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# BEHAVIOR OF AN ASSORTMENT OF SPRING OAT VARIETIES DEPENDING ON THE LEVEL OF MINERAL FERTILIZATION AND SOWING

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***Abstract***

*The study followed the behavior of an assortment consisting of eleven varieties of spring oats, depending on the level of mineral fertilization, on the level of production, crude protein content and fats. Mineral fertilization with nitrogen had five graduations: N0, N30, N60, N90 and N120, applied on a constant background of P60K60. The sowing density also had three graduations: 350 seeds/m$^2$, 450 seeds/m$^2$ and 550 seeds/m$^2$. The lowest production of 2961 kg/ha was recorded for the Lovrin 1 variety on the N0P60K60 agrofund and the density of 350 seeds/m$^2$, and the highest of 4879 kg/ha for the Gentiana variety, on the N120P60K60 agrofund and 550 seeds/m$^2$. The values of the protein content depending on the level of mineral fertilization ranged between 13.4 on the N0P60K60 agrofund and 15.05% on the N120P60K60 agrofund. As for the fat content, the highest value of 54.2% was also recorded on the agrofund fertilized with N120P60K60 and the Muresana variety.*

***Key words***: *chernozem, fat content, nitrogen, protein content.*

## INTRODUCTION

Oats have been cultivated for thousands of years due to their adaptability to various climates, nutritional benefits and versatile uses (Steward & McDougal, 2014; Kolmanic et al., 2022). As the global demand for oats is increasing, the optimization of fertilization technology along with the biological material becomes essential to increase productivity and ensure sustainable agricultural practices (Kiviharju et al., 1998; Hilli&Kapoor, 2023; Ruja et al., 2024). The climate changes of recent years, manifested by the lack of humidity and very high air temperatures, require the adaptation of cultivation technology by choosing resistant varieties, appropriate density and level of fertilization with nitrogen, phosphorus and potassium (Dvoracek et al., 2003; Midha et al., 2015; Fu et al., 2023). Mineral fertilization plays an essential role in optimizing oat production by ensuring adequate nutrient availability for optimal plant growth and development. Scientific studies highlight that nitrogen, phosphorus and potassium are the primary macronutrients required to improve oat yield and grain quality. Nitrogen is particularly important because it promotes vegetative growth, increases plant height, and improves the protein content of grains. However, excessive nitrogen can lead to deposition, reducing both yield and quality (Gordara et al., 2016; Bljahhina et al., 2023). Phosphorus supports root development, energy transfer and early plant vitality. Potassium contributes to water regulation, enzyme activation and disease resistance, while improving drought tolerance and grain filling (Ahmad & Zaffar, 2014; Singh et al., 2023). Precision in timing and application methods - such as split applications of nitrogen and phosphorus bands- improves nutrient use efficiency and minimizes environmental risks such as leaching and greenhouse gas emissions. In addition, balanced mineral fertilization improves the harvest index, straw yield and multi-element composition of oat grains (Murariu & Plăcintă, 2017; Ma et al., 2017; Warchol et al., 2023). Due to climate change, choosing the right oat variety is crucial to ensuring crop resilience and productivity (Gangoadhyay et al., 2015). Different oat varieties offer different levels of drought, heat and disease tolerance, allowing farmers to adapt to changing weather patterns. Climate-resistant oat varieties improve yield stability and grain quality under extreme conditions, increasing at the same time the nutrients use efficiency (Decker et al., 2014; Leszczynska et al., 2023). In addition, various genetic traits can help mitigate the risks associated with pests and soil degradation. Thus, choosing the right oat varieties plays an essential role in supporting agricultural productivity and environmental health in the current climate context (Sheoran et al., 2017; Smuleac et al., 2020; Quintarelli et al., 2022; Chițu et al., 2024).

## MATERIALS AND METHODS

The research was conducted in a three-factorial experiment, where Factor A - the cultivated variety, with 11 graduations: a1 - Lovrin, a2 - Jeremy, a3 - Ovidiu, a4 - Muresana, a5 - GK Pillango, a6 - Prokop, a7- Effectiv, a8 - Overdrive, a9 - Venafor, a10 - Earl, a11 - Genziana; Factor B - sowing density with 3 graduations: b1 - 350 seeds/m$^2$, b2 - 450 seeds/m$^2$, b3 - 550 seeds/m$^2$; Factor C - nitrogen fertilization level, on a constant background of P60K60, with 5 graduations: $N_0$, $N_{30}$, $N_{60}$, $N_{90}$ and $N_{120}$.

## RESULTS AND DISCUSSIONS

Table 1 presents the production results for the 11 oat varieties tested. The Genziana variety achieved the highest production (3999 kg/ha), respectively an increase of 297 kg/ha compared to Lovrin 1 (the control sample), a difference statistically ensured as highly significant.

