

WHEAT GRAIN QUALITY DEPENDING ON CULTIVATION TECHNOLOGY AND PREVIOUS CROP

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Abstract

Maintaining wheat quality in the context of climate change is a crucial challenge for ensuring food security and the economic value of agricultural production. In a difficult economic environment, farmers often tend toward cereal-dominated crop rotations, which increases the risk of yield and quality decline, particularly due to the unfavorable effect of preceding crops. The study comparatively evaluates the effect of conventional tillage and no-tillage on the yield and quality of winter wheat grains cultivated in a four-crop rotation, with soybeans, maize and winter rapeseed as preceding crops. The parameters analyzed include yield, crude fiber content, ash content, starch content, total fat, crude fiber and crude protein (both expressed on a dry matter basis), and moisture. The results confirm the clear influence of the preceding crop type and soil tillage system on wheat yield and quality, emphasizing the importance of choosing appropriate technologies to optimize crop performance, promote agricultural sustainability, and increase the competitiveness of the cereal sector.

Key words: crop rotations, tillage, winter wheat.

INTRODUCTION

Due to its high carbohydrate content, wheat (*Triticum aestivum* L.) is frequently perceived as a primary energy source, an aspect that confers it particular importance from this perspective. It also contains significant amounts of essential nutrients, including proteins, fibers, and minor components such as lipids, vitamins, and minerals that can contribute to a healthy diet (NDNS, Bates et al., 2014a, b). These characteristics make it a crucial agricultural crop globally, essential for human nutrition and the agricultural economy (Shewry & Hey, 2015). The quality and quantity of winter wheat production determine its economic value. These parameters make it possible to utilize the grain. Wheat intended for food consumption must have a high baking and milling value, or processing value. Therefore, in wheat production, both high yields and favorable grain quality parameters are important, such as protein content, quantity and quality of gluten, sedimentation value, and specific grain weight. Climate variability is already reshaping how wheat responds to disease pressure, altering both infection timing and pathogen aggressiveness across southern Romania (Paraschivu et al., 2023).

Wheat grain yield and quality are significantly influenced both by the previous crop and by the tillage system, with higher yields and superior quality parameters being obtained when wheat is cultivated after soybean and under conventional tillage (Gawęda and Haliniarz, Agriculture 2021; Slafer & Satorre, 1999). Thus, adapting cultivation technologies and applying appropriate agrotechnical measures play an essential role in increasing productivity and improving crop quality parameters, particularly under the variable climatic conditions of southern Romania (Iancu et al., 2009). Under conditions of good quality soils, characterized by high fertility, favorable structure and texture, and adequate porosity, high yields can be achieved, which can be realized under normal conditions through the application of appropriate technologies (Popescu et al., 2024). The implementation of modern cultivation technologies, including fertilization, crop rotation, and phytosanitary protection practices, affects not only yield but also quality parameters such as protein content, gluten, and hectoliter weight (Rusu et al., 2014). The application of alternative organic products with fungicidal effect in the management of major wheat diseases not only supports sustainable

agricultural practices compared to traditional fungicides, but can also contribute to improving grain quality, positively influencing its parameters (Paraschivu et al., 2024). An important role in improving soil structure and reducing diseases, with a direct impact on wheat production quality, is represented by the choice of the previous crop (García del Moral et al., 2003).

Furthermore, climate change represents a global challenge facing humanity today, due to continuously rising temperatures, which trigger numerous extreme meteorological phenomena such as heat waves, drought, and flooding, affecting crop production. (Soare et al., 2024).

Emphasizing the importance of adopting measures to counteract climatic variability in order to maintain the production and quality potential of crops, it is necessary to consider all crop protection methods starting from the time of planting. (Prioteasa et al., 2025).

Wheat grain quality depends on the interplay between genetics, cultivation technology, the previous crop, and environmental factors, including climate change. Adopting modern cultivation technologies, using alternative organic products, and making appropriate choices regarding the previous crop can improve both yield and grain quality.

Against this backdrop, selecting the tillage system and previous crop in southern Romania is no longer just an agronomic decision it is an economic and climate-adaptation strategy.

Climatic and environmental factors can considerably restrict agricultural performance through the occurrence of extreme water regimes, characterized either by excess or deficit of water during the growing period. Among these, drought represents the primary abiotic stress, and the interaction between atmospheric and pedological drought generates major effects on crop growth and development, manifested in significant yield reductions or even total crop failure (Nițu et al., 2024).

Intensive interventions such as overseeding and fertilization do not guarantee profitability, especially under unfavorable climatic conditions. Future decisions should integrate both economic calculations and sustainability objectives, possibly correlated with agri-

environmental policies or subsidies to support ecosystem restoration (Acatrinei et al., 2024).

Conservation agriculture systems, of which no-tillage represents the most advanced form, have demonstrated significant benefits in the context of climate change, through conserving soil moisture, improving soil structure, and reducing erosion losses (Kassam et al., 2019). At the same time, the choice of previous crop substantially influences the productive potential of wheat, through mechanisms involving the nutrient cycle, water reserve dynamics, and phytopathological pressure (Plaza-Bonilla et al., 2015).

