

INVESTIGATING THE IMPACT OF SPECIFIC TECHNOLOGIES ON THE PRODUCTION AND QUALITY OF THE AUTUMN BARLEY CROP

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Abstract

The purpose of this work was to evaluate the impact of soil tillage, sowing period and mineral fertilization (NPK) on the quantity and quality of the seed harvest, in the specific climate and soil conditions of the Arad Plain, more precisely in the chernozem microzone of Nădlac, Arad County. The use of ploughing in association with disc harrow determined a small and insignificant increase in production compared to plots where only disc passes were applied. The results obtained demonstrate the superiority of the tillage variants without furrow turning, compared to the classic tillage system by ploughing. Sowing in the period 25-30.IX and staggered in 06-10.X, did not attract, on average over the two years, any particular differences between the variants. Mineral fertilization (NPK) of the soil plays an essential role in optimizing the plant's nutrition requirements and achieving increased production. In addition, the tillage system and fertilization also influence soil fertility in the long term, a significant impact on other components of the environment. The variety of barley taken into cultivation was Melia.

Key words: technological links, barley, production, quality indices.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the oldest cereal crops, having a special economic and agricultural importance both nationally and globally. Barley is a winter crop well known for its small-seeded grains and self-pollinating characteristics. Flour derived from barley grains plays a crucial role in numerous processed foods, contributing to their taste and nutritional value (Kaur et al., 2024). Due to its adaptability to various climatic conditions, barley is widely cultivated, being used in the food industry, fodder and beer production (Boanta et al., 2020), it is also used in its form of pearl barley and as a coffee substitute in the human diet, it is a raw material for the production of beer, glucose and alcohol (Tarawneh et al., 2021; Gupta et al., 2010). It is also an important source of feed for animals that consume it in the form of cereals, green feed, straw and hay (Badea and Wijekoon, 2021). From these, winter barley is an appreciated crops by farmers due its ability to adapt to less favourable environmental conditions and also give high and economically efficient yields. The barley grain weight (GW) along with grain

size are universally considered to be closely correlated with the level of technological quality indicators required by the malt and beer industry. Grain weight is first trait used to classify the barley seed quality (Vasilescu et al., 2020; Leonte et al., 2023). Drought and heat stress substantially impact plant growth even the productivity of barley culture. When subjected to drought or heat stress, plants exhibit reduction in growth resulting in yield losses (Mahalingam et al., 2022).

In Romania, barley occupies a significant place in the agricultural sector, being grown both for domestic consumption and for export (Cristea et al., 2024).

The area cultivated with barley varies annually, but remains at a considerable level, due to the constant demand from the malt industry and the livestock sector.

Barley has a short vegetation period and good drought resistance, which makes it suitable for Romania's climate, especially in areas with low rainfall. It is grown in both autumn and spring variants, each having specific uses. Autumn barley is preferred for feed production, due to its high yield, while spring barley is essential in the beer industry, being used to obtain malt.

Economically, Romania is an important producer and exporter of barley in the European Union, with markets in the Middle East and Asia. The increase in foreign demand for Romanian barley contributes to the development of the agricultural sector and to the balancing of the trade balance. Through its agricultural, economic and food value, barley remains an essential crop for Romania and for the whole world.

A unique blend of macro and micronutrients makes barley an important industrial substrate for commercial use (Boukid, 2024; Raj et al., 2023; Lazaridou et al., 2022).

Barley consists of complex carbohydrates (80%), proteins (11.5-14.2%), lipids (4.7-6.8%), β -glucan (3.7-7.7%) and ash (1.8-2.4%). Starch is the most prevalent nutrient in barley, accounting for 70% of the total dry weight of the kernel (Asare et al., 2011; Baik and Ullrich, 2008; Li et al., 2001).

Barley is not just a cereal crop, but a vital resource for human health, food security and environmental sustainability (Alionte, 2006).

Under current climate change conditions, water stress is becoming a major limiting factor for cereal production. The qualitative variation of winter barley grains under water-restrictive conditions, highlights the significant differences between genotypes and their potential to translocate assimilates into grains during moisture deficit. These results provide an important starting point for the selection of varieties adapted to difficult pedoclimatic conditions (Vasilescu et al., 2023).

Continued scientific research and innovations in agriculture and the food industry will further strengthen the importance of this cereal within global food systems.

MATERIALS AND METHODS

The purpose of this work was to evaluate the effects of tillage, sowing time and mineral fertilization (NPK) of the soil on the quantity and quality of the seed yield when cultivating the plant in climatic and soil conditions in the Arad Plain.

