

ASSESSMENT OF GRAIN TECHNOLOGICAL QUALITIES
OF NEWLY ORIGINATED COMMON WINTER WHEAT
(*TRITICUM AESTIVUM* L.) LINES

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Received on July 28, 2025

Presented by H. Najdenski, Member of BAS, on September 30, 2025

Abstract

Common wheat (*Triticum aestivum* L.) is the most widely grown and consumed cereal crop for the majority of the world's population. The most important issue in breeding studies is the development of high yielding varieties with high grain quality. The main objective of the present study was to assess grain technological qualities of eleven newly originated common winter wheat lines and to establish the traits phenotypic variability and correlations between them. For three years (2018–2020), main physical properties and quality characteristics of the grain were determined in the grain quality testing laboratory of the Institute of Agriculture and Seed Science “Obraztsov chiflik”. Regarding physical properties, AL-3, AL-5 and AL-9 had the highest 1000-kernel weight, while the highest test weight in AL-7 and AL-8 was observed. The best results for wet gluten yield in AL-4 (21.2%) and AL-2 (21.0%) lines were found. AL-2 line was also distinguished by the highest rate of gluten release and gluten extensibility, while the highest bread-making strength index and sedimentation value were ascertained in AL-4. AL-2 and AL-4 lines can be used as a genetic source in wheat breeding for varieties with improved grain quality creation. Significant positive correlations ($r = 0.576$) was found between 1000-kernel weight and test weigh, as well as between gluten release and gluten extensibility ($r = 0.643$).

Key words: wheat, lines, physical properties, quality characteristics, correlations

Introduction. Common wheat (*Triticum aestivum* L.) is the most widely grown and consumed cereal crop for the majority of the world's population. It contributes substantially to national food security by providing more than 50% calories to the people who mainly depend on wheat [1].

The most important issue in breeding studies is the development of high yielding varieties resistant to biotic and abiotic stresses [2]. In addition to increasing the productive potential of newly created varieties, another main goal in breeding programmes is to improve the grain quality [3]. Wheat breeding materials have been evaluated for high quality in terms of protein content, gluten content, sedimentation value, test weight, bread-making strength, etc.

Worldwide, under different soil and climatic conditions studies on the grain technological qualities in wheat varieties and lines have been conducted aiming at selection of valuable genetic material for breeding process [4–6]. The wheat grain quality is a set of technological, biochemical, bread-making and nutritional properties that determine the biological value of wheat [7]. According to ZEČEVIĆ et al. [8], grain quality is a complex characteristic that depends on a number of traits, and the individual contribution of each trait varies depending on specific reaction to environmental conditions. For an effective selection for a particular trait, it is important to define the conditions of its maximum phenotypic expression [9].

Traditionally, wheat as the main and most important crop for our country is represented by rich and very dynamic varieties composition in the recent years [10]. A lot of data has been cumulated by our researchers to clarify the theoretical basis of breeding for quality [11, 12].

The main objective of the present study was to assess grain technological qualities of eleven newly originated common winter wheat lines and to determine magnitude of traits phenotypic variability and correlation nature and degree between them. The ultimate goal of investigation was to predict the lines' potential as appropriate genetic source for new wheat variety breeding with improved grain quality.

Material and methods. The field trial was carried out on experimental field of Institute of Agriculture and Seed Science “Obraztsov chiflik”, Rousse from 2018 to 2020. Experimental design was a completed block with three replications and harvesting plot size of 10 m².

The assessment of the technological qualities of 11 common winter wheat lines was conducted in a grain quality test laboratory of the Institute. Over three-year study period, the following qualitative characteristics were determined:

- The 1000-kernel weight/absolute kernel mass (TKW/AKM, g) was accounted by weighing two samples of 500 grains (BDS ISO 520:2003);
- Test weight (TW, kg hl) – Mass (kg) and grain volume (hl) ratio, according to (BDS EN ISO 7971-1:2009). When applying the method in accordance

with the requirements a feed meter (cylinder with a capacity of 1 L) for the measurements was used;

- Sedimentation value (SV) was determined according to BDS 13489:1986;
- Wet gluten yield (WGY, %) was estimated by the hand washing method according to BDS EN ISO 21 152:2008;
- Gluten release (GR, mm) and bread-making strength index (BMSI) were determined according to BDS 13375:1988 [13];
- Gluten extensibility (GE, %) was accounted according to BDS 13375:1988.

