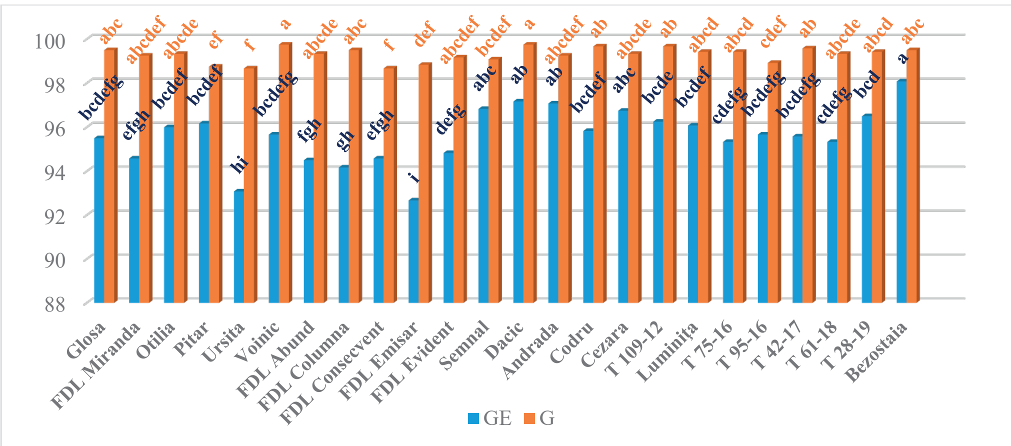

Figure 2. Genotype germination energy (GE) and germination (G) classification according to Duncan test

Between all the traits from this study Pearson correlation was calculated (Table 2), it turns out there's no correlations between GE, G or TKW and the other traits studied. TKW is the one yield component associated with grain quality, higher TKW indicates better germination of wheat grain and better milling quality (Jevtic et al., 2024), however in our study, TKW is positive correlated but not significant with GE (r= 0.156) or G (r= 0.292. There is a high correlation between GPC and TW (r = 0.583**), and a strongly negative correlation between GY and GPC (r -0.569**). This negative correlation has been documented in wheat breeding: higher grain yield is also linked to lower grain protein content. This negative correlation between grain yield and grain protein concentration is often with r values ranging from − 0.13 to − 0.60 (Donaire et al., 2023; Hoang et al., 2024).

Table 2. Pearson Correlation between all studied traits

	GE	G	TKW	GPC	TW	GY
GE	1					
G	0.323	1				
TKW	0.156	0.292	1			
GRP	-0.207	-0.099	-0.396	1		
TW	-0.056	0.050	-0.301	0.583**	1	
GY	-0.335	-0.119	0.113	-0.569**	-0.303	1

We investigated how the 24 genotypes behaved each year in comparison with the genotypes average (Ct.) for each fertilization rate used regarding TKW, GY (Table 3), GPC and TW (Table 4).

According to what other authors have observed, in our experiment N treatment had a significant and positive effect on yield. As total N applied increased, average yields across all years also increased (Burton et al., 2024). In F2 where we applied another 50 kg ha^{-1} nitrogen at boot stage, in comparison with F1 the yield increased in both experimental years. Similar to the effect on crop yield, applying N fertilizer before the beginning of grain filling period had a positive effect on TKW as well. The highest TKW mean was in 2024 F2 (46.75 g) followed by 2024 F1(45.68 g), 2023 F2 (45.58 g) and the lowest TKW were in 2023 F1 (44.60g). Mean GY obtained in 2024 F2 was the highest (9797 kg ha^{-1}), followed by 2024 F1 (9154 kg ha^{-1}), 2023 F2 (8583 kg ha^{-1}), and the lowest in 2023 F1 (7438 kg ha^{-1}) (Table 3). As we can see the environmental conditions and N fertilization had a strong influence on both TKW and GY, in our experiment as well.

Growing season and wheat genotypes significantly affected TKW, this yield component was significantly different between the genotypes, though controlled by the genetic features of a specific genotype TKW perform differently in different conditions during the process of yield formation (Hoang et al., 2024; Jevtic et al., 2024; Chen et al., 2024). The genotypes' response to N fertilization regarding TKW were very different. From of all the genotypes studied Luminiţa and T 75-16 are the only ones who recorded highly significant TKW values in both years in all the N fertilization rates. The varieties and breeding lines developed at ARDS Turda are characterized by a greater TKW, while the genotypes created at NARDI Fundulea are generally characterized by a medium TKW. The lowest values of TKW had Otilia, Voinic, FDL Emisar and FDL Evident in both years in all the N fertilization rates (Table 3).