The objective of the research refers to: establishing and implementing the cultivation technology; evaluation of production according to tillage; evaluation of production according to

sowing time; evaluation of production according to fertilization; determination of weight attributes (TKW, HW); determination of crude protein content; determination of starch content.

The cultivation technology, a factor of agricultural production, has an essential role in creating the conditions for the growth and development of the plant, along with the natural environmental factors (soil, climate) and in making the production process more efficient, and the improvement of agrotechnical cultivation methods is always a concern for agricultural research and practice, an effort to which these researches are modestly added.

The study focused on the technological sequences that underlie the optimization of the plant's cultural requirements, against the background of the soil and climate, and whose suitability and quality of application largely depends on the development of the plant and the level of production achieved, in addition, the tillage system and fertilization also have an impact on the evolution of soil fertility and other environmental components over time.

The aim of the study is to find solutions for the expansion of crop barley, given that this species is a rich source of starch and protein with applicability in various economic sectors, such as the beer industry or animal feed (Ungureanu et al., 2019; Ungureanu et al., 2021). The experiment organized on the gleic chernozem was monofactorial type, with the following variants: V1 – plow + disc harrow, V2 – disc harrow $\times$ 2 and V3 – scarifier + disc harrow.

In order to ensure fertilization levels, simple fertilizers based on nitrogen, phosphorus and potassium were administered, namely: ammonium nitrate (33.5%) 269 kg ha⁻¹, superphosphate (46%) 130 kg ha⁻¹ and potassium salt (50%) 160 kg ha⁻¹.

In 2022, January - March: the period was characterized by low temperatures, Figure 1, specific to the cold season, with moderate precipitation ensuring soil moisture; April - June: temperatures increased germination and vegetative development; July - September: high temperatures were recorded, with episodes of drought, which led to variations in precipitation; October - December: temperatures began to decrease; the rainfall recorded during

this period was variable, influencing the preparation for the cold season.

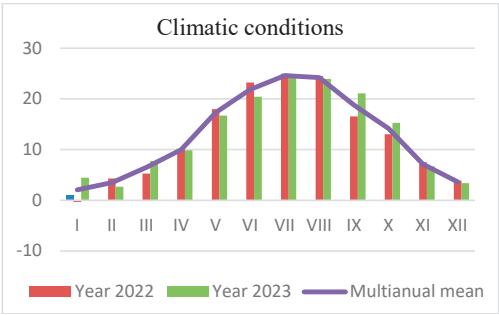


Figure 1. Temperatures regime during the experimentation period, 2022-2023

In 2023, January - March: data showed similar trends to the previous year, with temperature and precipitation values according to specific seasonality; April - June: temperatures and precipitation showed significantly favorable trends for barley, reaching averages between 15°C and 25°C; precipitation, Figure 2, was constant during this period, being favorable for growth, similar to previous years; July - September: periods of extreme heat were recorded, with sporadic precipitation that could negatively influence the harvest; October - December: the gradual cooling of the weather was accompanied by variable precipitation.

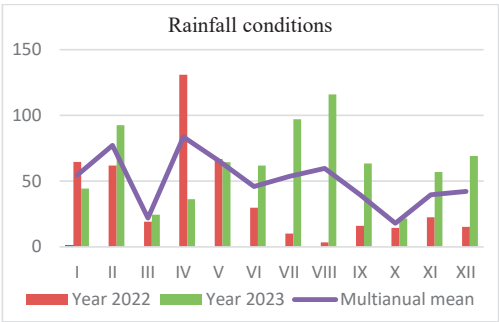


Figure 2. Rainfall regime during the experimentation period, 2022-2023

The fertilization levels studied were obtained by applying ammonium nitrate, superphosphate and potassium salt (kg ha⁻¹, etc.). The precursor plant was rapeseed crop. The barley variety taken in cultivation was MELIA, varieties belonging to the LIDEA company.

The experiment was located in the city of Nădlac, Arad County, on a chernozem - type soil.

RESULTS AND DISCUSSIONS

Results obtained demonstrate the superiority of the tillage variants without furrow turning, compared to the classic tillage system by ploughing.

Results of the research on the influence of the basic tillage system on the harvest

In Figure 3, the summary results on the average barley productions according to tillage in the 2022-2023 experimental cycle are presented. The use of ploughing in association with disc harrow determined a small and insignificant increase in production compared to plots where only disc harrow passes were applied. The largest harvests were obtained in the variant in which the scarification of the soil + 2 × disc harrow was carried out.

