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CONTENTS

THE INFLUENCE OF SALINE STRESS ON THE CONCENTRATION OF TOTAL POLYPHENOLS IN BITTER CUCUMBERS (*MOMORDICA CHARANTIA*)

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Abstract

Momordica charantia is a climbing plant from the *Cucurbitaceae* family known and widely used for its many medicinal properties including the fight against diabetes. Salinity is the main abiotic stress factor affecting every aspect of plant physiology and biochemistry significantly affecting growth, development and production yield. Polyphenols are natural phytokinins synthesized in plants as secondary metabolites with the role of signaling, plant defense, mediating auxin transport, antioxidant activity and free radical scavenging. To determine salinity resistance, 5 bitter cucumber genotypes were studied that were treated with different salt concentrations. The highest amount of total polyphenols was observed in the case of Line 4 where the value recorded at the treatment with saline solution 200 mM NaCl determined an increase by 125.9% compared to the untreated control. This value correlated negatively with the number of lateral shoots, which highlights a poor adaptation of the genotype to salt stress. Compared to this genotype, Line 3 showed a reduced increase in the content of polyphenols in the variants subjected to saline stress, but also an increase in the number of lateral shoots, observing a positive correlation in the two factors. This response of the genotype highlights a good adaptation to salt stress.

Key words: *Momordica charantia*, polyphenols, spectrophotometry, salinity

Momordica charantia is a climbing plant in the *Cucurbitaceae* family known and widely used in areas such as China, India, Malaysia and the tropical part of Africa (Ahmad *et al*, 2016). The popular name of bitter cucumber or bitter gourd comes from the particularly bitter taste that characterizes all the organs of the plant. It has a long and rich history of use in traditional medicine to treat conditions such as eczema, pneumonia, rheumatism, hypertension, psoriasis, cancer and diabetes (Alam *et al*, 2015). The bitter taste of the plant is given by momordicin, a bioactive compound with a strong hypoglycemic effect called vegetable insulin (Chanda and Banerjee, 2019). Analyzes have shown that this plant has the highest nutritional value of all species of the cucurbitaceae family, being an excellent source of fiber, vitamins, minerals, carbohydrates and proteins. Bitter cucumber is also used due to the high content of minerals such as: Cu, Ca, Fe, Mg and Zn. The fruit is rich in nutrients such as vitamins A and C, tocopherols, thiamin, riboflavin, niacin and folic acid (Yuwai *et al,* 1991, Singla *et al*, 2023). In food, the aerial parts of the plant are consumed, especially the fruits, leaves and young shoots.

Salinity is the main abiotic stress factor affecting every aspect of plant physiology and biochemistry significantly affecting growth, development and production yield (Munns, 1993). Saline stress affects almost half of the irrigated agricultural lands causing significant economic losses and negatively affecting food security (Zhu 2001, Ondrasek *et al,* 2022). A soil is considered to be saline when it exhibits an electrical conductivity (EC) of the soil solution greater than 4 dS m^{-1} (equivalent to 40 mM NaCl). This concentration of salts generates an osmotic pressure of about 0.2 MPa and significantly reduces the yields of most crops. High salinity compromises carbon fixation, leading to over-reduction of light-harvesting complexes that cause the production of reactive oxygen species (ROS) such as: hydrogen peroxide (H_2O_2), hypochlorous acid (HClO), ozone (O_3), singlet oxygen ($^1O_2$), superoxide anion radicals (O_2^-), hydroxyl radicals (OH^-), perhydroxyl radicals ($HO_2^\bullet$), organic alkoxy ($RO^\bullet$) and organic peroxyl radicals (Misra and Gupta, 2005; Hameed *et al*, 2015).

Polyphenols are naturally occurring phytokinins synthesized in plants as small, secondary metabolites that play numerous

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biochemical and molecular roles in plants, such as signaling molecules, plant defense, mediating auxin transport, antioxidant activity, and scavenging free radicals (Frisvold, 2022; Tohidi *et al*, 2017). Among the non-enzymatic antioxidants, phenols and flavonoids contribute significantly to the scavenging of free radicals in plants to tolerate salt stress by accumulating in various tissues. Polyphenols are present in free and bound forms in plant materials (Kiani *et al,* 2021).

MATERIAL AND METHOD

The plant material used for the analyzes in this work was represented by the leaves and lateral shoots of bitter cucumber. To obtain them, seeds of equal size, of bitter cucumbers belonging to two varieties (Brâncusi variety and Rodeo variety) and three experimental lines (Line 1, Line 3 and Line 4) were sown in cells in the greenhouse of the Agricultural Research Institute and Environment (ICAM) belonging to the "Ion Ionescu de la Brad" University of Life Sciences, Iași, Romania. To achieve germination, the seeds were kept at an average temperature of 28 °C. After germination, the seedlings were moved to 12-liter pots of vegetation in the University greenhouses. To determine the effect of salinity on the 5 genotypes, the plants were treated with saline solutions of concentrations 0 mM NaCl – Control (M), 100 mM NaCl – V1 and 200 mM NaCl – V2. In total, three treatments were applied at intervals of approximately 10 days. The first treatment was applied in phenophase 201 BBCH (representing the appearance of the first lateral shoot), the second treatment was applied in phenophase 501 BBCH (representing the appearance of the first flower) and the last treatment was applied in phenophase 701 BBCH (being equivalent to the appearance of the first fruit). The plants were treated with an amount of 300 ml of saline solution per treatment. The plant growth procedure was similar to that presented in our previous works on bitter cucumber (Ostaci *et al*, 2024; Ostaci *et al,* 2023, Ostaci *et al*, 2024). The leaves used for the analysis of the total content of polyphenols were harvested 7 days after the application of the last treatment. The analysis of the number of lateral shoots was carried out in the field on the 7th day after the last treatment.

The determination of polyphenols was carried out using the Folin Ciocalteu reagent. 0.1 g of plant sample was used which was mortared with 1 ml of distilled water. From the resulting sample, 0.1 ml was used, over which 0.5 ml of Folin Ciocalteau reagent and 2 ml of distilled water were added. After 5 minutes, an amount of 0.75 ml of 20% $NaCO_3$ and 2.95 ml of distilled water was added. The obtained mixture is left to rest for one hour at room temperature, after which it is read by the UV-Vis method at 675 nm.

Three repetitions were performed for each determination.

Statistical analysis was performed by applying Two Way Anova, Tukey and Pearson correlation matrix tests. Statistical analyzes were performed using Origin Pro 2022 software.

RESULTS AND DISCUSSIONS

Polyphenolic compounds are considered a group of molecules with similar biological activity, especially in physiological and biochemical studies, where they are used as a marker of biological activity (Šamec *et al*, 2021).

According to the spectrophotometric analysis of the total content of polyphenols (Figure 1), significant differences were noted between the genotypes studied under normal and saline stress conditions. The general trend was to increase the total amount of polyphenols in plants subjected to abiotic stress. In the control plants, the lowest amount of total polyphenols was recorded in the case of the Brâncusi variety (229.19 mg/L) and the highest amount was observed in the Line 3 genotype (421.11 mg/L). A high amount of polyphenols naturally existing in plants shows their good resistance to saline stress (Zagoskina *et al*, 2023). In the case of plants stressed with 100 mM saline solution, the lowest amount of polyphenols was recorded in the Brâncusi genotype (351.19 mg/L) and the highest amount was observed in Line 4 (524.83 mg/L). The plants subjected to the treatment with 200 Mm NaCl showed the lowest amount of total polyphenols in the case of the Brâncusi genotype (392.05 mg/L) and the highest amount in the Linia 4 genotype (780.55 mg/L). According to specialized literature, when saline stress occurs, the biosynthetic pathways of several phenolic compounds are stimulated, thus causing an increase in the amount of total polyphenols (Zagoskina *et al*, 2023). The highest increase in the total amount of polyphenols was recorded in the case of Line 4 where the treatment with 100 mM saline caused an increase of them by 51.89% compared to the control, and the treatment with 200 mM NaCl caused an increase of 125.9%. This increase in the total amount of polyphenols can highlight the effort made by the plants to resist the new conditions to which they were subjected. The low amount of polyphenols recorded in control plants of this genotype is an important indicator of their sensitivity to salt stress. Compared to Line 4, the smallest increases in phenolic compounds were recorded in the case of Line 3 where the treatment with 100 mM NaCl caused an increase of 11.11% compared to the control and the treatment with 200 mM NaCl caused a 17.76% increase. This reduced growth associated with a high amount of total polyphenols in the control plants indicates a good resistance of the genotype to salt stress and the absence of the installation of oxidative stress at a toxic level.

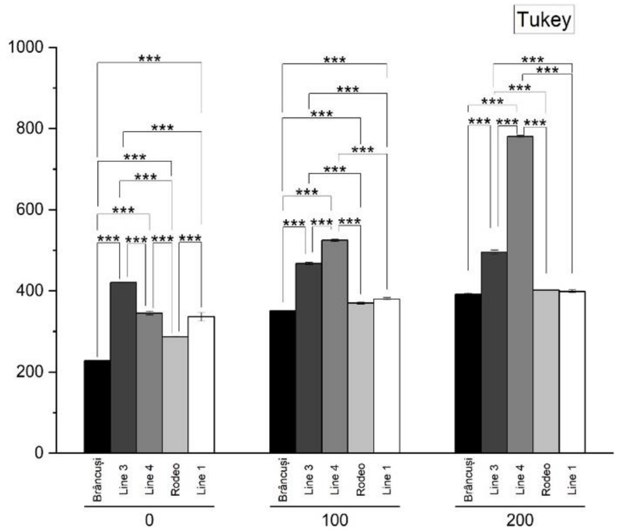

Figure 1 **Total polyphenol content of bitter cucumber leaves after the third saline treatment, measured in ml/L. The bars represent the standard deviation and the asterisks on the graph are placed using the Tukey test. *** - p < 0.001.**

Growth is the process of stable and irreversible increase in the weight and volume of plant cells, tissues and organs, due to the continuous increase in the amount of dry matter (Jităreanu, 2007). Salt stress caused a decrease in the number of lateral shoots in all the bitter cucumber genotypes studied in this work except Line 3 where an increase was observed compared to the untreated control. In the case of the control plants, the lowest number of lateral shoots was observed in the Line 4 genotype (5 shoots) and the highest number of shoots was recorded in Line 1 (7 shoots). The plants treated with 100 mM NaCl showed the lowest number of lateral shoots in the Line 4 genotype (4 shoots) and the highest number compared to the untreated control in Line 1 (6.3 shoots). Treatment with 200 mM saline revealed the lowest number of lateral shoots in Line 4 (3 shoots) and the highest number compared to the control in Line 3 (6.3 shoots). Polyphenols, in addition to the essential antioxidant role they have in plants, are indirectly responsible for energy transfer, growth regulation, the intensity of photosynthesis and morphogenesis (Duda-Chodak and Tarko, 2023). High amounts of polyphenols can negatively affect plant growth and development through their interaction with growth hormones. Thus, a large amount of polyphenols indicates a strong abiotic stress affecting the plant, which causes the use of a significant amount of energy and the reduction of essential processes. This effect could be noted from the analyzes performed. The lowest value of lateral shoots and the highest value of total polyphenol content were recorded in Line 4.

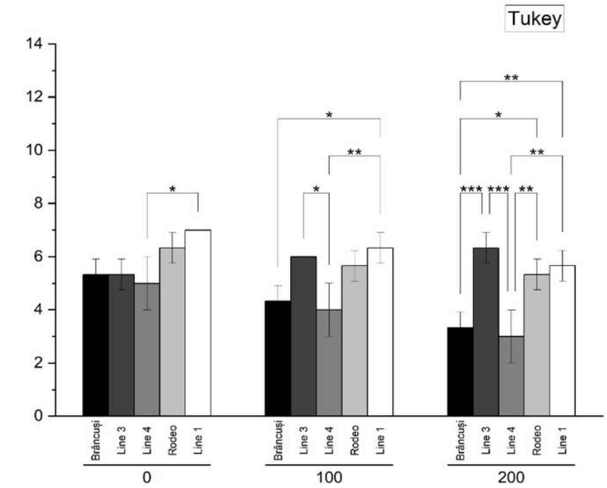

Figure 2 **The number of lateral shoots in the bitter cucumber genotypes studied after the application of the third saline treatment. Error bars represent the standard deviation and asterisks are placed using the Tukey test. *- p < 0.05, ** - p < 0.01, *** - p < 0.001.**

The correlation between the two analyzes was strongly negative (Figure 3) which may indicate a poor resistance of Line 4 to salt stress. Negative correlations were recorded in the case of all genotypes subjected to salt stress except for Line 3 where the variant treated with 200 mM NaCl recorded a positive mean correlation. This may represent the fact that this genotype is the least affected by salinity and therefore the small increase in the amount of polyphenols compared to the other genotypes has a positive role in the plant growth process.

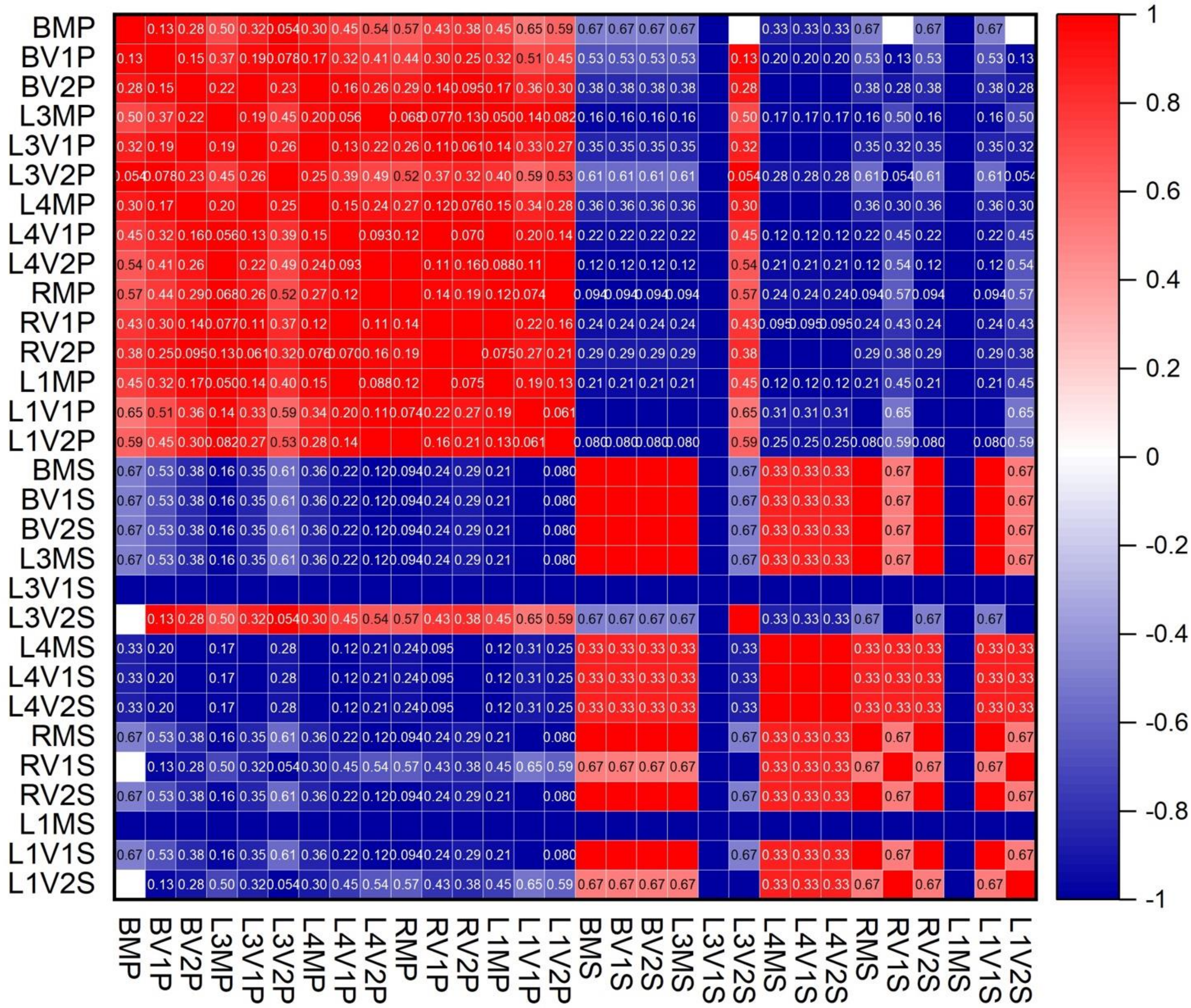

Figure 3 **Pearson correlation matrix between the total amount of polyphenols and the number of lateral shoots of the studied genotypes. The specific notations are composed of the first letter of each genotype (B, L3, L4, R, L1) followed by the treatment applied (M, V1, V2) and the analysis performed (P – polyphenols, S – shoots)**

CONCLUSIONS

Following the analyzes carried out, increases in the amounts of polyphenols were observed in all studied genotypes, the differences being significant both between treatments and between genotypes. The highest growth was observed in Line 4 where it was negatively correlated with the lowest number of lateral shoots. Compared to this genotype, the lowest increase compared to the untreated control was recorded in Line 3 which was positively correlated with an increase in the number of lateral shoots.

The statistical analyzes carried out had the role of validating the observations mentioned in this paper.

According to the analyzes carried out, we can recommend Line 3 as a salinity-resistant genotype, which makes it ideal for cultivation on saline soils.

REFERENCES

Ahmad N., Hasan N., Ahmad Z., Zishan M., Zohrameena S., 2016 - *Momordica Charantia: For Traditional Uses and Pharmacological Actions*. Journal of Drug Delivery and Therapeutics, 6(2):40–44.

Alam M.A., Uddin R., Subhan N., Rahman M., Jain P., and Reza H.M., 2015 - *Beneficial Role of Bitter Melon Supplementation in Obesity and Related Complications in Metabolic Syndrome*. Journal of Lipids, 2015:1–18.

Chanda R., Asim S., Janmajoy B., 2019 - *Anti-Diabetic Activity of Momordica Charantia or Bitter Melon : A Review*. Acta Scientific Pharmaceutical Sciences, 3(5):24–30.

Duda-Chodak A., and Tomasz T., 2023 - *Possible Side Effects of Polyphenols and Their Interactions with Medicines*. Molecules 28(6), 2436.

Frisvold M.H., 2022 - *Functional Foods and Nutraceuticals*.

Hameed A., Gulzar S., Aziz I., Hussain T., Gul B., & Khan M. A., 2015 - *Effects of salinity and ascorbic acid on growth, water status and antioxidant* *system in a perennial halophyte*. AoB PLANTS, 7(1):1–11.

J**ităreanu C.D., 2007** - *Fiziologia Plantelor*. Edit. "Ion Ionescu de la Brad", Iaşi, ISBN 978-973-7921-89-5.

Kiani R., Arzani A., Maibody S.A.M., 2021 - *Polyphenols, Flavonoids, and Antioxidant Activity Involved in Salt Tolerance in Wheat, Aegilops Cylindrica and Their Amphidiploids.* Frontiers in Plant Science, 12:1–13.

Misra N., Gupta A.K., 2005 - *Effect of Salt Stress on Proline Metabolism in Two High Yielding Genotypes of Green Gram.* Plant Science, 169(2):331–39.

Munns R. 1993 - *Physiological Processes Limiting Plant Growth in Saline Soils: Some Dogmas and Hypotheses*. Plant, Cell & Environment, 16(1):15–24.

Ondrasek G., Rathod S., Manohara K.K., Gireesh C., Anantha M.S., Sakhare A.S., Parmar B., Yadav B.K., Bandumula N., Raihan F., Zielińska-Chmielewska A., Meriño-Gergichevich C., Reyes-Díaz M., Khan A., Panfilova O., Seguel Fuentealba A., Romero S.M., Nabil B., Wan C.C., Shepherd J., Horvatinec J., 2022 - *Salt Stress in Plants and Mitigation Approaches*. Plants (Basel), 11(6):717.