MATERIALS AND METHODS

Experimental Location and Pedoclimatic Conditions

The experiment was conducted over two consecutive years (2022/2023 and 2023/2024) in southern Romania, in the Boian Plain, a subdivision of the Romanian Plain. The experimental site is characterized by cambic chernozem (Haplic Chernozem in WRB classification), a moderately developed chernozem subtype with high natural fertility and favorable structure in the upper horizon. The agrochemical properties determined in the 0-30 cm layer (horizon A) were as follows: humus content 3.7%, total nitrogen (N) 0.19%, available phosphorus (P_2O_5) 37 ppm, and exchangeable potassium (K_2O) 98 ppm. These characteristics provide favorable conditions for cereal cultivation, supporting optimal plant development, drought tolerance, disease resistance, and superior grain quality.

The study area is characterized by a temperate-continental climate with sub-Mediterranean influences, with a mean annual temperature of 11.6°C (average of the last 30 years) and mean annual precipitation of 541.7 mm (Romanian National Meteorological Administration, www.meteoromania.ro). The growing period of the 2022/2023 agricultural year was marked by deficient climatic conditions, with a cumulative rainfall deficit of 64.3 mm compared to the multi annual average and monthly mean temperatures 3.2°C above the climatological norm, which created conditions of moderate to severe water stress for the wheat crop.

Experimental Design and Treatments

The objective of this study was to evaluate the effects of the conventional tillage system versus the no-tillage system on yield and grain quality of autumn wheat. Two high-performing Romanian autumn wheat varieties were selected Glosa and Boema created at the National Agricultural Research and Development Institute Fundulea and recognized for their high productivity and superior drought tolerance.

The experiment was established according to a three-factor factorial design: Factor A (Variety): Glosa and Boema, both characterized by early maturity and drought resistance; Factor B (Tillage System): conventional tillage (conventional plowing followed by secondary tillage operations) and no-tillage system (direct seeding without soil tillage); Factor C (Previous Crop): rapeseed (*Brassica napus* L.), soybean (*Glycine max* L.), and maize (*Zea mays* L.).

The research was conducted according to a complete factorial design of $2 \times 2 \times 3$, resulting in 12 distinct experimental variants. Each experimental plot measured 30 m² (4 m $\times$ 7.5 m), with 1 m buffer zones between plots to prevent cross contamination.

The experimental factors were selected based on both scientific and practical considerations. The two varieties, Glosa and Boema, were chosen for their scientific relevance, representing distinct genotypic profiles in terms of drought tolerance and yield potential, as well as for their practical importance, together accounting for approximately 40-45% of the wheat cultivated area in Romania (Glosa 35%, Boema 10%). The tillage systems were selected to reflect the current transition from conventional to conservation agriculture in the context of climate change. The previous crops were chosen from distinct botanical families (Brassicaceae, Fabaceae, Poaceae), given their differentiated effects on soil fertility, edaphic structure, and phytopathological pressure.

Sowing and Seedbed Preparation

Due to the pedological drought conditions observed in the autumn of 2022, sowing was postponed until the third decade of October (October 25, 2022, for the 2022/2023 season and October 23, 2023, for the 2023/2024 season). All experimental variants were sown on the same day for each agricultural season, using a seeding rate of 550 viable seeds/m². This density

was established based on the variety characteristics (high tillering capacity, 600-650 plants/m² at harvest) and local pedoclimatic conditions (drought risk, estimated germination losses of 5-10%).

For conventional tillage, soil preparation included: plowing at 25 cm depth, performed immediately after harvesting the previous crops (June-July for rapeseed, September for soybean and maize); disk harrowing at 12-15 cm depth for breaking clods and leveling.

For the no-tillage variants, wheat was sown using a purpose-built no-tillage drill without any prior soil tillage. After harvesting the previous crops (soybean, rapeseed, maize), the crop residues were uniformly chopped and distributed on the soil surface using a straw chopper mounted on the combine harvesters. Sowing depth was 4-5 cm for both systems, with a row spacing of 12.5 cm, resulting in 32 rows per plot.

Regarding fertilization, this was uniform for all plots. Before sowing, the following were applied: N: 40 kg/ha (urea 46%), P₂O₅: 60 kg/ha (applied as simple superphosphate), and K₂O: 40 kg/ha (applied as potassium chloride). During the growing season, in March N: 60 kg/ha was applied (ammonium nitrate 34% N) and in April N: 40 kg/ha (as urea 46%). The total nitrogen dose was reduced by 20 kg N/ha in variants following soybean, which fixes an estimated 60-80 kg N/ha of atmospheric nitrogen, with 30-40% remaining available for the subsequent crop. Weed, pest, and disease control followed the principles of integrated pest management.

Harvesting and Data Collection

Yield Determination

Harvesting was performed at complete physiological maturity, when grain moisture was between 16-18%. Mechanized harvesting was carried out over the entire surface of each plot using a small-scale experimental combine harvester. Yield was weighed immediately after harvesting using a precision balance.