The yield difference between the scarified variant and the control variant shows 1,322 kg ha⁻¹, it is statistically ensured as very significant.

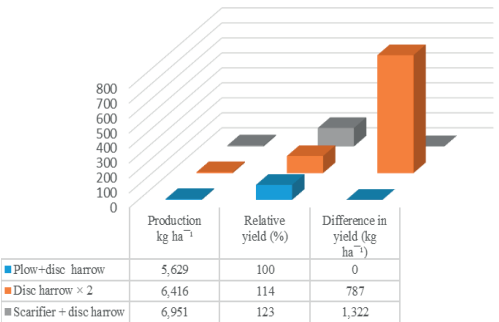


Figure 3. Summary of average barley yields by tillage in 2022-2023

Results of the research on the influence of the sowing time on harvest

In Figure 4 is presented the timing of sowing influences the evolution of plants by determining the time available for the normal stages of growth in autumn, including twinning and hardening before winter.

The sowing in the period 25-30.IX and staggered in 06-10.X, did not attract, on average over the two years, any particular differences between the variants, the average production value being 5,704 kg ha⁻¹ at the first

time and 6,314 kg ha⁻¹ at the second sowing period.

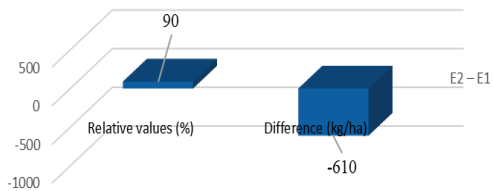


Figure 4. Summary of average barley yields by sowing time in 2022-2023

Sowing in the first days of October allows to avoid too advanced development of autumn vegetation and reduce the risk of attack by aphids and cicadas, which can transmit the dwarf and yellowing virus to barley. Overall, against the background of the climatic conditions of 2022-2023, sowing at the end of September led to a distinctly significant increase in production, by 610 kg ha⁻¹.

Results of the research on the influence of fertilization on the harvest

Mineral fertilization (NPK) of the soil plays an essential role in optimizing the plant's nutrition requirements and achieving increased production. It is noted in Figure 5 that the fertilizers applied, in the mentioned doses, strongly influenced the harvest in the two experimental years.

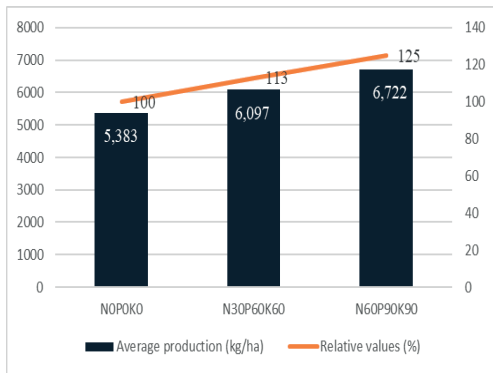


Figure 5. Synthesis of average barley yields for different fertilization treatments in the 2022-2023 experimental cycle

By fertilizing with N30, the average harvest increased by 13% compared to the control variant, registering a harvest difference of 714

kg ha⁻¹. The doubling of the nitrogen dose to N60 amplified the value of the harvest increase to 25%, returning a harvest difference compared to the control variant of 1,339 kg ha⁻¹. In both variants, the harvest results were statistically assured as very significant.

Results of the research on hectoliter mass values by sowing time

The hectoliter mass of barley is a measure of the density of barley grains and is a relevant indicator in assessing the quality and commercial value of this cereal crop. The term 'hectoliter mass' refers to the mass of barley grains expressed in kilograms per hectoliter (kg/hl), i.e. the amount of barley occupying a volume of one hectoliter. This measure provides significant information about the uniformity, density and usability potential of barley grains in various applications, including beer production, bakery and feed. Hectoliter mass is influenced by several factors, including the size, shape, weight, and density of barley grains. Hectoliter mass is often used as an important criterion in assessing the quality of barley grains. The higher the hectoliter mass of barley grains, the higher their density, reflecting a higher dry matter content. Considering the cumulative effect of the sowing season, in the agricultural year 2021-2022 (Table 1) the average values of the HM were recorded with the limits of 62.2 kg in the case of the establishment of the crop at the end of September and 62.5 kg in the case of sowing in the first days of October, against the background of a non-significant variation between the two years.

