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STUDY ON WINTER WHEAT PRODUCTION AND QUALITY IN THE PECICA-ARAD AREA

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Abstract

Although at present, both in our country and internationally, in the world grain trade, protein content is an indicator of grain quality, it is positively correlated with other quality indicators such as gluten content, gluten index and sedimentation index. The present study followed the influence of mineral fertilization and pedoclimatic conditions in the Pecica-Arad microzone on the level of production and its quality, expressed by protein content, gluten content, gluten index and sedimentation index. The study was conducted between 2019 and 2021, in the low plain of the Mures Meadow. The variety used in the experimentation was Ciprian, created at SCDA Lovrin. The protein content values achieved at the 5 N doses highlight that it ranges from 11.84% (N0) to 15.34% (N120). Analyzing the production obtained also from the point of view of the values of quality indicators (wet gluten over 25%, gluten index 86.33 and sedimentation index above the threshold of 50) and comparing these values with the regulated limits for each one, we can appreciate the special quality of the harvest.

Key words*: wheat, protein, gluten, quality.*

INTRODUCTION

Wheat, due to its chemical composition and multiple uses in human food, is the cereal with a crucial role in global food security (Erenstein et al., 2022; Gherasimescu et al., 2023). The proportion of land cultivated with this plant, the climate changes in recent years, restrictions on limiting the amounts of fertilizers applied, impose changing the cultivation technology and adapting it at the micro zone level (Smuleac et al., 2020; Gherasimescu, 2023; Sitnicki et al., 2024).

This is currently possible through the use of precision agriculture, which allows the rational use of resources in accordance with ensuring the necessary nutrients, so that we achieve productions both quantitatively and qualitatively while maintaining a clean environment (Smuleac et al., 2022; Dziekanski et al., 2022; Sitnicki et al., 2024). In the production of quality wheat, rational mineral fertilization plays a very important role in terms of the ratio between the three macronutrients N:P:K (Raun et al., 1999; Harrison et al., 2001; Mohammed et al., 2013; Blandino et al., 2015; Kozlovský et al., 2018).

MATERIALS AND METHODS

The purpose of the research was to evaluate the productive potential and the quality of wheat production, through the contribution of mineral fertilization with nitrogen, phosphorus, and potassium under the influence of climatic factors in the Pecica-Arad micro zone. The research was conducted within a bifactorial experiment, using the subdivided plot method with three repetitions and the following gradation of experimental factors: Factor A - the level of fertilization with P and K, with 5 gradations: a1 - P_0K_0; a2 - $P_{40}K_0$; a3 - $P_{80}K_0$; a4 - $P_{40}K_{40}$; a5 - $P_{80}K_{80}$. Factor B - fertilization with N, with 5 gradations: b1 - N_0; b2 - N_{30}; b3 - N_{60}; b4 - N_{90}; b5 - N_{120}. The variety used in the experiment was Ciprian, created at SCDA Lovrin, and the seeding density was: 550 germinable seeds/m^2.

To complement the analysis of wheat quality, particularly protein content as influenced by the fertilization levels, Near-Infrared Spectroscopy (NIR) analysis was employed using a Pfeuffer Granolyser, which analyses whole grains directly. This method involved placing whole wheat grains in the Granolyser, which irradiates the grains with near-infrared light. Multiple

scans of each sample were conducted to minimize random sampling errors and enhance the reliability of the spectral data. This rapid and non-destructive approach allowed for the efficient assessment of protein levels, providing a critical measure of the nutritional quality of wheat influenced by the experimental fertilization regimes.

The processing and interpretation of the experimental results were performed using the variance analysis program – statistics [ANOVA], MSTATC.

RESULTS AND DISCUSSIONS

Regarding the influence of phosphorus and potassium fertilization (Table 1), we note that, in comparison with the unfertilized control variant a1 [P_0K_0], insignificant production increases were obtained, except for $P_{40}K_{40}$ where a distinct significant increase of 8%, respectively 436 kg/ha, was achieved.

