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YIELD AND QUALITY PERFORMANCE OF NEW SPRING WHEAT GENOTYPES UNDER CENTRAL MOLDAVIA PEDOCLIMATIC CONDITIONS

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Abstract. *The development of high-yielding spring wheat genotypes with improved grain quality is an important objective of wheat breeding programs. This study evaluated the grain yield and quality characteristics of 23 spring wheat genotypes under the pedoclimatic conditions of the Agricultural Research and Development Station (ARDS) Secuieni, Romania, in 2026. The experimental material included five registered varieties and 18 promising breeding lines developed at ARDS Turda. The field experiment was arranged in a balanced square lattice design with three replications. The assessed traits included grain yield, thousand-kernel weight, hectolitre weight, grain protein content, wet gluten content, Zeleny sedimentation index, and dough deformation energy. Mean grain yield was 6,054 kg ha^{-1}, with the highest values recorded for T. 4183-19 (6,846 kg ha^{-1}), T. 2925-20 (6,649 kg ha^{-1}), and T. 2639-22 (6,502 kg ha^{-1}). The highest thousand-kernel weight was observed in T. 4194-19 (35.7 g), while T. 4183-19 and T. 4162-19 recorded the highest hectolitre weights, at 78.8 and 78.1 kg hL^{-1}, respectively. Mean grain protein and wet gluten contents were 13.2% and 26.6%, respectively. Among the promising lines, T. 2601-22 and T. 2928-20 showed favorable combinations of protein and wet gluten contents. The mean Zeleny index was 53.6 mL, although dough deformation energy varied considerably among genotypes. Overall, the results identified several promising lines combining high grain yield with favorable physical or technological quality traits. These genotypes need to further evaluation across years and locations to assess the stability of their performance and their suitability for future variety development under diverse growing conditions.*

Keywords: *genotype, grain yield, protein content, spring wheat*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops worldwide, providing a substantial proportion of the energy and protein consumed by humans (KALID et al., 2023). Its widespread cultivation is supported by the versatility of wheat grain, which can be processed into a broad range of food products, particularly bread, pasta, biscuits, and other bakery products. In addition to its nutritional importance, wheat plays a major role in agricultural economies and food security. Maintaining and improving wheat productivity and grain quality therefore remain central objectives of crop improvement programs, particularly in the context of increasing climatic variability and the need for sustainable agricultural production (ELBASYONI et al., 2026).

Spring wheat represents an important component of wheat production in regions where climatic conditions, sowing opportunities, or crop rotation requirements favor spring establishment. Compared with winter wheat, spring wheat generally has a shorter growing cycle and does not require the prolonged overwintering period characteristic of winter forms. These features allow it to be integrated into specific cropping systems and provide flexibility in agricultural planning. However, its shorter development period may also expose the crop to

high temperatures and water deficits during stem elongation, flowering, and grain filling, depending on the sowing date and regional climate. Consequently, the successful cultivation of spring wheat depends on the availability of genotypes capable of combining high yield potential with appropriate adaptation to local environmental conditions.

Grain quality is a particularly important consideration in spring wheat breeding (KALID et al., 2023; YAO et al., 2024). In some wheat classes, especially hard red spring wheat, grain protein concentration and several technological characteristics relevant to breadmaking may be higher than those of hard red winter wheat. MAGHIRANG et al. (2006) reported differences between these two wheat classes in a range of kernel, milling, flour, dough, and baking characteristics. Nevertheless, this advantage should not be regarded as universal, because grain quality is influenced by genetic background, environmental conditions, nitrogen availability, and crop management. Recent comparative research also indicates that the genetic basis of grain protein accumulation is largely shared between spring and winter wheat, despite differences in development and growing conditions (KISELEVA et al., 2025; SHANG et al., 2026). Therefore, the quality of spring wheat should be evaluated using measurable physical and technological parameters rather than growth habit alone.

