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STATISTICAL EVALUATION OF BARLEY PRODUCTION ACCORDING TO MORPHOLOGY, PROTEIN CONTENT AND HECTOLITER MASS

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Abstract: *The main objective of this work is to follow the behavior of varieties and hybrids of autumn barley under the influence of the biological, technological factor. The varieties of barley taken into cultivation are the following: Idyllic, Jup; Melia; SU Ellen; Azrah and Dakota The productive performance of the analyzed barley varieties varied significantly, highlighting a clear influence of genetic potential on yield under local pedoclimatic conditions. The Jup variety has demonstrated obvious superiority, registering the highest production and high statistical significance, which recommends it as an optimal choice for cultivation in the area. Protein content varied between varieties, with no direct correlation between production level and protein quality always observed. This variation suggests that the selection for yield must be balanced with the selection for quality, depending on the final destination of the production (feed, industrial, food). The hectoliter mass, an indicator of commercial quality, recorded good values for most varieties, but the differences between them were statistically significant only in some cases. Varieties with a high hectoliter mass can have a competitive advantage when it comes to recovery. All varieties analysed demonstrated a significant advantage over the Dakota control in terms of ear length, number of spikes and grains per ear, as well as grain weight.*

Key words: *barley varieties, technology, protein content*

INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the oldest cultivated cereals, holding significant agricultural, nutritional, and industrial importance. Globally, barley ranks fourth among cereal crops after maize, wheat, and rice, primarily used for animal feed, malt production, and, to a lesser extent, direct human consumption (BAIK & ULLRICH, 2008; NEWTON et al., 2011). Modern barley cultivation systems, especially in developed countries, largely rely on intensive technologies involving the use of chemical fertilizers and pesticides, which contribute to high yields but also generate environmental pressures (DURHAM & MIZIK, 2021; GŁODOWSKA & GAŁAZKA, 2018).

The increasing demand for barley-derived products, in the context of climate change and limited natural resources, necessitates the development of genotypes adapted to new agroclimatic conditions (VISIONI et al., 2020; TURNER et al., 2005). In Romania, agricultural research over recent decades has focused on breeding barley varieties for drought tolerance, frost resistance, disease resistance, and increased yield potential (ITTU & ITTU, 2014; MUSTEȚA & BĂRBULESCU, 2011; AXINTE et al., 2006).

The primary objective of barley breeding is to develop stable, productive, and resistant varieties amid increasingly pronounced climatic variability. In this regard, reducing the gap between genetic yield potential and actual field yields—often caused by climatic, technological, or biological factors—is crucial (ARAUS et al., 2002; FISCHER & EDMEADES, 2010). Recent studies have shown that selecting morphometric traits, such as thousand-kernel weight (TKW), can significantly enhance yield and its stability under stress conditions (REYNOLDS et al., 2009; KHALID et al., 2022).

The structure of the barley spike, as well as the position of the kernels, significantly influences their development and weight. It has been found that kernels in the upper portion of the spike often exhibit poorer development due to reduced nutrient supply (SHIMODA et al., 2022; LACHUTTA & JANKOWSKI, 2024). Therefore, selecting genotypes that exhibit uniform kernel development regardless of position in the spike may provide benefits in terms of final yield and harvest quality.

Barley is distinguished by its valuable nutritional composition, containing complex carbohydrates, proteins, dietary fibers, and a range of essential micronutrients, being regarded as a functional cereal with applications in nutrition and health (BIEL et al., 2020; SHEWRY & ULLRICH, 2002). Moreover, in the brewing industry, malt quality derived from barley directly depends on the physicochemical characteristics of the kernels, making the improvement of these traits a continuing priority (FOX et al., 2003; EDNEY et al., 2012).

In Romania, breeding barley for kernel size and yield stability has been consistently integrated into research programs to increase its competitiveness on the European market (MANDEA et al., 2023; IMBREA, 2014). Analyzing morphological variability based on kernel position within the spike and environmental conditions provides essential data for selecting superior genotypes, thereby contributing to the efficiency of the breeding process.

MATERERIAL AND METHODS

Research on the performance evaluation of barley (*Hordeum vulgare* L.) varieties was conducted during the 2023–2024 period on a chernozem-type soil, characterized by a high humus content and naturally superior fertility. This soil type provides favorable conditions for barley crop development; however, the response of each variety to environmental factors significantly depends on its genetic potential and its ability to utilize the available resources.

