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Yield Performance, Stability and Grain Quality of Spring Barley Genotypes under Climatic Variability

Ioana Crișan, Florin Russu, Emanuela Filip, Adina Tărău*, Camelia Urdă

Agricultural Research and Development Station Turda, 27 Agriculturii Street, 401100 Turda, Cluj County, Romania
*Corresponding authors. E-mail: adina.tarau@scdaturda.ro

ABSTRACT

Spring barley is a crop of major agronomic and industrial importance, widely used for malting and well suited to short crop rotations due to its reduced vegetation period. Under current climate change conditions, the identification of genotypes that combine high yield potential with stable performance across diverse environments is of increasing importance.

During the period 2021-2023, a total of 25 spring barley genotypes were evaluated at the Agricultural Research and Development Station (ARDS) Turda in a comparative field trial arranged in a randomized block design with five replications. Grain yield was assessed in relation to key agronomic traits and grain quality parameters. Two advanced breeding lines, To 2033/18 and To 1990/18, recently registered as the varieties Ioana and Dumbrăvița, were additionally tested within the national SITRV multilocation network. The variety Ioana achieved grain yields ranging from 6,000 to 7,700 kg/ha, with maximum values recorded at the Dej and Sibiu locations, indicating a high yield potential under favorable conditions. Dumbrăvița recorded yields between 5.500 and 6.800 kg/ha and showed a high degree of yield stability across environments. Protein content varied between 10.28% and 11.38%.

Compared with the standard variety Romanița, both newly registered cultivars demonstrated clear genetic progress. Ioana is a high-yielding malting-type variety recommended for intensive cropping systems, while Dumbrăvița is characterized by high stability and ecological plasticity, being well adapted to variable pedoclimatic conditions.

Keywords: spring barley, yield stability, genotype performance, new varieties, quality.

INTRODUCTION

Spring barley (*Hordeum vulgare L.*) is one of the most important cereal crops in temperate areas, being used both for animal feed and as a raw material for the brewing industry. Because it adapts well to diverse pedoclimatic conditions and shows comparatively high tolerance to abiotic stresses, including drought and high temperatures, spring barley is of strong interest under current climate change conditions, especially in rainfed cropping system (Bishnoi et al., 2022).

Spring barley yield results from the interaction of its main yield components, namely crop density, grains per spike, and grain weight. Interannual climatic variability strongly influences yield by affecting these components, particularly during the key phases of grain formation and grain filling (Yiğit and Chmielewski, 2024).

Genetic progress in improving spring barley yield has been relatively slow, highlighting the need for multi-year evaluation of genotypes under local growing conditions and for assessing their stability and adaptability to variable pedoclimatic environments (Åstrand et al., 2024). Yield variation in crop plants is largely driven by environmental conditions, which cause substantial differences in the expression of quantitatively inherited traits (Săulescu et al., 2025). Complementary evidence is provided by Vasilescu et al. (2022), who, in their study on grain morphometry of Romanian winter barley cultivars registered between 1959 and 2019, highlighted the role of both genetic background and environmental conditions in shaping yield-related traits and their variability over time. Consequently, the use of appropriate statistical methods is essential for assessing phenotypic stability across

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contrasting growing conditions, as stability is essential for evaluating cultivar productivity.

Yield stability is a major objective of agricultural research and reflects the capacity of cultivars to maintain consistent performance under variable environmental conditions, including water and thermal stress. Differences among cultivars in yield stability across environments are indicative of their adaptive capacity, emphasizing the importance of selecting genotypes with stable performance for both cultivation and breeding programs (Elakhdar et al., 2025). Genotypes intended for commercial cultivation must therefore exhibit a high level of stability in quantitatively inherited traits to ensure consistent yield performance under variable pedoclimatic conditions (Ceapoiu, 1968; Ciulcă, 2006).

In addition to yield level, plant morphological traits represent important criteria in assessing the agronomic value of cultivars. Plant height directly influences lodging resistance, which is a major yield-limiting factor (Shah et al., 2019). Genotypes with medium or reduced plant height generally show greater stability and use environmental resources more efficiently (Slafer and Savin, 1994). Thousand kernel weight (TKW) is also an important indicator of the physical quality of the harvest, being closely associated with yield potential and grain uniformity.

Grain biochemical quality, expressed through protein and starch content, is essential for the utilization of spring barley, particularly in the brewing industry. A moderate protein content combined with a high starch level is considered optimal for obtaining high-quality malt, influencing both malting performance and fermentation efficiency (Gorzelany et al., 2019; Solgajová et al., 2022). An antagonistic relationship between grain yield and protein content has been reported in both barley and wheat, requiring a balance between yield and quality traits in breeding programs (Geyer et al., 2022; Shewry, 2024).