Table 1. Average value of HM for barley for sowing times in 2021-2022

Sowing	HM (kg/hl)	Relative values (%)	Difference (kg/ha)	Signification
E ₂ - E ₁	62.5 / 62.2	100	0.3	
DL 5% = 0.55 KG/HL DL 1% = 0.83 KG/HL DL 0.1% = 1.33 KG/HL E1 - 25-30 IX 2022; E2 - 5-10 X 2022				

In the context of the 2022-2023 agricultural season, the overall analysis of the data revealed in Table 2 indicates a minor influence on the hectoliter mass following the delay in sowing from the end of September to the beginning of October. This delay generated a variation of only 0.2 kg in the hectoliter mass, with a negligible difference in this characteristic.

Specifically, the detailed analysis of the results suggests that the delay in sowing during the mentioned period did not have a significant impact on the quality of the crop's hectoliter mass. It is important to emphasise that this finding is supported by a minimum variation of only 0.2 kg, which can be considered statistically insignificant. This finding is of interest in the context of planning and managing the agricultural season, providing practical information for farmers and researchers.

In conclusion, the scientific analysis of the data from the agricultural year 2022-2023, on the effect of the sowing delay on the hectoliter mass, indicates a low influence, represented by an insignificant variation of 0.2 kg. It makes valuable contributions to the understanding of the relationships between the sowing period and crop qualities, having significant practical implications for the efficient management of agricultural resources.

Table 2. Average value of HM in barley for sowing times in 2022-2023

Sowing	HM (kg/hl)		Relative values (%)	Difference (kg/ha)	Signification
E ₂ – E ₁	61.6	61.4	99	0.2	
DL 5% = 0.74 kg/hl DL 1% = 1.17 kg/hl DL 0.1% = 2.14 kg/hl E ₁ – 25-30 IX 2022; E ₂ – 5-10 X 2022					

Values of the relative of thousand kernel weight grains (TKW) according to the sowing time of the barley crop. The determination of this physical property makes it possible to appreciate, on the one hand, the amount of food available to the sprouts, and on the other hand, the behavior of the different varieties in the given growing conditions that influence the size of the harvests. Dependent on TKW is also the vigor of the sprouts, which conditions the growth rate of the plants and ultimately the harvest. This physical seed attribute is part of the formula for determining the amount of seeds needed for sowing ha⁻¹ and the formula for approximating the probable harvest. The results of the analyses highlight (Figure 6) a significant correlation between the TKW value and the climatic conditions in the context of the two sowing seasons. In the agricultural year 2021-2022, characterized by a rainfall deficit, the

TKW recorded an average value of 39.9 g. This decrease can be attributed to drought conditions, which affected plant development and negatively influenced grain weight. On the other hand, in the agricultural year 2022-2023, in which climatic conditions were favorable, with an adequate rainfall intake, MMB recorded a significant increase, reaching 46.2 g. This improvement of 6.3 g indicates a positive influence of the wet environment on the process of grain formation.

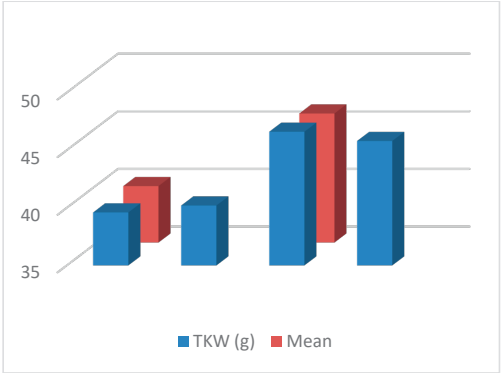


Figure 6. Results of the TKW determinations in experimental years according to the sowing period

Results of chemical analyses

From the data of the analyzes in Figure 7, it appears that in 2021-2022, in all variants, the protein content was higher than in the experimental year 2022-2023, which is due to the drought installed between May and June, which favored the accumulation of protein to the detriment of starch. In the agricultural year 2022-2023, in the months of May - June, higher amounts of precipitation fell, which caused a decrease in protein content and a favoring of starch content. Nitrogen fertilizers, on average over the two experimental years, favored the protein content, which increased compared to the control variant, from 13.5% to 14.6% in the N30 variant and to 15.6% in the N60 variant. On average over the two experimental years, the fertilization doses shown that the valorization of nitrogen fertilizers, at this level, is motivated even in the conditions of the fertile soil on which the experiments were carried out.

