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ANALYZING THE IMPACT OF CLIMATE VARIATIONS AND FERTILIZER APPLICATION ON SOYBEAN CULTIVATION ACROSS WESTERN, SOUTHERN AND CENTRAL REGION OF ROMANIA

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Abstract

Analyzing the soybean productions obtained at the national level in recent years, it has been observed that they are increasingly higher from year to year. This aspect reflects the growing interest of farmers in cultivating this plant. This work highlights how the climatic conditions in the year 2023 and the quantity of fertilizers applied influenced the development of soybean plants as well as the bean production. The experiment was conducted in three different agricultural areas in Romania, using four soybean varieties, and the fertilizers were applied in two different quantities. Throughout the vegetation period, several biometric measurements were taken, and the results of the experiment revealed how the climate of the selected regions, as well as the rate of applied fertilizers, influenced the development of the plants and the yields obtained.

Key words: *agriculture, biometrics, climate, fertilization, soybean.*

INTRODUCTION

The cultivation of soybeans represents a significant agricultural endeavor in Romania, contributing to both domestic food security and economic prosperity (Stanciu & Nastase, 2016). However, soybean cultivation faces numerous challenges, including climate variability and the optimization of fertilizer application practices (Ramesh et al., 2017). Understanding the interplay between these factors is essential for ensuring sustainable and efficient soybean production across different regions of Romania.
The background of soybean cultivation in Romania is characterized by its adaptation to diverse climatic and soil conditions. Western, Southern, and Central regions of the country exhibit distinct environmental profiles,
Climate variations, including changes in temperature, precipitation patterns, and the occurrence of extreme weather events, can significantly impact crop yields and quality, underscoring the need for robust adaptation strategies (Rusu & Moraru, 2015; Moraru et al., 2013).
Fertilizer application practices play a crucial role in optimizing soybean productivity and mitigating environmental impacts (Njeru et al., 2013).
Proper nutrient management is essential for maintaining soil fertility, enhancing plant growth, and maximizing yields (Selim, 2020). However, excessive or inadequate fertilizer usage can lead to environmental pollution, soil degradation, and economic inefficiencies (Selim, 2020). Balancing nutrient inputs with crop requirements while minimizing adverse effects on the environment is a complex endeavor that requires careful consideration of local conditions and agronomic practices (Magen, 2008).
The motivation behind analyzing the impact of climate variations and fertilizer application on soybean cultivation in Romania stems from the importance of this crop in the agricultural sector and the need to enhance its resilience and sustainability (Jurjescu et al., 2020).
As climate change continues to influence weather patterns and environmental conditions, understanding how soybean production systems can adapt and thrive in the face of these challenges is critical for ensuring food security and economic stability (Rötter et al., 2015; Hatfield et al., 2011).
The significance of this research lies in its potential to inform evidence-based decision-making and resource allocation in soybean

farming practices. By identifying the synergies and trade-offs between climate variability and fertilizer management, farmers, policymakers, and agricultural stakeholders can develop targeted interventions and adaptation strategies to enhance the resilience and productivity of soybean cultivation across different regions of Romania.

Existing literature provides valuable insights into the impacts of climate change on crop production and the optimization of fertilizer use in agriculture. However, few studies have specifically focused on soybean cultivation in the context of Romanian agricultural systems, particularly across multiple regions. Our research seeks to address this gap by conducting a comprehensive analysis of climate variations and fertilizer application practices and their implications for soybean yields and environmental sustainability.

In this study, we will employ a combination of field experiments, remote sensing techniques, and statistical modeling approaches to assess the effects of climate variability and fertilizer management on soybean cultivation across Western, Southern, and Central regions of Romania. We aim to provide actionable insights and recommendations for enhancing the resilience and sustainability of soybean production systems in the face of changing environmental conditions.

Our research differs from previous studies in its focus on soybean cultivation in Romania and its holistic approach to examining the interactions between climate variations as precipitation and temperatures (Figure 1) and fertilizer application practices.

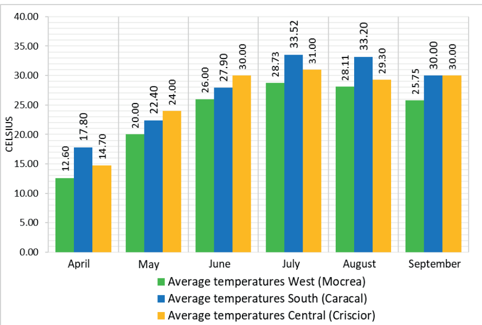

Figure 1. The average monthly temperatures during the growing season of 2023 (https://freemeteo.com/frame.asp?ifrid=236788_cazare-ranca.ro&pid=302)

By considering multiple regions and employing interdisciplinary methodologies, we seek to generate novel findings and practical recommendations that can support informed decision-making and promote the long-term viability of soybean farming in Romania.