The Transylvanian Plateau, where the Agricultural Research and Development Station (ARDS) Turda is situated exhibits significant pedoclimatic variability, with notable year to year changes in temperature and rainfall. In this context, assessing spring barley cultivars and advanced perspective breeding lines is essential to identify genotypes that offer high yield potential, environmental stability, and desirable quality.

The aim of this study is to evaluate the yield performance, stability, and adaptability of 25 spring barley genotypes cultivated during the 2021-2023 period at ARDS Turda, based on grain yield and associated traits, namely plant height and thousand-grain weight. Additionally, the agronomic performance and adaptability of two newly registered cultivars, Ioana (TO 2033/18) and Dumbrăvița (TO 1990/18), tested over three years in four ISTIS testing centres (Hărman, Dej, Rădăuți, and Sibiu), are assessed. Grain quality parameters (protein and starch content) are evaluated in comparison with the control cultivars Daciana and Romanița to highlight the yield potential, stability, and grain quality of the new genotypes.

MATERIAL AND METHODS

The research was conducted at the Agricultural Research and Development Station (ARDS) Turda over three consecutive years (2021-2023), under the pedoclimatic conditions specific to the Transylvanian Plain. The aim of the study was to evaluate grain yield and selected quantitative and qualitative traits of spring barley (*Hordeum vulgare L.)* genotypes under local environmental conditions.

The experiment was established on a cambic/vertic pseudogley chernozem soil, characterized by the following agrochemical properties: humus content 3.51%, total nitrogen 0.164%, available phosphorus 32 ppm, available potassium 480 ppm, and pH 5.82. Agrochemical analyses were performed using a PF 12 PLUS photometer, indicating medium nitrogen and phosphorus supply and very good potassium availability, conditions favorable for spring barley cultivation.

The biological material consisted of 25 spring barley genotypes, including both registered cultivars and advanced breeding lines from the ARDS Turda breeding program. Among these, lines TO 2033/18 and TO 1990/18 were officially registered in

2024 under the names Ioana and Dumbrăvița, respectively, and were evaluated throughout the entire study period. To complement the assessment of their performance, these cultivars were additionally tested in four ISTIS testing centers: Hărman, Dej, Rădăuți, and Sibiu.

Pea was used as the preceding crop. Soil preparation for sowing was carried out in autumn by ploughing to a depth of 20 cm, followed by two passes with a rotary harrow, with the final pass oriented perpendicular to the sowing direction to maximize soil water retention. Sowing was performed in the first decade of March at a density of 550 germinative seeds m². The plot size was 14 m², of which 10 m² were harvested. The experiment was conducted based on a randomized complete block design with five replications, ensuring a reliable statistical assessment of each genotype.

Fertilization was applied in a single dose, using 150 kg/ha of calcium ammonium nitrate active substance. Weed control was performed using a herbicide mixture consisting of Sekator (100 ml/ha) and DMA-6 (400 ml/ha). Harvesting was carried out in the first decade of July each year using a Wintersteiger plot combine harvester. Grain yield was expressed as the mean of the five replications, in kg/ha, adjusted to a standard moisture content of 14%.

The main yield-related traits analyzed were grain yield, plant height, and thousand-kernel weight (TKW). Grain quality was evaluated by measuring protein and starch content through near-infrared spectroscopy (FT-NIR; Tango FT-NIR, ARDS Turda). The obtained data were processed using Microsoft Excel software, and regression analyses were applied to investigate relationships between grain yield and the main analysed parameters.

During the three-year study period (2021-2023), climatic conditions in the Transylvanian Plain were characterized by pronounced variability in temperature and precipitation, directly affecting plant development and spring barley yield. Winters were generally warmer than the multiannual average, favouring early germination and plant survival, while spring seasons alternated between drought periods and lower temperatures, influencing early growth and crop development.

Summers were marked by high temperatures and substantial precipitation variability, with alternating drought periods and intervals of excessive rainfall, particularly during June-July. These fluctuations imposed multiple stresses on the crop, affecting grain uniformity and grain filling.

Climatic data recorded during the study period, presented in Tables 1 and 2, indicate significant deviations from the 65-year multiannual average, including extremely warm or cold months and excessively dry or wet periods. These conditions provide the environmental context for interpreting differences in yield and agronomic performance among the tested genotypes. Thus, the study was conducted under realistic and highly variable environmental conditions, highlighting the importance of multi-year evaluation of yield performance and phenotypic stability in spring barley genotypes

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Table 1. Monthly average air temperature registered in January and July, 2021-2023, ARDS Turda

Year	Month	Monthly mean (°C)	65-year multiannual mean (°C)	Deviation (°C)	Characterization
2021	January	-0,6	-3.4	+2.8	warm
	February	1.4	-0.9	+2.3	warm
	March	3,3	4.7	-1.4	cool
	April	7.8	9.9	-2.1	cold
	May	14.1	15.0	-0.9	normal
	June	19,8	17.9	+1.9	warm
	July	22.7	19.7	+3.0	warm