Table 1. Influence of phosphorus and potassium fertilization on wheat yield

Factor PK	Yield		Diff. (kg/ha)	Signif.
	kg/ha	%		
V1 - P0K0	5421	100.0	mt	
V2 - P40K0	5533	102.1	112	ns
V3 - P80K0	5698	105.1	277	ns
V4 - P40K40	5857	108.0	436	**
V5 - P80K80	5702	105.2	281	ns

DL 5% = 314 kg; DL 1% = 416; DL 0.1% = 540

Compared to the unfertilized control group b1[N_0], statistically significant yield increases were recorded, with the exception of the N_{30} dose, which resulted in an insignificant increase. The yields that were statistically ensured range from 363 kg/ha to 540 kg/ha, indicating distinct and significantly different increases. The doses N_{60}, N_{90}, and N_{120} surpass the control with an increase ranging from 7% to 10% (Table 2).

Table 2. Influence of nitrogen fertilization on wheat yield

Factor N	Yield		Diff. (kg/ha)	Signif.
	kg/ha	%		
V1 - N_0	5421	100.0	mt	
V2 - N_{30}	5533	102.1	112	ns
V3 - N_{60}	5698	105.1	277	ns
V4 - N_{90}	5857	108.0	436	**
V5 - N_{120}	5702	105.2	281	ns

DL 5% = 314 kg; DL 1% = 416; DL 0.1% = 540

From Figure 1, it can be observed that the yield increases with the PK dose up to $P_{40}K_{40}$, after which it declines. The lowest yield [5421 kg/ha] is obtained at P_0K_0, and the highest [5857 kg/ha] at $P_{40}K_{40}$. There are no significant differences between the yields obtained at the five PK doses. Wheat production increases up to the N_{60} dose, beyond which it decreases. The lowest yield is recorded at the N_0 level [5300 kg/ha], and the highest at N_{60} [5851 kg/ha], as shown in Figure 2.

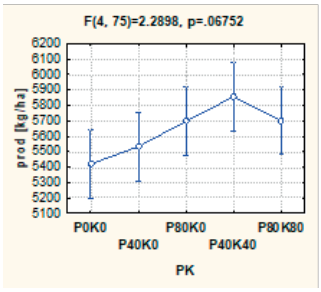

Figure 1. Yield variation under the influence of P and K fertilization

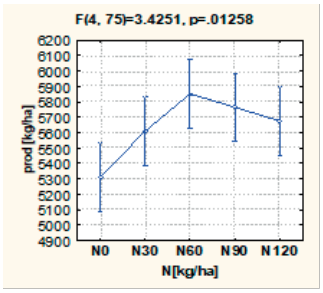

Figure 2. Yield variation under the influence of N fertilization

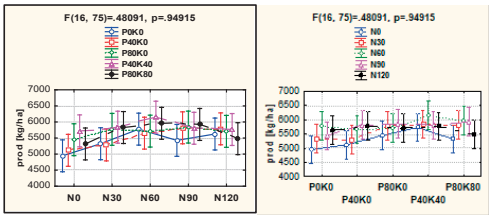

Figure 3. Variation in yield interacting factors by P, K and N fertilization

From Figure 3, it is evident that regardless of the PK doses [a], the lowest wheat production is obtained at N_0, with values ranging from 4948 kg/ha [$P_0K_0N_0$] to 5725 kg/ha [$P_{40}K_{40}N_0$]. The highest wheat production, 6150 kg/ha, is

achieved at $P_{40}K_{40}N_{60}$, followed by $P_{80}K_{80}N_{60}$ with 5959 kg/ha, and $P_{80}K_{80}N_{90}$ producing 5925 kg/ha.

