

AGRONOMIC EVALUATION OF COMMON WHEAT VARIETIES FOR PRODUCTIVITY AND QUALITY CHARACTERISTICS

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Abstract

A field trial of five common winter wheat cultivars was conducted from 2021 to 2024 in SouthEastern Bulgaria. The experiment was carried out employing a block-plot method of design with four replications and a plot area of 15 m², following a coriander predecessor. The winter wheat varieties Asterion, Sofru, Lazuly, Avenu, and Pibrak were examined. The objective of the study was to determine and compare elements of productivity, grain yield, and some qualitative measurements of five common wheat types in southeastern Bulgaria. The results demonstrate that the assessed varieties displayed the highest values of productive structural elements in Avenu cultivar. The thousand kernel grain- and Test Weight of the Asterion variety were the highest. The grain of the Sofru cultivar had the greatest vitreousness. The Lazuly variety indicate better technological features of grain (wet gluten, dry gluten, and gluten extension), compared to the other examined common wheat varieties.

Key words: common wheat, grain yield, thousand kernel weight, test weight, gluten content.

INTRODUCTION

One of the main tasks of agriculture on a global scale is solving the food problem for feeding the world's population. Wheat occupies first place in the group of cereals. More than half of the global population utilizes it for sustenance. Its wide and diverse use is determined by the high nutritional value and the excellent taste qualities of the products obtained from it. The variety with its specific genetic predispositions has a decisive influence on the realization of the productive possibilities (Aktas et al., 2017; Mut et al., 2017; Studnicki et al., 2018). New varieties of common wheat are continually developed and introduced both domestically and internationally, assessing their productivity and adaptation to environmental circumstances (Georgieva, & Kirchev, 2020; Chamurliiski, 2019; Matev & Kirchev, 2010; Mitkov et al., 2018; Tityanov et al., 2020). Research by numerous scientists indicates that common wheat varieties exhibit varying productive capabilities throughout distinct agroecological regions of the country (Dallev & Ivanov 2015; Dimitrov et al., 2023; Manilov, 2022; Uhr et al., 2023; Uhr et al., 2021; Chipilski et al., 2022; Stoyanova et al., 2022). The appropriate selection of a variety is crucial for both yield quantity and production quality. The quality of

wheat grain encompasses a range of indices that reflect its physical state, chemical composition, and biochemical-technological properties. The values of these indicators for each variety are genetically predetermined yet affected by the agricultural practices employed, climatic conditions throughout the growing season, and the particular agro-ecological circumstances of the region (Atanasov et al., 2020; Stamatov et al., 2017; Tsenov et al., 2020; Yanev et al., 2021). Therefore, research related to the cultivation of varieties of common wheat in different regions of the country has a certain scientific and practical importance (Dimitrov et al., 2016; Kaya & Akcura, 2014; Kirchev & Delibaltova, 2016; Tsenov et al., 2022). This requires the ongoing deployment of higher quality and stronger varieties that are most suitable and effective for individual microdistricts of the country (Ilieva, 2011; Ivanova et al., 2010; Yanchev & Ivanov, 2016). The study aimed to identify and compare the productivity components, grain yield, and certain qualitative markers of five varieties common wheat in South-Eastern Bulgaria.

MATERIALS AND METHODS

The experiment was performed on a carbonate resinous soil type from 2021 to 2024 in the

region of town Elhovo, Southeastern Bulgaria. The experiment was conducted using a block design with four replications, with a crop plot size of 15 m² following the predecessor of coriander. The cultivars 'Asterion', 'Lazuly', 'Sofru', 'Avenu', and 'Pibrak' were examined. The pre-sowing soil treatment involved 2-3 passes of harrow disking. Sowing occurred at an optimal period at sowing densities of 550 g.s./m² and a seeding rate of 240-260 kg ha⁻¹. Phosphorus and Potassium fertilizers (P₁₂, K₈) were spread during the initial treatment, along with one-third of the Nitrogen fertilizer (N₅), while the remaining Nitrogen fertilizer (N₁₀) was applied as top dressing in early spring. Weed management was executed using the herbicides Derby Super (30 g ha⁻¹) and Puma Super (1 L ha⁻¹). To achieve the study's objective, the subsequent indicators were considered: grain yield (kg ha⁻¹), plant height (cm), spike length (cm), number of spikelets per spike, number of grains per spike, weight of grains per spike (g), Thousand Grain Weight (TGW) - g, Test Weight - kg, vitreousness - %, dry and wet gluten - % and relaxation of gluten - mm.