Year	Month	Monthly mean (°C)	65-year multiannual mean (°C)	Deviation (°C)	Characterization
2022	January	-1.0	-3,3	+2.3	warm
	February	2.2	-0.6	+2.8	warm
	March	3.6	4.4	-0.8	normal
	April	8.8	10,0	-1.2	cool
	May	16.3	15.0	+1.3	warm
	June	21.1	18.0	+3.1	warm
	July	23.1	19.8	+3.3	warm
2023	January	2.8	-3.3	+6.1	very warm
	February	0,5	-0.6	+1.1	warm
	March	6.3	4.4	+1.9	warm
	April	8.8	10.0	-1.2	cool
	May	15.4	15.0	+0.4	normal
	June	19.0	18.0	+1.0	warm
	July	21.8	19.8	+2.0	warm

Table 2. Monthly rainfall registered in January and July, 2021-2023, ARDS Turda

Year	Month	Monthly amount (mm)	Average (65 years) (mm)	Deviation (mm)	Characterization
2021	January	27.0	21.8	+5.2	Rainy
	February	16.4	18.8	−2.4	Slightly dry
	March	27.3	23.6	+3.7	Slightly rainy
	April	38.4	45.9	−7.5	Slightly dry
	May	80.8	68.7	+12.1	Slightly rainy
	June	45.0	84.8	−39.8	Very dry
	July	123.1	77.1	+46.0	Excessively rainy
2022	January	10.9	21.7	−10.8	Very dry
	February	5.4	19.2	−13.8	Excessively dry
	March	8.3	24.3	−16.0	Excessively dry
	April	42.5	45.6	−3.1	Normal
	May	82.9	69.4	+13.5	Slightly rainy
	June	41.8	84.6	−42.8	Excessively dry
	July	25.2	78.0	−52.8	Excessively dry
2023	January	42.7	21.7	+21.0	Excessively rainy
	February	27.1	19.2	+7.9	Very rainy
	March	10.8	24.3	−13.5	Excessively dry
	April	30.5	45.6	−15.1	Very dry
	May	33.2	69.4	−36.2	Excessively dry
	June	144.5	84.6	+59.9	Excessively rainy
	July	85.8	78.0	+7.8	Normal

Source of primary data: Turda meteorological station (longitude: 23°4´; latitude: 46°35´; altitude: 427 m).

RESULTS AND DISCUSSION

During the study period (2021-2023), grain yield of the spring barley genotypes was significantly influenced by both genetic potential and the variability of climatic conditions characteristic of the Transylvanian Plain. The control cultivar Romanița (Ct) showed relatively stable yields over the three experimental years, ranging from 5.293 kg/ha (2023) to 5.978 kg/ha (2022), confirming its good adaptability to local pedoclimatic conditions. However, several experimental lines significantly outperformed the control, indicating substantial genetic progress (Table 3).

Among the tested genotypes, line TO 2033/18 (Ioana) stood out by achieving the highest yields in all years, with significant and highly significant increases over the control: 596 kg/ha in 2021, 953 kg/ha in 2022, and 924 kg/ha in 2023. This performance reflects a superior ability to utilize environmental resources and high phenotypic stability, even under contrasting climatic conditions. Similarly, lines

TO 2198-13 and TO 2096-10 showed higher yields than the control, particularly in 2022, which was characterized by high temperatures and pronounced precipitation deficit during spring-early summer. The performance of these genotypes suggests enhanced tolerance to water and heat stress, a crucial aspect for yield stability under climate change.

Our results are consistent with recent literature. For instance, Elakhdar et al. (2025), analysing grain yield of 32 barley genotypes over two years (2022-2023) across ten environments, reported that environmental conditions accounted for most of the yield variation, while some genotypes combined high yield potential with stability. Similarly, Rahmati et al. (2024) highlighted the importance of genotype × environment interactions across years and locations, identifying genotypes that maintain high productivity and stability under contrasting conditions. These findings underline the importance of multi-year testing across diverse pedoclimatic conditions.

These findings support our observations regarding lines TO 2198-13 and TO 2096-10, which achieved the highest yield gains over the control in 2022.

In contrast, several genotypes (TO 2017-93, TO 2167-01, TO 2247-01, TO 2014-99) recorded significantly lower yields than the control in all three years, indicating reduced adaptability to the local pedoclimatic conditions. These genotypes were more sensitive to fluctuations in temperature and precipitation, especially during years with severe drought or temporary excess moisture.

Yield reductions observed in 2023 for most genotypes can be attributed to excessive rainfall in June, followed by abrupt temperature variations, which negatively affected grain filling. These conditions resulted in more pronounced differences among genotypes, emphasizing the importance of multi-year testing for evaluating yield stability.