Table 1. Oat production according to cultivated variety

| Variety | Yield kg/ha | % | Difference kg/ha | Significance |
|---|---|---|---|---|
| Lovrin 1 | 3702 | 100 | - | - |
| Jeremy | 3865 | 104 | 163 | *** |
| Ovidiu | 3837 | 104 | 135 | *** |
| Muresana | 3937 | 106 | 235 | *** |
| GK Pillango | 3661 | 99 | -41 | 00 |
| Prokop | 3593 | 97 | -109 | 000 |
| Effectiv | 3839 | 104 | 137 | *** |
| Overdrive | 3881 | 105 | 179 | *** |
| Venafor | 3828 | 103 | 126 | *** |
| Earl | 3948 | 107 | 246 | *** |
| Genziana | 3999 | 108 | 297 | *** |
| DL 5% = 31.45 kg/ha, DL1%=41.46 kg/ha, DL 0.1%=53.53 kg/ha | | | | |

The Prokop variety had the lowest yield (3593 kg/ha), underperforming the control value (Lovrin 1) by 109 kg/ha, a difference statistically ensured as very significant in a negative sense. It should be noted that the other tested varieties Jeremy, Ovidiu, Muresana, Efectiv, Overdrive, Venafor and Earl also showed strong yield performances with high statistical significance over the Lovrin 1 control sample.

The results of oat production according to density are presented in Table 2. The density of 550 seeds/m² led to the highest yield (3980 kg/ha), significantly exceeding both lower densities, the difference of 306 kg/ha more than the lowest density, showing a highly significant relevance. To the density of 450 seeds/m² the difference of (151 kg/ha) compared to the density of 350 seeds/m², is also very significant.

Table 2. Oat production according to sowing density

| Density | Yield kg/ha | % | Difference kg/ha | Significance |
|---|---|---|---|---|
| 350 seeds/m$^2$ | 3674 | 100 | - | - |
| 450 seeds/m$^2$ | 3825 | 104 | 151 | *** |
| 550 seeds/m$^2$ | 3980 | 108 | 306 | *** |
| DL 5% = 16.43 kg/ha, DL1%=21.73 kg/ha, DL 0.1%=28.12 kg/ha | | | | |

Oat production results depending on nitrogen fertilization level on a constant P60K60 background, prove the beneficial effect of nitrogen fertilization, on all 4 fertilization levels the production exceeding the N0 with differences statistically assured as highly significant. The largest difference in yield compared to the N0 control was recorded on the agrofund fertilized with N120, respectively an increase of 1199 kg/ha.

Table 3. Oat production as a function of nitrogen fertilization level

| Nitrogen level | Yield kg/ha | % | Difference kg/ha | Significance |
|---|---|---|---|---|
| N0 | 3182 | 100 | - | - |
| N30 | 3637 | 114 | 455 | *** |
| N60 | 3844 | 121 | 662 | *** |
| N90 | 4087 | 128 | 905 | *** |
| N120 | 4381 | 138 | 1199 | *** |
| DL 5% = 21.20 kg/ha, DL1%=27.95 kg/ha, DL 0.1%=36.09 kg/ha | | | | |

The results of Duncan's multiple range tests (Figure 1), used to compare the means in different groups for three factors: the cultivated variety (factor A), the sowing density (factor B) and the level of nitrogen fertilization (factor C), show us that regarding the varieties: The

Genziana variety (3999.9 kg/ha) has the highest average and is marked with A, indicating that it is statistically superior. The Lovrin (3702.5 kg/ha) and Venafor (3828.2 kg/ha) varieties are marked with F and E, respectively, showing lower yields and significant differences from Genziana. Varieties such as Muresana and GK Pillango fall into groups DE and CD, suggesting intermediate performances. Letter clusters (A, B, C) denote groups that are not significantly different from each other. Regarding the three seeding densities, it is observed that increasing the seeding density from b1 (350 seeds/m$^2$) to b3 (550 seeds/m$^2$) has a result in significantly higher yields. Density B3 (550 kg/m²) significantly outperforms the others, suggesting that a higher density increases yield. Fertilization levels c4 (N90) and c5 (N120) are statistically the highest yielding, both marked A. The lowest yield is from c1 (N0), showing that no fertilizer significantly reduces yield.