Means for each evaluated qualitative trait were compared using One-way analysis of variance (ANOVA), and the significance of differences between wheat lines were detected by LSD test at 0.05% confidence level.

The degree of traits variation among wheat lines was determined through variation coefficient (CV) according to the scale of MAMAEV [14]: up to 7% – very low, 7.1 to 12% – low, 12.1 to 20% – moderate, 20.1 to 40% – high; over 40% – very high.

To identify the traits that are main source of total variability among the lines the principal component analysis (PCA) was applied.

The correlations between qualitative characteristics studied were established by correlation analysis (Pearson's correlation coefficient, r). The recorded data were analyzed using STATGRAPHICS Plus software.

Results and discussion. The results of analysis of variance for all characteristics from the means of three years are presented in Table 1.

The 1000-kernel weight is a variety trait and one of the most important indirect traits characterizing the grain size, its milling quality (relative endosperm content, potential flour yield with low ash content) and its quality as a seed material [10, 12, 15]. As STASYUK et al. [16] pointed out, absolute grain mass is a stable genotypic trait that is used as a morphological marker and is yield determinant. Data showed that 1000-kernel weight ranged from 40.4 g (AL-3 and AL-9) to 36 g (AL-1). There were non-significant differences among wheat lines, with the exception of AL-1 distinguishing with the lowest kernel absolute mass. Similar values were reported by VASILEVA et al. [17] who detected that 1000-kernel weight ranged from 48.57 to 34.38 g.

Data revealed that the test weight varied in narrow range (from 76.7 to 74.1 kg hl^{-1}) and differences between wheat lines were insignificant. The results were in agreement with values reported by MITURA et al. [15] when studying four spring varieties of common wheat at different farming systems (organic, integrated and conventional). The authors pointed out that TW of wheat grain intended for food processing should be no less than 72.0 kg hl^{-1} .

T a b l e 1

Means of the investigated technological qualities of eleven common winter wheat lines, 2018–2020

Wheat line	Physical properties				Quality characteristics									
	TKW, g	% to mean	TW, kg hl ⁻¹	% to mean	WGY, %	% to mean	GR, mm	% to mean	BMSI	% to mean	SV, cm ³	% to mean	GE, mm	% to mean
AL-1	36.0 ^b	91.6	74.4 ^{ns}	99.2	20.3 ^{abc}	104.8	7.8 ^a	140.5	46.7 ^{cd}	88.4	25.0 ^{bcd}	93.2	96.7 ^{ab}	104.4
AL-2	39.1 ^a	99.6	75.1 ^{ns}	100.1	21.0 ^{ab}	108.6	8.0 ^a	143.5	41.7 ^d	79.0	21.7 ^{cd}	80.9	103.3 ^a	111.6
AL-3	40.4 ^a	102.9	75.4 ^{ns}	100.5	19.3 ^{abc}	99.8	6.3 ^b	113.6	49.3 ^{bcd}	93.4	25.3 ^{bcd}	94.3	91.7 ^b	99.0
AL-4	38.6 ^a	98.3	74.9 ^{ns}	99.9	21.2 ^a	109.5	4.3 ^{de}	77.7	59.7 ^a	113.1	34.0 ^a	126.8	88.3 ^b	95.4
AL-5	40.3 ^a	102.7	75.3 ^{ns}	100.5	17.1 ^c	88.3	3.8 ^e	68.7	56.0 ^{abc}	106.1	24.7 ^{bcd}	92.1	90.0 ^b	97.2
AL-6	39.2 ^a	99.9	73.6 ^{ns}	98.2	17.4 ^{bc}	89.8	4.5 ^{de}	80.7	57.0 ^{ab}	108.0	26.3 ^{bcd}	98.1	90.0 ^b	97.2
AL-7	39.7 ^a	101.1	75.7 ^{ns}	101.0	19.8 ^{abc}	102.2	5.5 ^{bcd}	98.7	55.0 ^{abc}	104.2	35.3 ^a	131.6	91.7 ^b	99.0
AL-8	39.5 ^a	100.6	76.7 ^{ns}	102.1	18.2 ^{abc}	93.8	5.0 ^{bcd}	89.7	54.7 ^{abc}	103.7	21.0 ^d	78.3	93.3 ^{ab}	100.8
AL-9	40.4 ^a	102.9	75.2 ^{ns}	100.3	19.8 ^{abc}	102.1	6.0 ^{bc}	107.6	54.0 ^{abc}	102.3	29.0 ^{abc}	99.6	96.7 ^{ab}	104.4
AL-10	40.1 ^a	102.1	74.1 ^{ns}	98.9	18.6 ^{abc}	96.2	4.7 ^{cde}	83.8	54.7 ^{abc}	103.7	24.0 ^{bcd}	89.5	90.0 ^b	97.2
AL-11	38.7 ^a	98.4	74.5 ^{ns}	99.3	20.3 ^{abc}	104.8	5.33 ^{bcd}	95.6	51.7 ^{abc}	98.0	31.0 ^{ab}	115.6	86.7 ^b	93.6
Mean	39.29		74.98		19.37		5.57		52.77		26.82		92.58	
LSD _{0.05}	2.28		5.98		3.7		1.39		9.86		7.42		10.1	
SD	1.28		0.81		1.39		1.37		5.13		4.68		4.73	
CV, %	3.25		1.08		7.16		24.52		9.72		17.46		5.11	