The perspective line TO 1990/18 registered as Dumbrăvița variety exhibited an interesting response, achieving a yield higher than the control in 2021, with a significant increase of 371 kg/ha, indicating good productive potential under favourable climatic conditions. Although in the following years its yield was below the control, these differences can be associated with higher sensitivity to water and heat stress, particularly in 2022, which experienced pronounced drought during early vegetative growth. Nevertheless, the relatively close performance to the control over all three years suggests moderate adaptability, recommending line TO 1990/18 as valuable breeding material, especially for use as a parent in hybrid combinations aimed at increasing yield potential.

Overall, the results highlight the presence of genotypes with high yield potential and good stability, suitable for breeding programs and for expanding spring barley cultivation in the Transylvanian Plain.

For a more comprehensive understanding of the agronomic performance of the studied spring barley genotypes, grain yield was correlated with key yield components, namely thousand-kernel weight (TKW) and plant height. Scatter plots were used to illustrate the annual means of yield and the analysed traits, positioning each genotype relative to these reference values.

This approach allows a comparative evaluation of genotypes, facilitating the identification of those that combine high yield levels with favourable trait values, directly relevant for breeding selection. Quadrant representation, delimited by annual means, provides a synthetic overview of the relative performance and stability of the genotypes under different climatic conditions.

The literature supports the effectiveness of this type of multivariate analysis in assessing genotype adaptability and stability. For instance, Elakhdar et al. (2025) employed integrated approaches to identify barley genotypes combining high yield with stability across different environments, confirming the relevance of concurrently evaluating yield and quantitative traits in a comparative framework.

Table 3. Grain yield (kg/ha) of selected spring barley genotypes, ARDS Turda, 2021-2023

Genotype	2021			2022			2023		
	Yield (kg/ha)	Dif.	Sign.	Yield (kg/ha)	Dif.	Sign.	Yield (kg/ha)	Dif.	Sign.
Romanița (Ct.)	5627	0	Control	5978	0	Control	5293	0	Control
Daciana	5199	-428	0	5286	-692	ooo	5169	-124	o
Turdeana	4969	-657	000	5050	-928	ooo	4539	-754	ooo
To 2033/18	6223	+596	***	6931	+953	***	6217	+924	***
To 2270/94	5135	-492	00	5508	-469	ooo	4764	-529	ooo
To 2198-13	5894	+267	ns	6806	+828	***	5683	+390	***
To 2096-10	5635	+9	ns	6791	+813	***	5319	+27	ns
To 2172-01	5275	-352	0	5312	-665	ooo	4660	-633	ooo
To 2168-01	5212	-415	0	5118	-859	ooo	5144	-149	ooo
To 2115-94	4783	-844	000	5256	-721	ooo	5049	-244	ooo
To 2036-02	4865	-762	000	5279	-698	ooo	5067	-226	ooo
To 2054-97	5165	-462	00	5412	-566	ooo	4898	-395	ooo
To 2013-99	4706	-921	000	5129	-848	ooo	5076	-217	ooo
To 2095-01	4619	-1008	000	4993	-984	ooo	4816	-477	ooo
To 2149-99	4685	-942	000	5054	-923	ooo	4492	-801	ooo
To 2017-93	4458	-1169	000	5132	-845	ooo	4593	-700	ooo
To 2014-99	4693	-934	000	5166	-811	ooo	4243	-1050	ooo
To 2247-01	4835	-792	000	4816	-1161	ooo	4148	-1145	ooo
To 2167-01	4448	-1179	000	5172	-805	ooo	4518	-775	ooo
To 2051-10	4851	-776	000	5449	-529	ooo	4671	-622	ooo
To 2123-01	4714	-913	000	5408	-570	ooo	5176	-117	o
To 2027-10	5620	-7	ns	6020	+42	ns	5294	+1	ns
To 2170-01	4807	-820	000	5354	-623	ooo	4830	-463	ooo
To 2011-92	4667	-960	000	5545	-433	ooo	5342	+49	ns
To 1990/18	5998	+371	*	5352	-625	ooo	4747	-546	ooo

Year	LSD 5%	LSD 1%	LSD 0.1%
2021	333	441	569
2022	203	269	347
2023	95	126	163

Differences are calculated relative to the control cultivar **Romanița (Control)**.
Significance levels: p<0.05 (*), p<0.01 (**), p<0.001 (***), ns = not significant. *Dif. - Difference, *Sig - Significance, *Ct. – Control.

Similarly, De Santis et al. (2024) highlighted that interactions between environmental factors and crop management significantly affect both yield and grain quality, underlining the importance of an integrated evaluation to identify genotypes with high and stable agronomic performance.

The analysis of the relationship between yield and TKW for each experimental year revealed clear differences among the studied genotypes in terms of both performance and stability. Annual mean values of yield and TKW were used as reference points to define four quadrants, with attention focused on genotypes located in Quadrant II, characterized by above-average values for both yield and TKW (Figure 1). Positioning in this quadrant indicates a favourable combination of quantity and quality, particularly important in breeding programs aimed at simultaneously increasing yield and maintaining appropriate technological parameters.