The acquired data were quantitatively analyzed employing the analysis of variance (ANOVA) method, and the differences among the variants were assessed using Duncan's multiple range test. The correlation among grain yield, productivity factors, and the physical and technological attributes of grain was established following the methodologies of Gomez & Gomez (1984) and Sokoto et al. (2012).

The main meteorological factors influencing the growth and development of wheat are the average diurnal and nocturnal temperatures, together with the amount and distribution of precipitation throughout the growing season. Throughout the three years of the study, the monthly recorded temperature values are close or slightly higher than those of the multi-year average, with no observed deviations from crop requirements (Figure 1).

The differences among the three years of the study are manifested in the rainfall distribution during the growth season. The smallest amount of precipitation was observed in the year 2023-2024 - 324 mm, with a sum for multi-year period of 432 mm, indicating that this last experimental year is less favorable to plant growth and development compared to previous

years. The 2022-2023 year of study is marked by the highest volume of precipitation for vegetation, totaling 537 mm, which is irregularly distributed and exceeds the 1961-1991 average by 104 mm, rendering this economic year very advantageous for wheat cultivation. The period most conducive to plant development is 2021-2022. This year's precipitation was evenly distributed to satisfy the crop's needs during the growing season (Figure 2).

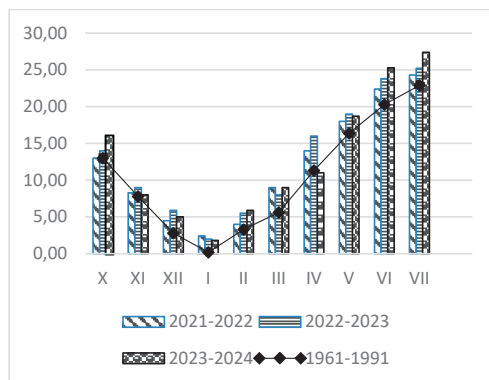


Figure 1. Average monthly air temperature, °C

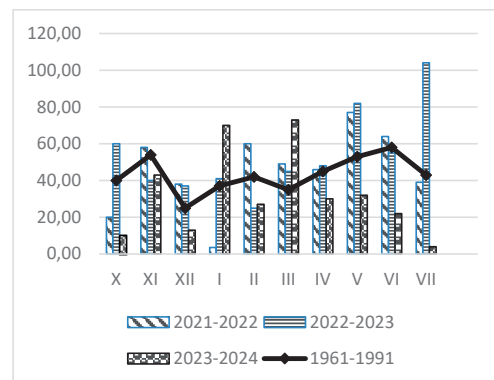


Figure 2. Rainfall, mm

RESULTS AND DISCUSSIONS

Table 1 indicates that, both annually and on average during the study period, the Avenu variety exceeds the other varieties in grain yield. The increased productivity of this variety is attributable to the superior values of the structural elements of yield. Due to improved moisture availability to plants during the growing season and the grain formation and filling period in 2021-2022, higher results were

achieved compared to 2022-2023 and 2023-2024. This year, yields range from 6040 kg ha⁻¹ for the Sofru variety to 7100 kg ha⁻¹ for the Avenu variety. In the Lazuly, Asterion, and Pibrak varieties, the yields were 400, 600, and

840 kg ha⁻¹ lower than the Avenu variety, and 660, 460, and 220 kg ha⁻¹ higher than the Sofru variety, respectively. Statistical evidence substantiates the differences among all cultivars.

Table 1. Grain yield - kg ha⁻¹

Variety	Years of study			Average for the period (kg ha ⁻¹)
	2021-2022	2022-2023	2023-2024	
Asterion	6500 ^c	5720 ^c	5600 ^b	5940
Lazuly	6700 ^b	5990 ^b	5670 ^b	6120
Sofru	6040 ^c	5390 ^c	5100 ^d	5510
Avenu	7100 ^a	6830 ^a	6320 ^a	6750
Pibrak	6260 ^d	5510 ^d	5420 ^c	5730

*Means within columns followed by different lowercase letters are significantly different (P<0.05) according to the LSD test.