MATERIALS AND METHODS

Experimental period and locations

In the spring of 2023, all three locations, Târnova, Caracal, and Criscior, were affected by significant precipitation that delayed soybean sowing as shown in the graph from Figure 2. The soybean vegetation period in these locations was limited to the interval between the second half of April and the first half of September.

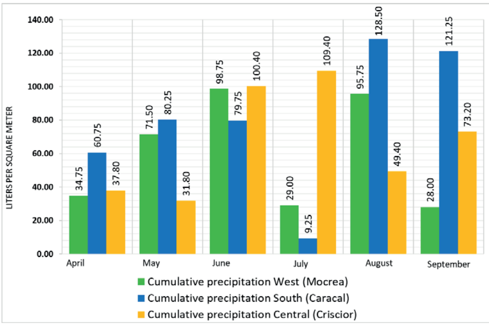

Figure 2. The cumulative precipitation during the growing season of 2023 (https://www.meteoblue.com/ro/vreme/historyclimate/weatherarchive/romania_s.u.a._4560808)

Soybean varieties

This study explores the performance of various soybean varieties across different regions of Romania. In the following, we will present the four selected varieties for our experiment.

The soybean variety **Orakel PZO** is a moderate type with good production potential, classified in maturity group 00, similar to wheat in development cycle. Yields range from 3000-3500 kg/ha, potentially exceeding 4500 kg/ha under favorable conditions. Sowing recommendations advise an optimal period based on local conditions, a seeding density of 60-65 viable seeds per square meter, and adjustable seeding depth based on soil type. Orakel PZO soybeans are ideal for producers aiming for consistent, high-quality harvests in diverse climates (https://ig-pflanzenzucht.de/wp-content/plugins/igp-filter/tpl/saatgut-generate-pdf.php).

The early soybean variety **Ovidiu F** has determinate growth and a semi-erect bush shape, reaching a height of 80-122 cm with gray pubescence. Its white flowers lead to dark brown pods containing yellow beans weighing 100-160 grams. It has a short vegetation period of 100-110 days, suitable for drought and heat conditions, and exhibits resistance to lodging, shattering, and various diseases including soybean rust, bacterial blight, and fusarium. With high protein (39.0-41.8%) and oil content (21.0-22.6%), it appeals to both the compound feed and food industries (Manea, 2018; www.incda-fundulea.ro/fise/pdf/ Soia/ovidiu.pdf).

Amyata is an early variety classified in group 00, highly adaptable to cultivation conditions, with remarkable morphological and technical characteristics.

It features indeterminate growth, early flowering, and harvesting, with medium to tall plant height and violet-hued inflorescences. The beans weigh between 170-210 grams, with high fat (over 20%) and protein (over 40%) content, and an open hilum.

Amyata exhibits vigor, tolerance to shattering, lodging resistance, and high production potential. It is robust, showing good tolerance to diseases and adverse environmental conditions. The ideal sowing period is from the second decade of April to mid-May, with optimal row spacing of 15-24 centimeters. Harvesting is feasible within a short interval due to early maturity (https://binealegibineculegi.ro/pdf/?id=9296).

Cypress is a semi-early variety known for its excellent plasticity and adaptability, providing reliable yields even in challenging environments.

The vigorous and healthy plants are suitable for soy milk extraction. With high production potential, Cypress can yield up to 4700 kg/ha under intensive technology and irrigation. It belongs to maturity group 0, featuring yellow hilum and white or white-gray flowers, with the first pod appearing around 12-14 cm (https://raiffeisen-agro.ro/cultura-de-soia-importanta-caracteristici-si-productii-medii-soia-cypress-rwa/).

Used techniques

To analyze the impact of climatic variations and fertilizer application on soybean cultivation in western, southern, and central regions of Romania, various methods and techniques were employed. Experimental plots of randomized blocks were established at various locations within the regions, where different quantities and types of fertilizers were applied, quantities displayed in Table 1.

These techniques allowed for the evaluation of the impact of fertilizer application on soybean yield under the varied climatic conditions of Romania.