Existing studies (Gorzelany et al., 2019; Solgajová et al., 2022) show a positive relationship between grain yield and quality traits in barley, indicating that genotypes with higher quality parameters produce favourable malt and highlighting the relevance of traits such as TKW and biochemical markers in yield evaluation. In this study, lines To 2033/18, To 2198-13, and To 2096-10 showed consistently above-average yield and TKW, confirming their superior agronomic potential and stability over time.

Other genotypes, such as Romanița, Daciana, and Turdeana, although not exceeding the annual means in every year, displayed relatively high TKW and stable performance, indicating a favourable balance between grain quality and quantity.

Line To 1990/18 warrants particular attention. Even though its values were slightly below the means in 2022 and 2023, it demonstrated stability and predictability of yield and TKW, indicating consistent and reliable performance under variable conditions. The stability of this line recommends it as a valuable genetic material for selection, consistent with recent findings on selecting genotypes with high agronomic stability across diverse experimental environments.

Overall, the combined analysis over the three years confirms the importance of integrating long-term data for selecting genotypes with superior performance and agronomic stability, essential in spring barley breeding programs at ARDS Turda. Modern studies show that multi-environment, multi-year approaches provide a more robust picture of genotype adaptability and yield potential.

In the correlation analysis between grain yield and plant height, particular attention was given to genotypes positioned in quadrant IV, characterized by below-average plant height and above-average grain yield. These genotypes are of special agronomic interest, as reduced plant height is generally associated with better lodging resistance and higher yield stability (Figure 2). This relationship is supported by the findings of Hu et al. (2021), who found a positive correlation between shorter barley plants and the ability of genotypes to maintain stable yields under water and heat stress conditions.

Positioning genotypes in this quadrant highlights the genetic material that successfully combines high yield potential with a favorable plant architecture, an essential trait for achieving stable and efficient crops under intensive management practices.

The approach used in this study, based on quadrant graphical analysis of the relationship between yield and key agronomic traits (TKW and plant height), aligns with breeding research methods that use visual classification to identify genotypes with high performance and stability. A similar strategy was applied by Urdă et al. (2017), who analyzed yield stability in soybean cultivars developed at ARDS Turda by positioning genotypes according to grain yield and regression coefficients, thereby highlighting genotypes adapted and stable across variable environmental conditions. Thus, the results obtained in the present study confirm the usefulness of this graphical approach for the selection of genotypes with high agronomic potential, adaptability, and stable performance, which represent essential traits in spring barley breeding programs conducted at ARDS Turda.

Two of the genotypes that stood out due to their favourable and stable positioning relative to the mean values of yield and yield components were subsequently evaluated within the national testing network to confirm their productive potential and adaptability. In this context, the lines To 2033/18 and To 1990/18 were tested at the Dej, Hărman, Rădăuți, and Sibiu centers, with the results serving as the basis for their official registration as the genotypes Ioana and Dumbrăvița, respectively, in 2024.

Analysis of multi-year mean yields highlights clear but complementary differences between the two registered genotypes. The genotype Ioana (To 2033/18) achieved the highest mean yields at the Sibiu center (7359 kg/ha). This confirms its superior productive potential under favorable pedoclimatic conditions. Moreover, at Dej and Hărman, the mean yields obtained (5513 kg/ha and 5022 kg/ha, respectively) indicate good adaptability and satisfactory yield stability under variable environmental conditions. At the Rădăuți center, although the mean yield was lower (3992 kg/ha), the genotype’s performance remained consistent throughout the study period.

The genotype Dumbrăvița (To 1990/18) exhibited a balanced productive profile across all testing centers, with mean yields ranging from 3898 kg/ha at Rădăuți to 6118 kg/ha at Sibiu.

Mean yields at Dej (5454 kg/ha) and Hărman (4804 kg/ha) indicate good stability of the genotype even under less favorable conditions, confirming its broad adaptability (Table 4). In contrast, multi-year averages show that Ioana has higher yield potential under favorable conditions, while Dumbrăvița exhibits more uniform yield stability across locations. Overall, the results highlight the complementarity of the two genotypes and support their registration, offering farmers options adapted to different pedoclimatic conditions.