Grain yield is a complex quantitative trait resulting from the combined contribution of several yield components, principally the number of productive spikes per unit area, the number of grains per spike, and the average grain weight. Thousand-kernel weight (TKW) is a widely used indicator of grain size and filling, whereas hectolitre weight provides information about bulk density and is commonly used in commercial grain assessment. Although these traits contribute to yield formation and grain value, their relationships are not necessarily consistent across genotypes and environments. Selection based on a single yield component may therefore fail to identify genotypes that combine high productivity with desirable grain characteristics. Multi-trait assessment is essential for identifying breeding material that meets both agronomic and processing requirements.

Grain quality is equally important when evaluating the suitability of wheat for food processing. Protein content and wet gluten content are important indicators of the composition of wheat grain and its potential technological value (SONG et al., 2026; SHAOHUA et al., 2024). However, protein quantity alone does not fully determine baking performance, since gluten functionality also depends on protein composition and the interactions between its constituent fractions. The Zeleny sedimentation index provides an indirect assessment of gluten-related properties, while dough deformation energy characterizes dough strength under specified testing conditions. Together with hectolitre weight and TKW, these indicators provide a more comprehensive description of grain quality and help distinguish genotypes with different end-use potential (MAGHIRANG et al., 2006; KISELEVA et al., 2025).

The identification of high-performing genotypes adapted to a particular agroecological area is a fundamental task of wheat breeding (YAN et al., 2019). Genotypic differences in productivity and grain quality may be substantial, while environmental conditions can modify both trait expression and the relationships among traits. Multi-environment studies have demonstrated that genotype, environment, and genotype × environment interaction can influence grain yield and quality, meaning that the most productive genotype in one location may not necessarily maintain the same advantage elsewhere (GÜNGÖR et al., 2022; TSENOV et al., 2023). Consequently, evaluating promising breeding lines under the specific soil and climatic conditions of the target region is necessary to identify material with practical value for local agriculture. Such evaluations can also reveal complementary strengths among genotypes, supporting selection for improved productivity without neglecting grain quality.

In this context, the present study aimed to evaluate grain yield and selected physical and technological quality traits in 23 spring wheat genotypes, including registered varieties and promising breeding lines developed at the Agricultural Research and Development Station Turda, under the pedoclimatic conditions of ARDS Secuieni, Romania. The study focused on identifying genotypes with favorable performance for grain yield, thousand-kernel weight, hectolitre weight, grain protein content, wet gluten content, Zeleny sedimentation index, and dough deformation energy. The results are intended to support the selection of promising breeding material for further testing and to contribute to the development of spring wheat genotypes combining high productivity with suitable grain quality under the conditions of central Moldavia.

MATERIAL AND METHODS

Experimental Site and Soil Characteristics

The field experiment was conducted in 2026 at the Agricultural Research and Development Station (ARDS) Secuieni, Romania. The experimental site is located on the second terrace of the Siret River, on a typical cambic Phaeozem (cambic chernozem) soil with medium texture (CARABULEA est al., 2022). Soil analyses indicated moderate nitrogen availability, with an IN value of 2.1, and medium organic carbon and humus contents of 1.55% and 2.67%, respectively. The soil was very well supplied with available phosphorus (PAL: 112.9 mg kg^{-1} soil) and potassium (KAL: 261.9 mg kg^{-1} soil). Magnesium (201.6 mg kg^{-1}), mobile sulfur (16.3 mg kg^{-1}), iron (43.5 mg kg^{-1}), and copper (3.3 mg kg^{-1}) were present at levels classified as adequate according to the soil analysis report. In contrast, zinc availability was low (1.2 mg kg^{-1}), while the reported boron and molybdenum indicators were 17.6 µg kg^{-1} and 6.2, respectively. Soil reaction was moderately acidic, with a pH of 5.79 measured in water, and the soil was classified as non-saline, with an electrical conductivity of 66.9 µS cm^{-1}.

The biologic material consists in 23 spring wheat genotypes with different origin- five homologated varieties: Pădureni; Feeling, Ciprian, Lennox and Feleacu, respectively 18 perspective spring wheat lines created at ARDS Turda (table 1).