Values within columns followed by different letter are significantly different at $P \leq 0.05$

TKW – Thousand kernel weight, **TW** – Test weight, **WGY** – Wet gluten yield, **GR** – Gluten release, **BMSI** – Bread-making strength index, **SV** – Sedimentation value, **GE** – Gluten extensibility

The values obtained for wet gluten yield indicated the lines exhibited different potential, as the differences between them were statistically significant ($P \leq 0.05$). It was determined that the wet gluten content was relatively low. Among the lines studied the highest WGY (21.2%) was recorded in AL-4, followed by AL-2 (21.0%). AL-5 line ranked last with mean value of 17.1% for the trait.

Significant differences were established between studied lines regarding gluten release, as they were classified into five homogenous groups. The maximum values for the trait in AL-2 and AL-1 were 8 and 7.8 mm, respectively. The differences vs. the other lines were statistically significant. AL-5 line was distinguished with minimum value (3.7 mm).

The averaged data for three-year study period show that bread-making strength had the highest value (59.7) in AL-4 line, and the lowest one in AL-2 (41.7) with statistically significant difference between them. The values established for the other lines were close and the differences were statistically insignificant. Nevertheless, it is evident that six lines exceeded mean value (52.77).

The sedimentation value is recognized as the main quality property of the grain and it is a highly heritable trait [18]. The highest value of the sedimentation rate (35.3 cm^3) was found for line AL-7, while the grain from line AL-8 was characterized by significantly lower value. High sedimentation values were also ascertained in AL-4 and AL-11, exceeding the mean for the lines by 26.8 and 15.6%, respectively.

Gluten quality is an important index of the bread-making potential and is characterized by the degree of extensibility which is one of the most common measurements used [13, 19]. In the present study, gluten extensibility values were in a wide range. Analysis of variance data indicated the AL-2 line characterized by the highest (103.3 mm) gluten extensibility, significantly exceeding the other lines, except for AL-1, AL-8 and AL-9, while line AL-9 had the least (86.7 mm) extensible gluten.

Among the technological qualities very low phenotypic variability was ascertained for TW (CV = 1.08%) and TKW (CV = 3.25%), whereas GR exhibited the highest variation (CV = 24.52%) (Table 1). It was also found that SV showed moderate variability (CV = 17.46%). The results are in agreement with the findings of IVANOV [7] that TW and TKW are weakly variable traits, while GR and SV varied strongly.

The results of Principal component analysis performed are presented in Table 2. Data showed that three main components (PC1, PC2 and PC3) gave Eigen values greater than 1.0 and explained 78.33% of the total variability among the lines for all investigated traits. The first PC, which is the most important component, accounted for 37.89% of the total variability. According to the corresponding eigenvector values it mostly resulted from the variation of traits gluten release (-0.545), bread-making strength (0.507) and gluten extensibility (-0.483). The second main component (PC2) justified 23.80% of the total variability and

T a b l e 2

Principal component analysis (PCA) of basic technological qualities

Physicochemical traits	Component		
	PC1	PC2	PC3
1000-kernel weight	0.313	0.458	0.234
Test weight	0.153	0.699	−0.076
Wet gluten yield	−0.220	0.233	− 0.768
Gluten release	− 0.545	0.003	0.024
Bread-making strength index	0.507	0.069	−0.319
Sedimentation value	0.202	−0.362	− 0.489
Gluten extensibility	− 0.483	0.331	−0.088
Eigenvector value	2.65	1.67	1.65
% of variance	37.89	23.80	16.65
Cumulative percentage	37.89	61.68	78.33

was correlated with the variation in test weight (0.699) and 1000-kernel weight (0.458). The PC3, accounted for 16.65% of the total variability and was mostly associated with quality traits such as wet gluten yield (−0.768) and sedimentation value (−0.489). Therefore, the traits falling to first PC may be given attention in wheat quality improvement programmes.