Ostaci Ș., Slabu C., Marta A.E., Covașă M., Miniață, I., Jităreanu, C.D., 2023 - *The Influence of Salt Stress on the Content of Vitamin C in the Leaves of Some Varieties and Lines of Bitter Cucumber (Momordica Charantia).* Bulletin of University of Agricultural Sciences ond Veterinary Medicine Cluj-Napoca. Horticulture 80(2):65–70.

.**Ostaci Ș., Slabu C., Marta A.E., Covașă M., Miniață, I., Jităreanu C.D., 2024** - *Spectral Study of Some Metabolites Involved in the Adaptation Reaction of Bitter Cucumber (Momordica Charantia) to Saline Stress.* Horticulturae, 10, 309.

Ostaci Ș., Slabu C., Marta A.E., Jităreanu C.D., 2024 - *Evaluation of the Resistance of Bitter Cucumber (Momordica charantia) to Saline Stress through Physical, Biochemical, and Physiological Analysis*. Horticulturae, 10, 893.

Šamec D., Karalija E., Šola I., Vujčić Bok V., Salopek-Sondi B., 2021 - *The Role of Polyphenols in Abiotic Stress Response: The Influence of Molecular Structure.* Plants*,* 10(1):1–24.

Singla D, Sangha M.K., Singh M., Pathak M., Bala M., 2023 - *Variation of Mineral Composition in Different Fruit Parts of Bitter Gourd (Momordica charantia L.).* Biological Trace Element Research 201(10):4961–71.

Tohidi B., Rahimmalek M., Arzani A., 2017 - *Essential Oil Composition, Total Phenolic, Flavonoid Contents, and Antioxidant Activity of Thymus Species Collected from Different Regions of Iran.* Food Chemistry, 220:153–61.

Yuwai K.E., Rao K.S., Kaluwin, C., Jones G.P., and Rivett D.E., 1991 - *Chemical Composition of Momordica Charantia L. Fruits.* Journal of Agricultural and Food Chemistry, 39(10):1762–63.

Zagoskina N.V., Zubova M.Y., Nechaeva T.L., Kazantseva V.V., Goncharuk E.A., Katanskaya V.M., Baranova E.N., Aksenova M.A., 2023.- *Polyphenols in Plants: Structure, Biosynthesis, Abiotic Stress Regulation, and Practical Applications (Review).* International Journal of Molecular Sciences 24(18).

Zhu J.K., 2001 - *Plant Salt Tolerance*. Trends in Plant Science 6(2):66–71.

METHODS OF DIGITALIZATION OF AGRICULTURE PRACTICED IN ROMANIA

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Abstract

In Romania, the agricultural sector is considered one of the most important sectors of the national economy, which has a strategic role in ensuring food security. In these conditions, along with the trend of population growth, there is also an increase in demand for agri-food products, and the influence of climate change on agricultural production requires the need to move from traditional agricultural methods to precision ones. This study aims to contribute to the development of research on this topic by investigating and presenting the most important and well-known ways of digitizing agriculture practiced in Romania.

Key words: agriculture, digitization, digitization methods.

Discussions regarding the digitalization of agriculture appeared for the first time since 1990. The first paper indexed in WoS on the subject of "digitalization in agriculture" was published in 1991, being developed by Everitt *et al*, (1991) which presented the importance of using aerial video systems for agricultural assessment. The findings of the study showed that aerial video systems used in agriculture are proposed as an alternative for providing real-time information on natural resources in agriculture.

The transformation of agriculture globally is being accelerated by the adoption of digital technologies, which are essential not only to meet the increasing food demands of a growing population, but also to meet the challenges of climate change, responsible use of resources and optimization economic efficiency. In Romania, the digitization of agriculture has become a strategic priority in the modernization of this crucial sector. Romanian farmers, from small owners to large agricultural companies, enthusiastically adopt the solutions offered by precision agriculture, which not only monitor crops and soil in real time, but also allow more effective interventions, customized to the needs of each farm.

Emerging technologies such as soil and crop sensors, satellite remote sensing, the use of drones for monitoring and enforcement, as well as the integration of IoT and AI systems into agricultural processes, not only increase productivity and reduce losses, but also contribute to increased sustainability in agriculture. The implementation of these technologies has begun to redefine farmers' interaction with supply chains and the market, giving them expanded control over the entire production and distribution process.

Digitization in agriculture represents not only a technological advance, but also a paradigm shift, transforming the role of farmers within the value chain and contributing to the development of a more resilient agriculture adapted to the challenges of the future. As Romania continues to adopt these innovations, it is essential to focus not only on implementing the technologies, but also on training and educating farmers to enable them to effectively use these new tools and realize their full potential.

Thus, the digitization of agriculture not only promises to improve yields and efficiency, but also plays a crucial role in achieving sustainable development goals, while ensuring long-term food security. The transition to digitized agriculture, however, requires close collaboration between government, the private sector and the scientific community to create an enabling environment for innovation and the widespread adoption of digital technologies in agriculture.

With the help of agricultural digitization methods, a farmer can simultaneously communicate with several robotic devices, sending them specific instructions, thus synchronizing the work between them. Such activities in the agricultural sector help to save time and achieve high productivity (Atkočiūnienė & Papšienė, 2023).

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Simo *et al*, (2022) presents the term digitization of agriculture referring to the concept of management, centered on industrial agriculture. Digital agriculture uses state-of-the-art technologies such as: Big data, Cloud and Internet of Things to monitor, automate and evaluate agricultural processes, therefore digital agriculture can be considered a management tool.

On the other hand, Meng *et al*, (2024) is of the opinion that the digitization of agriculture serves as an essential means of introducing innovative agricultural practices and achieving sustainable agricultural development. The authors also argue that although the digitization of agriculture has received increased attention, its development has been unbalanced. The gaps in the digitization process in agriculture represent great challenges in the development of sustainable agriculture. This is presented in the European Green Deal, in which the use of digital technology in agriculture (sensors, satellites, artificial intelligence, etc.) has been strengthened to develop sustainable agriculture and control the impact of climate change. Among the current challenges facing the agricultural sector, climate change is among the most important. (Pătărlăgeanu *et al,* 2024).

At the same time, Meghișan-Toma *et al,* (2020) consider that digitization is one of the tools that can make a significant contribution to the optimization of agricultural processes, from a sustainable perspective.

Although this aspect is obvious and already demonstrated, a large part of these new technologies and digital systems are pushed to farmers and are not developed following their requests. This situation is found among Romanian farmers in a very high percentage, but it is not an isolated situation, in a recent study Gaber K. *et al*, (2024) draw attention to the need to take into account the perception of stakeholders for a better adoption of new technologies (Gaber K. *et al*, 2024).

The impact of digitization on the development of agriculture is also analyzed in the specialized literature. A study by Rodino *et al,* (2023) showed that the digitization of agriculture has a significant impact on human and material resources, contributes to increasing crop productivity and improves the quality of agri-food products.

MATERIAL AND METHOD

Material and method. The research comprehensively analyzes existing literature studies, paying particular attention to studies addressing digitization methods used in agriculture.

The analytical and synthesis method of the information found in the specialized literature was used as a research method.

The selected articles and studies were identified in specialized journals, WOS, Scopus and Google Scholar and the selection period was from 1990 to the present. The search was carried out in Romanian using the keywords agriculture, digitization, digitization methods and in English using the keywords: digital, digitalization, agriculture.

RESULTS AND DISCUSSIONS

Results and discussions. The integration of digital technologies in agriculture has significantly contributed to the development of industrial agriculture (agriculture 4.0), which is also called smart agriculture or digital agriculture. Digital agriculture offers farmers a set of tools, shown in the figure below, so that they can address challenges regarding farm productivity, the impact of climate change on agricultural production, ensuring food security, crop losses and their sustainability (Abbsși *et al*, 2022).

The digitization of agriculture in Romania promises to significantly transform the way resources are managed and improve the sustainability of agricultural holdings. Modern technologies, such as ground sensors and satellite monitoring, provide essential data that enable accurate and efficient application of resources, reducing unnecessary consumption and optimizing productivity. This not only supports sustainable agriculture, but also contributes to rapid adaptation to climate change, preventing its negative effects through well-planned interventions.

Furthermore, innovations such as nanotechnologies open new perspectives for reducing the impact of chemicals on the environment, while blockchain guarantees the traceability of agri-food products, creating a transparent and reliable supply chain. However, the widespread adoption of these technologies is hampered by high costs and a lack of digital education, especially among small and medium-sized farmers. For Romania to fully capitalize on the benefits of digitization, an integrated approach that includes financial support, continuous training and collaboration between all actors in the sector is crucial.

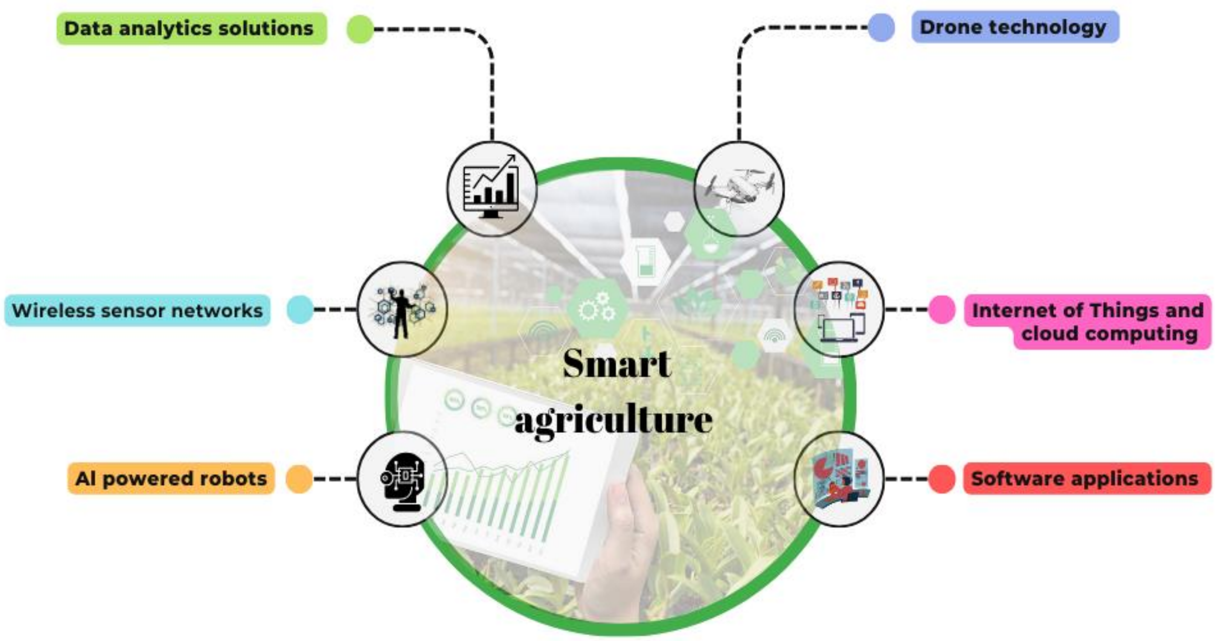

Figure 1 . **Digital Farming Toolkit**
Source: own processing, after Abbasi et al, (2022), using CANVA *application.*

Artificial intelligence (AI), machine learning, remote sensing, big data, blockchain technology (BCT) and the Internet of Things (IoT) are just some of the technologies that are revolutionizing agricultural value chains and modernization processes. Remote sensing, soil sensors, unmanned aerial surveys and market intelligence, among other technologies, enable farmers to collect, visualize and analyze crop and soil health parameters at different stages of production simply and cost-effectively. They can act as an early warning system, recognizing potential problems and providing real-time solutions to solve them (Javaid *et al*, 2022).

Despite the global accessibility of digital technologies, their adoption in the agricultural sector, especially among small and medium farms (family farmers), faces obstacles. Although it has been discussed for several years about the changes in the business models that come with these new technologies that define Agriculture 4.0 and the need to accelerate the transition. Shepherd, M. et al wrote in 2018 about the need to develop new skills and competencies (Shepherd *et al*, 2020).

Realizing the full potential of digital agriculture first requires understanding the factors influencing technology adoption (Fragomeli *et al,* 2024).

It can be stated that, unlike traditional agriculture, in precision agriculture, there are fundamental changes in the paradigm of agricultural production management, because, as a result of the robotization of production and the automation of production management systems, strategic decisions are made by humans and tactical decisions are made by machines based on displayed information (Homidov *et al*, 2024).

Digital innovations and artificial intelligence (AI) have a wide range of promising applications in the agricultural sector. Digital technologies can improve agricultural productions, both qualitatively and quantitatively, by using fewer production factors (water, energy, fertilizers and pesticides) and increase efficiency by performing agricultural practices remotely. Research shows that crop yields can increase significantly by 2050 with the introduction of precision agriculture technologies, with a yield increase of 18% due to precision fertilizer application, 13% due to precision planting, 4% due to precision spraying and 10 % thanks to precision irrigation. At the same time, the technologies practiced in precision agriculture allow for more efficient fertilization, adapted to the site, both with synthetic or mineral fertilizers and with manure. Fertilization based on soil needs is an essential starting point for avoiding nutrient surpluses. Thus, this directly contributes to meeting the objectives of the Nitrates Directive and the Water Framework Directive (Bahn *et al,* 2021; Garske *et al,* 2021).

One of the digitization methods identified in the specialized literature is represented by the Internet of Things (IoT) and Artificial Intelligence (AI). The Internet of Things is a network of physical objects called "things" with network connectivity that can enable these objects to collect and exchange data and at the same time interact with the environment. The application of this technology if supported by an intelligent and efficient management system can lead to a significant reduction of human resources in various agricultural activities. AI algorithms can generate real-time actionable information to help farmers increase crop yields, control pests, aid in soil screening, provide farmers with accurate data and reduce their workload. The correlation of the Internet of Things with AI results in the development of much more efficient systems. AI-based systems represent computer systems that can perform operations that require human intervention (speech, visual perception, decision-making, as well as language translations) (Matta & Pant, 2019; Subeesh & Mehta, 2021; Javaid *et al,* 2022).

The AI-based IoT system has a very high potential to make agricultural operations more controlled and precise by introducing smart applications, shown in the figure below. The scope of recent advances in these technologies is endless in agricultural practices as it can automate complex tasks with minimal human intervention.

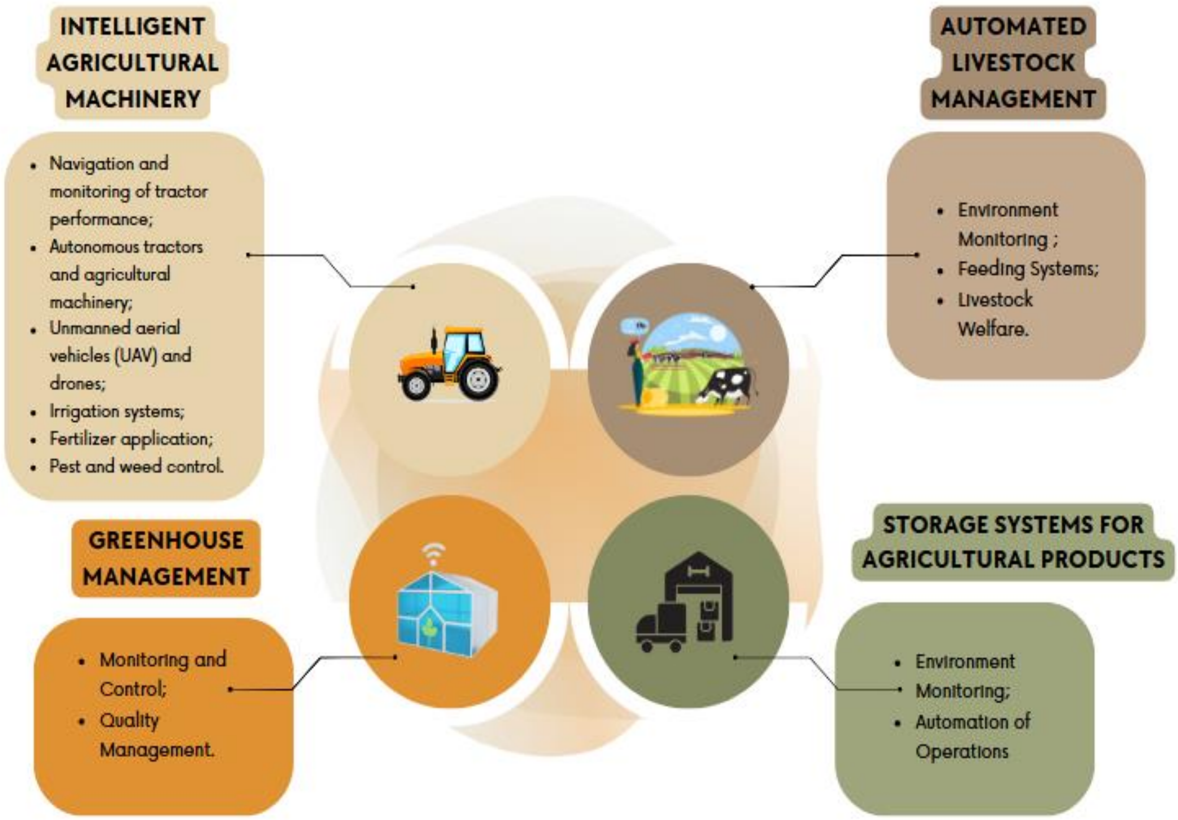

Figure **2 . Agricultural automation applications using IoT and AI**
Source: own processing after Subeesh & Mehta (2021), using CANVA application.

Another digitization method identified in the specialized literature is Blockchain Technology (BCT), a technology that has increased the confidence of both producers and consumers in the supply chain by providing truthful information on the quality of agri-food products.

Blockchain technology is a ledger of accounts and transactions that are written and stored by all the actors that take part in the agri-food chain, be it short or long. It allows access to transparent information, tracing the provenance of agri-food products by creating reliable agri-food supply chains aimed at strengthening a relationship of trust between producers and consumers. Additionally, used alongside smart tools, this technology enables real-time payments between interested actors that can be triggered by data changes occurring in the blockchain. Thus it can be stated that Blockchain technology can be applied in agriculture to improve food safety and transaction times (Chen *et al,* 2020).

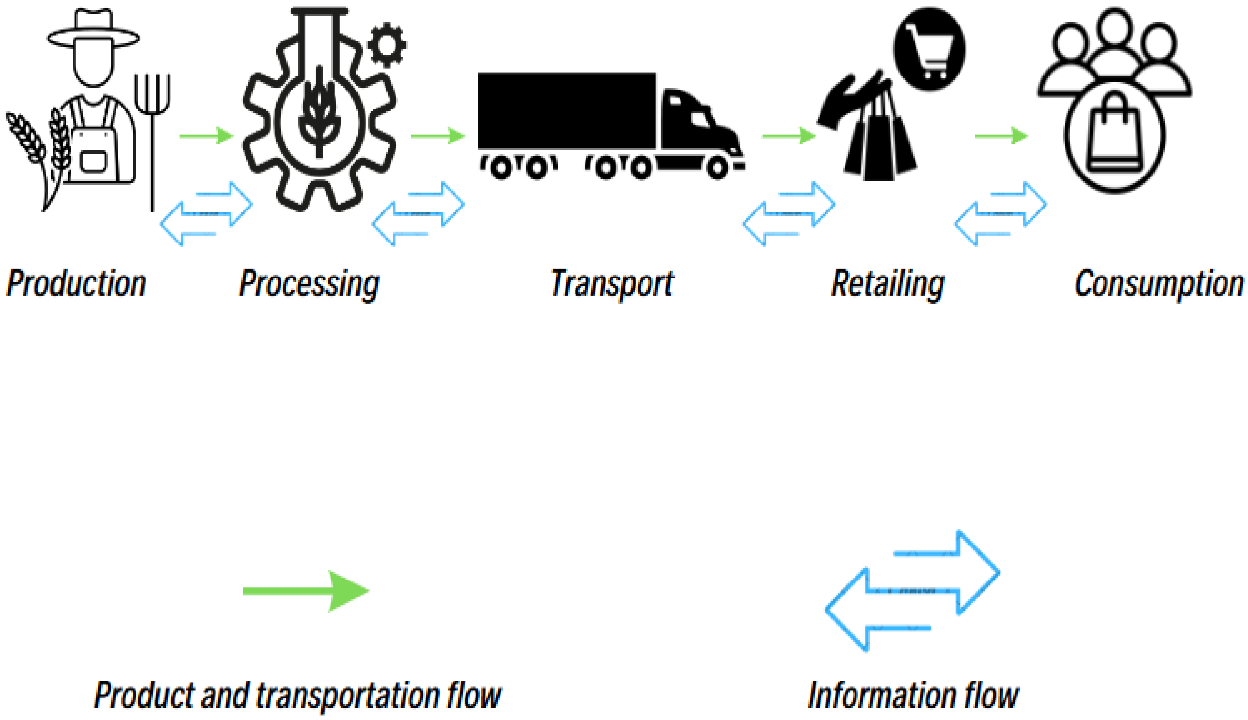

Figure **3 . Blockchain technology – the flow of products and information**
Source: own processing after Demestichas (2020), using the CANVA application.