During the 2022-2023 growing season, which recorded the highest precipitation levels, although less from April to June, the evaluated cultivars yielded on average of 10.7% lower than in 2021-2022. In the second experimental year, grain yields varied from 5390 kg ha⁻¹ for the Sofru variety to 6830 kg ha⁻¹ for the Avenu variety. The differences between the tested varieties have been mathematically substantiated. The lowest grain yields observed throughout the analyzed period occurred in the third experimental year (2023-2024), and were caused by insufficient moisture during the crucial stages of wheat plant growth and development. In this year, the lowest yields were

obtained from the Sofru variety - 5100 kg ha⁻¹, giving way to the varieties - Pibrak with 6.2% - Asterion with 9.8%, Lazuli with 11.2%, and for the Avenue variety with 23.9%. Over the three-year experimental period, the Avenue variety had the highest grain yield at 6750 kg ha⁻¹, followed by the Lazuli variety at 6120 kg ha⁻¹, and the Sofru variety with a yield of 5510 kg ha⁻¹. The Asterion and Pibrak cultivars yield 5940 kg ha⁻¹ and 5730 kg ha⁻¹, respectively.

The results of the variance analysis of the grain yield data of five varieties of common wheat show a significant reliable influence of the studied factors: year and variety, while the interaction between them is insignificant (Table 2).

Table 2. Analysis of variance ANOVA

Source of Variation	Sum of Square	df	Mean Square	F	P-value	F crit
Variety*	10968000	4	2742000	79.44756	0.00	2.578739
Year**	8317960	2	4158980	120.5036	0.00	3.204317
Interactions ^{ns}	527040	8	65880	1.908828	0.08	2.152133
Within	1553100	45	34513.33			

*F-test significant at P<0.05; **F-test significant at P<0.01; ns - non-significant

Owing to the unidirectional format of the data over the three-year study period, Table 3 displays the average values obtained for plant height and yield structural elements. The height of the plants partially influences the variety's resistance to lodging. Of all the varieties examined, the Pibrak variety formed the tallest plants - 103 cm, succeeded by the Asterion variety - 96.0 cm, while the Avenu variety was the shortest at 81.0 cm. The plant height of the

cultivars Lazuly and Sofru are 85.0 cm and 90.0 cm, respectively. The results obtained are statistically validated. Lodging was not observed in the investigated varieties during the investigation period. The primary structural components influencing grain yield are spike length, the number of spikes per plant, and the number and weight of grains per spike. The spike length in the examined cultivars varies from 8.3 cm in the Pibrak variety to 11.5 cm in

the Avenu variant. Statistically proven, this variety is superior in this indicator from 10.6 to 38.5% to the remaining varieties involved in the investigation. The Avenu variety exhibits the highest spikelet number - 23.0, followed by the Asterion and Lazuly cultivars with 21 and 20 spikelets, respectively, while the Sofru and Pibrak varieties have the lowest numbers at 18 and 17 spikelets. The quantity of grains per spike is of significant relevance. The Avenu variety is distinguished by the highest number of grains - 51 pieces. This cultivar surpassed Sofru, Pibrak, Asterion, and Lazuly by 34.0%, 27.0%,

18.6%, and 11.0%, respectively. The results were statistically significant, as were the differences between cultivars. In terms of the structural components of yield and the grain weight indicator values per spike, the Avenu variety outperforms the other varieties in the experiment. For this variety, an average of 1.76 g was documented during the period 2021-2024. The values for the remaining cultivars range from 1.29 g for the Sofru variety to 1.61 g for Lazuly. The disparities among the examined varieties have been mathematically proven.