**factor A[variety]**

| Variety | Yield kg/ha | |
|---|---|---|
| 11. Genziana | 3999. | A |
| 10. Earl | 3948. | B |
| 4. Muresana | 3937. | B |
| 8. Overdrive | 3881. | C |
| 2. Jeremy | 3865. | CD |
| 7. Effectiv | 3839. | DE |
| 3. Ovidiu | 3837. | DE |
| 9. Venafor | 3828. | E |
| 1. Lovrin | 3702. | F |
| 5. GK Pillango | 3661. | G |
| 6. Prokop | 3593. | H |

DL 5% = 31.4 kg/ha

**factor B[density]**

| Density | Yield kg/ha | |
|---|---|---|
| b3 – 550 seed/m$^2$ | 3980. | A |
| b2 – 450 seed/m$^2$ | 3825. | B |
| b1 – 350 seed/m$^2$ | 3674. | C |

DL 5% = 16.4 kg/ha

**factor C[density]**

| Nitrogen level | Yield kg/ha | |
|---|---|---|
| c5 – N120 | 4381. | A |
| c4 – N90 | 4087. | B |
| c3 - N60 | 3844. | C |
| c2 – N30 | 3637. | D |
| c1 – N0 | 3182. | E |

DL 5% = 21.20 kg/ha

Figure 1. The results of Duncan's multiple tests regarding the influence of nitrogen fertilization

Figure 2 highlights the percentage contribution of three important factors on the achievement of oat production. Each factor is measured according to its influence on the total production, and experimental error is included to assess the accuracy of the results.

Nitrogen fertilization has the greatest impact on the oat production, contributing 83.84% to the variation in yield, and is the essential factor for achieving high yields. Nitrogen doses such as N90 and N120 are probably the most efficient in maximizing production. This indicates that, under the experimental conditions, nitrogen nutrition plays a critical role in stimulating plant growth and grain development.

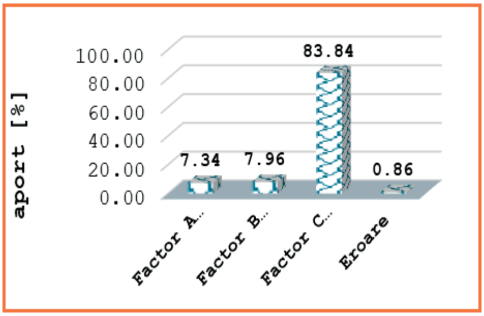


Figure 2. The contribution of factors A [cultivated variety], B [sowing density], C [nitrogen fertilization] to achieve production

Sowing density influences production in proportion to 7.96%. Adjusting seeding density can improve production, but the impact is much smaller compared to fertilization. It is important to choose an optimal density to avoid excessive competition between plants and to maximize the use of soil resources. Although the contribution is relatively small, a correctly chosen density can complement the effects of fertilization. The cultivated variety has a 7.34% influence on the production. While selecting the proper variety is important for certain quality characteristics (such as hectolitre mass - HLM), the impact on total production is less than that of fertilization. However, choosing a suitable variety can bring additional benefits in terms of disease resistance or adaptation to local climatic conditions.

The error value is 0.86%, indicating high precision of the experiment and precision of the results. Unexplained variability is minimal, suggesting that most of the variations in the data are due to the factors analyzed and not to external or random factors.

Table 4 presents the results regarding the hectolitre mass of the 11 oat varieties tested. The Jeremy variety has the highest hectolitre mass (48.05 kg/hL), with a significant difference of 0.52 kg/hL compared to Lovrin 1 (**).

Table 4. Hectoliter mass according to cultivated variety

| Variety | Hectolitre mass kg/hL | % | Difference kg/hL | Significance |
|---|---|---|---|---|
| Lovrin 1 | 47.53 | 100 | - | - |
| Jeremy | 48.05 | 101 | 0.52 | ** |
| Ovidiu | 45.94 | 97 | -1.59 | 000 |
| Muresana | 46.51 | 98 | -1.02 | 000 |
| GK Pillango | 47.1 | 99 | -0.43 | 0 |
| Prokop | 47.6 | 100 | 0.07 | ns |
| Effectiv | 47.66 | 100 | 0.13 | ns |
| Overdrive | 45.54 | 96 | -1.99 | 000 |
| Venafor | 47.49 | 100 | -0.04 | ns |
| Earl | 45.61 | 96 | -1.92 | 000 |
| Genziana | 47.41 | 100 | -0.12 | ns |
| DL 5% = 0.4 kg, DL1%=0.5 kg, DL 0.1%=0.7 kg | | | | |

The varieties with low hectolitric mass were Overdrive (45.54 kg/hL), Earl (45.61 kg/hL) and Ovidiu (45.94 kg/hL) have the lowest HLM values and are significantly weaker (000) compared to Lovrin 1. The varieties without significant differences: Prokop, Effectiv, Venafor and Genziana do not show significant differences compared to Lovrin 1 (ns), indicating a stability of the hectolitre mass between these varieties. Table 5 presents the results of hectolitre mass depending on the applied nitrogen dose. The results show that hectolitre mass increases as the nitrogen fertilization level increases. Without fertilization (N0), the hectolitre mass is 46.18 kg/hL. With maximum fertilization (N120), the hectolitre mass reaches 47.52 kg/hL, an increase of 1.34 kg/hL. All fertilization levels show significant differences (***), even at a low nitrogen level (N30), suggesting that fertilization has a significant impact on the quality of production.