Used together with the AI-based IoT system, blockchain technology can overcome several traceability issues and improve the transparency of the agri-food supply chain because it is plausible to keep chemical analysis data in chronological order, thereby eliminating data manipulation and falsification. From a supply chain and logistics perspective, blockchain technology has been valued for its visibility, immutability of transactions, and credibility among participating stakeholders (Rejeb *et al,* 2021).

Tabel 1

Digitization methods used at farm holding level

Digitization methods	Description
Precision agriculture - Optimal management	Decisions at the farm level are based on data obtained by IoT sensors and equipment used to develop a type of smart agriculture. State-of-the-art nanotools such as: nanofertilizers, nanopesticides, nanobiosensors and nanotechnology-based remediation techniques for polluted soils are being used to improve the yield and quality of agri-food products. Communication between hardware and sensors is used to automate agricultural decisions. Thus, autonomous robots have computer vision and learning algorithms to monitor crops and soil and perform predictive analytics to track and anticipate the influence of the environment on agricultural production. Smart agriculture emphasizes precision agriculture, the Internet of Things, and the use of big data to create improved economic efficiency in the face of population growth and climate change. Precision agriculture can significantly increase agricultural yields, enabling farms to become more efficient and sustainable. Through this agricultural practice, soil management is optimized using technology-based systems and tools, such as remote sensing and GPS (Ali et al. 2024). Thus, farmers can make better and more efficient decisions with the support of technologies, which can reduce farm expenses, increase profitability, reduce water wastage and help preserve soil quality.
Computer programs for soil composition analysis	The purpose of soil composition analysis is to help the farmer assess the level of nutrients in the soil. Drones, satellite imagery and computer software allow farmers to collect and harvest real-time crop data using tablets and mobile phones to help monitor crop health. This data is analyzed to develop insights that could improve overall production. More in-depth analysis helps farmers plan production from a given plot of land and monitor activity from seeding to harvest. Mining the voluminous data created by adopting information technology tools provides practical agricultural solutions that will improve the profitability, efficiency and sustainability of

	agricultural production. It creates a distributed and decentralized blockchain record of agricultural information that acts as a transparent and trusted source to improve agricultural supply chains. Thus, traceability options empower farmers and establish direct contact between farmers and customers.
Smart agricultural technologies that contribute to reducing the impact on the environment	Agricultural technologies such as blockchain, drones and IoT are resulting in increased yields, lower prices and a smaller environmental footprint. Farmers can use these technologies to grow new crops and increase their tolerance to extreme weather conditions and climate change. In this context, the agricultural sector will be better able to meet the demands of consumers of agri-food products and provide them with extensive information about each product with the help of smart technologies. Through smart harvesters, autonomous tractors and sensors that provide information on soil condition s and crops, digital agriculture has high potential to meet the environmental challenges of the coming decades. The development of a smart technology network and its goal-oriented use is a big challenge for farmers. IoT and digitalization in general offer improved control of agriculture and soil improvement. At the same time, the standards of traceability and transparency tend to increase recently, which makes it even more important to develop reliable and accurate tools to optimize agricultural production, while providing improved working conditions for farmers.
Smart agricultural technologies that contribute to combating crop diseases	Drones are already widely used in the agricultural sector to combat crop disease outbreaks, pest problems and efficient seeding. Studies have shown that in the last four years field robots have been used more and more frequently on farms, this trend appeared as an effect of the lack of labor during the pandemic. Because field robots can be used to move plants into greenhouses, check soil moisture, and apply automated pesticide sprays to infested crops, their popularity is expected to grow in the coming years. Solar pumping, cooling and drying are examples of practices that help farms adopt, develop and implement cost-effective marketing solutions for agricultural production, post-harvest processing and storage. For farmers and implicitly for agricultural holdings, technologies have the direct effect of reducing costs and achieving higher yields. The technologies not only bring direct benefits to farmers and their farms, but also generate jobs, currency and economic growth along the supply chain until the products reach the end consumers.
Smart agricultural technologies that ensure secure transactions and food tracking	Blockchain technology enables accurate and tamper-proof data about farms and stocks, as well as fast and secure transactions and food tracking. As a result, farmers no longer rely on documents or files to capture and store data. The implementation of these technological solutions allows for more reliable agricultural management and monitoring. Farmers can act accordingly after receiving an in-depth digital analysis of their crops in real time, eliminating the need to apply unnecessary pesticides and fertilizers and reducing overall water use.

Source: processing after Javaid et al, (2022).

CONCLUSIONS

Conclusions. In recent years, digitization methods in the agricultural sector have benefited from increasing popularity among farmers, given the current situation of agriculture, which is faced with an increase in demand for agri-food products, an increasing consumption of natural resources combined with the negative effects of climate change. In this context, digital agriculture can represent a solution for all these challenges, because it contributes to increasing the productivity of crops, improves the managerial process, reduces the impact on the environment by making the use of resources more efficient. From a climate point of view, digital agriculture can lead to reducing the effects of climate change by reducing greenhouse gas emissions. The integration of digital technologies in agriculture has led to the development of agriculture 4.0, also known as smart or digital agriculture, which provides farmers with a set of modern tools to address challenges related to productivity, climate change, food security, etc. Technologies such as artificial intelligence, remote sensing, blockchain and the Internet of

Things (IoT) play an important role in modernizing agriculture and improving the efficiency of this sector.

However, the adoption of these technologies faces obstacles, especially among small and medium-sized farms, and it is necessary to understand the factors that influence this adoption. Conclusions reached by Giorgio A et al. in a recent study carried out in a region of Italy, proposing a better awareness of the need to invest in human resources to develop the digital skills of farmers in order to optimally use new technologies (Giorgio A et al., 2024) Precision agriculture allows optimizing resources through the efficient use of fertilizers, water and pesticides, thus contributing to the achievement of sustainability goals.

IoT and AI-based systems have the potential to automate and streamline agricultural operations, reducing the need for human intervention and increasing crop yields. In addition, blockchain technology helps increase trust in the agri-food supply chain, providing transparency and food safety.

The combined use of digital technologies has the potential to fundamentally transform agriculture, facilitating the transition to more productive, sustainable and resource-efficient agriculture.

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REFERENCES

Abbasi R., Martinez P., & Ahmad R., 2022 - *The digitization of agricultural industry–a systematic literature review on agriculture 4.0.* Smart Agricultural Technology, 2, 100042.

Atkočiūnienė V., & Papšienė P., 2023 - *Opportunities for digitisation of agricultural and rural development solutions.* Management theory and studies for rural business and infrastructure development, 45(1), 1-8.

Bahn R.A., Yehya A.A.K., Zurayk R., 2021 - *Digitalization for sustainable agri-food systems: potential, status, and risks for the MENA region.* Sustainability, 13(6), 3223.

Chen Y., Li Y., Li C., 2020 - *Electronic agriculture, blockchain and digital agricultural democratization: Origin, theory and application.* Journal of cleaner production, 268, 122071.

Demestichas K., Peppes N., Alexakis T., Adamopoulou E., 2020 - *Blockchain in agriculture traceability systems: A review.* Applied Sciences, 10 (12), 4113.

Everitt J.H., Escobar D.E., Villarreal R., Noriega J.R., & Davis M.R., 1991 - *Airborne video systems for agricultural assessment.* Remote Sensing of Environment, 35(2-3), 231-242.

Fragomeli R., Annunziata A., & Punzo G., 2024 - *Promoting the Transition towards Agriculture 4.0: A Systematic Literature Review on Drivers and Barriers.* Sustainability, 16(6), 2425.

Garske B., Bau A., Ekardt F., 2021 - *Digitalization and AI in European agriculture: a strategy for achieving climate and biodiversity targets?* Sustainability, 13(9), 4652.

Homidov H., Penev N., Azimov D., Maxmudov A., & Nencheva I., 2024 - *Prospects of the introduction of digital technologies in agricultural activities.* In BIO Web of Conferences (Vol. 114, p. 01005). EDP Sciences.

Javaid M., Haleem A., Singh R. P., Suman R., 2022 - *Enhancing smart farming through the applications of Agriculture 4.0 technologies.* International Journal of Intelligent Networks, 3, 150-164.

Javaid M., Haleem A., Singh R.P., Suman R., & Gonzalez E.S., 2022 - *Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability.* Sustainable Operations and Computers, 3, 203-217.

Matta P., & Pant B., 2019 - *Internet of things: Genesis, challenges and applications.* Journal of Engineering Science and Technology, 14(3), 1717-1750.

Meghișan-Toma G.M., & Nicula V.C., 2020 - *Possible Use of ICT in Agriculture for a Sustainable Development*. New Trends in Sustainable Business and Consumption, 1287.

Meng J., Zhao B., Song Y., & Lin X., 2024 - *Research on the Spatial Dynamic Evolution of Digital Agriculture—Evidence from China*. Sustainability, 16(2), 735.

Zhao B., Song Y., & Lin X., 2024 - *Research on the Spatial Dynamic Evolution of Digital Agriculture—Evidence from China.* Sustainability, 16(2), 735.

Pătărlăgeanu S.R., Constantin M., Dinu M., Petrescu I. E., & Deaconu E.M., 2024 - *Farm Carbon Footprint Measurement Frameworks Based on the Digitization and Environmental Sustainability Paradigm.* In Proceedings of the International Conference on Business Excellence (Vol. 18, No. 1, pp. 1602-1612).

Rejeb A., Rejeb K., Abdollahi A., Zailani S., Iranmanesh M., Ghobakhloo M., 2021 - *Digitalization in food supply chains: A bibliometric review and key-route main path analysis.* Sustainability, 14(1), 83.

Rodino S., Buțu M., Buțu A., Lazăr C., Ciornei L., & Simion P.S., 2023 - *Challenges of Digital Transformation in Agriculture from Romania.* Rom. Agric. Res, 40, 713-721.

Simo A., Dzitac S., Badea G.E., & Meianu D., 2022 - *Smart agriculture: IoT-based greenhouse monitoring system*. International Journal of Computers Communications & Control, 17(6).

Subeesh A., Mehta C.R., 2021 - *Automation and digitization of agriculture using artificial intelligence and internet of things.* Artificial Intelligence in Agriculture, 5, 278-291.

Giorgio A., Penate Lopez L.P., Bertoni D., Cavicchioli D., Ferrazzi G., 2024 - *Enablers to Digitalization in Agriculture: A Case Study from Italian Field Crop Farms in the Po River Valley, with Insights for Policy Targeting.* Agriculture, 14(7):1074. https://doi.org/10.3390/agriculture14071074

Gaber K., Rösch C., & Bieling C., 2024 - *Digital transformation of fruit farming in Germany: Digital tool development, stakeholder perceptions, adoption, and barriers.* NJAS: Impact in Agricultural and Life Sciences, 96(1). https://doi.org/10.1080/27685241.2024.2349544

Shepherd M., Turner J.A., Small B. and Wheeler D. 2020 - *Priorities for science to overcome hurdles thwarting the full promise of the 'digital agriculture' revolution.* J. Sci. Food Agric., 100: 5083-5092. https://doi.org/10.1002/jsfa.9346

Ali A; Hassan MU; Kaul HP, 2024 - *Broad Scope of Site-Specific Crop Management and Specific Role of Remote Sensing Technologies Within It-A Review*. Journal of Agronomy and Crop Science, 210(4).

DYNAMICS OF ORGANISMS HARMING THE POTATO CROP IN THE YEAR 2024 IN THE CONDITIONS OF CENTRAL MOLDOVA, ROMANIA

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Abstract

Potato yield is diminished by a wide range of pathogens and pests that affect plants throughout the growing season. The research was carried out at ARDS Secuieni, where, in 2024, a potato experience was established that included monitoring pests and diseases in this crop. The climatic conditions from March to August characterized the analyzed period as extremely hot and dry. The species *Leptinotarsa decemlineata* and the pathogen *Phytophthora infestans* affected the potato crops. The *L. decemlineata* population density was from 4 adults/m^2 to 47.5 adults/m^2, and the number of larvae varied between 25 and 50 larvae/m^2. The *L. decemlineata* attack produced by adults and larvae on potato plants was between 0.7% (first part of June) and 22.3% (mid-July). The pathogen *P. infestans* produced attacks between 7.9% and 27.6% of potato crops.

Key words: adults, attack, larvae, *Leptinotarsa decemlineata, Phytophthora infestans*

The potato crop is an important food, and fodder plant and is highly suitable for industrialization (Mogârzan A., 2012). Potato tubers are rich in protein, calcium, and vitamin C and have a balanced amino acid content (CIP, 2024 https://cipotato.org/). Potato tubers produce the highest amount of energy per unit area and have the highest dry matter yield, 74.5% compared to wheat and 58% to rice (Ahmed B. *et al*, 2017).

Potato yield potential can be affected by several pests such as *Leptinotarsa decemlineata, Aphis sp., Myzus sp. Meloidogyne incognita, Ditylenchus destructor, Agriotes spp., Melolontha melolontha, Macrosiphon euphorbiae, Epitrix cucumeris, Phthorimaea operculella, Gryllotalpa Gryllotalpa, Agrotis segetum* or various pathogens: *Potato X virus, Potato Y virus, Erwinia carotovora pv. atroseptica, Synchytrium endobioticum, Phytophthora infestans, Fusarium solani, Alternaria solani* (Hatman M. *et al*, 1986).

Among the pests, adults, and larvae of the species *Leptinotarsa decemlineata* that consume the potato leaf, defoliating the plants produces the highest attacks (Tălmaciu M., 2017). The insect has other host plants such as tomatoes and eggplants, but it prefers potatoes for development (CABI, 2024). Among the many diseases that occur and spread in the potato crop, *Phytophthora infestans* is responsible for yield losses of 16% of world potato production (Haverkort A. *et al*, 2009). The high frequency of hot summers in Romania created favorable conditions for the appearance and spread of other pathogens such as *Alternaria* spp. whose incidence has increased in recent years, due to climate change, the cultivation of varieties with reduced tolerance to this pathogen, and the reduction in the number of products with fungal action that were used to prevent and combat the pathogen *Phytophthora infestans* (Adavi Z. *et al*, 2018; Hermeziu M. and Neguşeri N., 2024).

The present paper includes data related to the inventory of the organisms harming the potato crop that have been registered and produced attacks in the conditions of Central Moldova in the year 2024.

MATERIAL AND METHOD

The research was carried out at ARDS Secuieni (Neamt - Romania), where, in 2024, an experience was established that included the monitoring of pests and diseases that appear in potato crops.

In the experimental field of the Plant Protection Laboratory, an experiment was conducted with potatoes that were planted manually, at a distance of 70 cm between rows, in the first part of April 2024 (04.02.2024), using the Darilena variety. The plants emerged on 07.05.2024.

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The plant protection technology consisted of:
- weed control that was carried out pre-emergence with Sencor 0.9 l/ha (09.05.2024), and post-emergence with Sencor 0.6 l/ha (05.09.2024), and hand weeding (25.05.2024, 10.06.2024).
- pest control was carried out with Gazelle 0.150 kg/ha (27.05.2024), Imazuma 0.2 kg/ha (10.06.2024), and Mospilan 0.2 kg/ha (16.06.2024, 02.07.2024).
- disease control was achieved with Alcupral 3.5 kg/ha (17.05.2024) and Bordeaux juice 3.75 kg/ha (10.06.2024, 16.06.23024, 02.07.2024).

The appearance and evolution of pests were monitored periodically through ground surveys with a metric frame of 25/25 cm and with the Barber traps during the period between the emergence of the plants and the harvesting of the tubers.

During the potato vegetation period, observations and determinations were made regarding the attack produced by the specific harmful organisms, the adults and larvae of the species *L. decemlineata* respectively, by *P. infenstans*.

Pest and disease attack determinations were made by visual plant analysis (20 plants x 10 replicates). The ratings were made by assigning grades according to the scale 0-6, where 0 represents lack of attack, and 6 attacks greater than 75% of the plant; based on the grades given, the attack grade was calculated for each harmful organism (Baicu T. and Săvescu A., 1986).

RESULTS AND DISCUSSIONS

Climatic conditions

In the analyzed period, March - August, it was found that the monthly temperatures were much higher compared to the multiannual average (*figure 1*).

The spring months were characterized as warm, with average temperatures being higher by +3.6°C in March and April, except for May, which had a deviation of 0.4°C, being characterized as normal thermally.

The summer months were hot from a thermal point of view, which led to rapid plant growth and development in June, but very high temperatures in July led to premature drying of the leaves.

Average monthly temperatures increased by +3°C in June and +4°C in July above the multi-year average, a fact that negatively affected the development of plants, as they quickly went through the phenophases of development and ended the vegetative cycle faster (*figure 1*).

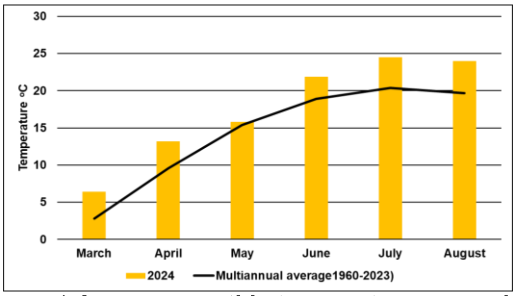

Figure 1 **Average monthly temperatures recorded during March-August, 2024, Secuieni – Neamț**

In terms of rainfall, a deficit was recorded in April, May, July, and August, and the months of March and June recorded rainfall close to the multiannual average (*figure 2*). The amount of rainfall below the multiannual average in April led to the uneven emergence of the potato plants. In May, half of the multi-annual amount of rainfall accumulated, negatively influencing the development of plants. The rainfall in June, which totaled 84.4 mm, helped the plants to develop rich foliage, but the water deficit in July (-61.6 mm) led to premature wilting and drying of the leaves (*figure 2*).

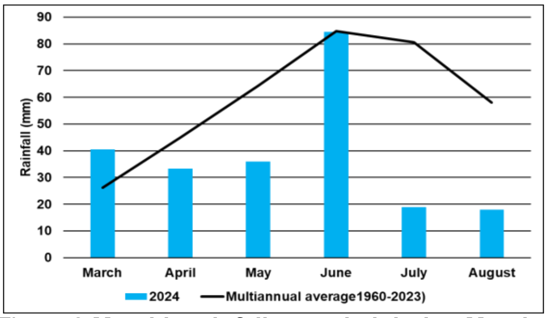

Figure 2 **Monthly rainfall recorded during March - August 2024, Secuieni - Neamț**

The entomofauna identified was made up of three pest species that totaled 207 specimens (*table 1*). The most specimens were recorded for *L. decemlineata*, with 107 specimens, followed by *Harpalus* spp., with 96 specimens, and *Agriotes* spp. with 4 specimens. The inventoried species are part of the Coleoptera order.

Analyzing the registered entomofauna, we found that the number of specimens collected was high, being between 2 specimens/m^2 as many as were registered in the first part of May, respectively 39 specimens/m^2, as many as were registered in the last part of June. The *Harpalus* species is spread throughout the territory of the unit, which is why it is captured in Barber traps, but also at the light trap (Trotuș E. *et al*, 2017). These species are described in local and foreign scientific literature as being predatory through their larvae, and the adults, being phytophagous, cause damage, especially to cereals with the grains they feed on.