Table 3. Height of plants and structural elements of the yield, average during the period 2021-2024

Variety	Height of plants (cm)	Length of spike (cm)	Number of spikelets per spike	Number of the grains per spike	Weight of the grains per spike (g)
Asterion	96.0 ^b	9.2 ^c	21.0 ^b	43.0 ^c	1.53 ^c
Lazuly	85.0 ^d	10.4 ^b	20.0 ^b	46.0 ^b	1.61 ^b
Sofru	90.0 ^c	8.5 ^d	18.0 ^c	38.0 ^c	1.29 ^c
Avenu	81.0 ^c	11.5 ^a	23.0 ^a	51.0 ^a	1.76 ^a
Pibrak	103.0 ^a	8.3 ^d	17.0 ^c	40.0 ^d	1.48 ^d
<i>LSD5%</i>	<i>3.84</i>	<i>1.11</i>	<i>1.86</i>	<i>2.46</i>	<i>0.13</i>

*Means within columns followed by different lowercase letters are significantly different (P<0.05) according to the LSD test.

The findings on the physical and technical features of the grain are displayed in Table 4. The TGW acts as an indicator of the grain's size, technological worth, and quality as seed material. The results indicate that the advantageous meteorological circumstances during the wheat growing season in the economic year 2022 resulted in higher values for this indicator compared to the other variables included in the experiment. The Asterion variety produces the largest grain at 51.6 g, followed by Lazuly and Pibrak at 48.0 g and 47.2 g, respectively, while the Sofru variety yields the smallest grain at 37.2 g. The differences among the examined cultivars were statistically confirmed. In the economic year 2022-2023, the TGW for the Sofru variety is 34.7 g, while for the Asterion variety, it is up to 46.0 g. Mathematical evidence demonstrates that the Asterion variety exhibits the greatest values of this indicator, while the Sofru variety displays the lowest. The distinctions among the other variations remain unproven. The drought and higher temperatures during grain formation and maturation in the previous research year (2023-2024) adversely affected grain size. The Sofru

variety exhibited the lowest weight per TGW at 32.0 g, succeeded by Avenu at 39.5 g, and the Pibrak and Lazuly at 41.0 g and 41.6 g, respectively. Statistically, the Asterion variety surpassed these by 3.6% and 34.7%. During the period from 2021 to 2024, the Asterion variety is distinguished by having the largest grain, followed by the Lazuly, Pibrak, Avenu, and Sofru varieties.

Test Weight is the commercial indicator of grain and plays an important role in determining the selling price. The values of this indicator for the tested varieties were the lowest in the 2024 business year compared to 2023 and 2022. The test weight in the last year of study ranged from 71.6 for the Avenu variety up to 75.0 in Asterion variety. During the first and second experimental years, the Test Weight values varied from 73.0 to 78.2 in 2023 and from 75.0 to 81.9 in 2022. During the experimental period, the Asterion variety exhibited the highest test weight of grain at 78.4, while the Avenu and Sofru variety recorded the lowest at 74.2 kg.

The overall vitreousness of the grain is an important indicator of the quality of the wheat grain. The highest percentage of vitreousness

from 69.3 to 84.6% in the studied varieties was reported in the economic year 2024, when the amount of precipitation was insignificant during the growing season. Lower values of this indicator for the tested varieties were reported in the 2023 harvest year, which can be accounted for by most of the precipitation during the wheat growing season. The percentage of vitreousness in the varieties is from 63.0% in the Avenue

variety to 77.5% in the Sofru variety. The vitreousness of the grain in the initial experimental year across the evaluated cultivars ranged from 67.1% to 83.0%. During the research period, the Sofru variety surpassed the Avenue, Pibrak, Lazuli, and Asterion varieties in total grain vitreousness by 22.8%, 11.2%, 10.5%, and 4.4%, respectively.