The next step involved monitoring the soybean plants and yields in these experimental plots, tracking plant development throughout the growing season and assessing yield and crop quality. Finally, the data collected from experiments and monitoring were analyzed and interpreted to identify relevant trends and correlations.

Tabel 1. The amount of applied nitrogen (kg/ha)

Control group	150
First trial	75
Second trial	125

This provided a deeper understanding of the impact of climatic variations and fertilizer application on soybean cultivation in Romania, contributing to the development of more efficient and sustainable agricultural practices in these regions.

Several biometric measurements of soybean plants were conducted during this experiment. Plant height was carefully monitored throughout their growth cycle, aiming to understand how environmental factors and agricultural techniques influence this crucial aspect of crop productivity.

Additionally, the height at the level of the first soybean pod was measured, as this indicator can provide important information about the timing and pace of plant development.

In addition to height and developmental stage, the number of pods produced by each soybean plant was recorded. This measure is essential for understanding the production potential of the crop and for evaluating the effectiveness of different crop management methods.

At the end of the experiment, detailed data on soybean production were collected. These pieces of information help assess crop perfor-

mance and identify potential improvements that could be made to agricultural practices.
Overall, these biometric measurements and collected data provide a comprehensive picture of soybean crop performance within the experiment. The collected data as well as the graphical representations were created using Excel from the Office 365 suite. They represent valuable tools for improving agricultural practices and optimizing production in the future.

RESULTS AND DISCUSSIONS

Soybeans, being leguminous plants, react differently to the level of nitrogen available in the soil (Rymuza et al., 2020).
To better understand the performance of soybean varieties in various regions of Romania, we analyzed the provided data presented on Figure 3, which includes the average height of soybean plants and the amount of nitrogen applied for each repetition.

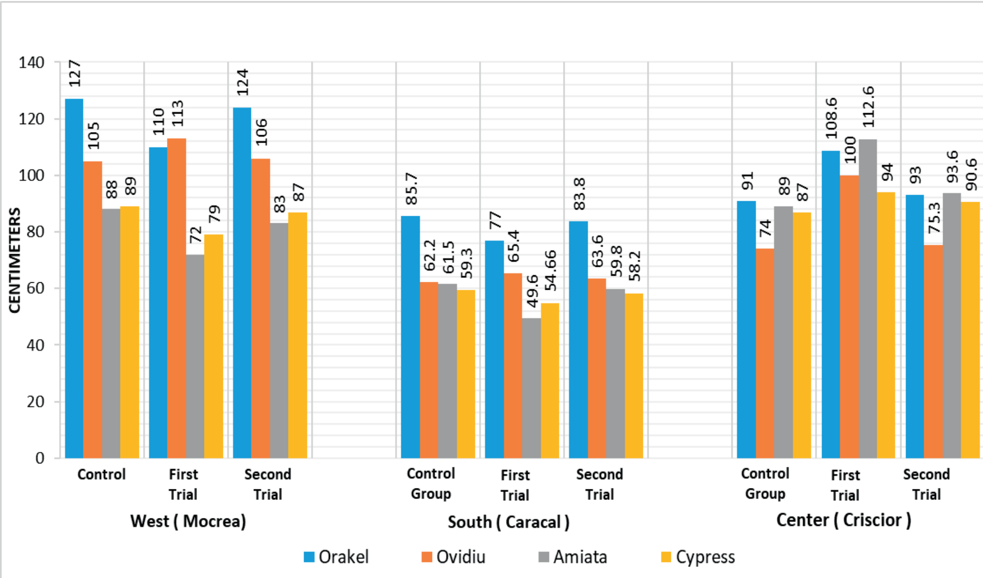

Figure 3. The average height of soybean plants across all three regions

In the West region, Mocrea, we observed that the presented varieties generally had higher average heights than their Control group counterparts. For example, Orakel control group exhibited an average height of 127 cm, surpassing the Orakel first trial, which had an average height of 110 cm, indicating superior plant development in this region. However, for the Amyata and Cypress varieties, no significant differences in average height were observed compared to their control group counterparts. Amyata control group displayed an average height of 88 cm, Amyata first trial had 72 cm, and Amyata second trial had 83 cm. Similarly, Cypress control group stood at 89 cm, Cypress first trial at 79 cm, and Cypress second trial at 87 cm.
Interestingly, analyzing the different nitrogen application rates, we can observe that they can influence the performance of soybean plants. Generally, varieties that received a higher amount of nitrogen had a higher average height, with the exception of Ovidiu, which, even with a lower amount of nitrogen, had a higher average height than the Control group. Ovidiu control group recorded an average height of 105 cm, Ovidiu first trial reached 113 cm, and Ovidiu Second Trial measured 106 cm.
In the South region, Caracal, the situation changed significantly, especially regarding the average height of soybean plants. All varieties had lower average heights than their control group counterparts except for Ovidiu, which exhibited higher values in height than the control group, indicating for the rest of the varieties a lower adaptation to the conditions in this region.
For instance, Orakel control group stood at 85.7 cm, Orakel first trial at 77 cm, and Orakel