The study analyzed six barley varieties: Jup, Melia, Idilic, SU Ellen, Dakota (hybrid), and Azrah, each exhibiting distinct adaptability, quality, and productivity traits. The primary objective was to identify the highest performing varieties in terms of yield and grain quality under the specific soil and climatic conditions of the testing area.

The experiment was arranged in a randomized block design with three replications to ensure high accuracy of results and allow for statistical analysis of differences between varieties. Throughout the growing season, key morphological and physiological indicators were monitored, including: spike length (cm); average number of spikelets and grains per spike; thousand kernel weight (g); hectoliter weight (kg/hl); and protein content (%).

Measurements were taken at full maturity, and the collected data were statistically analyzed to identify significant differences among the varieties.

The results obtained in the 2023 and 2024 growing seasons revealed significant variation between varieties. Jup and Melia demonstrated superior adaptability and high productivity, being recommended for optimal use of fertile chernozem soils. Idilic and SU

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Ellen showed below-average field performance, while Azrah was positioned near the experimental mean without significant advantages. The Dakota hybrid recorded the lowest results, being significantly outperformed by other genotypes in spike length, grain number, and average grain weight.

Comparative analysis between 2023 and 2024 indicated that 2024 was more favorable for Idilic and Jup, which showed increases in protein content, whereas Melia, Azrah, and Dakota exhibited a decline in performance. Overall, the synthesis of the two-year study confirms the presence of valuable genetic diversity that can be exploited in barley breeding and selection programs aimed at achieving stable and high-quality yields.

Cultivation technology, as a factor of agricultural production, plays a crucial role in creating the conditions necessary for plant growth and development, alongside natural environmental factors (soil, climate), and in enhancing the efficiency of the production process. The improvement of agrotechnical cultivation methods remains a continuous concern for agricultural research and practice, to which this study modestly contributes (NIȚĂ et al., 2025).

REZULTS AND DISCUSSIONS

The analysis of data obtained during the 2023–2024 period revealed significant differences among the tested barley varieties in terms of both yield and grain quality. Environmental factors, particularly temperature and rainfall patterns, directly influenced the performance of each genotype; however, genetic differences proved to be decisive in the efficient utilization of the resources provided by the chernozem-type soil.

Table 1 and figure 1 present a detailed comparison of the yields obtained from the different barley varieties, expressed relative to the field average. The analysis focused on average yield (kg/ha), relative yield (% compared to the field average), yield deviations (kg/ha), and the statistical significance level associated with each difference.

Table 1

Summary of the harvest results obtained in the 2023-2024 experimental cycle

Variant	**Yield (kga/ha)**	**Production Relative %**	**The difference of production kg/ha**	**Meaning**
Average of the field	6.732	100	Mt.	
Idilic	6.200	92	-532	000
Jup	8.010	119	1278	xxx
Melia	7.090	105	358	xxx
SU Ellen	6.170	92	-562	000
Azrah	6.520	97	-212	00
Dakota	6.400	95	-332	000

DL5% = 115 kg/ha; DL1% = 162 kg/ha; DL0,1% = 228 kg/ha

Soil Idilic achieved a production below the field average, with a reduction of approximately 532 kg/ha; however, the difference was not statistically significant. The relative production value of 92% highlights a lower capacity to adapt to the specific pedoclimatic

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conditions. The modest performance may be correlated with an increased sensitivity to stress factors during the growing season. The Jup variety stood out with a significantly higher production than the field average, showing a positive difference of 1278 kg/ha, which was considered highly statistically significant. With a relative production of 119%, this genotype demonstrates excellent adaptation to local conditions and high efficiency in utilizing soil and climatic resources.