Table 5. Hectoliter mass as a function of nitrogen fertilization level

| Nitrogen level | HLM kg/ha | % | Difference kg/ha | Significance |
|---|---|---|---|---|
| N0 | 46.18 | 100 | - | - |
| N30 | 46.68 | 101 | 0.50 | *** |
| N60 | 47.06 | 102 | 0.88 | *** |
| N90 | 47.31 | 102 | 1.13 | *** |
| N120 | 47.52 | 103 | 1.34 | *** |
| DL 5% = 0.3 kg/hL, DL1%=0.4 kg/hL, DL 0.1%=0.5 kg/hL | | | | |

The results of the Duncan test (Figure 3), prove that the best variety in terms of hectolitre mass (HLM) is Jeremy, it has the highest HLM (48.05 kg/hL) and is in group A, which indicates that it differs significantly from the other varieties. The Effectiv and Prokop varieties have high hectolitric mass, but are in different groups (B and C), indicating a significant difference from Jeremy. Varieties with low hectolitre mass are Overdrive (45.54 kg/hL) and Earl (45.61 kg/hL) are in groups J and I, having the lowest HLM values and being significantly inferior to the varieties in the higher groups. The Lovrin 1 and Venafor varieties are in the same group (D), indicating that there are no significant differences between them. Regarding the impact of nitrogen fertilization on hectolitre mass, the N120 fertilization level has the highest hectolitre mass (47.52 kg/hL) and is in group A, which indicates that it is significantly superior to the other fertilization levels. As the nitrogen level decreases, the hectolitre mass decreases progressively, with each fertilization level forming a distinct group (B, C, D, E). There are significant differences between all fertilization levels. Even a small increase from N0 to N30 brings a significant difference in hectolitre mass. The increase from N90 and N120 are close in value, but are in different groups, which shows a significant difference between them.

**factor A[variety]**

| Variety | HLM | |
|---|---|---|
| 2. Jeremy | 48.05 | A |
| 7. Effectiv | 47.66 | B |
| 6. Prokop | 47.60 | C |
| 1. Lovrin | 47.53 | D |
| 9. Venafor | 47.49 | D |
| 11.Genziana | 47.41 | E |
| 5.GK Pillango | 47.10 | F |
| 4. Muresana | 46.51 | G |
| 3. Ovidiu | 45.94 | H |
| 10.Earl | 45.61 | I |
| 8.Overdrive | 45.54 | J |

DL 5% = 0.04 kg/hL

**factor B[fertilization]**

| Nitrogen level | HLM | |
|---|---|---|
| c5 – N120 | 47.52 | A |
| c4 – N90 | 47.31 | B |
| c3 - N60 | 47.06 | C |
| c2 – N30 | 46.68 | D |
| c1 – N0 | 46.18 | E |

DL 5% = 0.03 kg/hL

Figure 3. The results of Duncan's multiple tests regarding the influence of hectolitre mass

Figure 4 shows the relative contribution of three experimental factors on hectolitre mass.

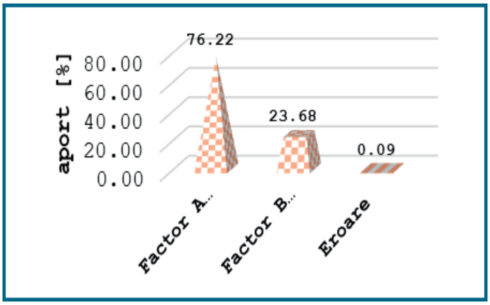


Figure 4. Contribution of factors A [cultivated variety], B [sowing density], C [nitrogen fertilization] to achieve the hectolitre mass

The cultivated variety has the greatest influence on the analyzed variable, with a contribution of 76.22%. Choosing the right variety is decisive for maximizing production or improving the quality of oats. Varieties such as Jeremy or Effectiv (according to previous analyses) would have the greatest positive impact on hectolitre mass or yield. Nitrogen fertilization contributes with 23.68% to the variation of the results. Even if fertilization has a significant impact, it is less influential than the variety.
However, applying optimal doses of nitrogen (for example, N90 or N120) can significantly improve the production and quality of oats. It is important to adjust fertilization according to the variety used and local conditions. The error value is almost insignificant (0.09%), indicating that the experiment was well controlled and the results are reliable. The unexplained variability is minimal, suggesting that most of the variation in the data is due to the factors tested and not random factors. Table 6 presents the fat content (%) in oats for different varieties, comparing the percentage values and the significant differences between them. The statistical significance limits for assessing the differences are also included.