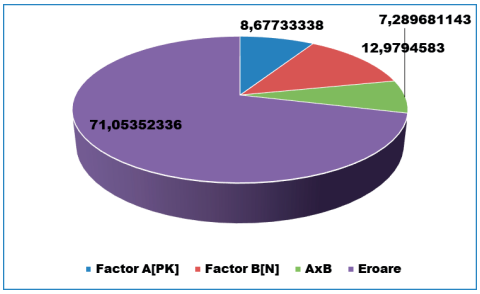

Figure 4. Contribution of factors and interaction of macro-elements with P, K and N in 2019-2021

Figure 4 indicates that phosphorus (P) and potassium (K) fertilizers make up 8.7% of the yield. Nitrogen (N) fertilizers contribute 13%, and the combined effect of using both types of fertilizers (interaction A x B) adds another 7.3%. This information highlights how different nutrients and their combination affect wheat production, stressing the importance of balanced fertilization for improving crop yields.

Table 3. Influence of phosphorus and potassium fertilisers on protein content (%) (2019-2021)

Factor PK	Protein	Diff. (kg/ha)	Signif.
V1 - martor P_0K_0	13.16	mt	
V2 - $P_{40}K_0$	13.41	0.25	ns
V3 - $P_{80}K_0$	13.68	0.52	*
V4 - $P_{40}K_{40}$	13.57	0.41	ns
V5 - $P_{80}K_{80}$	13.73	0.57	*

DL 5% = 0.45 DL 1% = 0.60 DL 0.1% = 0.78

The protein content, based on phosphorus and potassium fertilization, ranged from 13.16% [P_0K_0] to 13.73% [$P_{80}K_{80}$] (Table 3). Compared to the control variant a1 [P_0K_0], the increase in protein content was:

- Insignificant at $P_{40}K_0$ and $P_{40}K_{40}$.
- Significant at $P_{80}K_0$ and $P_{80}K_{80}$. The increases vary between 0.25 and 0.57%.

The analysis of the protein content at the five PK doses [factor A] highlights that it ranges from 13.2% obtained at P_0K_0 to 13.7% obtained at $P_{80}K_0$ and $P_{80}K_{80}$ (Figure 5). This indicates the influence of specific fertilization strategies on the nutritional quality of wheat, demonstrating that higher levels of phosphorus and potassium can enhance protein content within the grains.

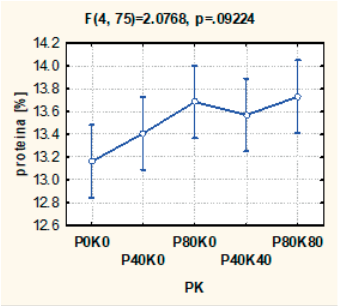

Figure 5. Variation of protein content under the influence of P and K fertilization

The influence of nitrogen fertilizers on the protein content (%), Table 4, recorded values ranging from 10.63% in the N_0 variant to 15.40% in the N_{120} variant.

Table 4. Influence of nitrogen fertilisers on protein content (%) (2019-2021)

Factor PK	Protein	Diff. (kg/ha)	Signif.
V1 - martor N_0	10.63	mt	
V2 - N_{30}	12.77	2.14	***
V3 - N_{60}	13.80	3.17	***
V4 - N_{90}	14.96	4.33	***
V5 - N_{120}	15.40	4.77	***

DL 5% = 0.45 DL 1% = 0.60 DL 0.1% = 0.78

Compared to the control b1[N_0], very significant increases were obtained regardless of the applied nitrogen dose. The increases varied between 2.14-4.77%, being distinctly superior to the control variant. The analysis of the protein content conducted on the 5 nitrogen doses [factor A] from Figure 6, highlights that it ranges between 10.4%-15.4%. The protein content increases with the increase of the applied nitrogen dose. The highest protein percentage, 15.4%, is achieved at N_{120}.

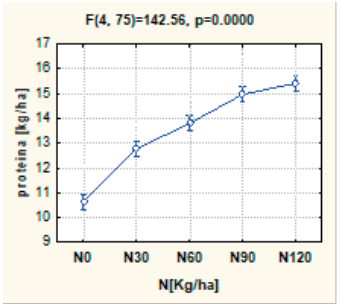

Figure 6. Variation of protein content under the influence of N fertilisation

The analysis of the results regarding the influence of the PK x N interaction [AxB] on the protein content (%), Figure 7, shows that the protein content increases with the nitrogen dose regardless of the PK dose. The highest values of protein content are obtained at N_{90} and N_{120} regardless of PK, and the lowest at N_0.