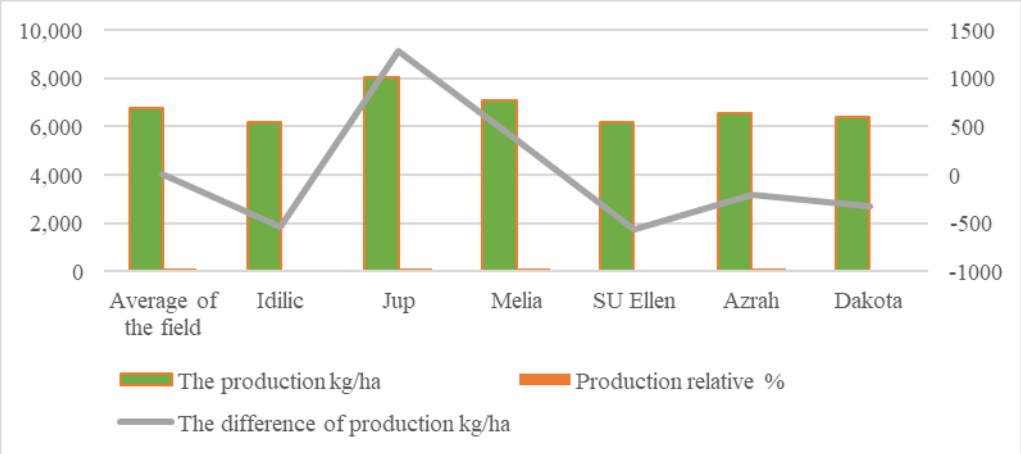

Figure. 1. Summary of the harvest results obtained in the 2023-2024 experimental cycle

Similarly, the Melia variety exceeded the field average, although to a lesser extent than Jup. This result suggests good productive potential and satisfactory adaptability, but further research is needed to identify the factors limiting maximum performance.

Like Idilic, the SU Ellen variety recorded results below the field average, with a reduction of 562 kg/ha. The relative production of 92%, combined with a significant negative difference, confirms poor adaptation to the conditions in the testing area.

The Azrah variety showed production close to the field average, with no statistically significant differences. This result indicates moderate stability as well as potential for improvement through optimized cultivation technology.

The Dakota hybrid was below the general average, with a decrease of 332 kg/ha and a relative production of 95%. Although the differences were not statistically significant, the results confirm lower productivity compared to the high-performing varieties, which limits its recommendation for local condition.

Results of quality indicators for the barley varieties tested

The quality indicators monitored during the experimental cycle were: hectoliter weight (HW) and protein content.

Statistical analysis of the hectoliter weight (HW) values obtained in 2023 and 2024 revealed significant differences between varieties, as well as year–variety interactions that directly influenced the level of this quality indicator.

In general, higher HW values reflect a greater grain density, associated with full kernel filling and efficient photosynthesis during the final vegetation phase. From this perspective, the

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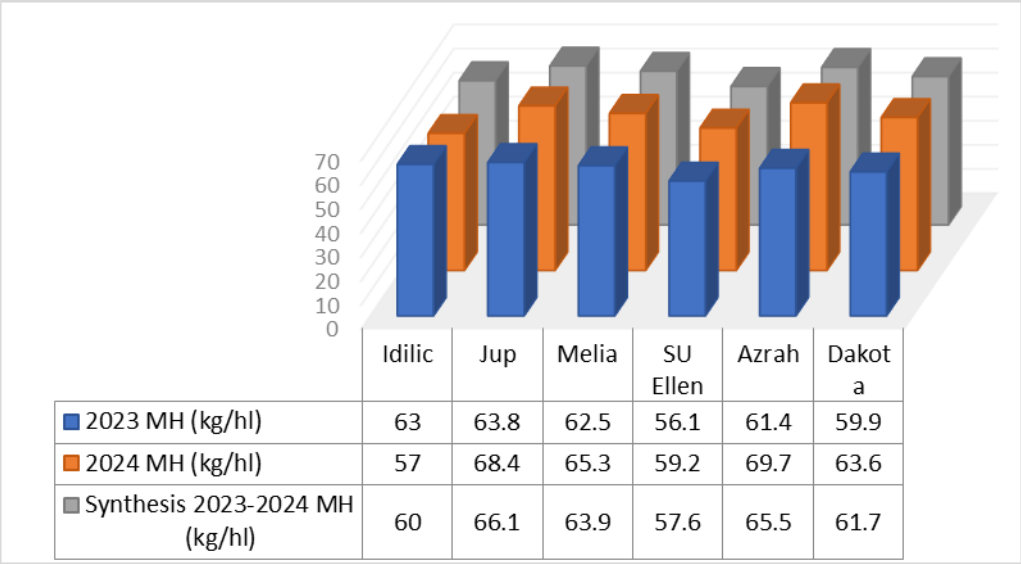
Azrah and Jup varieties demonstrated a superior capacity for dry matter accumulation in the grains, as confirmed by significant increases of 8.3 kg/hl and 4.6 kg/hl, respectively, in 2024 compared to 2023 (figure 2).