Grain Quality Analysis by NIRS Spectrophotometry

For the qualitative characterization of the harvested biological material, near-infrared spectrophotometry (NIRS) was implemented. This instrumental method presents decisive advantages in the context of analyzing cereals and products intended for the feed and food

industry: non-invasiveness, high execution speed, and no requirement for complex sample preparation. The spectrum of investigated parameters included protein content, starch and sugar concentration, digestibility of non-structural carbohydrates (NCGD), crude lipid fraction (ether extract EE), and the *Fah*_{as} indicator. The data obtained provides essential information for two distinct directions of utilization: evaluation of milling-baking aptitudes and establishing the potential for integration into industrial processing flows. Representative 500 g grain samples were collected from each plot.

RESULTS AND DISCUSSIONS

Climatic Aspects

The study area is under the influence of a temperate continental climate, characterized by non-uniform precipitation patterns. Given non-irrigated agriculture, autumn moisture deficit can compromise adherence to the optimal calendar for establishing wheat crops. From a thermal perspective, 2022 ranked among the three warmest years recorded in Romania. October showed notable climatic anomalies: precipitation was limited to 15 mm, representing a decrease of 16.8 mm compared to the climatological norm of 46.0 mm, making it one

of the driest Octobers in the meteorological record. At the same time, the monthly mean temperature of 13.6°C was considerably above the usual values for this period. These conditions had direct consequences for the germination process, which was compromised, negatively influencing the entire ontogeny of the plants and, implicitly, the qualitative characteristics of the grain yield.

In November, above-average temperatures persisted, with a mean temperature of 8.6°C, exceeding the multi-annual average by 3.6°C, placing it among the warmest Novembers on record. The rainfall deficit extended into February, when only 13.2 mm of precipitation was recorded, 14.7 mm below the reference value. The combination of atypically high soil and air temperatures in February led to the premature interruption of winter dormancy, activating vegetative growth processes before the normal physiological time. In contrast to the cold season, the spring period benefited from more favorable conditions, with rainfall within acceptable limits, which allowed the soil water reserve to be maintained at near-optimal parameters. It is important to note that, during the growing period, monthly mean temperature values were consistently above multi-annual averages (Table 1).

Table 1. The meteorological parameters in the experimental period 2022-2023
(Source: Romanian National Meteorological Administration, www.meteoromania.ro)

Specification	Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Average Total
Temperature °C	Monthly Average	13.7	8.6	2.8	4.0	3.6	7.7	10.6	16.4	21.2	25.8	25.7	21.5	13.4
	Multiannual Average Last 30 Years	11.7	5.1	0.3	-1.3	0.8	6.0	12.0	17.7	21.6	22.8	23.5	18.1	11.6
	Deviation Amount Monthly	+2.0	+3.5	+2.5	+5.3	+2.8	+1.7	-1.4	-1.3	-0.4	+3.0	+2.2	+1.4	+1.8
Precipitation mm	Multiannual Media Last 30 Years	15.0	78.8	33.8	103.4	13.2	20.8	68.8	78.6	44.4	120.0	40.8	35.8	653.4
		46.0	37.0	39.1	30.8	26.3	34.2	47.8	58.6	69.7	62.1	46.6	43.5	541.7
	Deviation	-16.8	+87.2	-17.7	-4.0	-14.7	-11.8	-21.8	+13.2	-38.1	+33.1	-40.6	-24.5	+111.7

The 2023-2024 agricultural campaign was marked by significant water deficits. In October, the month in which the experiment was established, precipitation was 16.8 mm below the climatological norm, with only 21.4 mm recorded. November brought a substantial improvement, with 124.2 mm of precipitation an

amount that exceeded the multiannual average by 87.2 mm ensuring a satisfactory reconstitution of soil moisture reserves. The winter and early spring period was characterized by insufficient rainfall, with a negative impact on plant growth dynamics. February represented the minimum seasonal

rainfall; with only 11.6 mm a deficit of 14.7 mm compared to the 30-year average of 26.3 mm. May played a crucial role in supplying the crop with water; the pluviometric input of 71.8 mm was 13.2 mm above the norm of 58.6 mm. This amount proved beneficial, occurring during critical phenological stages that require maximum water consumption: heading, flowering, and the processes of grain formation and filling.

From a thermal perspective, the entire growing period was dominated by positive anomalies, with monthly temperatures consistently exceeding reference values. The exception was

May 2024, when the mean temperature of 17.2°C was 0.5°C below the multi-annual average of 17.7°C. The most pronounced positive thermal deviations were recorded in February (+7.2°C) and October (+4.2°C), while in the summer months (June, July, August) the thermal excess remained constant between +3.3°C and +4.4°C (Table 2).

Over the entire growing period (October-September), the cumulative precipitation deficit reached 64.3 mm (477.4 mm vs. the norm of 541.7 mm), while the mean annual temperature of 14.8°C was 3.2°C above the multi-annual average of 11.6°C.