Table 1

Harmful entomofauna to potato crops inventoried in 2024, Secuieni – Neamț (specimens/m^2)

Species	Order	V			VI			VII			VII	Σ
		I	II	III	I	II	III	I	II	III	I	
Agriotes spp	Coleoptera	0	0	0	0	4	0	0	0	0	0	4
Leptinotarsa decemlineata	Coleoptera	2	5	6	15	17	21	13	12	6	10	107
Harpalus spp.	Coleoptera	0	0	4	8	10	18	18	16	15	7	96
Σ = three species	1 order	2	5	10	23	31	39	31	28	21	17	207

Calculating the share of species according to the number of specimens collected, we find that *L. decemlineata* had the share of 52% of the total catches, followed by *Harpalus* spp., with 46% and *Agriotes* spp. with 2% (*figure 3*).

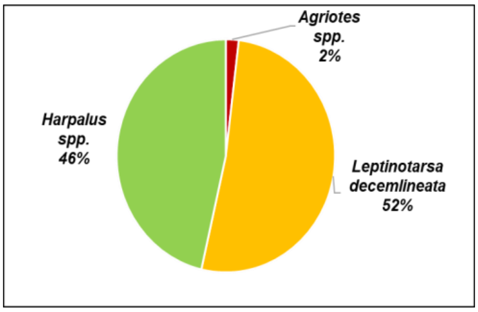

Figure 3 **The share of species according to the number of specimens collected, 2024, Secuieni – Neamț**

Observations and determinations regarding the appearance, spread, and attack of the species *L. decemlineata* were carried out weekly and it was found that the first adults were recorded in mid - May (5 adults/m^2), together with the identification of the first eggs laid by the insect (6 groups eggs/m^2) (*figure 4*). At the end of May, the first larvae were recorded, which required the application of a phytosanitary treatment to control and reduce the population density of larvae and adults. We find that the number of egg groups identified was between 4.5 and 9 egg groups/m^2, this stage being recorded throughout the vegetation period of the potato crop. The number of adults/m^2 was between 4 and 47.5 adults/m^2, their presence being signaled at each weekly determination. Regarding the number of larvae/m^2, it varied between 25 and 50 larvae/m^2.

The scientific literature mentions that the economic damage threshold is 1-2 adults/m^2 and 3-4 larvae/m^2 for potato crops (Tălmaciu M., 2017). In the case of potato crops from Secuieni, we can see that the EDT was exceeded during the entire monitoring period and it shows us the constant and high presence of the two stages that produce attacks in potato crops, the adult and the larva.

Hatman M. *et al.* (1986) mention that treatments against adults should be carried out when the numerical density exceeds 0.5 insects/m^2, i.e. one adult per 8-10 potato bushes. As we can see, the number of adults/m^2 recorded in the potato crops from Secuieni was close to the data from the scientific literature, a fact that indicates the maintenance of the high adult population density throughout the vegetation period. As for larvae, their density was high due to continuous egg-laying by adults and rapid hatching of larvae due to high temperatures.

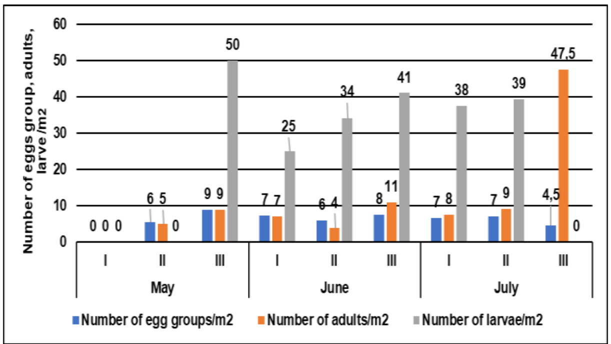

Figure 4 ***Leptinotarsa decemlineata* density/m^2, 2024, Secuieni – Neamț**

Along with the appearance and spread of the adults and larvae in the potato crops, the attack produced by the insect was also noted, which was between 0.7% as recorded in the first part of June and 22.3% as registered in mid - July (*figure 5*).

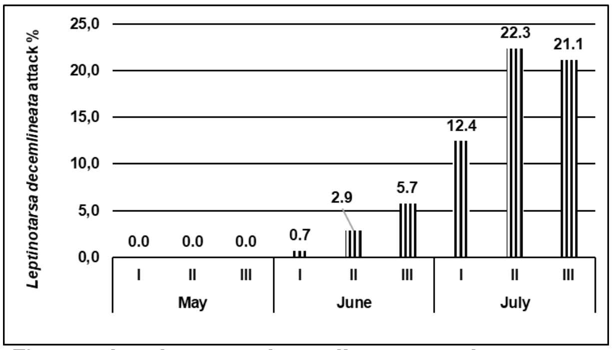

Figure 5 ***Leptinotarsa decemlineata* attack on potato crops, 2024, Secuieni – Neamț**

Among the pathogens, the appearance and spread of *P. infestans* were recorded, which depended on weather conditions, infection pressure, and potato development at the time of the disease attack (Razukas A. *et. al*, 2008). Potato late blight presents a complex evolution, which in current climate conditions is accentuated by extreme phenomena (torrential, short-term rains, large amounts of water in a short period) and continues to raise serious problems for farmers (Hermeziu M. *et al*, 2019; Hermeziu M., 2021).

The pathogen has been registered since the beginning of June, the attack being between 7.9% and 27.6% (*figure 6*). The disease had a constant evolution and was present in potato crops until the maturity of the plants and tubers.

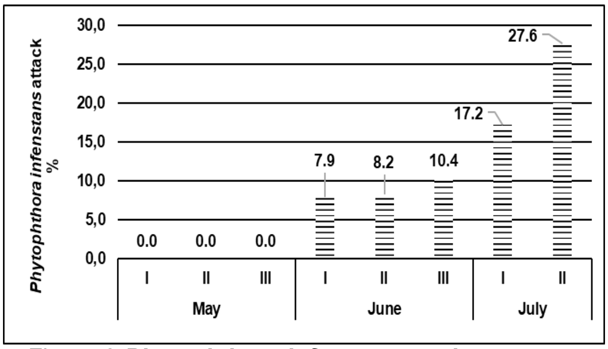

Figure 6 ***Phytophthora infestans* attack on potato crops, 2024, Secuieni – Neamț**

At harvest, potato tubers were analyzed to register the *Agriotes* frequency of attack and *P. infestans*. It was found that the frequency of tubers affected by the larvae of the *Agriotes* species was between 0% and 24%, with an average of 13.6%. The frequency of attack produced by *P. infestans* on tubers varied between 0 and 44%, with an average of 27.2% (*table 2*).

Table 2

Attack of harmful organisms on tubers

R	*Agriotes* spp. frequency of attack %	*P. infestans* frequency of attack %
R1	24	0
R2	12	20
R3	0	44
R4	12	36
R5	20	36
Average	13.6	27.2

CONCLUSIONS

The period March - August was characterized as being hot and dry, being unfavorable for the growth and development of the potato. In 2024, the climatic conditions in Secuieni - Neamț were favorable for the appearance, spread, and attack of *L. decemlineata* and the pathogen *P. infestans*. The *L. decemlineata* population density of adults was from 4 adults/m^2 to 47.5 adults/m^2, and of larvae, it varied between 25 and 50 larvae/m^2. The *L. decemlineata* attack of adults and larvae was between 0.7% (first part of June) and 22.3% (mid-July). The pathogen *P. infestans* produced attacks at plants with values between 7.9% and 27.6%. At harvest, it was found that the tubers were affected by *Agriotes* spp. (13.6%) and the pathogen *P. infestans* (27.2%).

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REFERENCES

Adavi Z., Moradi R., Saeidnejad A.S., Tadayon M.R., Mansouri H., 2018 - *Assessment of potato response to climate change and adaptation strategies*. Sci. Hortic., 228:91-102.

Ahmed B., Sultana M., Chowdhury M.A.H., Akhter, S., Alam M. J., 2017 - *Growth and yield performance of potato varieties under different planting dates*. Bangladesh Agron. J., 20(1):25–29.

Baicu T., Săvescu A., 1986 - *Systems of integrated control of diseases and pests on crops*, "Ceres" Publishing house, București: 110-125

CABI, 2024 available online at https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.30380#sec-15

CIP, 2024 available online at https://cipotato.org/

Hatman M., Bobeș I., Lazăr Al. Perju T., Săpunaru T., 1986 - *Protection of cultivated plants,* Ed. Ceres, București, 117:127

Haverkort A., Struik P., Visser R., Jacobsen E., 2009 - *Applied biotechnology to combat late blight in potato caused by Phytophthora infestans*. Potato Res., 52(3): 249-264.

Hermeziu M., Negrușeri N., 2024 - *Results regarding the re-emergence of early blight (Alternaria spp.) and risk management in potato growing areas*, Romanian Agricultural Research, 41:47-54

Hermeziu M., 2021 - *The relation between technologies for late blight (Phytophthora infestans) and the yield components (biomass) of different potato varieties*. Romanian Agricultural Research, 38:155-162

Hermeziu M., Morar G., Nitu S., Hermeziu R., Moldovan C., Donescu V., 2019 - *Influential factors upon the occurrence and evolution of late blight (Phytophthora infestans) on some potato varieties cultivated in Barsa Land,* ProEnvironment, 12:154-158

Mogârzan A., 2012 - *Fitotehnie*, "Ion Ionescu de la Brad" Publishing house, Iasi: 405-487

Razukas A., Jundulas J., Asakaviciute R., 2008 - *Potato cultivars susceptibility to potato late blight (Phytopthtora infestans)*. Applied Ecology and Environmental Research:95-106

Tălmaciu M., 2017 - *Cultivated plant pests from A to Z*, "Ion Ionescu de la Brad" Publishing house, Iasi:373-378

Trotuş E., Isticioaia S.F., Naie M., Buburuz A.A., Ursache P.L., 2017 - *Contributions to the study of some species from Harpalus genus, under conditions of Moldavia Center*, An. I.N.C.D.A. Fundulea, LXXXV: 217-228, Electronic ISSN 2067–7

RESEARCH ON THE IMPACT OF VARIETY ON GRAIN YIELD OF TRITICALE IN THE SPECIFIC CONDITIONS OF THE CENTRAL MOLDAVIA REGION

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Abstract

Choosing the right variety is one of the most critical factors in achieving successful agricultural yield. Varieties are selected according to several criteria, such as adaptability to climatic conditions, resistance to diseases and pests, yield, and product quality.

The paper presents the results of research to evaluate the impact of different triticale varieties on grain yield under the specific pedoclimatic conditions of the central region of Moldova. The study aimed to identify the most productive varieties, adapted to local conditions such as soil fertility, rainfall, and temperatures in this area. The research was conducted during 2023-2024, assessing indicators such as yield and resistance to biotic and abiotic stress factors.

During the analyzed period, the average grain yields for triticale ranged from 4767 $kg \cdot ha^{-1}$ (Negoiu) to 8390 $kg \cdot ha^{-1}$ (17241T1) in the fertilized system, and from 4592 $kg \cdot ha^{-1}$ (Negoiu) to 7358 $kg \cdot ha^{-1}$ (16026T1).

The results contribute to optimizing the selection of triticale varieties, providing valuable recommendations for increasing agricultural production efficiency in the central region of Moldova.

Keywords: triticale, grain yield, varietals impact

In recent years, agriculture has been facing soil drought, which worsens yearly. The triticale species, due to its strong root system and tolerance to abiotic stresses inherited from rye (Niedziela *et al*, 2014), can thrive on sandy and low-fertility soils, in dry and marginal conditions, giving it an increasing advantage over wheat. Triticale shows superior drought resistance compared to barley, wheat, and oats. Additionally, triticale adapts well to slightly acidic soils, with salinity and toxic aluminum ion content.

According to Bîlteanu, Gh. and collaborators (1988), high-yielding varieties of cereal grains have a medium tillering capacity. Plants shouldn't form a large number of tillers, as not all will reach maturity to produce grains, thereby unnecessarily consuming mineral resources and water. During periods of rainfall deficit, these tillers can become harmful to the main plant. To achieve a high number of ears per unit area and, consequently, high yields, it is preferable to have more plants with reduced tillering, rather than fewer plants with a large number of tillers.

Among all cereals available to farmers, triticale adapts best to soils with high pH (alkaline soils) or slightly lower pH (acidic soils), with water deficit or surplus, regardless of soil texture, being able to grow well on sodic soils and tolerate soils rich in boron. However, wet weather conditions close to harvest maturity can cause pre-harvest sprouting issues for triticale (Arseniuk E. *et al*, 2015).

Many scientists, along with farmers and growers from countries with advanced agriculture, have repeatedly demonstrated over the past decades that high agricultural yield is largely influenced by the quality of seeds used for planting production fields. The same view is supported by researchers and farmers in our country who work in this field. This is because high-quality seeds have superior genetic and biological value, varietal and physical purity, a high germination index, TKW (Thousand Kernel Weight), and test weight, as well as health and vigor, all of which contribute to increasing agricultural production (Păcurar I. *et al*, 2007).

In the second half of the last century (1950s-1970s), numerous researchers began studying genetic variability in populations of self-pollinating and cross-pollinating plants. Thus, from the definition of a variety in self-pollinating plants, it was determined that it is "a population

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composed of a mixture of homozygous lines" (Briggs *et al*, 1967). Research conducted in this field led to the formulation of a widely accepted concept, according to which a variety is considered a population, regardless of whether it belongs to a self-pollinating or cross-pollinating plant species (Ceapoiu N., 1976).

MATERIAL AND METHOD

The research was conducted during the 2023/2024 season and aimed to evaluate the performance of various Romanian triticale genotypes under conditions in the Moldova region.

At A.R.D.S. Secuieni, two mono-factorial experiments were set up: one unfertilized and one fertilized with NPK 18:46:0 in the autumn and ammonium nitrate in the spring. The autumn doses of NPK applied were 36 kg/ha of N and 92 kg/ha of P_2O_5, while in the spring, an additional 80 kg/ha of N was administered.

The soil used for the research is a typical cambic chernozem, characterized as being well-supplied with phosphorus (P_2O_5 - 39 ppm), calcium, and magnesium; moderately supplied with active humus (2.3%) and nitrogen; and poorly supplied with potassium (K_2O - 161 ppm), with a slightly acidic pH of 6.29% (Leonte *et al*, 2021).

The experimental layout was a randomized block design with 3 replications. The data obtained were analyzed using the analysis of variance method (Leonte C. and Simioniuc V., 2018).

The climatic conditions recorded during the growing season of the triticale species showed significant deviations compared to the multiannual average, with the growing season being characterized as hot and very dry.

The temperatures recorded from October 1, 2023, to July 31, 2024, deviated from the multiannual average by 3.1°C (Table 1). The average monthly deviations during the growing season of triticale ranged between 0.4°C, recorded in May, and 7.7°C, recorded in February (Table 1).

Table 1

Temperatures (ºC) and multiannual average (1962-2022) recorded at A.R.D.S. Secuieni, in the 2023/2024 year

Month	X	XI	XII	I	II	III	IV	V	VI	VII	Average
2023/2024	13	6.0	-0.9	-1.8	5.8	6.4	13	16	22	25	10.4
MM (1962-2023)	9.2	3.6	-1.5	-3.7	-1.9	2.8	9.6	15.4	18.9	20.4	7.3
Deviation	3.9	2.4	0.6	1.9	7.7	3.6	3.6	0.4	3.0	4.1	3.1

Rainfall recorded during the growing season of the cereals showed a deviation of -135.2 mm compared to the multiannual average of 429.6 mm for the same period (Table 2). The recorded monthly deviations ranged from an average of 23.9 mm in November to -61.6 mm in July (Table 2).

Table 2

Rainfall (mm) and multiannual average (1962-2022) recorded at A.R.D.S. Secuieni, in the 2023/2024 year

Month	X	XI	XII	I	II	III	IV	V	VI	VII	Sum
2023/2024	8.8	51.6	2.8	8.4	9.4	40.6	33.4	36.0	84.4	19.0	294.4
MM (1962-2023)	36.9	27.7	25.4	19.6	19.2	26.3	44.9	64.3	84.7	80.6	429.6
Deviation	-28.1	23.9	-22.6	-11.2	-9.8	14.3	-11.5	-28.3	-0.3	-61.6	-135.2

Based on the information presented, it can be stated that the research was conducted in the context of increasingly frequent climate changes, with average monthly temperatures exceeding the multiannual average through a decline in precipitation.

RESULTS AND DISCUSSIONS

This research focused on analyzing the factors influencing the productivity of triticale and identifying methods for optimizing production. Various parameters were considered, including seed quality, agro-climatic conditions, agricultural practices, and cultivation technologies. The study analyzed 25 native triticale cultivars to assess their performance under different growth and development conditions.

The research results provide an overview of how these factors contribute to increasing grain yield and open new perspectives for improving agricultural output in the future.

The number of grains per ear and the weight of grains per ear are important indicators of cultivar productivity.

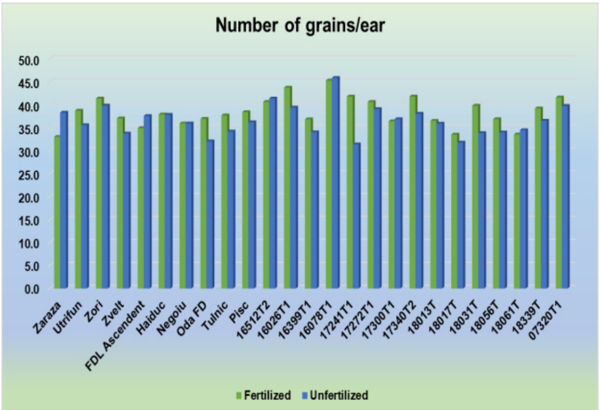

Figure 1. **The number of grains/ears registered at ARDS Secuieni in the period 2023/2024**

In the research conducted at SCDA Secuieni, the number of grains per ear in triticale ranged from 33.0 (Zaraza) to 45.3 (16078T1) in the fertilized system, and from 31.8 (18017T) to 41.4 (16512T2) in the unfertilized system (Figure 1).

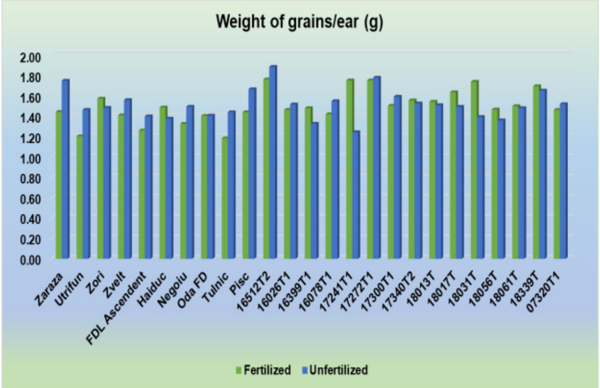

Figure 2. **The weight of grains/ear registered at ARDS Secuieni in the period 2023/2024**

Regarding the grain weight per ear, the average values ranged from 1.21 g for the Utrifun variety to 1.77 g for the 16512T2 line in the fertilized system. In the unfertilized variants, the grain weight per ear ranged between 1.25 g for the 17241T1 line and 1.78 g for the 17272T1 line (Figure 2).

The yields obtained from the studied triticale genotypes were influenced by the applied fertilization.

In the fertilized system, the average yields ranged from 4,767 kg· ha^{-1}, recorded in the variants sown with the Negoiu variety, to 8,390 kg· ha^{-1}, recorded in the variants sown with the 17241T1 line (Figure 3).

The Haiduc, Negoi, and Pisc varieties achieved average yields that, when analyzed statistically, were interpreted as highly significantly negative, with yield differences compared to the control (the experiment's average) ranging between 71% and 82% (Figure 3).

Among the 25 triticale genotypes studied, only the 17241T1 line achieved very statistically significant production increases, with an average yield of 8,390 kg· ha^{-1}, while the Zvelt variety registered statistically distinct significant increases, with an average yield of 7,933 kg · ha^{-1} (Figure 3).