Table 1

Origin of the genotype and year of registration

No.	Name of genotype	Year of release and breeding origin	No.	Name of genotype	Year of release and breeding origin
V 1.	Pădureni	1973- ARDS Turda, Romania	V 13.	T. 4194-19	Perspective spring wheat line
V 2.	Feeling	2015- Lemaire Deffontaines, France	V 14.	T. 2924-20	Perspective spring wheat line
V 3.	Ciprian	2003- ARDS Lovrin, Romania	V 15.	T. 2925-20	Perspective spring wheat line
V 4.	Lennox	2011- Strube Research GmbH & Co.KG, Germany	V 16.	T. 2929-20	Perspective spring wheat line
V 5.	Feleacu	2024 - ARDS Turda, Romania	V 17.	T. 2931-20	Perspective spring wheat line
V 6.	T. 4007-19	Perspective spring wheat line	V 18.	T. 2601-22	Perspective spring wheat line
V 7.	T. 4068-19	Perspective spring wheat line	V 19.	T. 4162-19	Perspective spring wheat line
V 8.	T. 4075-19	Perspective spring wheat line	V 20.	T. 2809-21	Perspective spring wheat line
V 9.	T. 4076-19	Perspective spring wheat line	V 21.	T. 2639-22	Perspective spring wheat line
V 10.	T. 4165-19	Perspective spring wheat line	V 22.	T. 2928-20	Perspective spring wheat line
V 11.	T. 4176-19	Perspective spring wheat line	V 23.	T. 2931-20	Perspective spring wheat line
V 12.	T. 4183-19	Perspective spring wheat line			

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Experimental Design and Crop Management

The experiment included 23 spring wheat genotypes arranged according to a balanced square lattice design with three replications. Each experimental plot covered an area of 10 m². Sowing was carried out on 16 March 2026 using an SCE 8 seed drill, with a row spacing of 12.5 cm. Winter oilseed rape was the preceding crop.

Crop management followed the cultivation practices commonly used for spring wheat under the environmental conditions of central Moldavia. Primary soil preparation included stubble cultivation with a disc harrow to a depth of 8 cm, followed by ploughing to a depth of 25 cm and seedbed preparation using a combination cultivator. However, the experimental description also indicates that primary soil tillage was performed using a subsoiler; this should be clarified to ensure consistency in the description of the tillage system.

Basal fertilization was applied in autumn using a compound NPK fertilizer with an 18:46:0 nutrient formulation, at a rate of 200 kg ha.

RESULTS AND DISCUSSIONS

Climatic conditions

Climatic characterisation of the experimental year (table 2) was made based on meteorological data recorded at the Secuieni Meteorological Station (26°5'E longitude, 46°5' N latitude, 205.7 m above sea level), located near the experimental site (PINTILIE et al., 2026).

The temperature regime for spring wheat crop registered high temperatures in March, with a positive deviation of +3.4°C from multiannual mean, but the amount of precipitation recorded this month was 32.6 mm, slightly above the multi-year average.

Table 2

Climatic conditions of experimental field

Climatic conditions		March	April	May	June	July	Sum/ mean
Temperature (°C)	Decade I	4,5	8,2	13,9	19,3	20,4	-
	Decade II	5,6	10,1	15,6	18,6	21,5	-
	Decade III	8,3	9,6	17,7	24,3	20,1	-
	Month mean	6,1	9,3	15,7	20,8	20,7	14,52
	Multiannual mean	2,8	9,6	15,4	18,9	20,4	13,42
	±	3,3	-0,3	0,3	1,9	0,3	1,1
Rainfall (mm)	Decade I	0,0	9,0	21,0	20,4	9,0	-
	Decade II	0,4	6,0	10,0	8,2	22,2	-
	Decade III	32,2	0,2	29,4	0,0	3,6	-
	Sum	32,6	15,2	60,4	28,6	34,8	171,6
	Multiannual mean	26,3	44,9	64,3	84,7	80,6	300,8
	±	6,3	-29,7	-3,9	-56,1	-45,8	-129,2

The month of April was, on the whole, normal from a thermal point of view, but with an extremely uneven distribution of temperatures, and the pluviometric regime recorded a deficit of 29.7 mm, these conditions reduced the availability of water in the soil during the period of tillering and the beginning of stem elongation, which limited the vegetative development and the capacity of the formation of tillers.