Table 2. The meteorological parameters in the experimental period 2023-2024
(Source: Romanian National Meteorological Administration, www.meteoromania.ro)

Specification	Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Average Total
Temperature °C	Monthly Average	15.9	8.2	3.9	0.9	8.0	8.8	14.9	17.2	26.0	27.2	26.8	20.2	14.8
	Multiannual Average Last 30 Years	11.7	5.1	0.3	-1.3	0.8	6.0	12.0	17.7	21.6	22.8	23.5	18.1	11.6
	Deviation Amount Monthly	+4.2	+3.1	+3.6	+0.4	+7.2	+2.8	+2.9	-0.5	+4.4	+4.4	+3.3	+2.1	+3.2
Precipitation mm	Multiannual Media Last 30 Years	21.4	124.2	21.4	26.8	11.6	22.4	26.0	71.8	31.6	95.2	6.0	19.0	477.4
		46.0	37.0	39.1	30.8	26.3	34.2	47.8	58.6	69.7	62.1	46.6	43.5	541.7
	Deviation	-16.8	+87.2	-17.7	-4.0	-14.7	-11.8	-21.8	+13.2	-38.1	+33.1	-40.6	-24.5	-64.3

Production and Quality

For both varieties and all three previous crops studied, the no-tillage system generated lower yields compared to the conventional system, with absolute differences ranging from -50 kg/ha to -380 kg/ha. This systematic trend suggests that, under the pedoclimatic conditions of 2022/2023, conventional primary tillage favored a more uniform seedbed and superior nutrient mobilization, conferring a net competitive advantage over the conservative variant.

Relative reductions range between -0.9% and -7.8%, a moderate interval. Irrespective of the tillage system, soybean proves to be the most valuable previous crop for wheat in both varieties, generating the maximum absolute yields (5.820 kg/ha for Glosa Conventional; 5.580 kg/ha for Boema Conventional). The beneficial effect of soybean was attributed primarily to biological nitrogen fixation, improved soil structure, and reduced pressure from cereal-specific diseases.

Regarding rapeseed as a previous crop, it occupied an intermediate position, maintaining high yields and offering recognized phytosanitary advantages in rotation with wheat. Notably, for the Glosa variety under no-tillage, the yield after rapeseed (5.330 kg/ha) was higher than that obtained after maize under conventional tillage (4.860 kg/ha), which underscores that the effect of the previous crop can partially compensate for the technological disadvantage of no-tillage.

With maize, the minimum absolute values (4.480 kg/ha for Glosa no-tillage; 4.460 kg/ha for Boema no-tillage) may signal the high risk of contamination with *Fusarium* spp., difficulties in incorporating voluminous crop residues, and imbalances in nitrogen dynamics.

For the Glosa variety, the maximum penalty under no-tillage is -7.8% (after maize), while for Boema it does not exceed -4.5% (also after maize). This behavioral difference suggests that the Boema variety shows superior adaptability to the conditions characteristic of conservation

systems, namely more compact soil, lower soil temperatures at germination, and increased competition with crop residues. This result recommends it preferentially for farms oriented toward conservation agriculture.

The fact that the conventional system surpasses no-tillage in the Boian Plain is easily explained by the nature of the chernozem and the climatic specifics of the area. The cambic chernozem of the Boian Plain, a moderately developed chernozem subtype with high organic matter content and good natural fertility, tends to form a compact surface crust in the absence of mechanical tillage, a phenomenon accentuated by late summer and autumn torrential rains followed by dry periods. In the no-tillage system, this crust limits the infiltration of autumn and spring precipitation water, reducing the hydrological reserve accessible to the crop precisely during the critical phases of tillering and stem elongation. Conventional plowing, through mechanical loosening of the superficial horizon, eliminates this impediment and restores hydraulic conductivity, with a direct positive effect on mineral nutrition through the

intensification of aerobic microbial activity and organic nitrogen mineralization.

Another characteristic specific to the Boian Plain is the increased risk of no-tillage compaction at 25-35 cm depth, which can become impermeable and restrictive for the wheat root system, limiting access to water from lower horizons precisely the strategic water reserve under drought conditions. Yields recorded in 2023, ranging between 4.460 and 5.820 kg/ha, reflect a medium to favorable agricultural year for the Romanian Plain, with sufficient precipitation during the crop's early phenophases, but with moderate water deficit in May-June. Differences of 4-8% in favor of the conventional system are agronomically significant and indicate superior adaptation of the conventional system to local pedoclimatic conditions.

The Glosa after soybean variant, with the smallest difference (-0.9%), suggested that the high nitrogen input from the previous legume crop could partially attenuate the disadvantages of no-tillage, compensating for part of the mineralization deficit (Table 3).