Table 4. Physical and technological properties of the grain

Variable		TGW (g)	Test Weight (kg)	Vitreousness (%)	Wet gluten content (%)	Dry gluten content (%)	Gluten Extension (mm)
Years (A)	2021-2022	45.8 ^a	77.7 ^a	75.7 ^b	23.2 ^b	7.9 ^b	8.5 ^b
	2022-2023	41.5 ^b	75.2 ^b	71.1 ^c	21.7 ^c	6.9 ^c	10.2 ^a
	2023-2024	39.4 ^c	73.1 ^c	77.5 ^a	25.7 ^a	8.7 ^a	7.7 ^c
Variety (B)	Asterion	47.0	78.4	78.2	22.9	7.4	7.9
	Lazuly	44.0	75.8	73.9	27.2	9.7	6.6
	Sofru	34.6	74.1	81.7	22.0	7.1	8.9
	Avenu	42.0	74.2	66.5	20.2	6.7	11.0
	Pibrak	43.7	75.1	73.5	25.2	8.5	9.6
2021-2022	Asterion	51.6 ^a	81.9 ^a	78.8 ^b	23.0 ^{b c}	7.6 ^c	7.3 ^d
	Lazuly	48.0 ^b	78.5 ^b	75.0 ^c	26.0 ^a	9.6 ^a	6.5 ^c
	Sofru	37.2 ^d	76.2 ^c	83.0 ^a	22.1 ^c	7.5 ^c	8.8 ^c
	Avenu	45.0 ^c	75.0 ^d	67.1 ^d	20.7 ^d	6.9 ^d	10.4 ^a
	Pibrak	47.2 ^b	76.8 ^c	74.5 ^c	24.0 ^b	8.2 ^b	9.7 ^b
2022-2023	Asterion	46.0 ^a	78.2 ^a	74.6 ^b	21.3 ^c	6.5 ^c	9.5 ^c
	Lazuly	42.5 ^b	76.0 ^b	70.2 ^c	25.4 ^a	8.4 ^a	7.4 ^d
	Sofru	34.7 ^c	73.6 ^c	77.5 ^a	20.8 ^c	6.2 ^c	10.0 ^c
	Avenu	41.4 ^b	73.0 ^c	63.0 ^d	18.0 ^d	5.6 ^d	13.2 ^a
	Pibrak	43.0 ^b	75.0 ^b	70.0 ^c	22.8 ^b	7.8 ^b	11.0 ^b
2023-2024	Asterion	43.1 ^a	75.0 ^a	81.2 ^b	24.5 ^c	8.0 ^c	7.1 ^d
	Lazuly	41.6 ^b	73.0 ^b	76.5 ^c	30.2 ^a	11.0 ^a	6.0 ^c
	Sofru	32.0 ^d	72.5 ^{b c}	84.6 ^a	23.0 ^d	7.7 ^c	7.9 ^c
	Avenu	39.5 ^c	71.6 ^c	69.3 ^d	22.0 ^d	7.5 ^c	9.5 ^a
	Pibrak	41.0 ^b	73.4 ^b	76.0 ^c	28.9 ^b	9.5 ^b	8.1 ^b
Anova	A	*	*	**	*	*	*
	B	**	*	*	**	**	**
	AB	*	*	ns	*	*	*

*Means within columns followed by different lowercase letters are significantly different (P<0.05) according to the LSD test.

*F-test significant at P<0.05; ** F-test significant at P<0.01; ns - non-significant.

The two-factor variance analysis of the grain's physical properties indicates that both the genetic predisposition of the varieties and the specific climatic conditions of the year show a statistically significant influence on the TGW, Test Weight, and total vitreousness. The interaction between the two factors (Variety x Year) has been statistically proven for the indicators of weight per 1000 grains (η 46) and test weight (η 52), whereas it is not significant for total vitreousness. The results obtained regarding the technological properties of the grain in the tested varieties over three years of research indicate that the wet gluten content is lowest in the Avenu variety, with values of 22.0%, 18.0%, and 20.7%, and highest in the Lazuli variety, with values of 30.2%, 25.4%, and 26.0% for the economic years 2022, 2023, and 2024, respectively. The results were statistically significant over all three years of the study. During the period from 2021 to 2024, the experimental varieties produced grains with wet gluten percentages of 7.9%, 18.8%, and 23.6% for the Pibrak, Asterion, and Sofru varieties, respectively, while the Avenu variety exhibited a percentage of 34.6%, all of which were inferior to that of the Lazuly variety. In the dry and warm year 2024, the content of both dry and wet gluten exhibits the highest proportion compared to other years. In the evaluated variations, this parameter ranges from 7.5% (for the Avenu variety) to 11.0% (for the Lazuly variety). During the second trial year, the dry gluten content exhibited its lowest values, ranging from 5.6% to 8.4%, whereas in the economic year 2022, it ranged from 6.9% to 9.6%. During the study period, the Lazuly variety exhibited the highest average percentage of dry gluten at 9.7%, while the Avenu variety had the lowest at 6.7%, with statistically significant differences between them. The gluten relaxation indicator shows that the data for the year that has more precipitation (2022-2023) for the investigated varieties exhibit slightly higher values compared to 2023-2024 and 2021-2022, ranging from 7.4