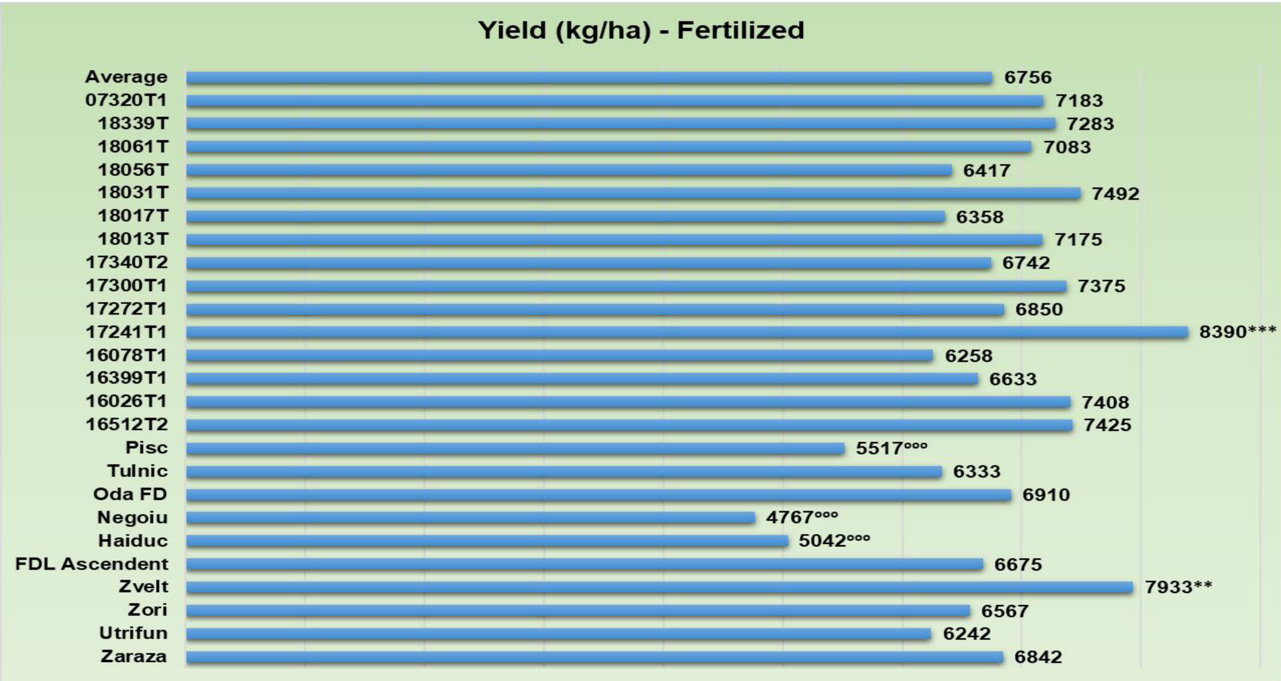

Figure 3. **The average productions obtained by the studied triticale genotypes in the fertilized system**

In the unfertilized system, the average yields ranged from 4,592 kg/ha, recorded in the variants sown with the Negoiu variety, to 7,358 kg/ha, recorded in the variants sown with the 16026T1 line (Figure 4).

Statistically significant yield increases were obtained in the variants sown with the Zvelt variety and the lines 16026T1, 17241T1, and 17272T1, which achieved yields ranging from 7,200 kg/ha (17272T1) to 7,358 kg/ha (16026T1) (Figure 4).

Similar to the fertilized system, in the unfertilized system, the Haiduc, Negoiu, and Pisc varieties achieved statistically highly significant negative yield increases compared to the control, while the Oda FD variety showed statistically distinct negative increases in yield compared to the control (Figure 3).

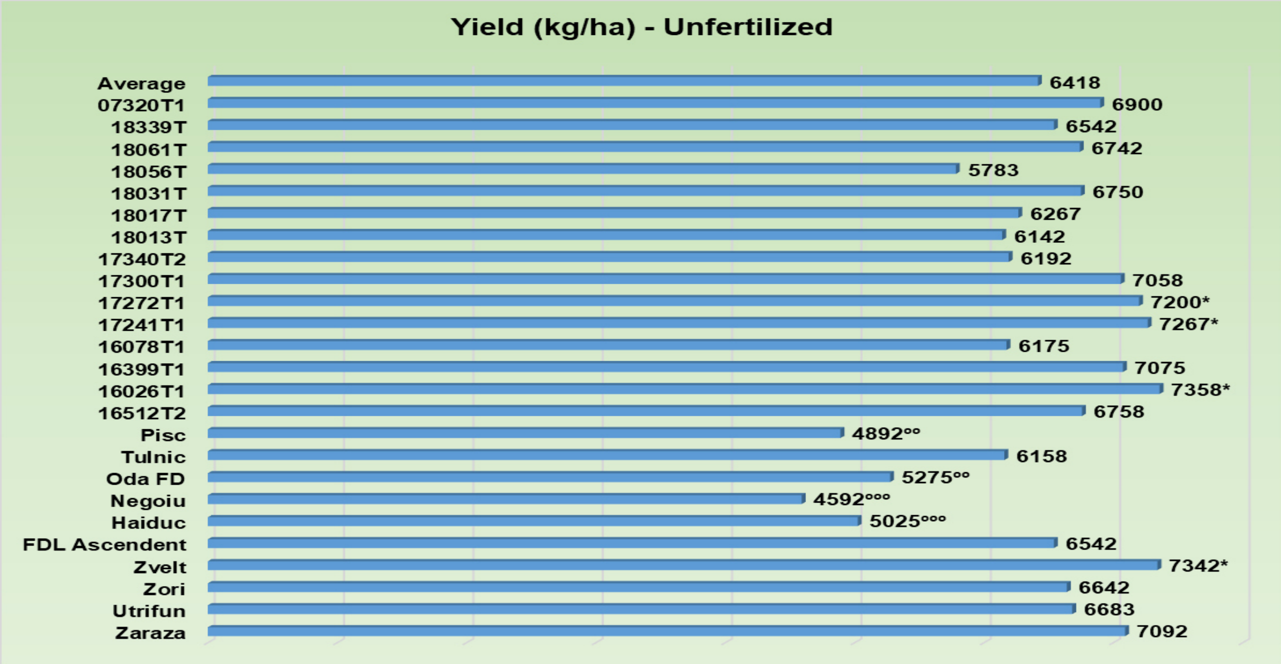

Figure 4. **The average productions obtained by the studied triticale genotypes in the unfertilized syste**

CONCLUSIONS

From the presented information, it follows that the yield of grains in triticale is influenced both by climatic conditions and by the variety.

The average temperature during the growing period of triticale showed a deviation of 3.1°C from the multiyear average, while the rainfall regime recorded a deviation of -135.2 mm from the multiyear average.

In the fertilized system, the number of grains per ear ranged from 33.0 (Zaraza) to 45.3 (16078T1), and from 31.8 (18017T) to 41.4 (16512T2) in the unfertilized system.

The average grain weight per ear varied from 1.21 g for the Utrifun variety to 1.77 g for the 16512T2 line in the fertilized system. In the unfertilized variants, the grain weight per ear ranged from 1.25 g for the 17241T1 line to 1.78 g for the 17272T1 line.

The yields ranged from an average of 4,767 kg/ha for the Negoiu variety to 8,390 kg/ha for the 17241T1 line in the fertilized system. In the unfertilized system, the average grain yields ranged from 4,592 kg/ha for the Negoiu variety to 7,358 kg/ha for the 16026T1 line.

Based on the information presented, it can be stated that the research was conducted in the context of increasingly frequent climate changes, with average monthly temperatures exceeding the multiannual average through a decline in precipitation.

ACKNOWLEDGMENTS

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REFERENCES

Arseniuk E., Góral T., 2015 - *Triticale biotic stresses - Known and novel foes*, In Triticale; Eudes F., Ed.; Springer: Cham, Switzerland, 83–108.

Briggs F.N., Knowles P.F., 1967 – *Introduction to plant breeding*. Reinhold Publ. Crop., New York

Ceapoiu N., 1976 - *Genetics and the evolution of genetic populations*. Edit. Acad. S.S.R., Bucharest

Leonte A., Agapie A., Pintilie P.L., Druțu A.C., Amarghioalei G., Eșanu S., 2021 - *Research regarding the influence of nitrogen and phosphorus fertilizers on winter wheat, in the pedoclimatic conditions in Central of Moldavia*. Journal Life Science and Sustainable Development, 2(2), 52–57

Leonte C., Simioniuc V., 2018 – *Methods and techniques used in agronomic research*, Ed. Ion Ionescu from Brad, Iasi;

Niedziela A., Bednarek P.T., Labudda M., Mańkowski D.R., Anioł A., 2014 - *Genetic mapping of a 7R Al tolerance QTL in triticale (x Triticosecale Wittmack)*. Journal Applied Genetics 55, 1–14.

Păcurar I., Oprea G., Sălăgean D., 2007 – *Research on the production of seeds in flat cereals*, AN. I.N.C.D.A. Fundulea, vol. LXXV, Anniversary volume

PHENOTYPIC EVALUATION *TRITICUM* SP. GENOTYPES VARIATION

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Abstract

The intensity of selection, improvement of different traits and the influence of climate change collectively amplify the frequency of detrimental alleles. This phenomenon causes genetic drift, resulting in an accidental decline in the diversity of plant germplasm sources. Genetic variability is of great importance for the adaptability and tolerance of a species to stress factors. Our investigation centres on Triticum germplasm within the agroclimatic conditions of the Ezareni Farm Iași, encompassing 2021–2022 field trials. Phenotypic characterization was performed for 15 genotypes, which belong to two species of *Triticum* (*T. aestivum* L. and *T. monococcum* L.). The data analysis involved the calculation of amplitude of variation, variance (s2), standard deviation (√s), and coefficients of variation (s%) for three pivotal agronomical traits: plant height, spikelets per spike, and total seeds per spike. The results showed a high coefficient of variation, indicating a significant variability within the analyzed germplasm. The genotypes that stood out with high results of the analyzed parameters can be used in future breeding programs.

Key words: *Triticum* germplasm, genetic variability, phenotypic characterization

INTRODUCTION

Wheat, *Triticum aestivum* L. is responsible for providing an important amount of carbohydrates, proteins and fibers for the diet of the ever growing population (Kumar *et al*, 2021).

Over the past five decades, bread wheat has been one of the most productive crops, and its production has increased due to advances in breeding programs (Rauf K. *et al*, 2020).

Bread wheat is a domesticated plant that originated through the crossing of wild ancestors about 10,000 years ago in the Fertile Crescent, a region in the Middle East, more precisely the territories where Israel, Iraq, Palestine, and Lebanon are located (He F. *et al,* 2019). *T. aestivum* L. (2n = 6x = 42; genome AABBDD), is an allohexaploid species that arose from the crossing of three diploid ancestors with genomes A, B and D. Most of the alleles of common wheat are found in its genome as triple homologous genes, originating from the donor species (Shitsukawa N. *et al*, 2007). Although this plant has 21 pairs of chromosomes, more precisely 3 homologous sets of 7 chromosomes for each of the 3 donor genomes (A, B and D), from a genetic point of view, it behaves like a diploid species (El-Esawi M.A. *et al*, 2022).

The limited genetic variability of wheat compared to other species is due to several reasons, such as the allohexaploid structure resulting from the crossing of three closely related species. Another reason refers to the low initial genetic variability of this species due to the fact that few plants from the ancestral species were involved in the formation of bread wheat. A third reason is the short time interval in which this species evolved (approx. 8000 - 10000 years), insufficient time for the accumulation of mutations or some alleles through interspecific hybridization (Venske E. *et al,* 2019).

The selection methods used in wheat breeding, obtaining semi-dwarf wheat during the Green Revolution, but also the use of highly performing cultivars in breeding programs can result in a decrease in wheat genotypic and phenotypic variability (Trethowan *et al*, 2018).

The identification and characterization of genes that control important traits in wheat is an important step in the breeding work of this species. These traits refer to plant height, spike density, grain weight and shape, resistance to diseases and pests, and tolerance to changing environmental conditions (Gabur I. *et al*, 2022).

Winter wheat genetic resources possess high variability for certain agronomic traits valuable for breeding programs aimed at increasing productivity and improving some agro-morphological traits. Still, the most used method in wheat breeding remains directed hybridization followed by selection works and in some cases backcrossing. The choice of the most valuable

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parents is paramount to the success of the breeding program, and phenotypic variability plays an important role in this activity (Mishra *et al*, 2015).

Germplasm conservation is an increasingly essential activity to overcome the danger of genetic erosion. Wild varieties, local populations and old varieties, have a valuable genetic background for improving some traits, such as mineral, protein, gluten content and of course resistance to biotic and abiotic stress (Yadav I.S. *et al*, 2023).

Genetic diversity is the key to success in wheat breeding programs and beyond. Selection results in high-yielding varieties adapted to diverse climatic conditions and resistant to diseases and pests. At the same time, these works can produce a decrease in phenotypic variability, which is largely determined by genes and their interaction with the environment (Voss-Fels K., Snowdon R., 2016).

In this study, the phenotypic diversity of 15 wheat cultivars was evaluated to identify the most diverse genotypes that can be used as parental forms in future breeding programs.

MATERIAL AND METHOD

The biological material used to determine the phenotypic variability of *Triticum* genotypes consists of the following:

- 10 cultivars of *T. aestivum* ssp. *aestivum*;
- 5 cultivars of *T. monococcum*.

The two species of *Triticum* mentioned above have the biological status of old varieties and local population, as follows:

• *Triticum aestivum*:
- local population – 5;
- old varieties – 5.

• *Triticum monococcum*:
- local population – 5.

The 15 wheat genotypes are part of the strategic national collection of the Suceava Gene Bank, and their choice was made based on the difference between the two species and the biological status.

The local populations, the most valuable genetic resources within the Gene Bank, come from rural areas in Transylvania and Maramureș.

The varieties of *Triticum* sp. were received from agronomic institutes in Romania or other countries.

The 15 wheat cultivars are part of a larger study aimed at the phenotypic evaluation of 380 wheat genotypes. The samples were sown in small blocks in the experimental field of Ezăreni Farm (Figure 1). Each genotype was sown in one row with the length of 2 m and the distance between rows of 50 cm. From each of the 15 genotypes, 10 plants were analyzed to determine the morphological descriptors.

Table 1

International Plant Genetic Resources Institute (IPGRI) descriptors used for the phenotypic evaluation of wheat genotypes

Descriptor	Significance
Growth type (FAO notes)	1. winter; 2. optional; 3. spring.
Plant height (cm)	Measured at maturity of plant height (ground level to tip of the spike), for 10 plants per genotype
Spike density (FAO notes)	Visual scoring using a scale from 1 to 9, ranging from very lax (1) to intermediary (5) to very dense (9)
Awn (FAO notes)	0 – without awn; 1 – short awn; 7 – high awn.
Colour of the glumes (FAO notes)	1 – white; 2 – red to brown; 3 – purple to black.
Presence of hair on the glumes (FAO notes)	0 – absent; 3 – low; 7 – significantly.
Number of spikelets per spike	Average number of spikelets per spike in 5 spikes selected from a genotype
Number of seeds per spikelets	Average number of seeds in a spikelet - sampled from the central area of the spike. 5 spikes from each genotype
Seeds color (FAO notes)	0 – white; 2 – red; 3 – purple (it is tested with NaOH 5%) Seeds were placed in Petri dishes and covered with 5% NaOH solution. Performed with 60–90 seeds. Red seeds – dark brown–orange; white seeds - pale yellow

For the measured parameters such as plant height (cm), number of spikelets/spike and number of seeds/spikelet, average, variance (s^2), standard deviation (√s) and coefficient of variation (s%) were calculated.

RESULTS AND DISCUSSIONS

The wheat genotypes were sown on October 19, 2021 in the experimental field of the Ezăreni Student Research and Practice Station, Iasi (Figure 1). The 380 varieties were grouped into six blocks, each sample being sown in a 2 m long row using approximately 50 seeds, with a row spacing of 50 cm. Due to the drought recorded during the sowing period (5.6 mm of precipitation in October) and low temperatures during the winter, the samples entered vegetation in spring of 2022. The samples were collected from the experimental field between July 12 – 16, 2022, when all genotypes were in the phenophase of full maturity.


Figure 1 **Sowing activity in the Student Research and Practice Station Ezareni**, **Iasi**

Phenotypic evaluation of selected wheat samples was performed for plant height (cm) (Figure 2), number of spikelets/spike and number of seeds/spikelet by calculating the arithmetic mean (x), variance (s^2), standard deviation (√s) and coefficient of variation (s%).

The results obtained for the three morphological descriptors mentioned above, which refer to the plant and spike architecture, are presented in Table 2. The interpretation of the results is based on the determination of the coefficient of variation (s%), which expresses the variability of the selected germplasm, recording a high coefficient of variation for the three analyzed descriptors (over 20%).

Table 2

The values obtained from statistical calculations for the phenotypic parameters analyzed in *Triticum* cultivars

Coefficients	Plant height (cm)	Number of spikelets/ spike	Number of seeds/ spikelets
Average	78,91	13,01	3,08
Max. value	122	37	5
Cultivar name	***T. monococcum***		***T. aestivum***
Min. value	47	13	1
Cultivar name	***T. aestivum***		***T. monococcum***
Standard deviation	426,67	35,44	2,15
Variance	20,66	5,95	1,47
Coefficients of variance (%)	26,18	45,75	47,66

Regarding the phenotypic descriptors for which FAO scores were given, for the samples harvested in the summer of 2022, the following results were obtained:

- **Growth type** was the same for all cultivars (winter types);
- **Spike density** – the scores given showed that the selected samples have a medium variation, between 5 and 9. Thus 4 genotypes of *T. aestivum* L. had intermediary spike and 6 had dense spike. All 5 einkorn genotypes had very dense spike;
- **Awn –** following the determinations, it was found that 3 genotype 3 genotypes were awnless, 1 genotype presented short awns and 11 had obvious awns; All *T. monococcum* L. samples had obvious awns;
- **Glumes colour** – all 15 *Triticum* genotypes had white glumes;
- **The presence of hair on glumes** - all samples studied were hairless on glumes;

CONCLUSIONS

Wheat is an important plant that belongs to the *Triticum* genus. The hexaploid genetic structure of bread wheat is complex, originating from interspecific crosses that occurred approximately 10,000 years ago between the ancestors of this species.

The results obtained highlight a high genetic variability of the *Triticum* germplasm analyzed. All the morphological traits measured had a coefficient of variation of over 20%.

The highest coefficients of variation were recorded for the number of spikelets/spike (45.75%) and for the number of seeds/spikelet (47.66%).

The samples analyzed were uniform in terms of the type of growth, the awns, the color of glumes, the presence of hair/glumes and the color of the seeds.

Wheat germplasm preserved in gene banks represents a valuable resource of genetic material for researchers and breeders. The conserved genotypes can be used as initial material to obtain new wheat varieties with improved production, quality and stress resistance characteristics.

Due to the high coefficient of variation, analysed genotypes can be introduced into a winter wheat breeding program.

ACKNOWLEDGMENTS

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REFERENCES

El-Esawi M. A., Elashtokhy M. M., Shamseldin S. A., El-Ballat E. M., Zayed E. M., Heikal Y. M. 2022 – *Analysis of genetic diversity and phylogenetic relationships of wheat (Triticum aestivum L.) genotypes using phenological, molecular and DNA barcoding markers.* Genes, 14, 1:34.

Gabur I., Sârbu T. E., Dumitriu Gabur G. D., Murariu D., Simioniuc V., Simioniuc D. P. 2022 - *Phenotypic analysis of a wheat diversity panel from the vegetal genetic resources bank" Mihai Cristea" Suceava*. Lucrări Ştiinţifice seria Agronomie, 65, 2:59-62.

He F, Pasam R, Shi F, et al. 2019 – *Exome sequencing highlights the role of wild-relative introgression in shaping the adaptive landscape of the wheat genome*. Nat Genet. 51, 5:896-904.

Mishra C. N., Tiwari V., Satish-Kumar V. G., Kumar A., Sharma I. 2015 – *Genetic diversity and genotype by trait analysis for agro-morphological and physiological traits of wheat* (*Triticum aestivum* L.). Sabrao J. Breed. Genet, *47*, 1:40-48.

Rauf K., Rahman R., Saeed A., Ali M., Noureen F., Amir R., Gul A., 2020 – *Next-generation sequencing in bread wheat*. Climate Change and Food Security with Emphasis on Wheat, 311-320.