Table 3. Production results obtained for wheat crops in 2023 and 2024

Year	Variety	Previous Crop	Conventional System kg/ha	No-tillage System kg/ha	Relative Difference %
2023	Glosa	Rapeseed	5570	5330	-4.3
		Soybean	5820	5770	-0.9
		Maize	4860	4480	-7.8
	Boema	Rapeseed	5330	5150	-3.4
		Soybean	5580	5340	-4.3
		Maize	4670	4460	-4.5
2024	Glosa	Rapeseed	4900	4840	-1.2
		Soybean	5100	4950	-2.9
		Maize	4550	4480	-1.5
	Boema	Rapeseed	4810	4760	-1.0
		Soybean	4920	4800	-2.4
		Maize	4460	4370	-2.0

The 2023/2024 campaign was marked by severe drought, a recurring phenomenon in this area of southern Romania, with significant rainfall deficits in March-May and high temperatures that accelerated evapotranspiration. The reduction in yields compared to the 2022/2023-year ranges between 600 and 1.160 kg/ha, confirming the devastating impact of water stress on the productive potential of both varieties. Differences between the two technological systems vary from 180-380 kg/ha

in 2023 to only 50-150 kg/ha in 2024. This convergence can be explained by the partial reversal of advantages: under extreme drought conditions, conventional soil, better aerated and with superior porosity, loses moisture more rapidly through direct evaporation from the loosened layer, while no-tillage maintains a more favorable moisture gradient in the superficial horizon due to the mulch of crop residues. The two opposing effects partially compensate each other, bringing the

performance of the systems closer together. This tendency is confirmed by the research of Pittelkow, C.M. et al. (2015), Hemmat, A. & Eskandari, I. (2004), Balwinder-Singh et al. (2016), which demonstrate that the relative benefits of no-tillage increase with intensifying aridification.

From the perspective of climate change, this dynamic has implications: if the frequency and severity of droughts in the Boian Plain continue to increase a well-documented trend for southern Romania the advantage of the conventional system will gradually diminish, and no-tillage will gradually become competitive and possibly superior in the long term. The benefits of no-tillage (He et al., 2011) appear after the progressive accumulation of organic matter over the long term, not in the initial years.

Soybean excels as a previous crop due to biological nitrogen fixation, essential in a region where the cost of mineral nitrogen is high and where its use efficiency decreases under drought conditions. Rapeseed, although excellent from a phytosanitary standpoint, benefits less from the structural advantages of the taproot in the local chernozem, which already exhibits a naturally favorable structure in the upper horizon.

The Glosa variety records higher absolute yields than Boema in all variants, with an average advantage of approximately 250-350 kg/ha under normal conditions and 200-300 kg/ha under drought conditions. This indicates a superior genetic potential of the Glosa variety in the conditions of the Boianu Plain, but also a greater sensitivity to water stress, reflected in the more pronounced yield decline in 2024. The Boema variety presents superior inter-annual productive stability an essential quality for farms in southern Romania where drought is an endemic, not exceptional, risk.

The data obtained in the Boian Plain over the 2023-2024 campaigns demonstrate that, under the specific conditions of the chernozems of southern Oltenia and the highly continental climate, the conventional tillage system ensures yields superior to the no-tillage system in years with relatively normal pluviometry, due to the positive effects of periodic decompaction and accelerated nitrogen mineralization. At the same time, the 2024 data reveal that severe drought

significantly reduces the difference between systems, opening the prospect that conservation agriculture will gradually become more competitive as the region undergoes progressive climatic aridification. This tendency requires continuous monitoring of the experiment for a minimum of 5-7 years and the inclusion of complementary indicators, soil water reserve, compaction indices, and organic carbon balance for a complete basis for long-term agrotechnical decisions. From the perspective of current agricultural practice in the Boian Plain, the rotation with soybean as the previous crop and the Glosa variety in years with medium climatic risk, respectively the Boema variety in years with high drought risk, represents the optimal combination identified by the present study.

Biochemical parameters

Regarding the biochemical parameters, crude protein represents the most important qualitative indicator of bread wheat, directly conditioning gluten content, water absorption capacity, and the technological behavior of flour in the baking process. The synthesis and accumulation of storage proteins in the endosperm, respectively gliadins and glutenins, the main constituents of gluten are determinately influenced by nitrogen availability during the critical phases of grain filling, by the variety genotype, and by climatic conditions during the maturation period (Pechanek et al., 1997; Shewry & Hey, 2015). Protein values from the 2022/2023 campaign ranged from 12.559% to 13.808%, an interval lower than that recorded in the 2024 campaign, reflecting the different climatic context of the two years. The better water supply in 2023 stimulated higher biomass accumulation and more abundant grain filling with starch, diluting the available nitrogen across a greater amount of dry matter and thus reducing the relative protein concentration, a phenomenon known as the protein dilution effect (Triboi & Triboi-Blondel, 2002). The higher yields of 2023 thus came at the expense of grain protein quality, a classical negative relationship between quantitative yield and protein content, with direct practical implications for the fractioned nitrogen fertilization strategy during critical phenophases of wheat cultivation in the conditions of the Boian Plain. None of the variants reaches the premium quality threshold of 14% (Figure 1).