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The month of May, essential for growth processes, was normally warm and rainy, recording a deviation of +0.3°C, respectively -3.9 mm from the multi-year average.

During the anthesis and grain filling stages (June), the average temperature was 20.8°C, 1.9°C above the multiannual average, and precipitation had a deficit of 56.1 mm which determined some accelerated evolutions of the specific phenological stages.

During the month of July, when the spring wheat plants reached their physiological maturity (second decade of the month), although the monthly rainfall deficit was 45.8 mm, these conditions did not directly influence the production capacity of the studied genotypes.

Grain yield

Although the climatic conditions were not extremely favorable for the manifestation of the yield potential of the studied genotypes (mainly cause to the lack of precipitation in the second and third decades of June, as well as the first decade of July), the productions achieved in field conditions at the ARDS Secuieni recorded an average of 6 054 kg ha^{-1} (figure 1). Among the genotypes studied, the promising lines T. 4183-19 with a production of 6846 kg ha^{-1}, the line T. 2925-20 with 6 649 kg ha^{-1} and T. 2639-22 with 6 502 kg ha^{-1} are noteworthy.

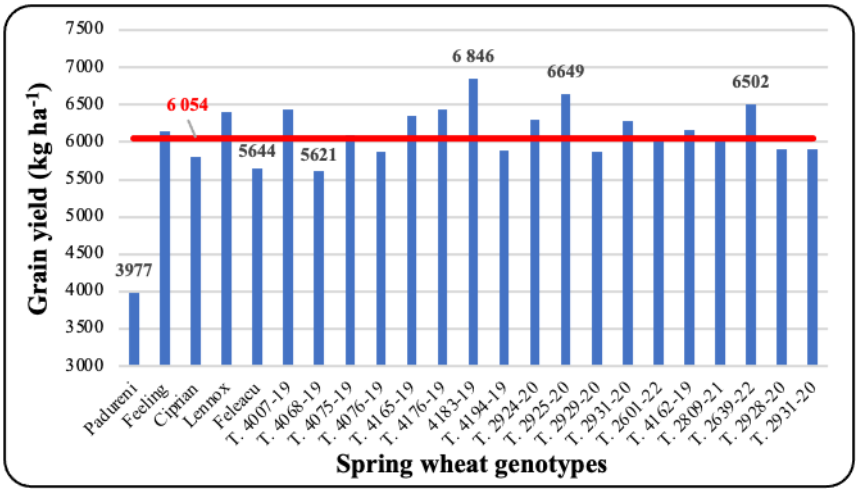


Figure 1. Grain yield of spring wheat genotypes under ARDS Secuieni conditions

A low production capacity can be observed in the case of the old Pădureni wheat variety (3977 kg ha^{-1}) whose adaptability to current environmental conditions is limited. Also, among the studied genotypes with a lower level of productivity compared to the average of the genotypes, we can also observe the perspective line T. 4068-19 (5 621 kg ha^{-1}) respectively that of the Feleacu variety (5 644 kg ha^{-1}). Furthermore, the fact that the yields of the Feleacu cultivar are surpassed in most cases by those achieved by the new promising lines provides further evidence of the sustained genetic progress achieved through recent breeding efforts.

Thousand kernel weight-TKW

The highest average value of the character thousand kernel weight was recorded in line T. 4194-19 (35.7 g) being 4.5 g above the average of all analysed genotypes- 31.2 g (figure 2). Values that exceed the threshold of 35 g or close to this value can also be observed in the case of the Feeling varieties (35.1 g) and the Ciprian variety (35.0 g). Among the perspective

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lines that record values over 34 g for the TKW can be mention the perspective line T. 2809-21 (34.8 g), T .4162-19 (34.4 g), respectively T. 2639-22 (34.0 g).