IDENTIFICATION OF LOCAL TOMATO VARIETIES (*SOLANUM LYCOPERSICUM*) WITH GENETIC RESISTANCE TO RADIAL CRACKING

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Abstract

The study was conducted in 2023, with the main objective of evaluating the resistance to radial cracking of fruits of 44 tomato landraces from 5 countries. 15 of these landracess come from different geographical regions of Romania, particularly Transylvania. This phenomenon is caused by alternating climatic conditions between drought and heavy rains, and it is quite a common problem for this crop. The landraces were studied in the experimental field of UASVM Cluj-Napoca, and the applied technology was ecological. The evaluation of tomato cracking resistance was performed by determining the frequency of cracked fruits, the intensity of cracking, and the degree of cracking coverage (following the model used in phytopathology). The Kruskal-Wallis test and the Dunn post-hoc test were used for statistical analysis. The Bonferroni correction was applied for the adjustment of multiple comparisons. The results highlighted significant differences between landraces in terms of cracking resistance. Among the 44 landraces, five cherry landraces (520 CDN, 525 CDN, 503 USA, 533 PL, and 509 CDN) did not show any radial cracking on the fruits. Nine normal-sized tomato landraces - 532 DJ, 515 CDN, 516 CDN, 519 CDN, 542 MS, 541 DJ, 526 CDN, 524 CDN, and 527 CDN - exhibited very high resistance to cracking. Conversely, 29 landraces were found to be highly sensitive to this phenomenon, with p-values below 0.0011628, indicating very low genetic resistance. The crack-resistant cultivars can be used directly in organic farming or can serve as the genetic basis for the creation of new tomato varieties, in the context of climate change and the need to optimize the use of fresh water resources.

Key words: tomatoes, radial cracking, genetic resistance, landraces, climate change

Tomatoes (*Solanum lycopersicum*) are among the most important vegetables cultivated on a large scale and are believed to have been domesticated in Central America. They arrived in Europe in the 16th century thanks to Spanish explorers. In 2022, 4.9 million hectares were cultivated globally, with a total production of 186 million tons, making it the most widely cultivated vegetable species in the world (FAO, 2022). The largest global producers of tomatoes are China, India, Turkey, the USA, and Egypt, while within the European Union (EU), the main producers are Italy, Spain, Poland, Greece, France, and the Netherlands. Romania ranks 7th in the EU in terms of tomato production (Agridata, 2023).

Efforts to increase agricultural production have resulted in the industrialized farming systems used today. Among these efforts is the practice of cultivating high-yield hybrids. With the emergence of intensive agriculture, there has been a decline in the number of landraces cultivated, due to the development of modern cultivars, hybrids, and intensive farms (Corradoa, 2014). Although these agricultural practices are more financially feasible in the short and medium term, they lead to the intensification of "genetic erosion" (Rogers, 2004) through the loss of local varieties, which are an important source of genes that confer resistance to biotic and abiotic stress factors. The FAO estimated that from 1900 to 2000, approximately 75% of the genetic diversity of cultivated plants disappeared (FAO, 2004) and estimates that by 2055, an additional 22% of the wild varieties of major crop plants will also disappear (Jarvis, 2008). The reintroduction of local tomato varieties, as well as other vegetables, into agriculture necessitates the identification of the most suitable varieties for a specific climate or microclimate. Marone (2021) claims that preserving local varieties and agricultural biodiversity, in general, constitutes an important source of genes for better nutrient absorption and utilization from the soil, as well as resistance to diseases, pests, drought, and other stress factors. Thus, the specific characteristics of these varieties can be exploited without the additional costs created by climate change.

An important step in the development of organic tomato cultivation is studying the ability of fruits from various local varieties to withstand stress caused by the alternation between periods of drought and heavy rainfall. This alternation is typical for the summer period and manifests itself through the occurrence of cracks on the surface of tomato fruits, resulting from increased rigidity and resistance of the cuticle. This phenomenon appears

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42-49 days after flowering (Ehret *et al*, 1993). Numerous researchers have pointed out that high temperatures reduce the breakage resistance of the fruit's pericarp (De Oliveira *et al,* 2015). Additionally, irregular and excessive irrigation increases the incidence of fruit cracking (Kasai *et al*, 2008; Hossain and Nonami, 2010; Khadivi-Khub, 2015).

The development of berry-type fruits occurs in two phases: the cell division phase followed by the cell expansion phase. When the expansion of the cells in the mesocarp, due to turgor pressure, exceeds the resistance capacity of the exocarp cells, the exocarp cracks. Subsequently, the fissures rapidly spread toward the mesocarp of the fruit. Therefore, resistance to cracking is directly proportional to the thickness of the exocarp (Khadivi-Khub, 2015; Ginzberg, 2015). Yang et al. (2016) suggest that the thickness of the exocarp should be the main criterion for assessing tomato resistance to cracking.

From a biochemical perspective, Domínguez *et al*, (2011) attribute the extensibility of the cuticle to cutin—a fatty lipid substance on the surface of the fruit—while polysaccharides and flavonoids are responsible for the rigidity of the cuticle.

Cracks can be radial or concentric, and their development is partially influenced by the genetic system. Research in this field has demonstrated the existence of specific genes for both radial cracks (Young, 1958) and concentric cracks (Avdeyeev, 1979). These genes determine, in turn, the chemical composition of the cuticle and exocarp, and consequently their biomechanics (Domínguez *et al*, 2009). Ultimately, for practitioners, the type of cracks is not very important, as both are equally damaging to tomato crops and storage. Moreover, the preventive measures for this phenomenon are the same for both types of cracks.

Another important characteristic is the length of the cracks, which is known to be controlled by a set of genes separate from those responsible for their orientation (Cortes, 1983). Clearly, the intensity of periods of alternating drought and heavy rainfall also plays a significant role in this equation. Cuartero *et al*, (1981) conclude that the heritability of this trait is low and that environmental influence is high.

The weakening of the plant due to the appearance of cracks on the fruit occurs through both the process of water loss and the creation of an entry point for phytopathogenic agents (Liu, 2022). Fruits with cracks can thus develop associated complications that lead to economic losses.

Global warming is known to have an intensifying effect on weather events, making them noticeably more intense in recent years, with some tending towards being labeled as "extreme events." Such extreme events include sudden shifts from prolonged droughts to short periods of heavy rainfall, which in turn affect agricultural production, including tomato yields. Managing water resources is becoming increasingly important in the context of global warming and the reduction of freshwater resources. The dynamics of precipitation patterns, one of the sources of freshwater, are deeply influenced by climate change. These climatic changes cause significant variations in average precipitation values (Konapala, 2020). The rise in global temperatures contributes to the accelerated evaporation of water from soil and bodies of water, thereby reducing water availability for agriculture, industry, and human consumption. These changes necessitate the development and implementation of advanced technologies and strategic adaptations to optimize the use of freshwater resources. Among these measures is the implementation of sustainable agricultural practices aimed at reducing water consumption, such as identifying and utilizing varieties and cultivars resistant to the alternation of drought and heavy rainfall.

This study examined 44 landraces/traditional tomato cultivars. The aim of the research was to identify solutions for adapting agriculture to climate change. The main objective was to determine the most resistant landraces/traditional cultivars to radial cracking. Identifying these can contribute to the development of sustainable agricultural practices through the more responsible use of available water resources.

MATERIAL AND METHOD

Plant Material and Growing Conditions

The experiment took place in 2023 at the Agrobotanical Garden of UASVM Cluj-Napoca. In this study, 44 landraces and traditional tomato cultivars (513 CDN, 520 CDN, 525 CDN, 533 PL, 503 USA, 509 CDN, 542 MS, 514 CDN, 511 CDN, 541 DJ, 537 DJ, 515 CDN, 516 CDN, 535 DJ, 510 CDN, 536 DJ, 544 MS, 517 CDN, 539 DJ, 527 CDN, 519 CDN, 530 CDN, 518 CDN, 521 CDN, 538 MS, 524 CDN, CHANDONA, 508 CDN, 540 DJ, 526 CDN, 504 USA, 522 CDN, 512 CDN, 523 CDN, 543 MS, 532 DJ, CASSIANA, 531 CDN, DANAMARI, 528 CDN, 529 CDN, 534 DJ, 505 BE, 506 BE) were cultivated. These were obtained from various sources such as seed fairs organized in Romania and European NGOs specializing in the preservation and cultivation of landraces and old varieties. The CHANDONA, CASSIANA, and

DANAMARI varieties were obtained at UASVM Cluj-Napoca through negative selection from landraces from Alba and Sălaj counties, which is why they are considered traditional cultivars. These varieties were homologated and patented by ISTIS (State Institute for Variety Testing and Registration) in Bucharest.

After selecting the landraces/traditional cultivars used in the study, the germination capacity of each was determined using glass germinators. One hundred seeds from each variety were soaked and placed on a hemp fiber substrate. Based on the results obtained from this process, the seeds were sown in cups with fine peat in a greenhouse at the end of March. The classic technology for producing seedlings was then applied until the beginning of May, when they were transplanted into the field.

The experimental field was divided into 44 variants (each representing a variety), with 10 plants per variant. The crop was maintained organically, using recycled wooden stakes for plant support and jute twine for tying the plants. Mulch made of hay and leaves was applied to maintain soil moisture, prevent erosion, and inhibit weed growth. This mulch also facilitated access to the field in conditions of high humidity. For disease and pest control, seven phytosanitary treatments were carried out, including three with Bordeaux mixture (*Bouillie Bordelaise WDG*, 1%), two with horsetail macerate (*Equisetum arvense*, 20%), and two with nettle macerate (*Urtica dioica*, 20%). When using Bordeaux mixture (Bouillie Bordelaise WDG), the limits imposed in organic farming for this product (4 kg/ha/year) were observed. The first spraying was performed when the foliage reached a density that favors infections, and after fruit set, to avoid flower abortion.

The summer of 2023 was characterized by prolonged periods of drought followed by short periods of heavy rainfall, creating ideal conditions for radial cracking in tomato fruits. In July and August, four such periods were recorded, with 15-18 days without precipitation and high temperatures, followed by rains measuring 21-32 mm.

Observations and measurements were made during July and August when cracks appeared. The evaluation of tomato resistance to cracking was performed by determining the frequency of cracked fruits ($F\% = \frac{n*100}{100}$) and the intensity of cracks ($I\% = \frac{\sum(i*f)}{n}$), and subsequently calculating the degree of crack coverage for each cultivar ($DCC\% = \frac{FxI}{100}$), following the model used in phytopathology. In our experiments, radial cracks were predominant (about 90%), which is why we did not differentiate between the two categories of cracks—radial and concentric—in our observations.

Statistical Analysis

To compare the resistance to radial cracking among the 44 tomato landraces, we used the Kruskal-Wallis method, a non-parametric test suitable for comparisons between multiple groups without assuming normal distribution. This test is appropriate for the high variability in the data.

The statistical analysis was conducted using Microsoft Excel and the Real Statistics Resource Pack, applying the Kruskal-Wallis test, followed by the Dunn post-hoc test to identify significant differences between varieties. Due to the large number of multiple comparisons, we applied the Bonferroni correction, adjusting the significance level p to ~0.0011628 to prevent Type I errors. The 513 CDN variety was chosen as the control due to the absence of radial cracks, serving as an ideal reference point for comparing the cracking resistance of the other varieties.

RESULTS AND DISCUSSIONS

The synthesized data presented in Table 1 show the average frequency of fruit cracking (F%), the average intensity of cracking (I%), the average degree of crack coverage (DCC%), and the p-value calculated based on DCC% for each of the 44 cultivars.

Our research shows that the cherry landraces (figure 1) 520 CDN, 525 CDN, 503 USA, and 509 CDN demonstrated remarkable resistance equal to the control variety, with no cracks recorded from the alternating drought and heavy rainfall. Nine normal-sized tomato landraces (figure 2) — 532 DJ, 515 CDN, 516 CDN, 519 CDN, 542 MS, 541 DJ, 526 CDN, 524 CDN, and 527 CDN — also exhibited high resistance, although they sporadically developed small radial cracks during the ripening period. These performances make them ideal candidates for use in organic agriculture and for selection in breeding programs. Our results align with the literature, which highlights the correlation between fruit size and the intensity of tomato fruit cracking. Thus, varieties with larger fruits tend to have a higher incidence of cracks (Emmons and Scott, 1998; Demers *et al*, 2001). What is noteworthy in our studies is that we identified large-fruited landraces that exhibit resistance to cracking. Similar research was conducted by Espana *et al*, (2014), but they only studied tomato varieties with different patterns of cuticle growth. Their experiments focused on the correlations between the mechanical properties of the cuticle and tomato fruit growth.

Table 1

Analysis of Tomato Landraces: Fruit Type, Crack Frequency and Intensity, Degree of Coverage, and Statistical Significance

No.	Landraces	Fruit type	Mean frequency of cracked fruits (F%)	Mean intensity of cracks (I%)	Mean degree of crack coverage (DCC%)	*p*-value DCC%
1	513 CDN	Ch	0	0	0	Control
2	520 CDN	Ch	0	0	0	1.000000000000
3	525 CDN	Ch	0	0	0	1.000000000000
4	503 USA	Ch	0	0	0	1.000000000000
5	509 CDN	Ch	0	0	0	1.000000000000
6	533 PL	Ch	0	0	0	1.000000000000
7	532 DJ	N	5	1	0.05	0.379149547644
8	515 CDN	N	5	2	0.1	0.253534216513
9	516 CDN	N	5	2	0.1	0.225085853246
10	519 CDN	N	10	2.5	0.25	0.042438478416
11	542 MS	N	15	2	0.3	0.027373930212
12	541 DJ	N	10	3	0.3	0.026165219938
13	526 CDN	N	10	3	0.3	0.017878384987
14	524 CDN	N	15	3	0.45	0.004779892411
15	527 CDN	N	10	5	0.5	0.004523932031
16	540 DJ	N	20	3	0.6	0.001057060005
17	539 DJ	N	15	5	0.75	0.000835048389
18	538 MS	N	15	4	0.6	0.000798734388
19	512 CDN	N	20	3	0.6	0.000615839113
20	536 DJ	N	20	3	0.6	0.000578995904
21	508 CDN	N	15	4	0.6	0.000506374409
22	544 MS	N	20	3	0.6	0.000503058979
23	521 CDN	N	15	5	0.75	0.000461760128
24	CHANDONA	N	15	4	0.6	0.000357256894
25	514 CDN	N	20	3	0.6	0.000320712056
26	518 CDN	N	25	3	0.75	0.000190130602
27	535 DJ	N	25	3	0.75	0.000125675942
28	504 USA	N	20	4	0.8	0.000051695781
29	523 CDN	N	30	3	0.9	0.000031267837
30	CASSIANA	N	25	4	1	0.000019193367
31	531 CDN	N	25	4	1	0.000008407160
32	537 DJ	N	30	4	1.2	0.000006116238
33	517 CDN	N	25	4	1	0.000002702334
34	530 CDN	N	25	5	1.25	0.000001213991
35	534 DJ	N	40	5	2	0.000000559318
36	543 MS	N	30	4	1.2	0.000000383546
37	522 CDN	N	50	4	2	0.000000299747
38	510 CDN	N	30	5	1.5	0.000000147496
39	DANAMARI	N	25	7	1.75	0.000000144700
40	511 CDN	N	35	5	1.75	0.000000042077
41	506 BE	N	40	5	2	0.000000028046
42	528 CDN	N	40	6	2.4	0.000000000455
43	505 BE	N	40	8	3.2	0.000000000126
44	529 CDN	N	70	8	5.6	0.000000000002

Meaning of symbols: Ch – Cherry, N - Normal

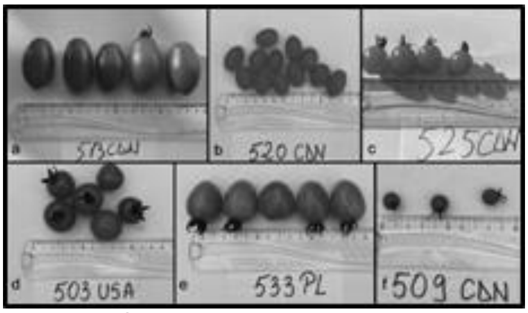

Figure 1. **Cherry tomato landraces with high resistance to cracking (a. 513 CDN, b. 520 CDN, c. 525 CDN, d. 503 USA, e. 533 PL, f. 509 CDN)**

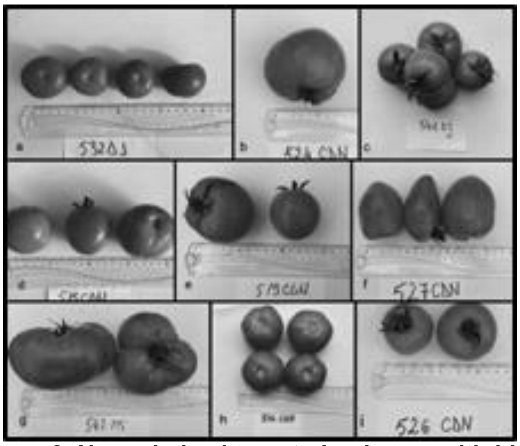

Figure 2. **Normal-sized tomato landraces with high resistance to cracking (a. 532 DJ, b. 524 CDN, c. 541 DJ, d. 515 CDN, e. 519 CDN, f. 527 CDN, g. 542 MS, h. 516 CDN, i. 526 CDN)**

29 normal-sized landraces/traditional tomato cultivars (540 DJ, 539 DJ, 538 MS, 512 CDN, 536 DJ, 508 CDN, 544 MS, 521 CDN, CHANDONA, 514 CDN, 518 CDN, 535 DJ, 504 USA, 523 CDN, CASSIANA, 531 CDN, 537 DJ, 517 CDN, 530 CDN, 534 DJ, 543 MS, 522 CDN, 510 CDN, DANAMARI, 511 CDN, 506 BE, 528 CDN, 505 BE, 529 CDN) showed statistically significant differences compared to the control. These varieties performed poorly during the two months of observations, as they recorded a significantly higher frequency and intensity of radial cracks compared to the control variety. Although some of these landraces/cultivars exhibit exceptional taste and technological qualities (such as high productivity and resistance to pathogens), they can only be cultivated under irrigation conditions.

Similar studies on the resistance of tomato varieties to cracking have been conducted by numerous researchers: Peet and Willits (1995), Cotner *et al*, (1969), Cortés *et al*, (1983), Wacquant (1995); Emmons and Scott (1998). The conclusions of these studies highlight the limited number of tomato varieties with resistance to cracking and the fact that this resistance is mainly determined by the thickness of the epicarp.

The Kruskal-Wallis test result indicated an H value of 308.645, with a p-value < $5.13E^{-42}$, confirming significant differences between the varieties. Subsequently, the Dunn post-hoc test, adjusted using the Bonferroni correction (~0.001), allowed for the identification of varieties that show significant differences compared to 513 CDN variety. The study results emphasize the importance of conserving local tomato landraces, especially given climate change and the need to improve freshwater management in agriculture. The cherry and normal-sized landraces that demonstrated high resistance to radial cracking clearly illustrate the potential of these valuable genetic resources. The literature repeatedly recognizes the importance of preserving landraces and traditional cultivars, which are essential sources of genes conferring resistance to various biotic and abiotic stresses (Rogers, 2004; Marone *et al*, 2021). Our study validates these perspectives, demonstrating that tomato landraces can be successfully used in breeding programs to create new varieties capable of coping with climate challenges. In a global context where freshwater resources are becoming increasingly limited, using cultivars resistant to water stress and cracking can significantly reduce the need for intensive irrigation, thus diminishing the impact on these vital resources (Konapala *et al*, 2020).

This study not only highlights the resistant local varieties but also underscores the need for continued research, given the limited number of studies on the possibilities of identifying genes responsible for resistance to radial cracking.

CONCLUSIONS

Global climate change and the depletion of natural resources necessitate finding solutions for sustainable agriculture.

Periods of drought alternating with rainy periods are becoming increasingly frequent in the current climate context. This alternation promotes cracking in tomato fruits, which then become entry points for pathogens and negatively affect the commercial appearance of the fruits.