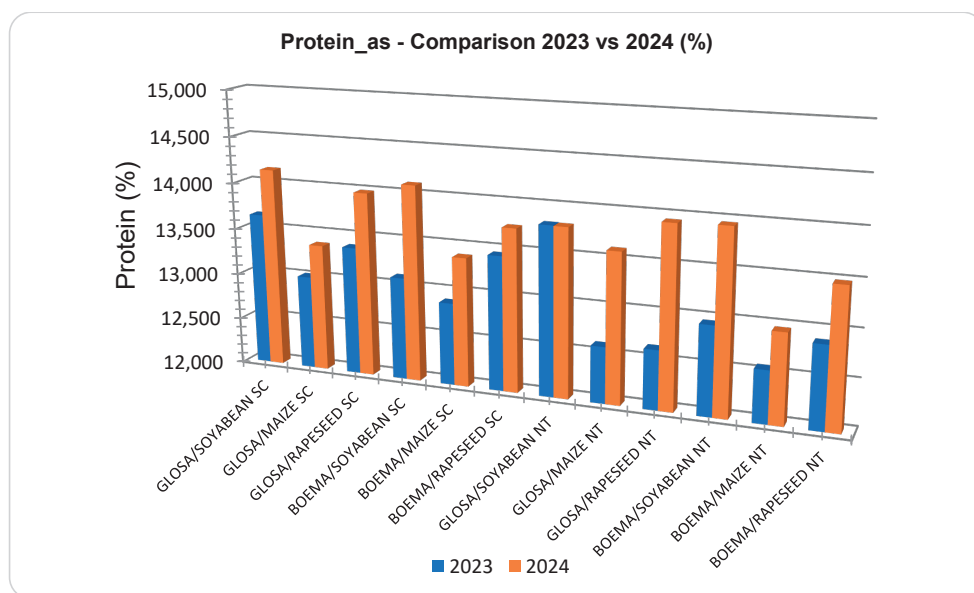


Figure 1. Comparative analysis of protein for the years 2023 vs 2024 (%)

Regarding the previous crop, soybean brings the highest protein values in both systems (12.95-13.81%), followed by rapeseed (12.63-13.44%), then maize (12.55-13.01%). This is logical because soybeans and rapeseed leave better residual nitrogen in the soil. Regarding the two tested varieties, the Glosa variety generally has higher protein than Boema, regardless of the tillage system or previous crop, making it more competitive for the bread wheat market.

Starch values ranged from 58.09% for Glosa Conventional after soybean to 62.33% for Boema No-tillage after maize, confirming the inverse protein-starch relationship, whereby variants with the highest protein content recorded the lowest starch values and vice versa. The Boema No-tillage after maize variant reached the maximum starch value of 62.33%, corresponding also to the lowest protein value, thus confirming the inverse relationship mentioned. This variability is important from the perspective of industrial applications: wheat with high starch and low protein content is preferred for biscuit manufacturing and industrial starch processing, while wheat with high protein content is intended for bread-making and traditional baking. Sugar content varied between 0.003% (Boema Conventional after maize) and 2.251% (Glosa No-tillage after rapeseed), with no negative values recorded.

Previous crops of rapeseed consistently generated the highest sugar values, while maize produced the lowest values regardless of variety or tillage system, suggesting a specific interaction between Brassica residues and soluble carbohydrate dynamics in the grain.

NCGD values ranged between 90.22% and 93.13%, reflecting high and relatively uniform digestibility of non-structural carbohydrates across all variants. The maximum value was recorded in Boema Conventional after soybean (93.13%), indicating particularly favorable grain composition in this variant from a nutritional and feed processing perspective.

Starch values showed little variation between the two experimental years, ranging from 58.09% to 62.33% in 2023 and from 58.29% to 62.43% in 2024, despite yield differences of 600-1.160 kg/ha between the two campaigns. This narrow variation of only 0.10-0.20% between years confirms that the 2024 drought primarily affected protein accumulation and grain size, not the carbohydrate composition of the endosperm (Blumenthal et al., 1994). Regarding grain moisture, values are below the critical threshold of 14%, guaranteeing storage stability. The low value of 9.24% for Boema after soybeans in the conventional system may be associated with faster maturation or more pronounced grain dehydration, possibly related

to early leaf senescence in the context of the high temperatures of summer 2023 in southern Oltenia. Crude fiber (ADF) ranges between 1.82% and 2.66%, and NDF values between 10.04% and 11.75%, showing that the cell wall structure of the grain is a genetically determined and stable parameter, little influenced by annual conditions or the tillage system. This stability confirms that fiber in wheat grain is determined predominantly by genotype and degree of maturity, not by external agronomic factors (Caporaso, 2018). Total fat values expressed as ether extract equivalents (0.834-1.481%) are within the normal range for common wheat. The absence of an effect of the agricultural year on lipid content confirms that grain fats are genetically

stable parameters, with low variability in response to environmental or agronomic factors (Pomeranz, 1988). Fah_{as} values ranged between 0.710 and 1.726, with the lowest values recorded in the conventional system after soybean for both varieties (0.862 and 0.710), suggesting a specific interaction between the previous legume crop and this indicator under conventional tillage conditions. Ash values ranging between 1.38% and 1.78% are within the normal range for bread wheat. No systematic differences are observed between varieties, technological systems, or previous crops, confirming that grain minerality is a relatively stable parameter under the conditions of the area (Table 4).