second trial at 83.8 cm. In contrast, Ovidiu control group recorded 62.2 cm, Ovidiu first trial reached 65.4 cm, and Ovidiu second trial measured 63.6 cm. Similarly, Amyata control group displayed 61.5 cm, Amyata first trial had 49.6 cm, and Amyata second trial had 59.8 cm. Moreover, Cypress control group exhibited 59.3 cm, Cypress first trial showed 54.66 cm, and Cypress second trial measured 58.2 cm.

Despite the varying nitrogen application rates across trials, some varieties experienced a notable decrease in average height compared to the control group. This indicates that, in this region, the lower amount of nitrogen applied was insufficient to support optimal soybean plant growth.

In the Center region, Criscior, the results were diverse. Orakel and Ovidiu recorded a significant increase in average height compared to their control group counterparts, regardless of the amount of nitrogen applied. Orakel control group measured 91 cm, whereas Orakel first trial reached 108.6 cm and Orakel second trial stood at 93 cm. Similarly, Ovidiu control group was 74 cm, Ovidiu first trial recorded 100 cm, and Ovidiu second trial measured 75.3 cm.

Conversely, Amyata's first and second trials did not exhibit a similar average height to Amyata Control group, regardless of the nitrogen application, indicating a better adaptation to local conditions. Amyata control group displayed 89 cm, Amyata first trial measured 112.6 cm, and Amyata second trial stood at 93.6 cm.

Similarly, Cypress's first and second trials demonstrated consistent performance, with an average height close to Cypress Control group, regardless of the amount of nitrogen applied. Cypress control group exhibited 87 cm, Cypress first trial measured 94 cm, and Cypress second trial stood at 90.6 cm.

The analysis of soybean variety performance in different regions of Romania has revealed significant differences in their adaptability to local conditions and the amount of nitrogen applied in the soil. As shown in Figure 4 the study highlighted that soybean varieties exhibit varied responses depending on the region they are cultivated in, reflecting the complexity of interactions between plant genotype and the surrounding environment.

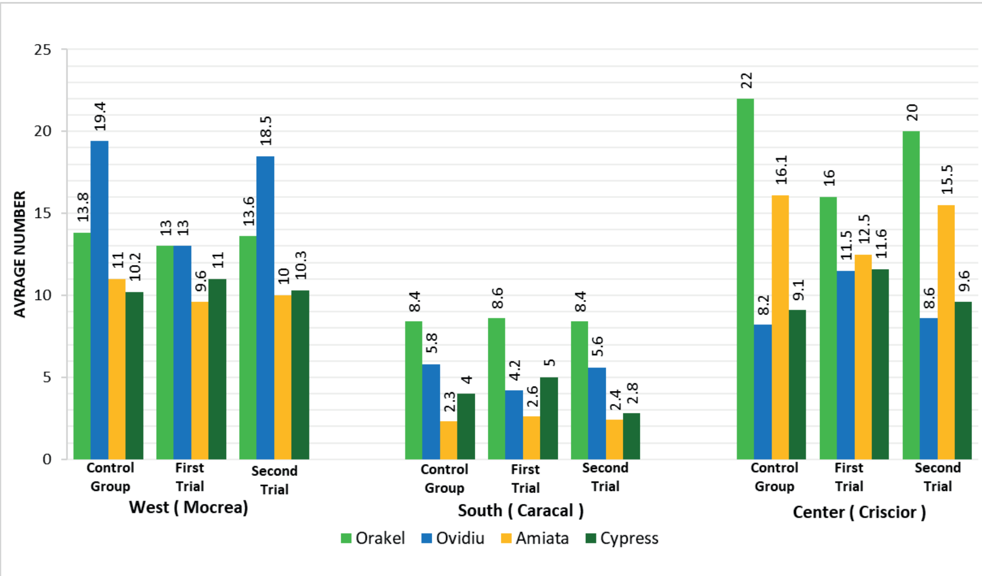

Figure 4. Average number of branches in all three regions

In the West region of Mocrea, the Orakel and Ovidiu varieties exhibited promising behavior regarding the number of branches, indicating their favorable adaptation to the local conditions. Orakel showed consistent branch development across its control and trial groups, with an average number of branches ranging from 13 to 13.8. Similarly, Ovidiu displayed robust branch growth, with control group branches averaging 19.4, and trial groups maintaining high branch counts around 13 to 18.5.