Genotype it is a significant factor in determining yield, as well the environmental conditions have a considerable effect on yield (Burton et al., 2024; Hoang et al., 2024). The yield of the 24 genotypes in our two-year trial varies from one year to another despite using the same methodology (Lobell et al., 2012; Semenov & Shewry, 2011). From all two seasons 2023-2024 was the warmest, high temperatures and the lack of precipitations at the end of the winter wheat vegetation period determined the speed up of the heading and ripening stages of wheat plants, GY in 2024 was significantly higher, compared to 2023 when April and May were dry and it rained a lot in June and July.

It stands out the genotypes that had a highly significant GY in F1, where no N were applied during vegetation, like FDL Columna, FDL Evident, T 95-16, T 42-17, T 28-19 in 2023, FDL Abund, FDL Consecvent, FDL Emisar, Dacic, Codru, T 109-12, T 75-16, T 95-16, T 42-17, T 61-18 in 2024. This indicates that genes, more than the environment, influence the genotypes production, as is known that wheat productivity is constrained by genetic,

agronomic, and climate factors (Vafa et al., 2024; Leonte, 2011)
Certain genotypes, such as Glosa, FDL Miranda, Pitar, Voinic, and FDL Columna, had significantly decreased GY, but this was not because they were less productive; rather, it was because they are less adapted to the experiment's environment, these genotypes being developed at NARDI Fundulea, are more adapted for the southern region of Romania.
The N fertilizer effect on yield is obvious, as other authors observe, but fertilizer application during important crop growth stages could improve yield (Jarecki, 2024; Hamani et al., 2024; Sun et al., 2022). N is the most important crop yield limiting-factor (Pacifico et al., 2024). The highest yield was obtained by Ursita (10592 kg ha $^{-1}$), followed closely by FDL Emisar (10549 kg ha $^{-1}$), and Dacic (10322 kg ha $^{-1}$) in 2024 in F2. The breeding lines created at ARDS Turda like T 75-16 recorded yields over 10000 kg ha $^{-1}$ in 2024 both in F2 and F1 and T 109-12, T 95-16, T 42-17, T 61-18 recorded yield over 10000 kg ha $^{-1}$only in F2. In 2023 in F2 T 75-16 had the highest yield (9293 kg ha $^{-1}$), followed by Cezara (9111 kg ha $^{-1}$), FDL Evident (9094 kg ha $^{-1}$) and Semnal (9005 kg ha $^{-1}$) (Table 3).

Table 3. The influence of the experimental factors on TKW and Grain Yield

Experimental factors	TKW g				Yield kg ha^{-1}			
	2023		2024		2023		2024	
Genotype	F1	F2	F1	F2	F1	F2	F1	F2
Glosa	45.70	48.40**	46.75	46.90	7319	7908^{000}	8094^{000}	8864^{000}
FDL Miranda	45.00	44.75	45.25	45.75	7192	8138^{0}	8717^{0}	9230^{00}
Otilia	41.40^{00}	42.60^{00}	42.50^{00}	43.50^{00}	7560	8546	9295	9975
Pitar	42.95	44.60	46.45	47.65	7590	8603	8661^{0}	9524
Ursita	39.75^{000}	44.30	43.60^{0}	45.70	7251	8506	9321	10592***
Voinic	41.45^{00}	41.70^{000}	41.85^{000}	40.95^{000}	7424	8223	8580^{00}	9549
FDL Abund	42.00^{00}	44.55	45.85	47.40	7242	8635	9601*	10275*
FDL Columna	45.40	48.35**	46.65	49.00*	7851*	8606	9053	9326^{0}
FDL Consecvent	42.25^{0}	44.95	43.25^{0}	45.85	7350	8735	9567*	9922
FDL Emisar	41.95^{00}	40.45^{000}	42.50^{00}	42.50^{000}	7029^{0}	8701	9689**	10549***
FDL Evident	41.25^{000}	42.10^{000}	42.40^{00}	42.75^{000}	8097**	9094*	9080	9761
Semnal	43.40	45.75	43.55^{0}	45.05	7425	9005*	8977	9977
Dacic	47.55**	44.75	47.35	49.95**	7397	8494	9625*	10322**
Andrada	48.55***	49.40***	49.25***	48.00	7248	8479	8957	9773
Codru	49.25***	49.05***	49.00**	49.55**	7479	9111**	9553*	10140
Cezara	42.20^{0}	38.90^{000}	45.20	44.90	7470	7895^{000}	9443	10141
T 109-12	49.40***	50.60***	48.45**	48.40	7620	8549	9806**	10364**
Luminița	49.60***	49.75***	49.05***	49.45**	7119	8849	9269	9958
T 75-16	47.40**	49.45***	49.25***	51.30***	7738	9293***	10162***	10347**
T 95-16	47.55**	50.15***	47.30	50.10**	8186***	9311***	9571*	10104
T 42-17	43.35	42.45^{00}	43.70^{0}	44.80^{0}	7947*	9046*	9912***	10186
T 61-18	42.65^{0}	44.25	44.25	47.65	7284	8710	9874***	10458**
T 28-19	45.55	48.20**	48.40**	49.60**	7979**	8678	8896	9361^{0}
Bezostaia	44.95	44.45	44.45	46.15	5710^{000}	6879^{000}	5985^{000}	6419^{000}
Mean (Ct.)	44.60	45.58	45.68	46.75	7438	8583	9154	9797
	p 5% 1.95; p 1% 2.58; p 0.1% 3.33				p 5% 393.62; p 1% 519.50; p 0.1% 668.96			