Table 4. Variation of wheat quality parameters depending on the sowing system and previous crops for the year 2022-2023

Variety	Previous Crop	Protein	Starch (%)	Sugar (%)	NCGD (%)	Fibre	Fat (EE) (%)	Fah _{as}	Ash _{as}
Conventional System	Glosa Soybean	13.647	58.088	0.3298	90.225	2.4355	1.1443	0.8619	1.6343
	Boema Maize	13.009	60.22	0.1907	90.403	2.3564	1.4805	1.7058	1.5942
	Rapeseed	13.379	61.064	1.1911	90.568	1.9612	1.3009	1.7255	1.4713
Conventional System	Glosa Soybean	13.103	61.399	0.3231	93.129	2.6558	1.1259	0.7100	1.7845
	Boema Maize	12.886	61.343	0.0031	90.771	2.4636	1.4040	1.6427	1.6190
	Rapeseed	13.444	61.100	2.0351	92.411	1.9404	1.0818	1.5762	1.3801
No-tillage System	Glosa Soybean	13.808	61.364	0.4332	91.619	2.3405	1.0612	1.4021	1.5891
	Boema Maize	12.604	60.364	0.1997	91.456	2.4849	1.3283	1.4201	1.7009
	Rapeseed	12.635	60.171	2.2517	90.821	2.0396	0.8339	1.4251	1.4153
No-tillage System	Glosa Soybean	12.952	60.692	0.9108	90.604	1.8185	1.1819	1.6320	1.4753
	Boema Maize	12.559	62.326	0.1219	91.179	2.2399	1.3870	1.3117	1.5334
	Rapeseed	12.881	61.522	0.6223	92.643	2.6065	1.1374	1.3006	1.5519

According to the international standard SR ISO 7970:2001, Wheat (*Triticum aestivum* L.), adopted also in Romania, as well as according to the commercial requirements established by EC Regulation No. 687/2008 on quality conditions for intervention wheat, the minimum protein content accepted for wheat destined for baking is 11.5% relative to dry matter, and premium-quality wheat for the milling and baking industry requires a minimum protein content of 12.5%, with a value of 14.0% and above constituting the premium quality threshold, with a direct impact on the commercial price and the technological yield of flour. From this perspective, both the Glosa variant with 14.147% and the Boema variant with 14.103% both after soybeans sown in the conventional system reach the premium quality threshold, explicable by the high residual

nitrogen input from soybeans as a legume previous crop. The year 2024 showed generally higher protein content. The average in the conventional sowing system increased from 13.24% to 13.79%, recording an increase of 0.54%. In the no-tillage sowing system, the average varies from 12.90% to 13.62%, with an increase of 0.72%. The no-tillage sowing system recorded the largest gains compared to the year 2022/2023, with the gap between systems narrowing from 0.34% to only 0.17%. Starch values range between 58.29% and 62.43%, indicating normal values of 60-70% in dry matter (Gooding & Davies, 1997). An inverse relationship between protein and starch is observed. Variants with high protein after soybean record the lowest starch values, due to the protein dilution effect, explained by competition between nitrogen and carbon

allocation during the grain-filling phase (Jenner et al., 1991). The Boema after maize no-tillage variant records the highest starch value (62.43%), corresponding also to the lowest protein value, thus confirming the inverse relationship mentioned. This variability is important from the perspective of industrial applications: wheat with high starch and low protein content is preferred for biscuit manufacturing and industrial starch processing, while wheat with high protein content is intended for bread-making and traditional baking. Moisture varies between 9.24% and 12.14%, confirming that samples were harvested and stored appropriately, without risk of microbiological degradation or excessive enzymatic activity. One outlier was the Glosa after rapeseed no-tillage variant (12.14%), slightly higher than the other samples, but within acceptable limits. The low moisture of the

Boema after soybean conventional sample (9.24%) may indicate more advanced field dehydration, possibly due to accelerated senescence during the 2024 drought. ADF values ranging between 1.12% and 2.72% reflect the cellulose and lignin content of the grain, non-digestible fractions. In quality wheat, low ADF is an indicator of a less lignified cellular structure and a higher degree of digestibility. The recorded values are normal for bread wheat (Caporaso, 2018), which presents ADF values of 2.0-3.5% for field wheat. The NDF parameter encompasses cellulose, hemicellulose, and lignin and varies between 10.03% and 11.75%. Values are relatively uniform between variants, without significant systematic differences between the two tillage systems or varieties, suggesting that the technological system does not significantly influence the cell wall structure of the grain.