Contrastingly, the Amyata and Cypress varieties demonstrated slightly fewer branches on average. Amyata control group exhibited 11 branches, while its trial groups showed a slight decrease to around 9.6 to 10 branches. Cypress control group displayed an average of 10.2 branches, and its trial groups maintained similar levels around 10 to 11 branches.

These observations underscore the varieties capacity to adapt to the local environment. Moreover, the positive response to varied nitrogen application rates suggests their efficient utilization of available resources, contributing to their overall growth and development in the region.

In the South region - Caracal, all soybean varieties displayed a lower average number of branches compared to the other two regions. Orakel control group exhibited 8.4 branches, with minimal variation in its first and second trial groups. Similarly, Ovidiu control group showed 5.8 branches, while its first and second trial groups exhibited even fewer branches, ranging from 4.2 to 5.6. Amyata control group had the lowest average number of branches at 2.3, with slight increases in its first and second trial groups, reaching 2.6 and 2.4 branches, respectively. Cypress control group displayed 4 branches, with slight increases in its first trial group but a decrease to 2.8 branches in its second trial group.

These findings suggest that the environmental conditions or plant nutrition management in the South region - Caracal may be less conducive to robust branch development in soybean varieties. Adjustments to cultivation practices, including nutrient management strategies, may be necessary to enhance crop performance and yield in this region.

In the Central region - Criscior, the Orakel and Ovidiu varieties continued to exhibit a significantly higher average number of branches compared to their Control group counterparts. Orakel control group displayed 22 branches, with a slight decrease in its first trial group to 16 branches and a subsequent increase to 20 branches in the second trial group. Similarly, Ovidiu control group showed 8.2 branches, while its first trial group exhibited an increase to 11.5 branches, and its second trial group maintained a relatively stable average of 8.6 branches.

Moreover, Amyata and Cypress also demonstrated promising results in the region. Amyata control group exhibited 16.1 branches, experiencing a slight decrease in its first trial group to 12.5 branches before rebounding to 15.5 branches in the second trial group. Cypress control group displayed 9.1 branches, with increases in both its first and second trial groups, reaching 11.6 and 9.6 branches, respectively.

These findings underscore the robust adaptation of Orakel and Ovidiu varieties to the specific conditions in the Central region - Criscior, as well as the adaptability of Amyata and Cypress varieties to diverse growing environments.In conclusion, the analysis of soybean variety performance in various regions of Romania underscores the importance of adaptability and proper plant nutrition management for achieving optimal and sustainable yields.

After analyzing the data regarding the average number of pods in the three regions presented in Figure 5, and taking into account the different quantities of nitrogen applied in each repetition, some important conclusions can be drawn.

In the West region - Mocrea, the Orakel and Amyata varieties exhibited a higher average number of pods compared to their Control group counterparts, irrespective of the nitrogen quantity applied. Orakel control group displayed an average of 32.6 pods, with slight increases in its first and second trial groups to 35 and 33.3 pods, respectively. Similarly, Amyata control group exhibited an average of 35 pods, maintaining relatively consistent pod counts in its first and second trial groups, ranging from 35.1 to 34.2 pods.

Conversely, the Ovidiu and Cypress varieties showed comparable average numbers of pods to their Control group counterparts, regardless of the nitrogen quantity. Ovidiu control group displayed a notably higher average of 63.4 pods, with minor variations in its first and second trial groups, ranging from 61.16 to 62.2 pods. Cypress control group exhibited an average of 29.5 pods, experiencing a slight increase in its first trial group to 34.5 pods before returning to 30.5 pods in its second trial group.