Table 6. Fat content according to cultivated variety

| Variety | Fat content % | % | Difference % | Significance |
|---|---|---|---|---|
| Lovrin 1 | 48.8 | 100 | - | - |
| Jeremy | 48.49 | 99 | -0.31 | 00 |
| Ovidiu | 50.13 | 103 | 1.33 | *** |
| Muresana | 52.08 | 107 | 3.28 | *** |
| GK Pillango | 51.99 | 107 | 3.19 | *** |
| Prokop | 48.24 | 99 | -0.56 | 000 |
| Effectiv | 48.33 | 99 | -0.47 | 000 |
| Overdrive | 50.91 | 104 | 2.11 | *** |
| Venafor | 49.58 | 102 | 0.78 | *** |
| Earl | 48.92 | 100 | 0.12 | ns |
| Genziana | 47.29 | 97 | -1.51 | 000 |
| DL 5% = 0.18 %, DL1%=0.24 %, DL 0.1%=0.32 % | | | | |

The varieties with the highest fat content were Mureșana (52.08%) and GK Pillango (51.99%) have the highest fat content, exceeding the control Lovrin 1 by 3.28% and 3.19%, respectively. The differences are significant at a high level (***). The varieties Overdrive (50.91%) and Ovidiu (50.13%) also have a significantly higher fat content than the control, with differences of 2.11% and 1.33%. Low-fat varieties: Genziana (47,29%) has the lowest fat content, with a significant negative difference of -1.51% compared to Lovrin 1 (000). The varieties Prokop (48.24%) and Effectiv (48.33%) also have a lower fat content than the control, with significant negative differences. Earl variety (48.92%) shows a very small difference from the control (0.12%) and is not significantly different (ns), and Jeremy (48.49%) has a slight decrease compared to the control, but the difference is significant at a less strict level (00). The fat content according to the level of nitrogen fertilization is presented in Table 7.

Table 7. Fat content as a function of nitrogen fertilization level

| Nitrogen level | Fat content % | % | Difference % | Significance |
|---|---|---|---|---|
| N0 | 47.39 | 100 | - | - |
| N30 | 49.00 | 103 | 1.61 | *** |
| N60 | 49.58 | 105 | 2.19 | *** |
| N90 | 49.97 | 105 | 2.58 | *** |
| N120 | 51,68 | 109 | 4.29 | *** |
| DL 5% = 0.12 %, DL1%=0.16 %, DL 0.1%=0.21 % | | | | |

As the nitrogen fertilization level increases, the fat content also increases significantly. From N0 (47.39%) to N120 (51.68%), the fat content increases by 4.29%, a significant difference (***). There is a direct correlation between the level of nitrogen applied and the fat content of oats. High nitrogen levels, especially N120, determine a maximum fat content (51.68%). Fertilization not only improves production (according to previous analyses), but also has a positive impact on the nutritional content, increasing the percentage of fat in oats. Depending on the purpose of production (human consumption, feed, industrial processing), fertilization levels can be adjusted to optimize fat content. Results of Duncan's Test (Figure 5), for Factors A (Varieties) and B (Nitrogen Fertilization) to compare the means of fat content (%) according to the cultivated variety (Factor A) and the level of nitrogen fertilization (Factor B).

The varieties with the highest fat content are Mureșana (52.10%) and GK Pillango (52.00%) are in group A, which means that they are statistically the best varieties in terms of fat content. The differences from the other varieties are significant. Varieties with average fat content are Overdrive (50.90%) and Ovidiu (50.13%) are in separate groups (B and C), indicating significant differences between them and from the varieties in group A, and the variety Venafor (49.58%) is in group D, close to the average. Varieties with low fat content: Genziana (47.29%) has the lowest fat content and is part of group H, significantly lower than all other varieties. Varieties without significant differences: Lovrin (48.80%) and Earl (48.92%) are in the same group (E), which means that there is no significant difference between them.

**factor A[variety]**

| Variety | FAT | |
|---|---|---|
| 4. Muresana | 52.10 | A |
| 5.GK Pillango | 52.00 | A |
| 8.Overdrive | 50.90 | B |
| 3. Ovidiu | 50.10 | C |
| 9. Venafor | 49.60 | D |
| 10.Earl | 48.90 | E |
| 1.Lovrin | 48.80 | E |
| 2.Jeremy | 48.50 | F |
| 7.Effectiv | 48.30 | G |
| 6.Prokop | 48.20 | G |
| 11.Genziana | 47.30 | H |

DL 5% = 0.18 %

**factor B[fertilization]**

| Nitrogen level | FAT | |
|---|---|---|
| c5 – N120 | 51.68 | A |
| c4 – N90 | 49.97 | B |
| c3 - N60 | 49.58 | C |
| c2 – N30 | 49.00 | D |
| c1 – N0 | 47.39 | E |

DL 5% = 0.12 %

Figure 5. The results of Duncan's multiple tests regarding the influence of fat content

The contribution of factors A (cultivated variety) and B (nitrogen fertilization) to achieving fat content is shown in Figure 6.

Cultivated variety accounts for 53.77% of the variation in fat content which suggests that the variety choosing has the greatest impact on the amount of fat in oats. Varieties such as Mureșana and GK Pillango, which were identified in the previous analysis as having high fat content, contribute significantly to the increase in this parameter.