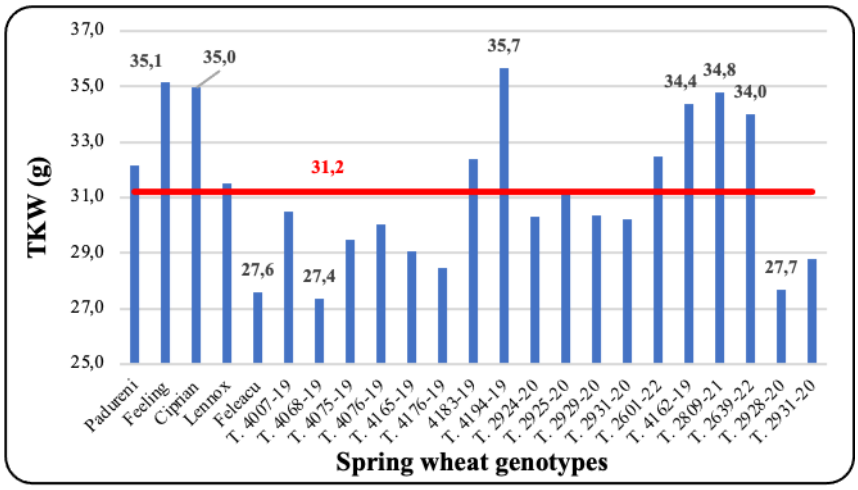


Figure 2. Thousand kernel weight of spring wheat genotypes under ARDS Secuieni conditions

The average values for TKW of the variety Feleacu (27.6 g) T. 4068-19 (27.4 g) and T. 2928-20 (27.7 g) respectively stand out among the lowest values within the group of studied genotypes, thus, of the 18 perspective lines tested, only six exceed the average value of all genotypes, the T. 2925-20 line being at the average level - 31.2 g. From the point of view of the breeding process, a significant progress can be observed compared to the Feleacu variety (this being the most recent creation of the Agricultural Research and Development Station Turda for spring wheat) for the most perspective breeding lines.

Hectolitre weight

The hectolitre weight of the analysed genotypes had a mean value of 75.5 kg/hl, placing them- in this respect- at the threshold for classification into the bread-making category (figure 3). Nevertheless, the mean hectolitre weight values for the T. 4183-19 and T. 4162-19 promising lines exceed the 78 kg hl^{-1} threshold, placing them in the category of high-quality grain, characterized by a high milling yield and good flour quality.

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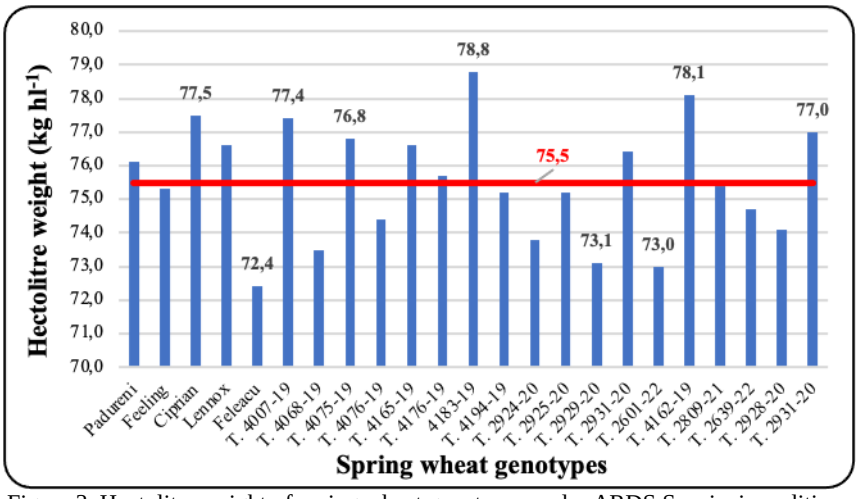