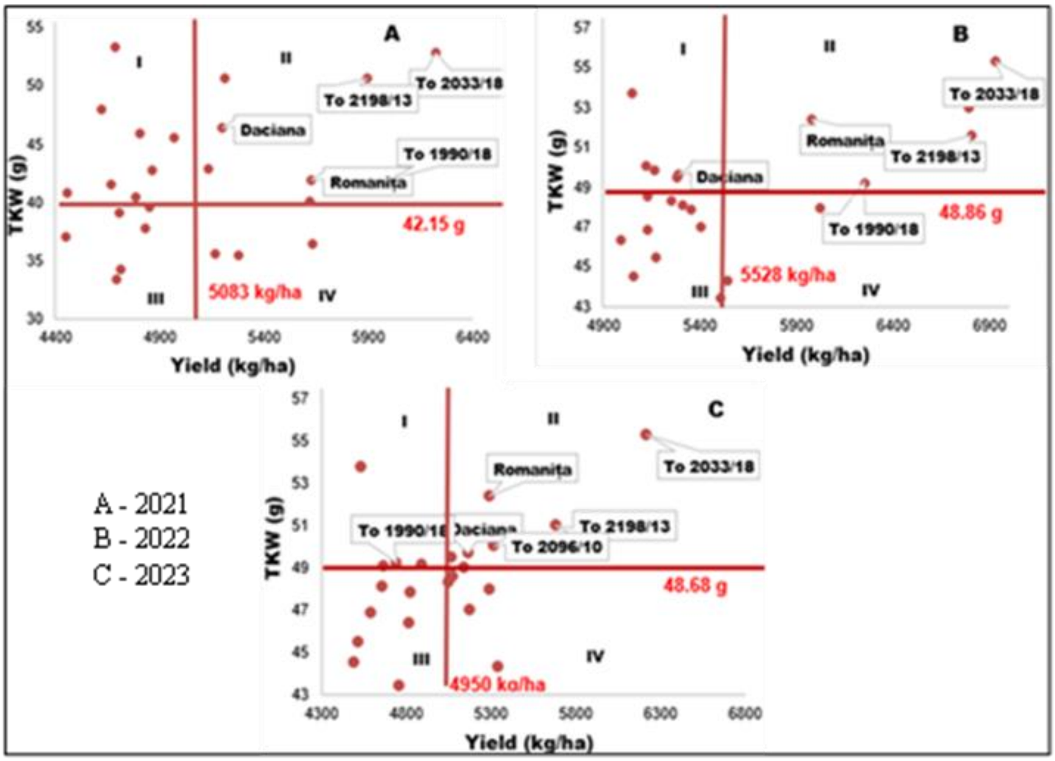

Figure 1. Grouping of genotypes based on TKW height and grain yield

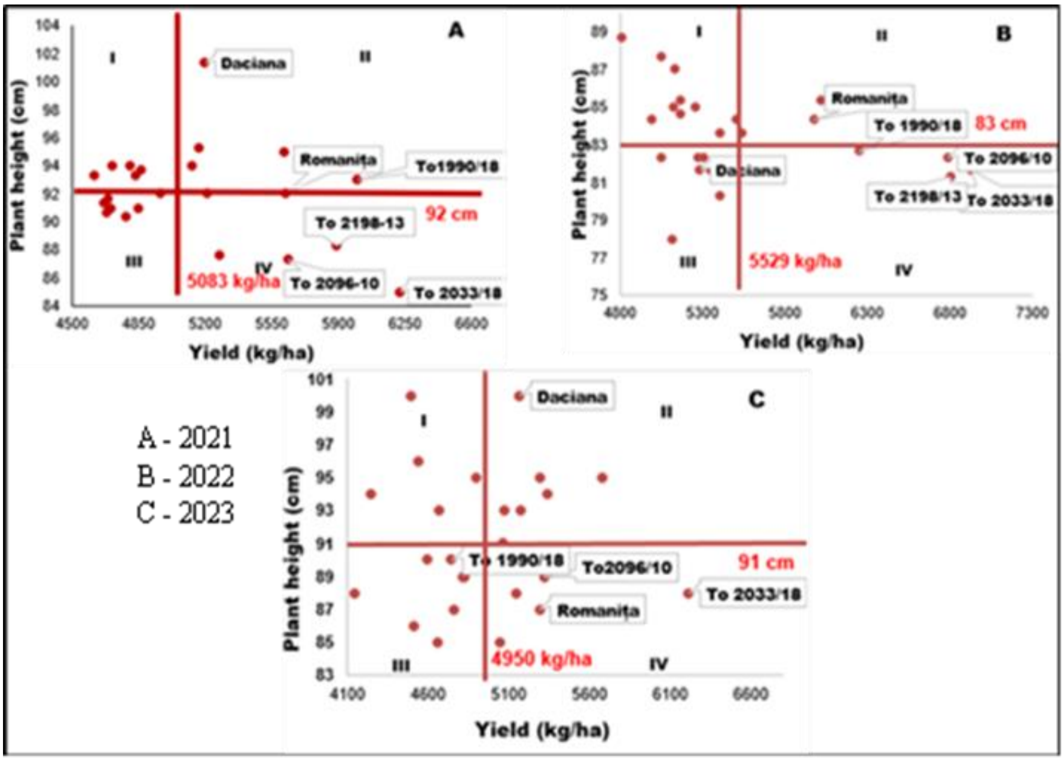

Figure 2. Grouping of genotypes based on plant height and grain yield

Table 4. Grain yield (kg/ha) of the genotypes Ioana and Dumbrăvița in the testing centres during 2021-2023