Choosing an appropriate variety is essential for achieving optimal fat content, whether the goal is to increase or reduce it.

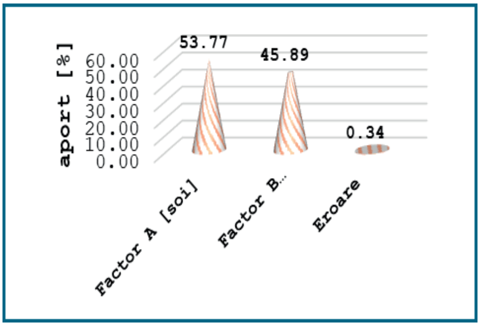


Figure 6. The contribution of factors A [cultivated variety], B [nitrogen fertilization] to achieve the fat content

Nitrogen fertilization contributes 45.89% to the variation in fat content, having an impact almost as important as the cultivated variety. High nitrogen levels (such as N120) have previously been shown to significantly increase fat content. Fertilization not only influences total production, but also plays a crucial role in modifying the nutritional composition, especially in increasing fat. The error value is 0.34%, indicating high measurement accuracy and negligible variability due to uncontrolled factors. The accuracy of the data is high, and most of the variations in fat content can be attributed to the analysed factors (variety and fertilization). The protein content according to the cultivated variety is presented in Table 8.

Table 8. Protein content according to cultivated variety

| Variety | Protein content % | % | Difference % | Significance |
|---|---|---|---|---|
| Lovrin 1 | 13.97 | 100 | - | - |
| Jeremy | 14.26 | 102 | 0.29 | *** |
| Ovidiu | 14.11 | 101 | 0.14 | *** |
| Muresana | 13.91 | 100 | -0.06 | 000 |
| GK Pillango | 13.93 | 100 | -0.04 | 0 |
| Prokop | 14.17 | 101 | 0.20 | *** |
| Effectiv | 13.96 | 100 | -0.01 | ns |
| Overdrive | 14.03 | 100 | 0.06 | *** |
| Venafor | 13.91 | 100 | -0.06 | 000 |
| Earl | 14.39 | 103 | 0.42 | *** |
| Genziana | 14.47 | 104 | 0.50 | *** |
| DL 5% = 0.03 %, DL1%=0.05 %, DL 0.1%=0.06 % | | | | |

The varieties with the highest protein content are Genziana (14.47%), followed by Earl (14.39%) and Jeremy (14.26%). The differences compared to the control Lovrin 1 (13.97%) are positive, but are not marked as statistically significant, which suggests that the variations are small and may not be relevant from a practical point of view. Varieties with low protein content are Mureșana (13.91%), Venafor (13.91%) and GK Pillango (13.93%). They have a slightly lower protein content than the control, but the differences are insignificant.

All varieties show very small variations in protein content. The differences are not marked as statistically significant, which indicates that the cultivated variety has a low impact on protein content. The protein content depending on the nitrogen fertilization level is presented in Table 9.

Table 9. Protein content as a function of nitrogen fertilization level

| Nitrogen level | Protein content % | % | Difference % | Significance |
|---|---|---|---|---|
| N0 | 13.5 | 100 | - | - |
| N30 | 13.95 | 103 | 0.45 | *** |
| N60 | 14.12 | 105 | 0.62 | *** |
| N90 | 14.24 | 105 | 0.74 | *** |
| N120 | 14.70 | 109 | 1.20 | *** |
| DL 5% = 0.02 %, DL1%=0.03 %, DL 0.1%=0.04 % | | | | |

The protein content increases progressively as the nitrogen fertilization level increases. The N120 dose (14.70%) has the highest protein content, with an increase of 1.20% compared to the unfertilized control (N0). The increases from N30 to N90 are gradual and consistent, suggesting a cumulative effect of nitrogen on protein content. However, none of these differences are marked as statistically significant, suggesting that the impact of fertilization on protein content is limited. Analyzing the data according to Duncan's Test (Figure 7), the varieties with the highest protein content are Genziana (14.50%) which has the highest protein content and is in group A, being significantly superior to all other varieties. Earl (14.40%) follows closely and is in group B, differing significantly from Genziana, but having a high content compared to other varieties. Varieties with medium protein content are Jeremy (14.30%) and Prokop (14.17%) in groups C and D, which indicates significant differences from the varieties in the higher groups, and with low protein content Venafor (13.91%), Mureșana (13.90%), GK Pillango (13.93%) and Effectiv (13.96%) are part of group G, having the lowest protein content, being significantly inferior to the varieties in the higher groups. Varieties Lovrin (14.00%) and Overdrive (14.03%) are in the same group (F), which means that there are no significant differences between them. Maximum fertilization significantly increases. N120 (14.70%) has the highest protein content is significantly superior to all other fertilization levels (Group A), followed by N90 (14.24%) and N60 (14.12%) levels found in different groups (B and C), indicating significant differences between them, but also compared to maximum fertilization. Fertilization with N30 (13.95%) has a moderate impact on protein content and is in group D. Fertilization level N0 (13.50%) has the lowest protein content and is significantly lower than all other fertilization levels (Group E).