Figure 3. Hectoliter weight of spring wheat genotypes under ARDS Secuieni conditions

Comparing the values for this trait with those recorded for the registered varieties, it is observed that there are several genotypes (T. 4007-19, T. 4075-19, T. 4165-19, T. 2931-20) that exhibit values similar to, or even superior to, those of the registered varieties. Compared to the average values recorded for the Feleacu variety (72.4 kg hl^{-1}), most of the promising lines exhibit higher values for the trait of hectolitre weight, which suggests that progress has been made among these new creations.

Grain protein content

The average protein content of the grains of spring wheat genotypes was 13.2% (figure 4). The highest values of protein content of the grains (14.3%) were achieved by the homologated varieties – Pădureni, Lennox and Feleacu. Among the promising lines, values exceeding the average for all analyzed genotypes were recorded for genotypes T. 4068-19 (13.3%), T. 2601-22 (13.8%), T. 2809-21 (13.5%), T. 2639-22 (13.3%), and T. 2928-20 (13.8%); these genotypes are identified as potential varieties intended for official registration.

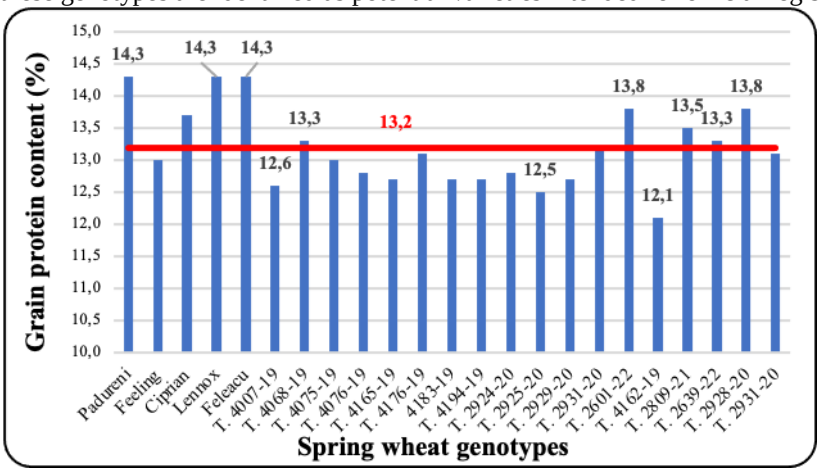


Figure 4. Grain protein content of spring wheat genotypes under ARDS Secuieni conditions

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Values below the mean for the genotypes (13.2%) regarding grain protein content were recorded for eleven promising lines, as well as for the registered variety 'Feeling' (13.0%); this suggests that the breeding process for new varieties should aim to improve this quality parameter.

Wet gluten content

The wet gluten content of the grains in the analysed genotypes is similar to their protein content; in the specialized literature, these two quality indices show a high degree of correlation, which largely explains the results obtained (figure 5). Similarly, the highest average values for the wet gluten content of the grains (29.1-29.2%) were recorded for the homologated varieties – Pădureni, Lennox and Feleacu. Furthermore, mean values above the average of the studied genotypes (26.6%) were recorded for the lines T. 4068-19 (26.8%), T. 2601-22 (27.9%), T. 2809-21 (27.5%), T. 2639-22 (26.9%) respectively T. 2928-20 (28.0%).