GPC is strongly influenced by variety, N fertilization, and year. The environmental conditions like the amount of rainfall during the growing season can play a significant role in determining GPC (Burton et al., 2024). Because there were more precipitations during the 2022-2023 growing season than during the 2023-2024 growing season, in our experiment, the GPC was higher in 2023 than in 2024. Also, the temperatures during winter wheat vegetation period, especially during the grain filling period, strongly influenced GPC. In our two experimental years as we can see in Table 4, during 2023-2024 growing season the temperatures were higher in comparison with 2022-2023 growing season, the values of GPC were lower (mean GPC in 2024 was 10.69%, and in 2023 was 11.94% both in F2). This could be connected to the impact of high temperatures on reducing the duration of dry matter accumulation, shortening the grain-filling period, and finally reducing GPC (Hoang et al., 2024). Recent evidence has indicated that an increase in temperature has led to a serious deterioration in wheat grain quality, when the temperature exceeded 32ºC, the winter wheat experienced heat stress, leading to a decrease in the grain protein content (Cao et al., 2024).

The nitrogen fertilization effect on GPC and on TW is evident (Table 4), Nitrogen is necessary for the growth of all crops, but especially winter wheat requires N for storing proteins in the grains (Pacifico et al., 2024). With the reduction in the nitrogen fertilizer application rate, the GPC decreased, as other authors have noticed (Cao et al., 2024) in both years in F1 GPC values were lower than in F2. Therefore, these genotypes necessarily require nitrogen fertilization during vegetation, even in amounts greater than 50 kg ha^{-1} as used in this experiment, in order to obtain a good percentage of GPC, supplementary application of Nitrogen at heading or anthesis, is generally recognized as beneficial for increasing grain protein content (Hamani et al., 2024). In 2023, the best GPC had FDL Columna (12.90), followed by FDL Emisar, Bezostaia (12.80), and Pitar (12.70); on the other hand, in 2024, Bezostaia had the best value of GPC (12.17), followed by FDL Columna (11.93), Glosa (11.67), Pitar, and Voinic (both with 11.30).

Table 4. The influence of the experimental factors on Grain protein content and Test weight