Organic agriculture, characterized by reduced energy inputs and minimal pollution, is a rapidly expanding field. In the European Union, it is projected that by 2030, organically cultivated areas will reach 25%, while currently, in Romania, only 4.4% of the cultivated area is organic.

Our research aimed to identify tomato landraces and traditional tomato cultivars resistant to the alternation of drought and heavy rainfall. Of the 44 cultivars studied in the experimental field under conditions favorable to this phenomenon, six cherry-type landraces — 513 CDN, 520 CDN, 525 CDN, 503 USA, 533 PL, 509 CDN — and nine normal-sized landraces — 532 DJ, 515 CDN, 516 CDN, 519 CDN, 542 MS, 541 DJ, 526 CDN, 524 CDN, and 527 CDN — proved to be the most resistant to cracking. These cultivars are suitable for direct use in organic farming and can also serve as valuable genetic sources for breeding work.

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REFERENCES

Avdeyeev I.T., 1979 - *Inheritance of resistance to concentric fruit cracking*. Tomato Genet. Coop. Rep. 29, 20.

Corrado G., Caramante M., Piffanelli P., & Rao R., 2014 - *Genetic diversity in Italian tomato landraces: Implications for the development of a core collection*. Scientia Horticulturae, 168, 138-144.

Cortés C., Ayuso M. C., Palomares G., Cuartero J., & Nuez F., 1983 - *Relationship between radial and concentric cracking of tomato fruit.* Scientia Horticulturae, 21(4), 323-328.

Cotner S.D., Burns E.E., Leeper P. W., 1969 - *Pericarp anatomy of crack-resistant and susceptible tomato fruits*. J. Am. Soc. Hort. Sci. 94:136–137.

Cuartero J., Palomares G., Balasch S., Nuez F.,1981 - *Tomato fruit cracking under plastic-house and in the open air. II. General and specific combining abilities.* Genetics and Breeding of Tomato. Avignon, France, Proc. Meeting Eucarpia Tomato Working Group. 91-98.

De Oliveira G.H.H., Correa P.C., Botelho F.M., de Oliveira A., 2015 - Mechanical properties of tomatoes subjected to an induced compression during storage. J. Texture Stud. 46,293–301. https://doi.org/10.1111/jtxs.12129.

Demers D.-A., Dorais M. and Papadopoulos A.P. 2001 - *Yield and cuticle cracking of greenhouse tomato (Lycopersicon esculentum Mill.) as influenced by leaf to fruit ratio and relative humidity*. J. Am. Soc. Hort. Sci.

Domínguez E, Cuartero J, Heredia A., 2011 - *An overview on plant cuticle biomechanics.* Plant Sci. 181(2): 77-84.

Domínguez E, España L, López-Casado G, Cuartero J, Heredia A., 2009 - *Biomechanics of isolated tomato (Solanum lycopersicum) fruit cuticles during ripening: the role of flavonoids*. Funct Plant Biol. 36 (7): 613-620. doi: 10.1071/FP09039. PMID: 32688674.

Ehret D.L., Helmer T., Hall J.W., 1993 - *Cuticle cracking in tomato fruit*. J. Hort. Sci. 68:195–201.

Emmons C.L.W., and Scott J.W., 1998 - *Ultrastructural and anatomical factors associated with resistance to cuticle cracking in tomato (Lycopersicon esculentum Mill.).* Int.J. Plant Sci. 159:14–22.

Espana L., Heredia-Guerrero J.A., Segado P., Benitez J.J., Heredia A., Domínguez E., 2014 - *Biomechanical properties of the tomato (Solanum lycopersicum) fruit cuticle during development are modulated by changes in the relative amounts of its components.* New Phytol. 202,790–802. https://doi.org/10.1111/nph.12727.

Ginzberg I., & Stern R. A., 2016 - *Strengthening fruit-skin resistance to growth strain by application of plant growth regulators*. Scientia Horticulturae, 198, 150-153.

Hossain M.M., Nonami H., 2010 - *Effects of water flow from the xylem on the growth-induced water potential and the growth-effective turgor associated with enlarging tomato fruit.* Environ. Control Biol. 48, 101–116 (https://jsabees.org/ecb/index. html).

Huijie Liu X.H., 2022 - *Prediction of the cracking susceptibility of tomato pericarp: Three-point bending simulation using an extended finite element method,* Postharvest Biology and Technology, 187.

Jarvis A., Lane A., & Hijmans R. J., 2008 - *The effect of climate change on crop wild relatives*. Agriculture, Ecosystems & Environment, 126(1-2), 13-23.

Kasai S., Hayama H., Kashimura Y., Kudo S., Osanai Y., 2008 - *Relationship between fruit cracking and expression of the expansin gene MdEXPA3 in ‘Fuji’ apples (Malus domestica Borkh.).* Sci Hortic 116(2):194–198

Khadivi-Khub A., 2015 - *Physiological and genetic factors influencing fruit cracking.* Acta Physiol. Plant. 37, 14. https://doi.org/10.1007/s11738-014-1718-2.

Konapala G. M., 2020 - *Climate change will affect global water availability through compounding changes in seasonal precipitation and evaporation*. Nature Communications.

Marone D., Russo M. A., Mores A., Ficco D. B., Laidò G., Mastrangelo A. M., & Borrelli G.M., 2021 - *Importance of landraces in cereal breeding for stress tolerance*. Plants, 10(7), 1267.

Peet M.M., and Willits D.H., 1995 - *Role of excess water in tomato fruit cracking*. HortScience 30:65–68.

Rogers, D. L., 2004. *Genetic erosion: no longer just an agricultural issue*. Native Plants Journal, 5(2), 112-122.

Wacquant C., 1995 - *Microfissures ou rugosité des fruits de la tomate*. Ctifl, Centre de Balandran, France.

Yang Z., Wu Z., Zhang C., Hu E.M., Zhou R., Jiang F.L., 2016 - *The composition of pericarp, cell aging, and changes in water absorption in two tomato genotypes: mechanism, factors, and potential role in fruit cracking.* Acta Physiol. Plant. 38, 215. https://doi.org/10.1007/s11738-016-2228.

Young H., 1958 - *Inheritance of fruit cracking. tomato genetics cooperative*, 38.

Food and Agriculture Organization of the United Nations (FAO). 2004 - *What is happening to agrobiodiversity? Building on gender, agrobiodiversity and local knowledge.* Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).

https://agridata.ec.europa.eu/extensions/DashboardFruitAndVeg/FruitandVegetableProduction.html (accessed on 20.07.2024)

https://www.fao.org/faostat/en/#data/QCL (accessed on 20.07.2024

STUDY REGARDING THE HEIGHT OF POTATO PLANTS DEVELOPED IN VARIOUS CULTURE SYSTEMS AND DIFFERENT SUBSTRATES

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Abstract

This paper presents 2 research studies. First one is about influence of culture system and variety on potato plants height, a bifactorial experience, 5 x 4 type and followed the effect of experimental factor a, culture system (without automation on perlite substrate; NFT system; Wilma system, aeroponic system; classic system: on classic substrate: peat and perlite) and the experimental factor b, the variety. Second study is about the influence of cultivation substrate (inorganic substrate, without substrate -in aeroponic culture, classical substrate -peat and perlite) and the variety on the height of the potato plants (also, a bifactorial experience). In both studies' variety factor b, had 4 graduations: Azaria, Brașovia, Cosiana and Cezarina. From the first study it emerged that the best plant height values were obtained in the aeroponic system (no type of substrate), followed by the NFT system, and low values presented the plants developed in the conventional system. From second study best development of the plants was observed in the aeroponic culture (no substrate) and on the last place is classical substrate. Regarding the variety, the best results were obtained for Brașovia variety in both studies.

Key words: potato, culture system, substrate, plants height.

Sustainable agricultural practices safeguard the food supply and the land, and ensure global food security by addressing the challenges posed by climate change (Rajendran S. *et al*, 2024).

The definition of hydroponic culture, in various publications, shows that this: "is the culture in which nutrients are supplied to the plant through irrigation water, and the growth substrate is without soil, mainly inorganic" (Devries, 2003, cited by Jones, 2005) or " is the science of growing plants, without the use of soil, by using an inert substrate, such as gravel, sand, vermiculite, pumice, sawdust, to which is added the nutrient solution that contains all the essential elements needed by plants for normal growth and development" (Resh, 1995, cited by Jones, 2005). A soilless growing medium is often used to support the plant's root system."

Hydroponic culture appeared somewhere around the 19th century and expanded after 1937, when the term "soilless culture" appeared, i.e. culture without soil or hydroponics, the term introduced by a researcher at the Department of Plant Nutrition at the University Berkeley in California. Dr. William Frederick Gericke (1937), discovered that in reality this cultivation existed since ancient times.

Hydroponics is a soilless cultivation method in which plants are grown using a nutrient solution. This production system removes the dependency on agricultural land and soil, reduces the presence of diseases and can mitigate the negative effects of extreme weather events utilizing precisely dosed nutrient solution (fertigation) (Woznicki *et al,* 2021).

Hydroponics is a soilless agri-production system widely suitable for the cultivation of greenhouse crops. Hydroponics is one of the rapidly growing fields in agriculture and could be the alternate choice for sustainable agriculture. The world's population is growing faster than ever before, and this has led to the development of hydroponics, a potential method of growing vegetables without soil in cities. Controlled conditions, nutrient substrate and solid support pave the way for the development of hydroponics systems across the world, even in agro-climatic zones (Rajendran *et al*, 2024).

In the conditions of our country, in recent years there has been an increase in interest in these unconventional culture technologies, which open attractive perspectives for professional growers (Atanasiu, 2007).

The high technological level of hydroponic cultures is based on state-of-the-art facilities that include equipment and material carefully developed and manufactured by a specialized parallel industry, without which the realization of

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high-performance installations for soilless cultures would be practically impossible (Atanasiu, 2007).

Aeroponic culure is a plant culture technique in which mechanically supported plant roots are intermittently misted with nutrient solution (Barak *et al*, 1996). The plants are grown in air without the use of soil medium. This system has potential to produce disease free planting materials with high multiplication rate.

Aeroponics is a modern, soilless technology for the production of minitubers. In the aeroponic cultivation system, the underground parts (roots and underground stems) of potato plants are situated in a dark chamber, called the module, suspended in the air, and supplied with water and nutrients through a nutrient solution dispersed in the form of fine fog particles (30–100 microns), while the foliage is grown above the module under greenhouse conditions (Broćić *et al,* 2022). Due to the recirculation of nutrient solution, minimal environmental pollution and efficient usage of space, aeroponic technology enables the production of potato minitubers, as well as cultivation of other vegetable and ornamental plants (Gopinath, 2017), in an environmentally friendly manner.

The aims of this study were to evaluate the effects of system culture and genotype on height plant at 4 weeks after plantation and the effects of substrate and genotype on height plant.

MATERIAL AND METHOD

In 2024 at National Institute of Research and Development for Potato and Sugar Beet Brașov, Romania (NIRDPSB) in Laboratory of Research for Vegetal Tissue Culture tested the behavior of 4 Romanian varieties created at NIRDPSB in various culture systems regarding plants height of the 4 weeks after planting the material obtained *in vitro*, respectively virus-free plants. The bifactorial experiment (*table 1*), 5 x 4 type, included 20 variants, on 3 repetitions and followed the effect of combining two experimental factors: the experimental factor a, the culture system (with five gradations: a_1: system without automation on perlite; a_2: Nutrient Film Technique system; a_3: Wilma system; a_4: aeroponic system, a_5: classis system with substrate peat and perlite) and the experimental factor b, the variety (with four gradations).

Biological material used consisted of plants belonging to the varieties: Azaria, Braşovia, Cosiana, Cezarina. Plants were obtained *in vitro*, free of virus, starting from meristem culture.

Materials used in hydroponic culture: hydroponic systems (culture tanks (trays) for system without automatisation; Wilma system, Nutrient Film Technique (NFT GT 100) (*figure 1*); industrial substrate made of inert inorganic materials obtained following simple industrial processes (perlite); nutrient solution for prepared soilless crops; high performing portable conductivity meter, portable pH meter, timers for each type of automation system

Materials used in aeroponic culture: aeroponic system equipped with water chilling, pH and EC sensors, timer, water filtration system; the nutrient solution. In *figure 2* can be seen plants development in aeroponic system.

For conventional culture was used a substrate consisting of a mixture of red peat with bentonite, black peat and perlite.

Table 1

Experimental variants

Variant	Type of culture	Culture system	Variety (b)
V_1	Hydroponic	Culture on perlite substrate (without automation)	Azaria
V_2			Brașovia
V_3			Cosiana
V_4			Cezarina
V_5		Culture on substrate with perlite (with automation) in NFT system	Azaria
V_6			Brașovia
V_7			Cosiana
V_8			Cezarina
V_9		Culture on substrate with perlite (with automation) in the Wilma system	Azaria
V_{10}			Brașovia
V_{11}			Cosiana
V_{12}			Cezarina
V_{13}	Aeroponic	Aeroponic system (without any kind of substrat)	Azaria
V_{14}			Brașovia
V_{15}			Cosiana
V_{16}			Cezarina
V_{17}	Conventional	Classic system, on classic substrate (peat and perlite)	Azaria
V_{18}			Brașovia
V_{19}			Cosiana
V_{20}			Cezarina

The Wilma system is used as a fully recirculating hydroponic system that can reuse the unabsorbed nutrient solution in the irrigation process (contains: basin, tray, pot, pump). In the root zone, drainage is free, avoiding the deposition of excess nutrients or water.

The Nutrient film technique NFT GT 100 culture system is a system through which the growth of the root system is achieved in permanent contact with the very thin layer of circulating nutrient solution and a good oxygenation of the nutrient solution due to its very large contact surface with air.

In the culture tanks (trays) are placed pots with industrial substrate, with sides of 0.9 m and the height of the tank of 10 cm, provided with a plug for draining and refreshing with new solution;

The technique consists in growing plants without soil, directly in the substrate that allows good plant growth. Through the hydroponic system, the plants are directly and regularly supplied with nutrient solution, being a more efficient way of providing the plants with the necessary food, than planting them in the soil.

The *in vitro* material is planted with special attention by experienced personnel from laboratory. These plantlets must be of the same size (5-7 cm) and the same period of growth and development: from cuttings inoculation to plantlets development - a period of 4 weeks and they must go through a period of acclimatization before planting.

Plants in Wilma system

Plants in NFT System

Figure 1 **Development of plants in different hydroponic system culture**

Also, in 2024, a study was carried out regarding the influence of the culture substrate on plant height. The experience included 3 types of substrates: perlite; without any substrate (in aeroponique culture); mixture of red, black peat and perlite. The bifactorial experiment, 3 x 4 type, included 3 repetitions and followed the effect of the combination of two experimental factors: the experimental factor a, the culture substrate (with three gradations) and the experimental factor b, the variety (with four gradations).

Figure 2 **Developed plants aeroponic culture**

RESULTS AND DISCUSSIONS

From the analysis of variance *table 2*, it can be seen that both factors: culture system, variety and interaction culture system/variety distinctly significantly influence plant height.

The F values of plant height indicate distinctly significant variations of the growing substrate, variety, and substrate/variety interaction (*table 3*).

Table 2

Analysis of variance (4 weeks after planting) for plant height

Source of variation	Sum of squares	DF	Mean square	Sample F
Culture system (a)	3764.21	4	941.05	176.469 **(3.84; 7.01)
Variety (b)	1744.37	3	581.46	83.507 **(2.92; 4.51)
Culture system * Variety	644.29	12	53.69	7.711 **(2.09; 2.84)

Table 3

Analysis of variance (4 weeks after planting) for plant height

Source of variation	Sum of squares	DF	Mean square	Sample F
Culture substrate (a)	3461.44	2	1730.72	565.134 **(6.94; 18,0)
Variety (b)	879.90	3	293.30	92.711 **(3.16;5.09)
Culture substrate *Variety	260.98	6	43.50	13.749 **(2.66; 4.01

From *figure 3* it can be seen how in the aeroponic system the value of mean plants height

(40.6 cm) is detached from the other system in a positive sense.

The four varieties studied differ significantly in systems culture (*figure 4*). Braşovia variety presented the ability to produce plants with the highest average height (33.8 cm), it is followed by Cosiana variety (30.5) and Cezarina variety ranks last (19.4 cm).

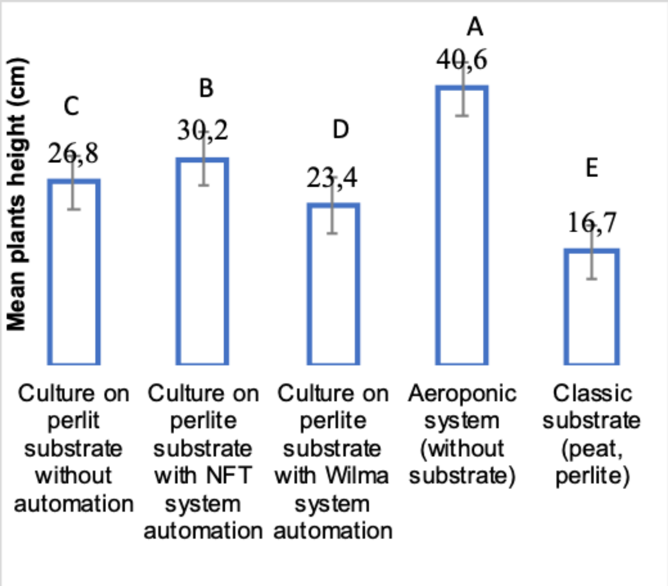

Figure 3 **The influence of cuture system, on mean height of plants (cm) (4 weeks after planting)**
Significance between varieties was determined by Duncan's test. Values followed by the same letter are not significantly different ($p < 0.05$) (LSD p 5% = 2.18).

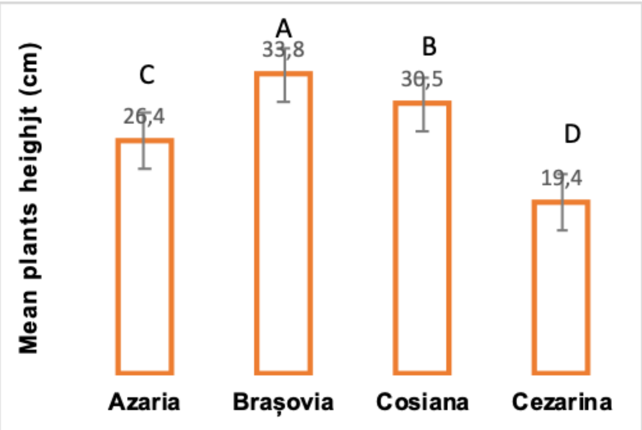

Figure 4 **The influence of variety cultivated on different system culture on mean plants height (cm) (4 weeks after planting)**
Significance between varieties was determined by Duncan's test. Values followed by the same letter are not significantly different ($p < 0.05$) (LSD p 5% = 1.97).

When growing plants on different culture substrates (*figure 5*), it is observed how in the aeroponic culture (without using a type of substrate) plants height (40.6 cm) is significantly different from the plants grown on the substrate with perlite (26.8 cm), the lowest value being obtained when classic substrate was used (16.7 cm).

On three culture substrates, it can be seen from *figure 6* that Braşovia variety records the highest value of plant height, significantly different from the other varieties (33.5 cm).

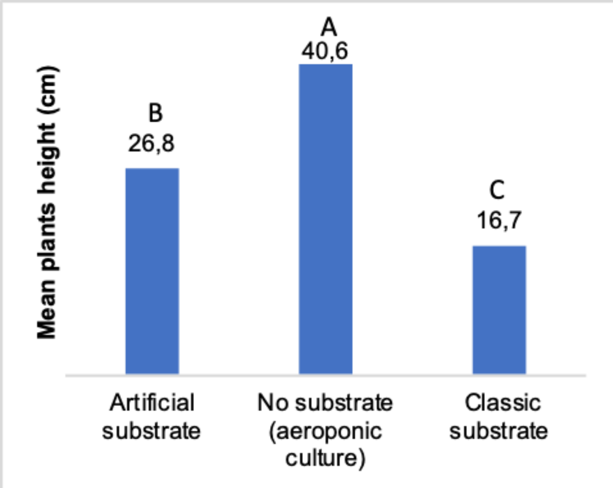

Figure 5 **Influence of culture substrate on mean plants height (cm) (4 weeks after planting)**
Significance between substrate type was determined by Duncan's test. Values followed by the same letter are not significantly different ($p < 0.05$) (LSD p 5% = 1.99).