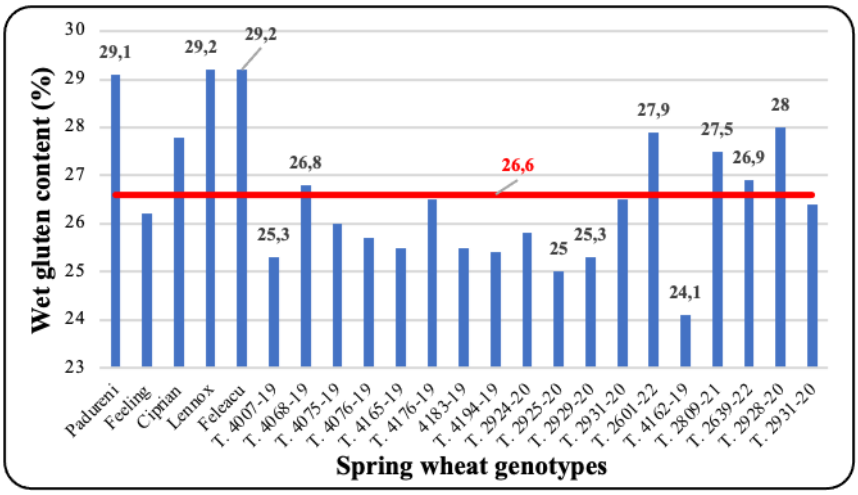


Figure 5. Wet gluten content of spring wheat genotypes under ARDS Secuieni conditions

Thirteen promising lines were recorded with mean values below the average for all analyzed genotypes; among these, line T. 4162-19 exhibited the lowest wet gluten content in the grains (24.1%).

Zeleny index

The Zeleny sedimentation index is an essential indicator used in the milling and baking industry to assess the quantity and, above all, the quality of gluten in wheat. (HRUŠKOVÁ and FAMĚRA, 2003). For the genotypes we analyzed, the mean value of this index was 53.6 ml, which places the gluten quality of the spring wheat grains in the medium or satisfactory quality category (suitable, in particular, for general bread-making) (Vishwakarma et al., 2024). Among the genotypes studied, four of the five registered varieties (Pădureni, Ciprian, Lennox and Feleacu) and three promising lines (T. 4068-19, T. 2601-22 and T. 2928-20) achieved values above their average.

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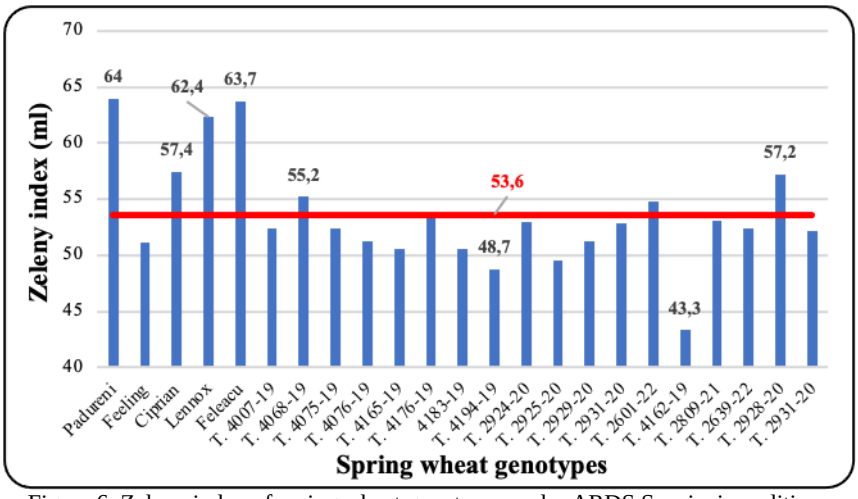


Figure 6. Zeleny index of spring wheat genotypes under ARDS Secuieni conditions

Although the variation in this quality index was quite significant among the prospective lines tested—with sedimentation index values ranging from 43.3 ml for line T. 4162-19 to 57.2 ml for line T. 2928-20—it is observed that the vast majority of these prospective lines (fifteen lines) exceed the 50 ml threshold, indicating an optimal structural strength of the gluten network; this network is capable of effectively retaining fermentation gases, without the gluten being excessively rigid.

Deformation energy -W

Deformation energy (W) showed a fairly wide variation among the group of genotypes analysed, with recorded values ranging from 193.4 × 10^{-4} J (perspective line T. 2929-20) to 309.3 × 10^{-4} J (for the Pădureni variety) (figure 7).