For the SU Ellen and Idilic varieties, the differences were smaller and statistically insignificant, suggesting lower genetic stability for this trait, possibly influenced by climatic variations during the maturation period. The decrease recorded for the Idilic variety (−6 kg/hl) indicates a marked sensitivity to water or heat stress during grain formation, which affected the filling process and, consequently, the grain density.

Physiologically, the increase in hectoliter weight in 2024 can be correlated with a more balanced rainfall regime during the grain filling period and moderate temperatures, which favored the efficient translocation of assimilates to the kernels. Conversely, the less favorable conditions in 2023, characterized by higher temperatures and soil moisture deficit, led to decreased HW values in some varieties.



	Idilic	Jup	Melia	SU Ellen	Azrah	Dakota
2023 MH (kg/hl)	63	63.8	62.5	56.1	61.4	59.9
2024 MH (kg/hl)	57	68.4	65.3	59.2	69.7	63.6
Synthesis 2023-2024 MH (kg/hl)	60	66.1	63.9	57.6	65.5	61.7

Figure 2. Synthesis of the results regarding the hectoliter mass in the experimental cycle 2023-2024.

Protein Content

Figure 3 presents the protein content values for the six barley varieties for the years 2023, 2024, and a combined summary for both periods (2023–2024). We can observe how the values evolve for each variety individually, as well as the differences between years and between the summarized values.

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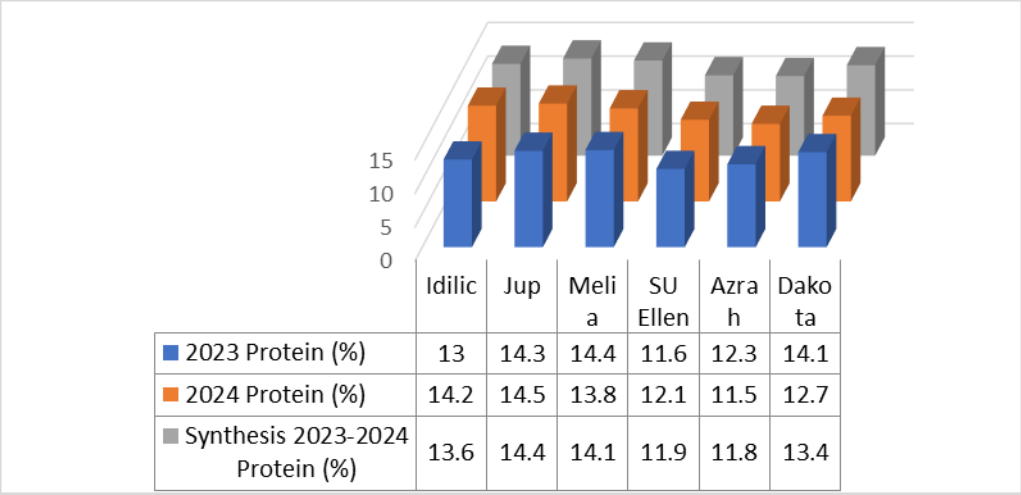

	Idilic	Jup	Melia	SU Ellen	Azrah	Dakota
2023 Protein (%)	13	14.3	14.4	11.6	12.3	14.1
2024 Protein (%)	14.2	14.5	13.8	12.1	11.5	12.7
Synthesis 2023-2024 Protein (%)	13.6	14.4	14.1	11.9	11.8	13.4

Figure 3. Protein content recorded in the six barley varieties in the experimental cycle 2023-2024

For the Idilic variety, protein content increased in 2024 compared to 2023 by 1.2%. The 2023–2024 summary suggests an intermediate value (13.6%), meaning that the protein content in 2024 is considerably higher than in 2023. Protein content in the Jup variety rose slightly in 2024 (by 0.2 percentage points). The 2023–2024 summary indicates a very close value (14.4%). In Melia, protein content decreased in 2024 compared to 2023 by 0.6%. The summary shows a value closer to 2023 (14.1%), suggesting a slight reduction in 2024 compared to 2023.