to 13.2 mm. This year, the Lazuly variety had the lowest gluten relaxation, succeeded by the Asterion and Sofru variety, while the Avenu variety demonstrated the highest gluten relaxation. In the years 2023-2024 and 2021-2022, the values of this indicator ranged from 6.0 to 9.5 mm and from 6.5 to 10.4 mm, respectively, with the lowest confirmed values recorded for the Lazuly variety. The average data for the three-year period indicates that the variety Lazuly demonstrates the lowest level of gluten relaxation at 6.6 mm, followed by Asterion at 7.9 mm, Sofru at 8.9 mm, Pibrak at 9.6 mm, and Avenu at 11.0 mm. The analysis of variance results indicated that the variety had the most significant impact on the levels of wet gluten, dry gluten, and gluten extension (Table 4). The year with the specific meteorological conditions demonstrably affects the values of these indicators. The interactions between the examined parameters are significant for all the analyzed technological properties of the grain. In the correlation analysis between grain yield, structural elements and grain quality indicators, a very high correlation dependence ($r > 0.9$) was found between the following indicators: grain yield and spike length; number of grains per spike and grain yield; grain weight per spike and grain yield; the length of spike and number of spikelets per spike; number of grains per spike and spike length; number of spikelets per spike and number of grains per spike; wet and dry gluten content (Table 5). High positive values of r ($r > 0.8$) are reported between grain yield and number of spikelets per spike; spike length and spike weight; number of spikelets per spike and grain weight per spike. Average correlation dependencies exist between indicators: Test Weight and TGW ($r = 0.745$); TGW and grain weight per spike ($r = 0.514$). Weak correlation dependences ($r > 0.3$) were reported between grain yield and TGW; grain yield and gluten extension; plant height and vitreousness; TGW and number of grains per spike; vitreousness and wet gluten content.

Table 5. Values of the coefficient of correlation

	1. Grain yield	2. Height of plant	3. Length of spike	4. Nr of spikelets per spike	5. Nr of grains per spike	6. Weight of grains per spike	7. TGW	8. Test Weigh	9. Vitreousness	10. Wet gluten content	11. Dry gluten content	12. Gluten extension
1.	1											
2.	-0.684	1										
3.	0.954	-0.853	1									
4.	0.897	-0.739	0.901	1								
5.	0.989	-0.723	0.977	0.902	1							
6.	0.959	-0.524	0.891	0.811	0.965	1						
7.	0.322	0.193	0.214	0.269	0.354	0.514	1					
8.	-0.165	0.281	-0.172	-0.011	-0.118	-0.046	0.745	1				
9.	-0.807	0.364	-0.697	-0.552	-0.775	-0.829	-0.345	0.161	1			
10.	-0.277	0.272	-0.209	-0.399	-0.191	-0.079	0.181	0.042	0.308	1		
11.	-0.171	0.153	-0.087	-0.319	-0.081	0.016	0.228	0.055	0.242	0.969	1	
12.	0.317	-0.041	0.149	0.191	0.203	0.201	-0.138	-0.291	-0.599	-0.793	-0.781	1

*significance level $\alpha = 0.05$.

CONCLUSIONS

The studied common wheat varieties - Asterion, Lazuly, Sofru, Avenu, and Pibrak - exhibit no tendency for lodging. In the research period (2021-2024), the Avenu variety achieved the highest grain yields at 6750 kg ha⁻¹, surpassing other varieties by 10.3 to 22.5% in term of yield, due to the higher values of its structural elements. Throughout the study period, common wheat varieties in South-Eastern Bulgaria formed a grain, the values of the indicators - TGW and Test Weight were the highest in the Asterion variety (47.0 g and 78.4 kg). The Sofru variety showed the highest vitreousness percentage at 81.7%, while the Avenu variety displayed the lowest at 66.5%. The analyzed technological properties of the grain (wet gluten, dry gluten, and gluten extension) in the evaluated common wheat varieties exhibit the best results in the Lazuly variety (27.2%, 9.7%, and 6.6 mm).

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