Genotype	Year	Dej	Hărman	Rădăuți	Sibiu
Ioana	2021	4375	5366	3318	7217
	2022	6849	4884	4532	7698
	2023	5314	4817	4125	7162
	Average 2021-2023	**5513**	**5022**	**3992**	**7359**
Dumbrăvița	2021	5286	4801	3270	5993
	2022	6985	4478	4491	6833
	2023	4091	5132	3934	5529
	Average 2021-2023	**5454**	**4804**	**3898**	**6118**

In addition to yield level and stability, the evaluation of new spring barley genotypes must include the analysis of grain quality, an essential criterion for their utilization in various end-use directions. Determining protein and starch content allows an integrated assessment of the technological value of the newly registered genotypes, compared with the established varieties developed at ARDS Turda, namely Daciana and Romanița. This comparative approach ensures continuity in the analysis and provides a relevant framework for assessing the genetic progress achieved through the new genotypes Ioana and Dumbrăvița, not only in terms of yield but also regarding harvest quality.

The analysis of protein content highlights differences between the evaluated genotypes, determined both by genotype and by the climatic conditions of the testing years. The Dumbrăvița genotype shows protein values comparable to those of Romanița, with mean values around 11%, confirming a favourable balance between yield and protein content. The Ioana genotype exhibits slightly lower protein content but remains relatively stable over the three years, which is characteristic of genotypes with high yield potential (Figure 3). These results are in agreement with the findings of Deme et al. (2020), who reported that barley genotypes with good agronomic stability and balanced protein content produce high-quality malt, demonstrating the importance of evaluating yield and biochemical traits simultaneously.

Regarding starch content, the differences between genotypes are more pronounced. The Ioana genotype stands out with high and consistent starch levels, exceeding 59% in all three years, indicating good suitability for uses where the energetic content of the grains is important.

These observations support the conclusions of Fox and Kelly (2007), who noted that high starch content in barley is essential for producing high-quality malt and for the efficiency of the brewing process. In contrast, the Dumbrăvița genotype shows starch levels comparable to the control genotypes, but in a favorable balance with a higher protein content (Figure 4), highlighting stability and adaptability under variable environmental conditions. Referring to the previously presented yield data along with the determined grain quality values, it is evident that the newly released genotypes provide a valuable contribution to the genetic portfolio of ARDS Turda. The Ioana genotype stands out for its high yield potential combined with elevated starch content, making it suitable for agricultural technologies aimed at maximizing both production and the energetic value of the harvest. In contrast, the Dumbrăvița genotype shows a favourable balance between protein and starch content, characterized by stability and adaptability, qualities that give it versatility under diverse growing conditions.

Compared with the established genotypes Daciana and Romanița, the new varieties confirm the genetic progress achieved, both in terms of yield and grain quality, supporting their introduction into cultivation. These conclusions align with recent studies by Gorzelany et al. (2019) and Solgajová et al. (2022), which demonstrated that genotypes with superior quality parameters produce technologically favourable malt, highlighting the importance of including biochemical characteristics in the overall evaluation of barley's productive and technological value.

The pronounced pedoclimatic variability during 2021-2023 provided an appropriate framework for evaluating the agronomic performance of spring barley genotypes under contrasting environmental conditions.

The study conducted at ARDS Turda allowed an objective assessment of the yield potential, stability, and adaptability of the analysed genotypes, as well as the identification of genetic materials with practical value for breeding and cultivation.

Integrating yield analysis with the evaluation of thousand-kernel weight (TKW), plant height, and quality parameters offered a comprehensive approach to the agronomic performance of the studied genotypes. Additionally, validation of the results through testing in the ISTIS network confirmed the behaviour of the new varieties under diverse pedoclimatic conditions, ensuring the practical relevance of the conclusions drawn.