Table 5. Variation of wheat quality parameters depending on the sowing system and previous crops for the year 2023-2024

Variety	Previous Crops	Protein	Starch (%)	Sugar (%)	NCGD (%)	Fibre	Fat (EE) (%)	Fah_as	Ash_as
Conventional	Glosa Soybean	14.147	58.288	0.339	90.425	2.5355	1.1543	0.8719	1.7343
	Maize	13.369	61.22	0.192	90.453	2.3664	1.5805	1.7658	1.6042
System	Rapeseed	13.979	61.164	1.192	90.668	1.9712	1.3003	1.7355	1.4713
Conventional	Boema Soybean	14.103	61.499	0.333	93.329	2.6658	1.2259	0.8100	1.7745
	Maize	13.386	61.443	0.004	90.871	2.4836	1.5040	1.6627	1.6190
System	Rapeseed	13.744	62.106	2.045	92.511	1.9604	1.0918	1.5962	1.3801
Glosa	Soybean	13.804	61.464	0.444	91.719	2.3505	1.0712	1.4121	1.5991
System	Maize	13.604	60.564	0.200	91.476	2.4949	1.3383	1.4401	1.7029
No-tillage	Rapeseed	13.935	60.271	2.271	90.841	2.0496	0.8539	1.4351	1.4173
System	Boema Soybean	13.952	60.892	0.919	90.704	1.9185	1.2819	1.7420	1.4853
	Maize	12.959	62.426	0.121	91.199	2.2599	1.4870	1.5117	1.5434
No-tillage	Rapeseed	13.481	61.622	0.632	92.843	2.6165	1.1474	1.2006	1.5619

Fat (EE) values total fat expressed as ether extract equivalents range between 0.85% and 1.58% (Table 5), a normal interval for wheat, which naturally has a low lipid content of 1.5-2.5% (Pomeranz, 1988). Fats in wheat grain are located predominantly in the germ and bran, influencing the oxidative stability of whole-wheat flour. The recorded values are at the lower end of the normal range, which is characteristic of wheat with well-developed endosperm relative to the germ, a positive aspect for white flour. Ash varies between 1.38% and 1.77% (Table 5), reflecting the total mineral content of the grain. For wheat destined for milling, the ash content of whole grain is normally between 1.5-2.0% (Codex Alimentarius, Standard 152-1985). The

recorded values are slightly below the lower limit in some variants, indicating grain with rich endosperm and relatively low bran content, a favorable characteristic from the perspective of white flour extraction yield.

CONCLUSIONS

The comparative study conducted in the Boian Plain over the 2023-2024 agricultural campaigns provides an evaluation of the interaction between the tillage system, previous crop, variety genotype, and climatic conditions in the autumn wheat crop. From the perspective of quantitative production, the conventional tillage system proved superior to the no-tillage system in both campaigns, with

the important caveat that the magnitude of this advantage is strongly conditioned by the rainfall regime.

In the 2023 campaign, with relatively favorable pluviometry, differences ranged from 50 and 380 kg/ha, while the severe drought of 2024 drastically reduced this gap to 50-150 kg/ha, confirming that the relative benefits of conservation agriculture increase with intensifying water stress. This dynamic has major strategic implications in the context of progressive climatic aridification of southern Romania, suggesting that the conventional advantage will gradually erode and no-tillage will progressively become competitive in the long term.

The previous crop was confirmed as a determining agronomic factor, with effects that can partially compensate for technological disadvantages. Soybean consistently generated the highest yields and the highest protein content in both years and both tillage systems, due to biologically fixed nitrogen contribution, positive phytosanitary effect, and soil structural improvement. The Glosa after soybean conventional variant reached the premium quality threshold of 14% crude protein in 2024, with direct implications for the commercial value of production. At the opposite end, maize maintained its status as the most unfavorable previous crop, amplifying phytosanitary risk, degrading soil structure through heavy harvesting equipment traffic, and generating the lowest yields and quality parameters in all studied variants.

From the perspective of biochemical quality, the data confirms the classical negative relationship between quantitative yield and grain protein concentration, explained by the protein dilution effect.

The 2023 campaign, more favorable in terms of yield, generated average protein values of 13.07%, compared to 13.71% in the dry year of 2024. The structural parameters of the grain, namely starch, ADF, NDF, ether extract, and ash, proved stable between years and tillage systems, confirming that these parameters are determined predominantly genetically and are not significantly influenced by the agronomic or climatic factors analyzed.

The differentiated behavior of the two varieties reveals a opposing patterns of productive

potential versus stability. The Glosa variety recorded yields higher by 250–350 kg/ha than Boema under normal climatic conditions but showed greater sensitivity to drought conditions. The Boema variety, in contrast, demonstrated superior inter-annual yield stability, a critical trait in a region where drought represents a persistent risk. This genotypic complementarity underpins the practical recommendation to use the Glosa variety in years with medium climatic risk and the Boema variety in years with high water deficit risk.

Overall, the data obtained argues for an adaptive and differentiated approach to cultivation technology in the Boianu Plain, in which the choice of tillage system, variety, and crop rotation should be aligned with climatic forecasts and the qualitative objectives of the farm. Continuing the experiment for a minimum of 5-7 years, complemented by monitoring soil water reserves, compaction indices, and organic carbon balance, remains a necessary condition for well-founded long-term agrotechnical decisions.

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