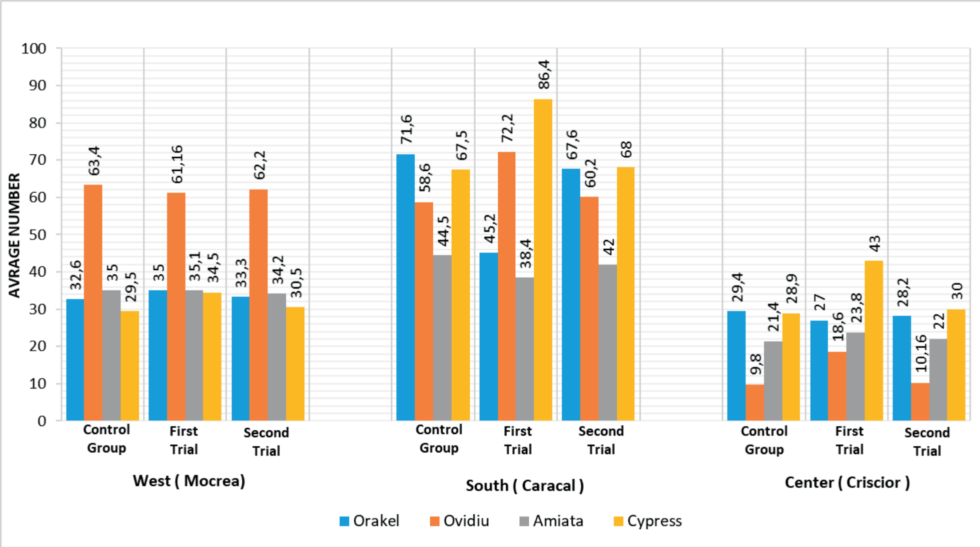

Figure 5. Average number of pods in all three regions

These results suggest that the Orakel and Amyata varieties may possess better adaptation to local conditions in the West region - Mocrea, allowing for increased pod production independent of nitrogen levels. Conversely, the Ovidiu and Cypress varieties seem less influenced by nitrogen levels, maintaining similar pod counts to their Control groups.In the In the South region - Caracal, Ovidiu and Cypress demonstrated a significantly higher average number of pods than their Control group counterparts, regardless of the nitrogen quantity applied.

Ovidiu control group exhibited an average of 58.6 pods, with increases in its first and second trial groups to 72.2 and 60.2 pods, respectively. Similarly, Cypress control group displayed an average of 67.5 pods, experiencing a notable increase in its first trial group to 86.4 pods before returning to 68 pods in its second trial group.

Conversely, while Orakel control group initially displayed a high average of 71.6 pods, its first trial group showed a substantial decrease to 45.2 pods before partially rebounding to 67.6 pods in its second trial group. Additionally, Amyata control group exhibited an average of 44.5 pods, with slight decreases in its first and second trial groups to 38.4 and 42 pods, respectively.

These results underscore the better adaptation of Ovidiu and Cypress varieties to the specific conditions of the South region - Caracal, leading to increased pod production regardless of the available nitrogen level.

In the Central region - Criscior, the results showed a more varied pattern. The Orakel variety displayed a lower average number of pods compared to their Control group counter-parts, regardless of the nitrogen quantity applied. Orakel control group exhibited an average of 29.4 pods, with slight decreases in its first and second trial groups to 27 and 28.2 pods, respectively.

Conversely, the Ovidiu and Cypress varieties in their first and second trial groups exhibited a higher average number of pods than their Control group counterparts, regardless of the nitrogen quantity. Ovidiu control group displayed an average of 9.8 pods, while its first and second trial groups showed increases to 18.6 and 10.16 pods, respectively. Similarly, Cypress control group exhibited an average of 28.9 pods, with significant increases in its first trial group to 43 pods before returning to 30 pods in its second trial group.

These results indicate a diverse response of soybean varieties to the varied nitrogen levels available in the soil within the Central region - Criscior.

Such variability underscores the complexity of genotype-environment interactions in soybean cultivation, emphasizing the importance of tailored management practices to optimize yield outcomes.

After analyzing the data regarding the average bean yield recorded in various regions and taking into account the variations between varieties, trials, and the quantities of applied nitrogen, the following conclusions can be drawn.

As observed in Figure 6 in the West region - Mocrea, the Orakel control group exhibited a bean yield of 0.224 kg/m^2, with slight variations in its first and second trial groups, ranging from 0.214 to 0.224 kg/m^2.