The SU Ellen variety experienced a moderate increase in protein content in 2024 compared to 2023, by 0.5%. The 2023–2024 summary confirms a slightly lower average value (11.9%), but the change is still positive. Azrah showed a decrease in protein content in 2024 by 0.8% compared to 2023. The summary shows an intermediate value of 11.8%, indicating that the decline was more pronounced in 2024 relative to 2023.

The Dakota hybrid experienced a significant decrease in protein content in 2024 compared to 2023, by 1.4 percentage points. The 2023–2024 summary indicates an average value of 13.4%.

The statistical analysis was performed on: spike length; number of spikelets per spike; number of grains per spike; and grain weight per spike.

Spike Length

Figure 4 presents the average spike length over the two experimental years. Analyzing the barley spike length graph, considering that the Dakota hybrid is used as a control, the following observations can be made:

All other varieties analyzed (Idilic, Jup, Melia, SU Ellen, Azrah) exhibit a spike length greater than the control. Spike length varies between 15.65 cm (Dakota) and 20.875 cm (Jup), indicating moderate variability among the tested variants. Jup records the greatest spike length (20.875 cm), suggesting possible superior genetic adaptability or performance under the studied conditions. Other varieties with high values include SU Ellen (20.525 cm), Azrah (20.35 cm), and Idilic (20.025 cm), all having spike lengths exceeding 20 cm.

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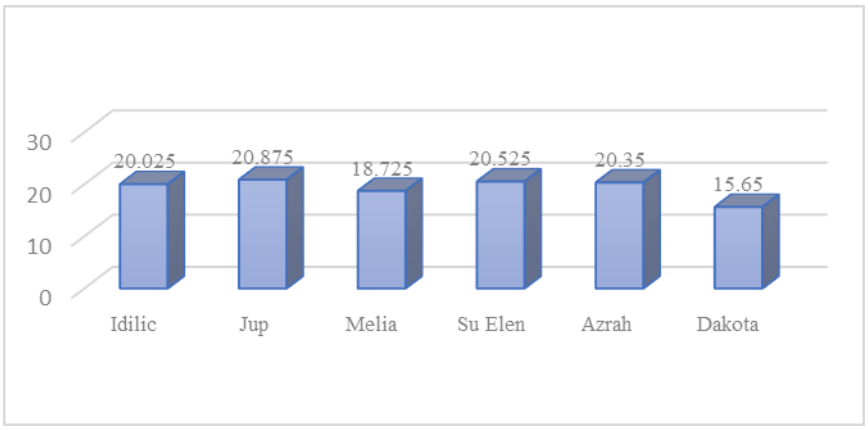

Figure 4. Average ear length of the six barley varieties in the two experimental years.

Number of Spikelets per Spike

The average number of spikelets per spike is presented in Figure 4. Analyzing the graph for the number of spikelets per barley spike, with the Dakota hybrid as the control, it can be observed that all the analyzed varieties (Idilic, Jup, Melia, SU Ellen, Azrah) exceed the Dakota hybrid in terms of spikelets per spike. The number of spikelets per spike ranges from 15.65 spikelets (Dakota) to 20.875 spikelets (Jup), indicating moderate variability of this parameter among the variants. Although the graph does not explicitly indicate statistically significant differences, the values show a clear trend of superiority of all varieties compared to the control.