The cultivated variety contributes 18.73% to the variation in protein content. Even if variety has a smaller influence than fertilization, choosing the right variety can add additional value in optimizing protein content. Varieties such as Genziana and Earl, previously identified as having higher protein content, contribute significantly to this variation.

**factor A[variety]**

| Variety | Protein | |
|---|---|---|
| 11.Genziana | 14.50 | A |
| 10.Earl | 14.40 | B |
| 2.Jeremy | 14.30 | C |
| 6.Prokop | 14.20 | D |
| 3. Ovidiu | 14.10 | E |
| 8.Overdrive | 14.00 | F |
| 7.Effectiv | 14.00 | F |
| 1.Lovrin | 14.00 | F |
| 4. Muresana | 13.90 | G |
| 5.GK Pillango | 13.90 | G |
| 9.Venafor | 13.90 | G |

DL 5% = 0.03 %

**factor B[fertilization]**

| Nitrogen level | Protein | |
|---|---|---|
| c5 – N120 | 14.70 | A |
| c4 – N90 | 14.24 | B |
| c3 - N60 | 14.12 | C |
| c2 – N30 | 13.95 | D |
| c1 – N0 | 13.50 | E |

DL 5% = 0.02 %

Figure 7. The results of Duncan's multiple tests regarding the influence of protein content

However, the contribution of variety is smaller compared to fertilization, which means that in the absence of adequate fertilization, differences between varieties are less relevant. Principal component analysis (PCA) simplifies the visualization of relationships between variables and observations. In figure 8, the projection of the variables in the plane of the factorial axes of the two main components [Factor 1/CP1 and Factor 2/CP2] is presented. This biplot illustrates the relationships between variables (Hectolitre mass, Protein, Fat) based on the first two principal components (Factor 1 [CP1] and Factor 2 [CP2]). Factor 1 explains 52.40% of the total variance, while factor 2 explains 32.93%, cumulatively representing 85.33% of the variability of the data set. Protein and fat are closely aligned, indicating a positive correlation between these two variables. Hectolitre mass (possibly related to mass or weight) is positioned in a different quadrant, suggesting a weaker or negative correlation with protein and fat. The length of the vectors indicates the strength of the contribution of each variable to the cultivated variety contributes 18.73% to the variation in protein content. Even if variety has a smaller influence than fertilization, choosing the right variety can add additional value in optimizing protein content. the principal components. Protein and fat have longer vectors, meaning they contribute significantly to the variation in the data set. The angles between the vectors show correlation: smaller angles indicate stronger positive relationships, while larger or perpendicular angles suggest a weak or no correlation.

The results of the principal component analysis (PCA) show that the protein and fat content of oats are closely related, while hectolitre mass behaves differently, probably influenced by other factors.

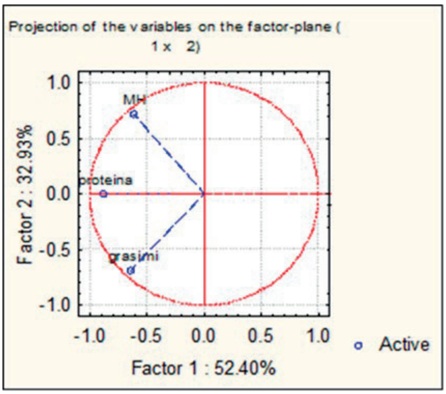


Figure 8. Projection of the variables in the plane of the factorial axes of the two principal components [Factor 1/CP1 and Factor 2/CP2]

Figure 9 shows the projection of the cases [variety x fertilization levels combinations] in the factorial axes plane of the two main components [Factor 1/CP1 and Factor 2/CP2]. This graph shows how individual cases (soil combinations, fertilization, and other factors) are distributed based on the first two principal components. Each point represents a specific combination, appropriately labelled (for example, s1N1, s4N3, etc.), where s represents the soil type and N denotes the fertilization level. The spread of points indicates the diversity of responses to different variety and fertilization treatments. Cases clustered closely together have similar characteristics, while those more distant are more distinct in their responses.