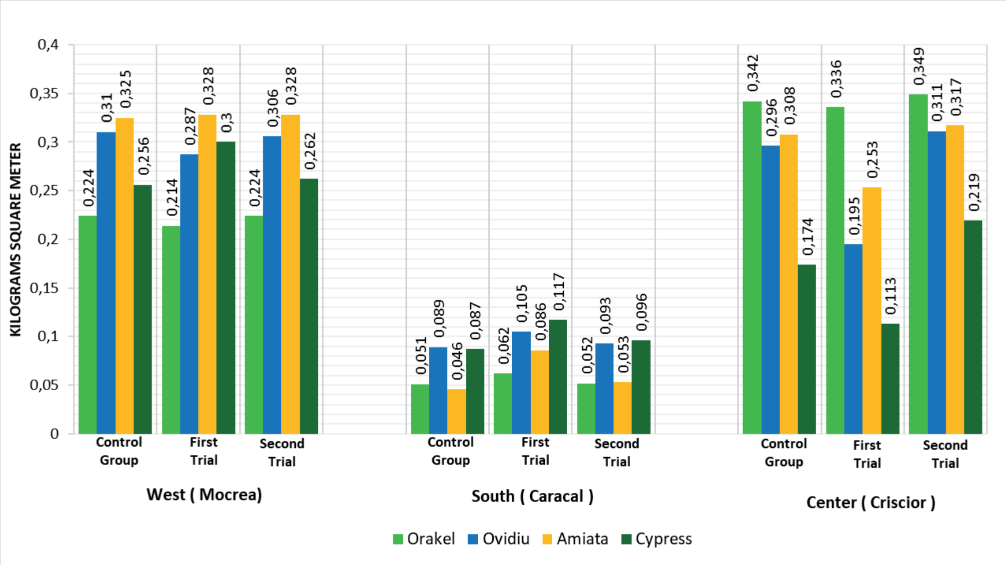

Figure 6. The average grain yield for all three regions

Similarly, the Ovidiu varieties displayed bean yields with the control group at 0.31 kg/m^2, and its first and second trial groups ranged from 0.287 to 0.306 kg/m^2.

Additionally, the Amyata varieties showed consistent bean yields across control and trial groups, averaging at 0.325 kg/m^2 for the control group and maintaining values around 0.328 kg/m^2 for both trial groups.

Moreover, the Cypress varieties exhibited bean yields with the control group at 0.256 kg/m^2, experiencing an increase in its first trial group to 0.3 kg/m^2 before returning to 0.262 kg/m^2 in the second trial group.

These results indicate varied bean yields across different soybean varieties in the West region - Mocrea, suggesting potential differences in adaptability to local conditions and responses to applied nitrogen levels.

In the Central region - Criscior, the Orakel variety demonstrated higher average bean yields compared to other varieties. Orakel control group exhibited a bean yield of 0.342 kg/m^2, with slight variations in its first and second trial groups, ranging from 0.336 to 0.349 kg/m^2.

Conversely, the Ovidiu and Cypress varieties showed poorer performance in terms of bean yields, even under higher levels of applied nitrogen in all trials. Ovidiu control group displayed a bean yield of 0.296 kg/m^2, while its first trial group exhibited a decrease to 0.195 kg/m^2 before increasing slightly to 0.311 kg/m^2 in the second trial group. Similarly, Cypress control group exhibited a lower bean yield of 0.174 kg/m^2, with decreases observed in its first trial group to 0.113 kg/m^2 before a slight increase to 0.219 kg/m^2 in the second trial group.

The Amyata varieties also demonstrated relatively high bean yields across control and trial groups, with the control group averaging at 0.308 kg/m^2 and maintaining values around 0.253 to 0.317 kg/m^2 for both trial groups.

These results support the observation that the adaptability of soybean varieties to different nitrogen levels may vary depending on the region and other environmental factors.

While Orakel and Amyata showed resilience and higher yields across varied nitrogen levels in the Central region - Criscior, Ovidiu and Cypress displayed poorer performance, suggesting a higher sensitivity to nitrogen level fluctuations.

The analysis of the data provided so far reveals essential aspects regarding the performance of soybean crops in different regions and under various management conditions.

Firstly, it is important to mention that three distinct regions were monitored: West (Mocrea), South (Caracal), and Center (Criscior). Each of these regions showed varied results, reflecting the influence of local environmental conditions and applied agricultural management.

Analyzing the average bean yield, we can observe in Figure 6 that some varieties performed better in certain regions.

For instance, in the West - Mocrea region, Amyata first and second trial recorded higher average bean yields compared to other varieties. This suggests excellent adaptability and performance of these varieties under the specific conditions of this region.