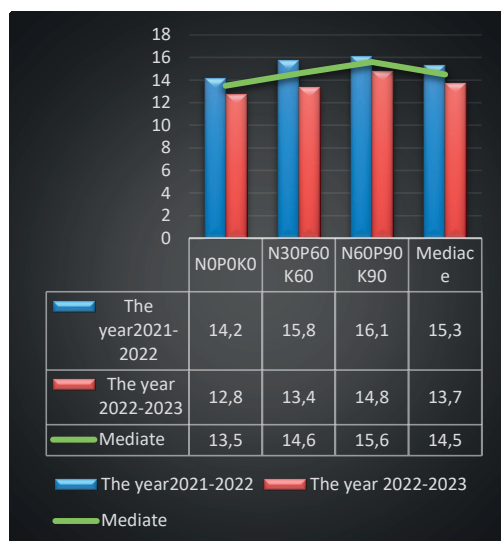


Figure 7. Variation in crude protein content depending on fertilization

Variation of starch content depending on fertilization

The results of the analyzed data present in Figure 8, show that in the drier year of the grain formation and filling period 2021-2022, the starch content was lower than the content of 2022-2023, which is explained by the higher amount of rainfall.

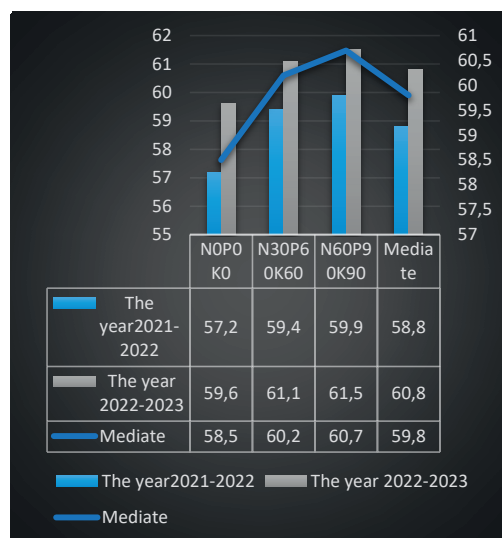


Figure 8. Starch content % by fertilization

CONCLUSIONS

The high yields of barley for grains in the last decades, of 8-10 t ha⁻¹ under appropriate technology conditions, motivate the expansion of this crop. The shorter vegetation period than wheat, the higher drought resistance compared to wheat, makes it possible that after the barley harvest, successive crops can be established that provide increases that increase the profit per unit area and keep the soil covered with vegetation until autumn.

Basic tillage experienced in the conditions of the gleic chernozem in Nadlac have demonstrated that the traditional ploughing work, by which the furrow is turned over, with negative effects on the loss of moisture from the soil and disturbance of the activity of microorganisms, can be replaced by superficial works without turning the furrow. The harvest increase obtained through the double tillage system ensured the increase of the harvest by 17% compared to the ploughing work option.

The highest harvest increase was obtained in the variant in which scarification was carried out and a double disc harrow of 31% in the period 2021-2022 and by 12% in the variant by double disc harrow and 17% in the variant scarified + double disc harrow in 2022-2023.

The research on the influence of the sowing time on the harvest varied between the two years due to the rainfall regime during the land preparation period and sowing in autumn.

On average, over the two years, research has highlighted the first decade of October as optimal.

In conclusion, the results of the experiment highlight that proper fertilization, especially with nitrogen, phosphorus and potassium, significantly influences crop production.

Under the analyzed conditions, the variants fertilized with N30P60K60 contributed to the increase of production with very significant differences of 18% and 31% in the N60P90K90 variant compared to the control variant N0P0K0 in 2021-2022 and with increases of 9% in the N30P60K60 variant and 20% in the N60P90K90 variant in the experimental year 2022-2023, represented effective options for increasing yield, stressing the need for proper fertilizer management in modern agriculture,

with a significant impact on the sustainability and profitability of agricultural production. In conclusion, the scientific analysis of the data from the agricultural year 2022-2023, on the effect of the sowing delay on the hectoliter mass, indicates a very low influence, represented by an insignificant variation of 0.2 kg. It makes valuable contributions to the understanding of the relationships between the sowing period and crop qualities, having significant practical implications for the efficient management of agricultural resources. The experimental results obtained in the two years proved that the climatic deviations in the vegetation period greatly influence the results obtained, which is why another year of research is required and only by analyzing the synthesis of the experimental cycle can conclusions be drawn that can be transformed into recommendations for growers.

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