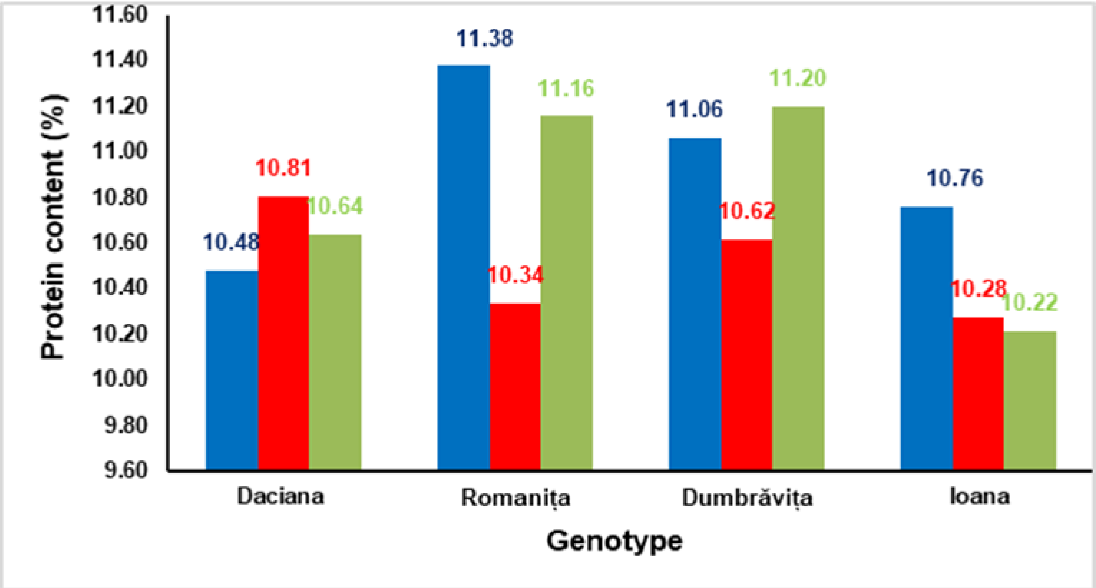

Figure 3. Protein content (%) of spring barley genotypes at ARDS Turda

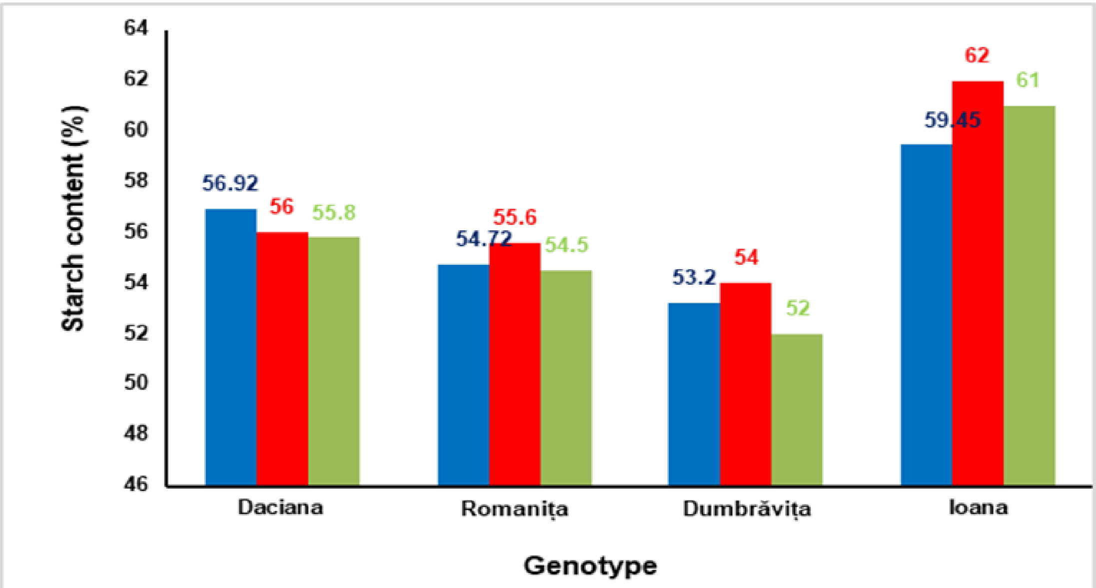

Figure 4. Starch content (%) of spring barley genotypes at ARDS Turda

CONCLUSIONS

Spring barley grain yield was strongly influenced by the climatic conditions of the study years, highlighting the necessity of multi-year evaluations to accurately assess genotype stability.

The line To 2033/18 line, released as Ioana, stood out for consistently higher yields than the Romanița, confirming its high yield potential and good adaptability to variable environmental conditions.

The line To 1990/18 line, released as Dumbrăvița, recorded yields comparable to control variety, with moderate variations across years and locations, demonstrating broad adaptability and good production stability.

The analysis of the relationship between yield, thousand-kernel weight (TKW), and plant height allowed the identification of genotypes that combine high productivity with favorable morphological traits, illustrating the usefulness of quadrant graphical representations as a tool for breeding selection.

Testing within the State Institute for Tasting and Registration of Varieties confirmed the complementarity of the two newly released varieties, with Ioana showing superior yield potential under favorable conditions, and Dumbrăvița exhibiting more uniform yield stability across locations.

Grain quality evaluation revealed genotype-dependent differences: Ioana stood out for high and stable starch content, while Dumbrăvița showed a favorable balance between protein and starch content, comparable to the control varieties.

The results support the agronomic and breeding value of the Ioana and Dumbrăvița varieties, justifying their release and recommendation for cultivation across different pedoclimatic conditions.

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