	Protein Content, %				Test weight, kg hl^{-1}			
	2023		2024		2023		2024	
Genotype	F1	F2	F1	F2	F1	F2	F1	F2
Glosa	9.30	12.50**	10.20***	11.67***	79.60**	81.20*	77.37	78.40
FDL Miranda	8.50^{000}	11.30^{00}	9.13	10.47	76.40^{000}	79.20^{000}	75.33^{000}	76.47^{000}
Otilia	9.30	12.43*	9.73	11.27**	79.50**	81.60***	78.13***	79.10**
Pitar	9.20	12.70***	9.90*	11.30**	78.10	80.40	76.73	77.80
Ursita	9.40	12.10	9.70	11.07	80.20***	81.60***	78.50***	79.73***
Voinic	9.47	12.50**	10.07**	11.30**	80.40***	82.00***	78.27***	79.73***
FDL Abund	10.10***	12.33	9.73	10.70	78.80	80.20	76.97	77.63
FDL Columna	9.73*	12.90***	10.23***	11.93***	79.80***	80.40	76.40	78.00
FDL Consecvent	10.00***	12.43*	9.37	10.80	78.20	80.40	76.57	77.77
FDL Emisar	10.40***	12.80***	9.37	10.17^{0}	78.50	79.60^{0}	76.57	77.83
FDL Evident	8.80^{0}	11.97	9.50	10.70	79.70***	80.00	77.07	77.43
Semnal	9.03	12.07	9.33	10.63	77.60^{0}	80.80	76.43	77.50
Dacic	8.60^{00}	10.67^{000}	8.73^{000}	9.90^{000}	75.00^{000}	76.80^{000}	74.13^{000}	75.70^{000}
Andrada	9.50	11.83	8.57^{000}	9.90^{000}	78.30	80.80	77.57*	79.10**
Codru	9.00	11.20^{000}	8.57^{000}	9.80^{000}	76.90^{000}	79.60^{0}	75.50^{000}	77.17^{0}
Cezara	8.90	11.20^{000}	9.13	10.00^{000}	80.20***	80.80	76.73	78.80*
T 109-12	9.00	11.70	9.33	10.13^{00}	80.60***	81.60***	77.63**	78.97**
Luminița	9.43	11.60	8.77^{00}	10.03^{00}	78.60	80.80	77.37	79.00**
T 75-16	8.60^{00}	11.30^{00}	9.30	10.43	78.60	80.80	77.27	78.80*
T 95-16	8.20^{000}	10.90^{000}	8.63^{000}	10.03^{00}	75.80^{000}	77.60^{000}	73.30^{000}	74.80^{000}
T 42-17	9.03	11.50^{0}	9.47	10.17^{0}	78.90	80.40	76.47	77.47
T 61-18	9.37	11.70	9.40	10.57	76.60^{000}	80.50	76.57	78.07
T 28-19	9.03	12.20	9.90*	11.37***	77.10^{000}	80.20	76.77	77.80
Bezostaia	10.13***	12.80***	10.47***	12.17***	79.90***	81.30**	77.97***	79.27***
Mean (Ct.)	9.25	11.94	9.44	10.69	78.47	80.36	76.73	78.00
	p 5% 0.40; p 1% 0.53; p 0.1% 0.68				p 5% 0.68; p 1% 0.90; p 0.1% 1.16			

Aside from protein content, TW acts as an essential attribute of quality for baking and milling. Because of the high correlation between GPC and TW (Table 2), TW values were higher in 2023 when GPC increased, and in 2024, TW values were lower when GPC decreased. Similar to the effect of Nitrogen fertilization on GPC, TW values were higher in F2 in comparison with F1. In 2023 best TW values had Voinic (82.0), Otilia, Ursita, T 109-12 (81.60), Bezostaia (81.30) and Glosa (81.20). In 2024 Ursita and Voinic had the best TW value (79.73), followed by Bezostaia (79.27), Otilia, Andrada (79.10) and Luminiţa (79.0) (Table 4).

CONCLUSIONS

The 24 genotypes from this study differ from each other regarding GE, and does not demonstrate a significant difference between the genotypes studied regarding G, all the genotypes registered very good G. It is reasonable to assume that a low GE does not always indicate a low G.

Growing season and nitrogen fertilization highly influenced GY and GPC. As total Nitrogen applied increased, average yields across both years also increased.

Genotype it is a significant factor in determining yield. The yield of the 24 genotypes in our two-year trial varies from one year to another despite using the same methodology.

A negative correlation has been documented in wheat breeding: higher GY is also linked to lower GPC; in 2023, when the yield was low, the GPC was high, and in 2024, when we obtained the highest yields, the GPC was low.

Growing season and wheat genotypes significantly affected TKW, this yield component was significantly different between the genotypes, though controlled by the genetic features of a specific genotype TKW perform differently in different conditions during the process of yield formation.

The nitrogen fertilization effect on GPC and on TW is evident. With the reduction in the nitrogen fertilizer application rate, the GPC decreased, in both years in F1 GPC values were lower than in F2. Therefore, the genotypes from this study necessarily require nitrogen fertilization during vegetation, even in amounts greater than 50 kg ha^{-1} as used in this experiment, in order to obtain a good percentage of GPC and a high TW value.

The genetic potential when it comes to grain yield of the new varieties and breeding lines is evident in comparison with the Bezostaia variety. Thus, showing the genetic progress of the new varieties and breeding lines. However, in terms of grain quality, some varieties like FDL Columna, FDL Emisar, Glosa have a GPC that are comparable to those recorded by Bezostaia.

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