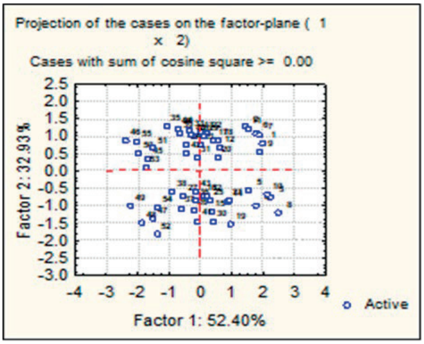


Figure 9. The projection of cases [variety combinations x fertilization levels] in the plane of the factorial axes of the two main components [Factor 1/CP1 and Factor 2/CP2]

PCA helps identify combinations of variety and fertilization that lead to similar results in terms of yield, protein, fat or hectoliter mass. This analysis helps identify the optimal soil and fertilization combinations that produce the desired results (for example, high protein content or improved yield).

The correlation between protein and hectoliter mass (Figure 10) and the correlation between protein and fat content (Figure 11), show that there is a moderate but statistically significant positive correlation between protein and fat content in oats.

While higher protein levels tend to coincide with increased fat levels, the relationship is not strong enough to be the only predictor, indicating that other variables probably play a role in the variability of fat content.

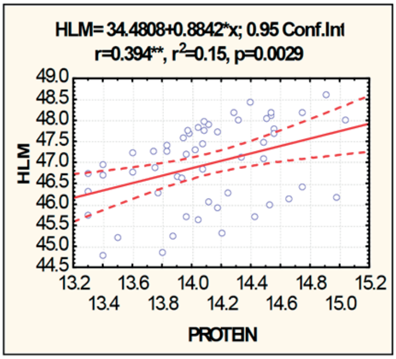


Figure 10. Correlation between protein and hectolitre mass

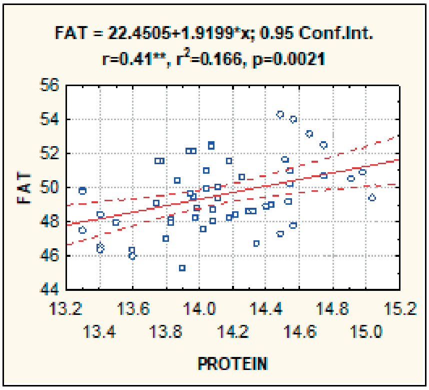


Figure 11. The correlation between proteins and fats

The correlation between nitrogen fertilization level and hectolitres mass is presented in Figure 12 and shows that nitrogen has a moderate effect on hectolite mass, implying that other factors could play a more significant role in determining hectolite mass, especially moisture.

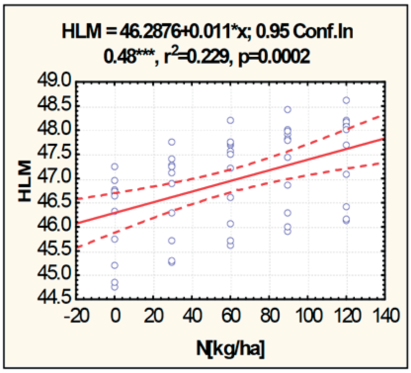


Figure 12. Correlation between nitrogen fertilization level and hectolite mass

Nitrogen also has a strong positive effect on fat content, although not as pronounced as in the case of protein (Figure 13).

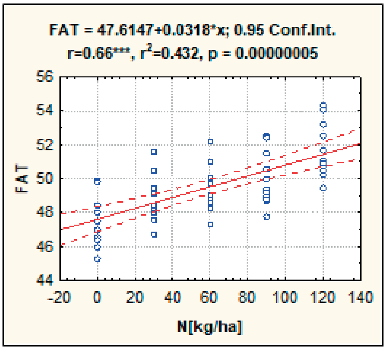


Figure 13. Correlation between the level of nitrogen fertilization and fat content

The strongest correlation is between nitrogen and protein content, suggesting that nitrogen fertilization is essential for maximizing protein levels in oats (Figure 14).

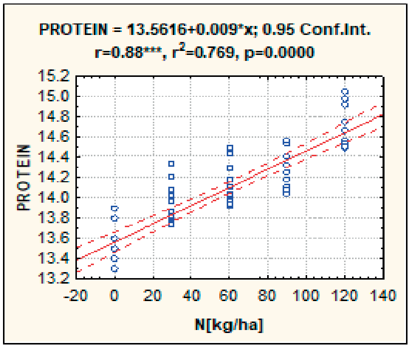


Figure 14. Correlation between nitrogen fertilization level and protein content

## CONCLUSIONS

Fertilization plays a critical role in oat production, influencing yield, grain quality and environmental sustainability. By adopting best practices, valorisation the technological advances and integrating sustainable approaches, farmers can optimize oat production while minimizing environmental impact.
Continued research and innovation in the creation of valuable biological material and fertilization strategies will be essential to meet the growing global demand for oats and ensure the resilience of agricultural systems.

Protein and fat content are closely related, principal components analysis (PCA) confirms a strong positive correlation between protein and fat levels in oats, suggesting that fertilization strategies targeting protein may also influence fat content.

The behaviour of hectolitres mass in PCA indicates that it is influenced by different factors compared to protein and fat, possibly related to environmental or genetic variables.

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