On the other hand, in the South - Caracal region, the Cypress first and second trials showed superior average bean yields, indicating adaptability and increased resistance to local stresses, including lower levels of nitrogen.

In the Center - Criscior region, varied performances were recorded, with varieties such as Orakel and Amyata recorded higher average bean yields compared to other varieties. Presenting higher average bean yields, while other varieties had weaker results.

CONCLUSIONS

The analysis of soybean variety performance across different regions of Romania, considering varied nitrogen levels and local conditions, emphasizes the importance of adaptation and proper resource management to achieve optimal and sustainable yields.

Variations in varieties response to nitrogen levels and local conditions highlight the complexity of interactions between plant genotype and environment. In the West region - Mocrea, varieties like Amyata and Orakel exhibited promising adaptability and yields, while in the South - Caracal, Cypress varieties showed increased resistance to nitrogen stress.

In the Central region - Criscior, performances varied, with Orakel and Amyata showcasing notable bean yield.

In conclusion, soybean variety selection and management should be tailored to local conditions and specific crop needs to ensure sustainable and efficient production.

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REFERENCES

Jurjescu, A.L., Nan A., Mateoc, T., Bacau, C., Mateoc-Sirb, N. (2020). Study on Cultivated Areas and Productions in Romania in the Main Crops in an European Context *Scientific Papers Series. Management, Economic Engineering In Agriculture And Rural Development, Vol. 20 Issue 3*, 297-302.

Hatfield, J. L., Boote, K. J., Kimball, B. A., Ziska, L. H., Izaurralde, R. C., Ort, D., Wolfe, D. (2011). Climate impacts on agriculture: Implications for crop production. *Agronomy Journal, 103(2)*, 351–370.

Manea, D. (2018). Early Soybean Variety Ovidiu F. *An. I.N.C.D.A. Fundulea, Vol. LXXXVI*. ISSN 2067–7758.

Magen, H. (2008) Balanced Crop Nutrition: Fertilizing for Crop and Food Quality, *Turkish Journal Of Agriculture And Forestry: Vol. 32: No. 3, Article 5*.

Moraru, P., Bogdan, I., Pop, A. I., Cacovean, H., Rusu, T. (2013). Impacts of Climate Change on Agricultural Technology Management in the Transylvanian Plain, Romania. *Scientific papers. Series A. Agronomy, Vol. LVI.*

Njeru, E., Maingi, J., Cheruiyot, R., Mburugu, G. (2013). Managing Soybean for Enhanced Food Production and Soil Bio-Fertility in Smallholder Systems through Maximized Fertilizer Use Efficiency. *International Journal of Agriculture and Forestry*. 3(5). 191-197.

Ramesh, K., Patra, A., Biswas, A. (2017). Best Management Practices for Soybean under Soybean-Wheat System to Minimize the Impact of Climate Change. *Indian Journal of Fertilisers. 13(2),* 42-55.

Rötter, R. P., Tao, F., Höhn, J. G., Palosuo, T. (2015). Use of crop simulation modelling to aid ideotype design of future cereal cultivars, *Journal of Experimental Botany, Volume 66, Issue 12*, 3463–3476.

Rusu, T., Moraru, P. (2015). Impact of Climate Change on Crop Land and Technological Recommendations for the Main Crops in Transylvanian Plain, Romania. *Romanian Agricultural Research, 56*, 113-118.

Rymuza, K., Radzka, E., Wysokiński, A. (2020). Nitrogen Uptake from Different Sources by Non-GMO Soybean Varieties. *Agronomy 10(9),* 1219.

Selim, M. M. (2020). Introduction to the Integrated Nutrient Management Strategies and Their Contribution to Yield and Soil Properties. *Hindawi International Journal of Agronomy* Volume 2020 (2), 1-14.

Stanciu, S., Nastase M. (2016). Crop Management. Case Study: Romanian Soybean Production. *Review of International Comparative Management. 17(4),* 392-402.

https://www.meteoblue.com/ro/ vreme/historyclimate/weatherarchive/romania_s.u.a._ 4560808

https://freemeteo.com/frame.asp?ifrid=236788_cazare-ranca.ro&pid=302

https://binealegibineculegi.ro/pdf/?id=9296

https://www.incda-fundulea.ro/fise/pdf/Soia/ovidiu.pdf

https://ig-pflanzenzucht.de/wp-content/plugins/igp-filter/tpl/saatgut-generate-pdf.php

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