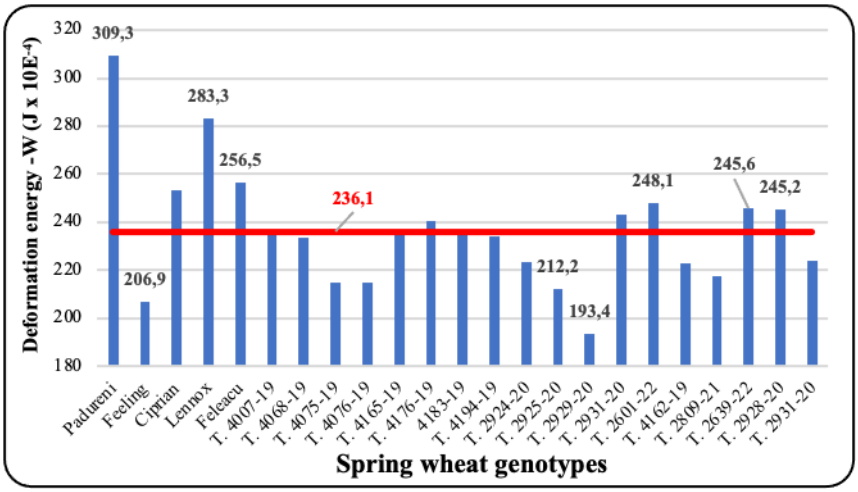


Figure 7. Dought deformation energy of spring wheat genotypes under ARDS Secuieni conditions

For the genotypes studied, the mean value of this indicator was 236.1, suggesting a satisfactory to high-quality performance of the dough during the flour processing stage. Although the mean value for this indicator is satisfactory, the contributions of the 'Padureni' variety, as well as those of the 'Lennox' or 'Feleacu' varieties, significantly elevate this figure; conversely, the mean values for the promising breeding lines regarding this parameter are quite low, which underscores the need for greater attention when defining future breeding objectives.

CONCLUSIONS

Grain yield varied considerably among the 23 spring wheat genotypes, with an overall mean of 6,054 kg ha^{-1} under the pedoclimatic conditions of ARDS Secuieni in 2026. The highest yields were recorded for the promising lines T. 4183-19 (6,846 kg ha^{-1}), T. 2925-20 (6,649 kg ha^{-1}), and T. 2639-22 (6,502 kg ha^{-1}), highlighting their potential for further evaluation.Several newly developed breeding lines outperformed the Feleacu cultivar in grain yield, supporting the existence of promising genetic progress in spring wheat breeding. In contrast, the old Pădureni variety had the lowest yield (3,977 kg ha^{-1}), indicating comparatively poor performance under the environmental conditions of the experimental year.

Thousand-kernel weight (TKW) showed substantial variation among genotypes, with an overall mean of 31.2 g. The highest value was recorded for T. 4194-19 (35.7 g), followed by the registered varieties Feeling (35.1 g) and Ciprian (35.0 g). These results identify T. 4194-19 as a promising source of high kernel weight.

Hectolitre weight differed among genotypes, averaging 75.5 kg hL^{-1}. The lines T. 4183-19 (78.8 kg hL^{-1}) and T. 4162-19 (78.1 kg hL^{-1}) recorded the highest values, suggesting favorable grain physical characteristics and potential for milling quality.

Grain protein and wet gluten contents highlighted contrasting quality profiles. The highest protein content (14.3%) and wet gluten content (approximately 29.1–29.2%) were recorded in the registered varieties Pădureni, Lennox, and Feleacu. Among the promising lines, T. 2601-22 and T. 2928-20 combined above-average protein contents (13.8%) with relatively high wet gluten contents (27.9% and 28.0%, respectively).

Gluten quality and dough properties varied considerably among the tested genotypes. The mean Zeleny sedimentation index was 53.6 mL, and 15 promising lines exceeded 50 mL. However, the relatively low deformation energy values recorded for many promising lines indicate that further selection should consider not only yield and protein content but also dough strength and processing performance.

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