The distribution of the lines, according to their values for the first, second and third components, is presented in Table 3. The first main component included three lines two of which (AL-1 and AL-2) were negatively associated with PC1. The positive value (1.901) of PC1 was found for AL-5. It was established that

T a b l e 3

Distribution of the eleven common winter wheat lines for the first, second and third components

Lines	Component		
	PC1	PC2	PC3
AL-1	− 2.884	−1.295	−1.147
AL-2	− 3.798	0.743	0.217
AL-3	−0.385	0.780	0.451
AL-4	1.384	− 2.135	0.878
AL-5	1.901	1.451	−0.322
AL-6	1.543	−0.054	− 1.915
AL-7	0.716	−0.810	1.659
AL-8	0.369	1.791	0.720
AL-9	−0.318	0.567	0.686
AL-10	1.032	0.383	− 1.506
AL-11	0.437	− 1.599	−0.123

T a b l e 4

Relationships between analyzed parameters

	TKW	TW	WGY	GR	BMSI	SV	GE
TKW	1						
TW	0.576**	1					
WG	-0.225	0.208	1				
GR	-0.325*	-0.160	0.235	1			
BMSI	0.247	0.290*	-0.018	-0.759**	1		
SV	0.030	-0.246	0.068	-0.129	0.263	1	
GE	-0.150	0.135	0.418*	0.643**	-0.508**	-0.358*	1

the second main component was represented by four lines, as AL-8 was positively connected (1.788) to PC2. Negative connection to PC2 was found for AL-3, AL-9 and AL-11. PC3 included the lines AL-6, AL-7 and AL-10.

The wheat grain quality parameters were assessed by correlation analysis, too. Correlation coefficients calculated for determining the relations between the studied characteristics are presented in Table 4.

Significant positive correlation ($r = 0.576$) was found between 1000-kernel weight and test weight. The phenotypic correlation coefficients revealed that 1000-kernel weight was negatively related with wet gluten content ($r = -0.225$) and gluten release ($r = -0.325$). A similar result was reported by ANGELOVA et al. [20], where five Hungarian varieties (MVNador, MV-Nemere, MV-Menrot, MVMente, MV-Kaplar) and two Bulgarian varieties (Sadovo 1, Enola) grown in the Central South Bulgaria region were evaluated. A statistically significant positive correlation ($r = 0.643$) was found in wheat lines for the gluten release and gluten extensibility whereas, gluten release was strongly but negatively related ($r = -0.759$) with bread-making strength. The bread-making strength was determined to be negatively correlated ($r = -0.508$) with gluten extensibility. Furthermore, there was lack of relationships of sedimentation value and with both 1000-kernel weight and gluten release. Similar results were reported by SOUROUR et al. [2].

Conclusions. Regarding physical properties, AL-3, AL-5 and AL-9 had the highest 1000-kernel weight, while the highest test weight in AL-7 and AL-8 was observed. The best results for wet gluten yield were found in lines AL-4 (21.2%) and AL-2 (21.0%). AL-2 line was also distinguished by the highest rate of gluten release and gluten extensibility, while the highest bread-making strength index and sedimentation value were ascertained in AL-4. The results revealed that AL-2 and AL-4 lines can be used as a genetic source in breeding programmes for wheat varieties with improved grain quality creation.

The very low phenotypic variability was found for TW (CV = 1.08%) and TKW (CV = 3.25%), whereas GR exhibited the highest variation (CV = 24.52%).

The results indicated that three main components (PC1, PC2 and PC3) explained 78.33% of the total variability among the lines for all investigated traits. The first PC accounted for 37.89% of the total variability and it mostly resulted from the variation of gluten release (-0.545), bread-making strength (0.507) and gluten extensibility (-0.483).

Significant positive correlation was found between 1000-kernel weight and test weigh ($r = 0.576$). A statistically significant positive correlation ($r = 0.643$) was also found for gluten release and gluten extensibility whereas, gluten release was strongly but negatively related ($r = -0.759$) with bread-making strength.

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