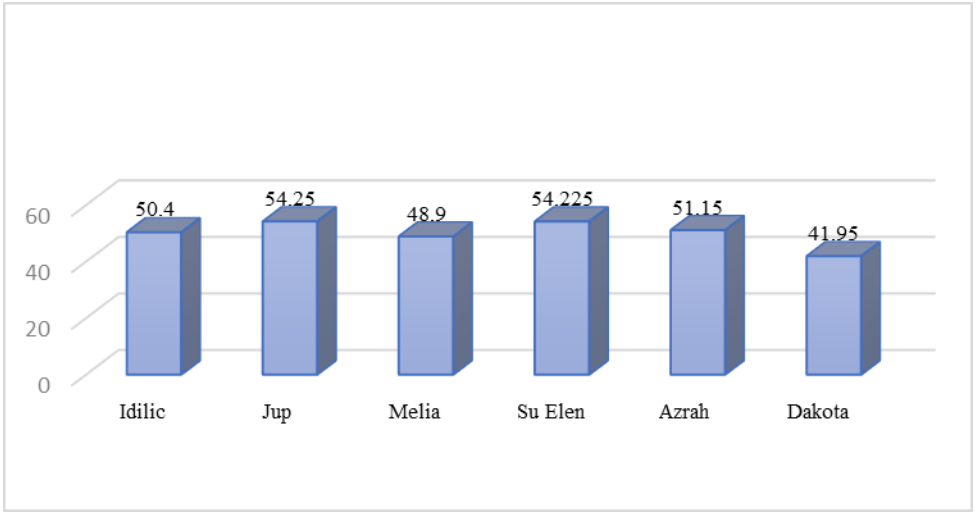

Figure 5. Average number of grains/ear of the six barley varieties in the two experimental years.

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Grain Weight per Spike

All the analyzed varieties (Idilic, Jup, Melia, SU Ellen, Azrah) exhibit higher grain weights per spike compared to the control (Figure 5). Grain weight ranges from 2.139 g (Dakota) to 3.4425 g (Azrah), indicating considerable variability between the varieties and the control. The difference between the variety with the highest grain weight (Azrah) and the one with the lowest grain weight (SU Ellen) is 0.71975 g, indicating a moderate difference in the performance of the varieties.

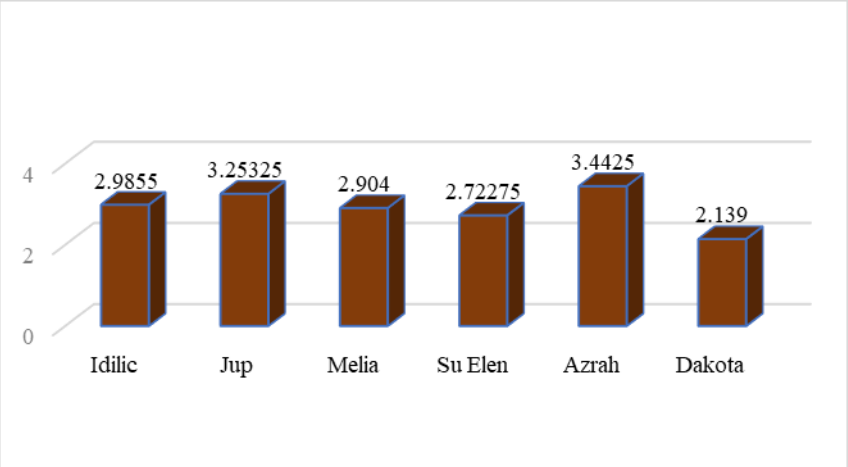

Figure 6. Average grain/ear weight in the two experimental years

CONCLUSIONS

Barley, through its inclusion in crop rotation, contributes to improving soil structure, reducing disease and pest pressure, and efficiently utilizing natural resources—essential aspects for sustainable agriculture.

For fertile chernozem soils, selecting varieties with high genetic potential, such as Jup and Melia, is crucial for achieving superior and stable barley yields. Varieties with lower performance, such as Idilic, SU Ellen, and Dakota, can only be used under advanced technological conditions that support their adaptation. In contrast, the Azrah variety can serve as a balanced option with moderate adaptability under variable pedoclimatic conditions.

Quality assessments revealed clear differences between genotypes. Generally, high-yielding varieties (Jup, Melia) maintained good hectoliter weight values and protein content appropriate to technological requirements.

In conclusion, the significant differences between varieties and years confirm the combined influence of genetic and environmental factors on hectoliter weight. The Azrah and Jup varieties stand out for their consistent ability to maintain superior grain quality and are recommended for fertile chernozem soils where they can optimally utilize available resources.

Comparative analysis across years showed that 2024 was more favorable for the Jup and Idilic varieties, which recorded an increase in protein content, likely due to better

coordination between water supply and grain filling processes. Conversely, Melia, Azrah, and Dakota showed a decline in performance, suggesting greater sensitivity to temperature and humidity variations that year.

Further statistical analyses are essential to confirm the significance of these differences and to validate the selection of the best varieties.

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