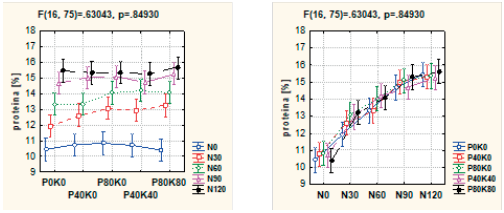

Figure 7. Variation of protein content under the influence of PK x N fertilisation interaction

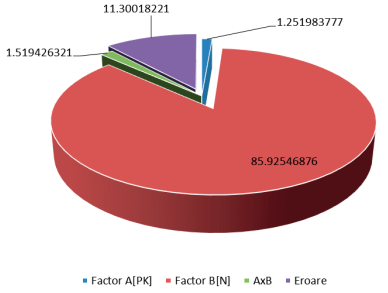

Figure 8. Contribution and interaction of P, K and N fertilization on protein content

Analysing the contribution of experimental factors to the achievement of protein content (figure 8), we observe that nitrogen fertilization contributes 85.93% to the protein yield, while fertilizers with P, K contribute only 1.25%, and the AxB interaction contributes 1.52%.

Although at present, both in our country and internationally, in the global grain trade, the protein content is an indicator of grain quality, it is positively correlated with other quality indicators such as gluten content, gluten index, and sedimentation index.

The quantity and quality of gluten are very important quality indicators in evaluating a variety and for the technological process, contributing to the characterization of the dough, especially its processing capacity and baking potential.

In table 5, the average values of the quality indicators (wet gluten, gluten index, and sedimentation index) are presented, depending on the experimental micro-zone and climatic conditions.

Table 5. Average values of quality indicators, depending on the micro-area of experimentation and climatic conditions

Quality index	Wet gluten	Gluten index	Sedimentation index
Average	26.5	86.63	52.07

Analysing the obtained data and comparing these values with the regulated limits for each one, we can appreciate the exceptional quality of the harvest achieved during the experimental period in the Pecica micro-zone. Thus, besides the values of the protein content ranging between 13%-15.6%, if we also analyse the values of the three quality indicators (wet gluten, gluten index, and sedimentation index), we have certification of the baking quality of the obtained productions.

During the experimental period, the content of wet gluten exceeded on average the percentage of 25%, which demonstrates that in the researched area, very good quality wheat for baking is obtained. The quality assessment of baking wheat based on the gluten index is done according to the following scale:

- "very good" quality > 80;
- "good" quality - 65-80;
- "unsatisfactory" quality < 65.

The values of the sedimentation index on average during the experimental period were 86.33. This value also confirms through this indicator the very good quality of the production obtained. According to the quality assessment scale of baking wheat based on the sedimentation index, varieties with values above 50 are considered category I, those with values between 50-35.01 are category II, category III is 35-20.01, and category IV are those with values below 20. The average value of this quality index recorded during the experimental period was above the threshold of 50, indicating category I productions.

CONCLUSIONS

The results obtained from monitoring the influence of mineral fertilization levels with N, P, and K on the production of the Ciprian wheat variety in the Pecica-Arad micro-zone, which is representative of the wheat culture in the

western part of the country, have demonstrated that the most significant influence on production is exerted by the nitrogen dose, followed by the phosphorus dose, and finally, the potassium dose. The highest wheat production of 5851 kg/ha is achieved with a fertilization regime of $P_{40}K_{40}N_{60}$.

In the Pecica-Arad micro-zone, the protein content obtained with any of the N_{30}-N_{120} doses is significantly higher than that of the N_0 dose. The surplus in protein content, compared to the N0 control, ranged between 2.4-4.77%.

By analysing the obtained production and from the perspective of the quality indicator values (wet gluten - 26.5, gluten index - 86.33, and sedimentation index - 52.07) and comparing them with the regulated values for each indicator, we can appreciate the exceptional quality of the harvest produced in the studied area.

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