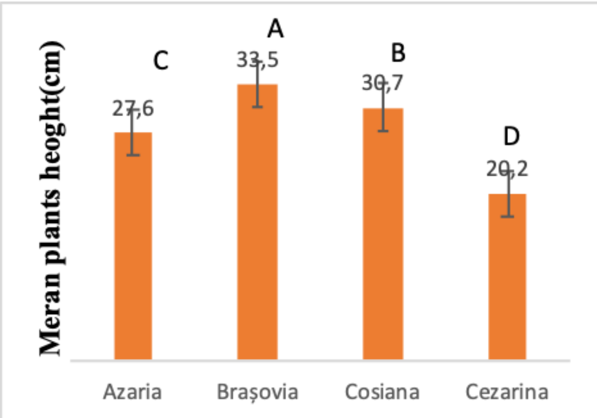

Figure 6 **The influence of the variety cultivated on different culture substrate on the average height of plants (cm) (4 weeks after planting**
Significance between varieties was determined by Duncan's test. Values followed by the same letter are not significantly different ($p < 0.05$) (LSD p 5% = 1.76).

The behavior of the 4 varieties regarding the mean plants height on different system culture (*table 4*) is similar in the NFT system and in the aeroponic system (Azaria, Braşovia and Cosiana varieties, registering very significant positive differences compared to the control variety). By comparing the culture system with classical one, it is observed that in aeroponic culture, all varieties regarding plants height differ positively, very significantly, from the conventional system.

Both on the substrate with perlite and in the aeroponic culture (*table 5*), Azaria, Brașovia and Cosiana varieties registered very significant, positive differences compared to the control variety. Brașovia and Azaria varieties stand out on the classic substrate, with distinctly significant positive difference (4.7 cm) and positive significant difference (3.1 cm), compared to the control variety. Brașovia and Cosiana varieties are distinguished by very significant positive differences, both on the inorganic substrate with perlite (15.5 and 14.0 cm) and in the aeroponic culture (28.2 and 29.7 cm), compared to the plant height values on the classic substrate.

The experience on perlite substrate and in the aeroponic culture determined larger plants obtaining for Azaria variety, compared to the classic substrate, obtaining distinctly significant positive differences (7.3 and 23.7 cm).

From the combined interaction of variety and culture substrate, for Cezarina variety was a very significant positive difference for plants height in aeroponic culture, compared to the classic culture (14.2 cm) and a significant positive difference on perlite culture substrate (3.8 cm).

Table 4

Combined influence of system culture and cultivar on plants height (cm) 4 weeks after planting

Culture system/ Variety	Culture on perlite substrate without automation (a_1)		Culture on perlite substrate with NFT system automation (a_2)		Culture on perlite substrate with Wilma system automation (a_3)		Aeroponic system (a_4)		Classic system (peat and perlite substrate) (a_5)		a1-a5/ Sign.	a2-a5/ Sign.	a3-a5/ Sign.	a4-a5/ Sign. Semn.
	Plant height (cm)	Diff./ Sign.	Plant height (cm)	Diff./ Sign.	Plant height (cm)	Diff./ Sign.	Plant height (cm)	Diff./ Sign.	Plant height (cm)	Diff./ Sign.				
Azaria	24.9	7.4 **	31.3	10.9 ***	17.6	1.2 ns	41.0	12.6 ***	17.3	3.1 ns	7.6 **	14.0 ***	0.2 ns	23.7 ***
Brașovia	30.4	12.9 ***	35.9	15.5 ***	36.9	20.5 ***	47.1	18.7 ***	18.9	4.7 *	11.5 ***	17.0 ***	18.0 ***	28.2 ***
Cosiana	34.4	16.9 ***	33.3	12.9 ***	22.8	6.4 **	45.9	17.5 ***	16.2	1.9 ns	18.2 ***	17.2 ***	6.6 **	29.7 ***
Cezarina (Ct)	17.5	-	20.4	-	16.3	-	28.4	-	14.3	-	3.2 ns	6.2 **	2.1 ns	14.2 ***

LSD 5% = 4.40; 1% = 5.92; 0,1% = 7.86. LSD 5% =4.38; 1% = 6,01; 0,1% = 8.22.

Table 5

Combined influence of growing medium and variety on plant height (cm) 4 weeks after planting

Culture substrate/ Variet	Perlite (a_1)		Aeroponic culture (no substrate) (a_2)		Substrat clasic (turbă, perlit) (a_3) (Ct)		a1-a3/Sign.	a2-a3/ Sign.
	Plants height (cm)	Diff/Sign.	Plants height (cm)	Diff/Sign.	Plants height (cm)	Diff/Sign.		
Azaria	24.6	6.5 ***	41.0	12.6 ***	17.3	3.1 *	7.3 **	23.7 **
Brașovia	34.4	16.3 ***	47.1	18.7 ***	18.9	4.7 **	15.5 ***	28.2 ***
Cosiana	30.2	12.1 ***	45.9	17.5 ***	16.2	1.9 ns	14.0 ***	29.7 ***
Cezarina (Ct)	18.1	-	28.4	-	14.3	-	3.8 *	14.2 ***

LSD 5% = 3.05; 1% = 4.18; 0,1% = 5.69. LSD 5%= 3.28; 1% = 4.77; 0.1% = 7.33.

CONCLUSIONS

The varieties analyzed behaved differently regarding plant development depending on the culture systems and the substrates used.

Both when studying the influence of the variety on culture systems and culture substrates, Brasovia variety showed superior behavior to the other varieties, producing plants with the best developed stem.

Plants with the highest stem value (40.6 cm) are obtained in the aeroponic system, followed by the NFT culture system (30.2 cm).

Regarding the culture substrate, the plants reach high values in the aeroponic system without substrate (40.6 cm), followed by the perlite substrate (26.8 cm). The lowest plant height values are obtained on classic substrate (16.7 cm)

ACKNOWLEGMENTS

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REFERENCES

Atanasiu N.E., 2007 - *Culturi agricole fără sol, ediţia a II-a revizuită şi adăugită*, Editura ATAR, Bucureşti.

Barak P., Smith J.D., Krueger A.R., Peterson L.A. - 2006. *Measurement of short-term nutrient uptake rates in cranberry by aeroponics*, Plant Cell and Environment 19(2):237 – 242.

Broćić Z., Oljača J., Pantelić D., Rudić J., Momčilović I., 2022 - *Potato Aeroponics: Effects of Cultivar and Plant Origin on Minituber Production*, Horticulturae. 8(10):915. https://doi.org/10.3390/horticulturae8100915

Gericke W.F., 1937 - *Hydroponics Crop production in liquid culture media*. Science, 85: 177-178.

Gopinath P., Vethamoni I., Gomathi M., 2017 - *Aeroponics Soilless Cultivation System for Vegetable Crops*, Chemical Science Review and Letters, 6(22), 838-849.

Jones J.B., 2005 - *Hydroponycs: A Practical Guide for the Soilless Grower*, CRC Press, Boca Raton, FL.

Rajendran S., Domalachenpa T., Arora H., Li P., Sharma A., Rajauria G., 2024 - *Hydroponics: Exploring innovative sustainable technologies and applications across crop production, with Emphasis on potato mini-tuber cultivation.* Helyon 10 e26823.

Woznicki T., Møllerhagen P.J., Heltoft P., Kusnierek K., 2021 - *Growing Potatoes (Solanum tuberosum L.) Hydroponically in Wood Fiber—A Preliminary Case-Study* Report. Agronomy 2021,11, 1369. https://doi.org/10.3390/agronomy11071369

PHOMOPSIS CANCKER AND DIEBACK OF *ELAEAGNUS ANGUSTIFOLIA* L. FROM THE SPONTANEOUS FLORA OF IASI COUNTY, ROMANIA

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Abstract

Russian olive (*Elaeagnus angustifolia* L.) started to be regarded in the last time more as a very useful multipurpose tree species with a high potential for forest land reclamation, rather than a dangerous invasive one. In the perspective of contemporary climate change, characterized by higher temperatures and lower rainfall, Russian olive trees could gain more attention from foresters, ecologists and land managers who should develop an integrated management plan for this species. Nevertheless, due to one of the most serious diseases of *Elaeagnus angustifolia* L., that is caused by the fungus *Phomopsis elaeagni* Sandu. (1962) also phytopathologists attention and interest must be increased regarding the Russian olive trees. The disease symptoms were observed in May 2024 on the several branches of *Elaeagnus angustifolia* L. trees from a spontaneous flora area of Iasi county, Romania. The primary aim of the present study was to identify and at the same time to signal the presence of *Phomopsis elaeagni* fungus on the Russian olive tree in the mentioned area. In order to confirm the field diagnosis observed several laboratory determination were made, so the fungus can be identified and morphological described.

Key words: *Phomopsis elaeagni, fungus occurrence, Elaeagnus angustifolia*

Elaeagnus angustifolia L. (oleaster, Russian olive) is a small tree or large multistemmed shrub, member of the *Elaeagnaceae* family, which contains three genera (*Elaeagnus, Sheperdia, Hippophae*) and arround 80 species (Patel S., 2015). Species of *Elaeagnus* genera is widespread from north Asia and Himalaya to Europe being otherwise originating from Eurasia (Torbati M. *et al*, 2016). At the end of the XIX *Elaeagnus angustifolia* L. was also introduced in North America at the end of the XIX century as species used in fields affected by landslides or erosion or in horticulture. *Elaeagnus angustifolia* L. shows also some pharmacological and therapeutic effects, different parts of the plant species, especially fruits being used in the traditional medicine (Farzaei H.M., 2015; Hamidpour R., 2017).

In Romania, *Elaeagnus angustifolia* L is found predominantly as naturalized stand in steppe forest covers, on marine sands and on saltings (seashore, Danube Delta or along the other rivers), and primarly has a major ecologic purpose in fixing and improving unstable fields (ravines, shores, cloughs) or in preventing weeds and grazing (Dincă L., Timiş-Gânsac V., 2020).

Due to a synonymization following the one-fungus-one name paradigm linked both individual groups together, with the older name *Diaporthe* has receiv priority over *Phomopsis* (Rossman *et al*, 2015). Based on recent nomenclature changes (e.g. One fungus, One name), according to EPPO Global Database the name *Phomopsis* is considered a synonym of *Diaporthe*. Among disease symptoms causally linked to *Diaporthe* infections are leaf spots, cankers, dieback and fruit rots as well as decays and wilt (Guarnaccia *et al*, 2018).

Besides the fact that members of the genus *Phomopsis* (syn. *Diaporthe*) are most well-known as phytopathogens in agriculture and for the economically impactful through infections of grapevines, forest trees and plants of ornamental value their ubiquitous dispersion are conceivably among the main reasons why *Diaporthe* and the former *Phomopsis* spp. are studied extensively also for their capability to produce bioactive natural products (Xu *et al*, 2021).

In Romania, *Phomopsis elaeagni* was first mentioned by Sandu-Ville C., in 1962 (Bontea V., 1985). Due to the importance of the Russian olive tree for the foresters, ecologists and land managers knowing the occurrence and distribution of *Phomopsis elaeagni* the causal fungus of cancker and dieback of *Elaeagnus angustifolia* L. is also needed.

MATERIAL AND METHOD

The occurrence of the *Phomopsis* cancker and dieback on *Elaeagnus angustifolia* l. tree reported trough this article was observed in May 2024, to some Russian olive trees from a naturalized stand located in Rediu Aldei village at 4 km away from Aroneanu commune, Iasi city,

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Romania, GPS Coordinates: www. google.com/maps, accessed on May 2024, 47°14'17"N 27°38'02"E (*figure 1*).

Figure 1. **A natural habitat of *Elaeagnus angustifolia L.* located in Rediu Aldei village, Aroneanu commune of Iasi city, Romania. Blue mark represent the exact location of the plant material investigated. Red x marks the physical location of the plant tree.**

Branches of *Elaeagnus angustifolia* L. that presented perennial cankers observed in spur positions, cordons, and/or trunks were collected and investigated in the research laboratory of the phytopathology discipline within the "Ion Ionescu de la Brad" Iasi University of Life Sciences (IULS). After a putative micromycete identification based on visual symptoms, fungal morphology, as described by Rnold R.H and Straby A. E. (1973) or other specialized scientific guidance, we followed a standard procedure for fungal isolation in order to confirm the presence of *Phomopsis elaeagni* (syn *Diapothe elaeagni*) on *Elaeagnus angustifolia* L. (Úrbez-Torres J. R., *et al,* 2006). Forwards, infected tissues of Russian olive that showed characteristic dieback symptoms were cut into small pieces and then rinsed 3~4 times with diluted water after being treated with 70% (v/v) ethanol for 2~3 s. The treated tissues were transferred to potato dextrose agar (PDA) medium and cultured at 25 °C in order to isolate the fungus.

RESULTS AND DISCUSSIONS

Environmental conditions registred in the spring of 2024 showed to be favorable for *Phomopsis elaeagni* occurrence on Russian olive (*Elaeagnus angustifolia* L.) from a natural habitat situated in Rediu Aldei village, Aroneanu commune of Iasi city, Romania. Symptoms were first observed as a wilting of brances and twings of the Russian olive tree. Leaves on the infected branches become dry, turn tan and remained attached during all the growing season (*figure 2*).

Figure 2. **Wilted branches of the Russian olive tree affected by *Phomopsis* cancker (original).**

On branches smaller, around one centimeter in diameter infected bark remained smooth and becomes reddish brown or orange with dark brown margins. On larger branches canckers becomed sunken and rough textured. Cankers ranged from 2- 15 cm long but those of 2-10 cm prevailed. Sapwood beneath cancker were brown with discolored areas extended to a short distance outside the margins of diseased bark. *Phomospis elaeagni* developed on beneath the branches bark of *Elaeagnus angustifolia* and formed numerous black pycnidia, pinhead-sizead pimples, pushed thorugh the bark and roughen the canker surface (*figure 3*).

Pycnidial stromata of *Phomospsis elaeagni* formed in the bark of infected stems and branches becoming erumpent, subspherical, with closely adhering bark, less than 1 mm diameter, around 800 µm diameter and about 500 µm high, very numerous (*figure 4, a*).

Conidiophores (phialids) had a cylindrical shape, slightly inclined or occasionally branched once near the base (*figure 4, b*).

Figure 3 ***Phomopsis elaeagni* cancker on host plant branches of *Elaeagnus angustifolia* L. (original)**

In the pycnidial stromata on the host were found only alpha conidia, ellipsoidal, fusiform, sometimes more conical at one end, straight or slightly curved, hyaline, single (*figure 4, c*).

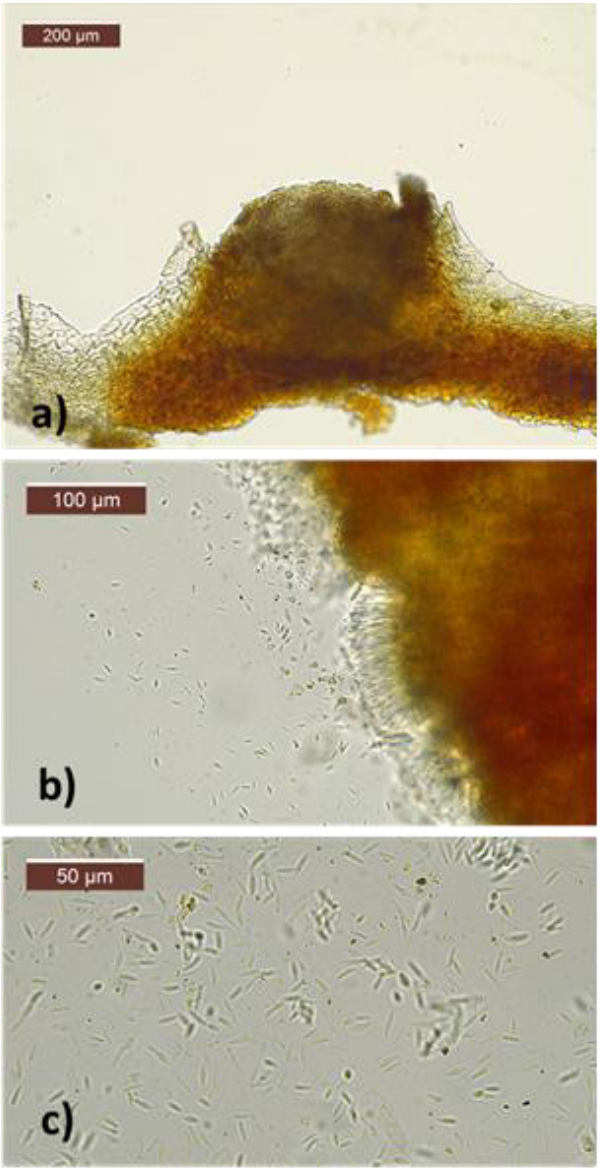

Figure 4 ***Phomopsis elaeagni:* a), b), sections trought picnidiol stomata; c) alpha conidia (original)**

The *Phomopsis* fungus can overwinte in cankers as mycelium and pycnidia. Conidia are produced in large numbers during extended periods of wet weather and usually are spread by insects, splashing water, or mechanically by man. Primarlly path of entry into healthytree tissue is through bark wounds, branch stubs and damaged thorns. The fungus is virulent and can infect Russian olive trees of all sizes throughout the growing season.

CONCLUSIONS

Considering the severity of the symptoms described, *Phomopsis elaeagni* (syn. *Diapothe elaeagni*) is an aggressive pathogen that can attack vigorous trees and it is also a serious threat to young nursery-grown Russian olive trees as well as toolder trees in ornamental plantings.

Even if the genus *Diaporthe* recieved priority over *Phomopsis* and is a group of fungi frequently reported as phytopathogens, their importance for agriculture and biotechnology attracts constantly the interest of taxonomists and natural product chemists alike in context of plant protection and exploitation for their potential to produce bioactive secondary metabolites.

REFERENCES

Bontea V, 1985 - *Ciuperci parazite si saprofite din Romania***,** Editura Academiei Republicii Sociale Romania, Bucuresti, Vol. I, 303 p**.**

Dincă L., Timiș-Gânsac V., 2020 - *Oleaster (Eleegnus angustifolia L.) – A Constituent Element of the Biodiversity from Dobrogea Plateau,* Journal of Horticulture, Forestry and Biotechnology, Volume 24(1), 17 – 22.

Farzaei H. M., Bahramsoltani R., Abbasabadi Zahra, Rahimi R., 2015 - *A comprehensive review on phytochemical and pharmacological aspects of Elaeagnus angustifolia L.* Journal of Pharmacy and Pharmacology, 67: 1467–1480.

Guarnaccia V., Groenewald J.Z., Woodhall J., Armengol J., Cinelli T., Eichmeier A., Ezra D., Fontaine F., Gramaje D., Gutierrez-Aguirregabiria A., Kaliterna J., Kiss L., Larignon P., Luque J., Mugnai L., Naor V., Raposo R., Sándor E., Váczy K.Z., Crous P.W., 2018 - *Diaporthe diversity and pathogenicity revealed from a broad survey of grapevine diseases in Europe.* Persoonia 40(1): 135–153. https://doi.org/10.3767/persoonia.2018.40.06

Hamidpour R., Hamidpour S., Hamidpour M., Shahlari M., Sohraby M., Shahlari N., Hamidpour R., 2017 - *Russian olive (Elaeagnus angustifolia L.). From a variety of traditional medicinal applications to its novel roles as active antioxidant, anti-inflammatory, antimutagenic and analgesic agent.* Journal of Traditional and Complementary Medicine, 7(2): 24-29.

Patel S., 2015 - *Plant genus Elaeagnus: underutilized lycopene and linoleic acid reserve with permaculture potential,* Fruits, 70(4), 191-199.

Rnold R.H. and Straby A. E., 1973- *Phomopsis elaeagni on Russian olive (Elaeagnus angustifolia) in Canada, Can. Plant dis. Surv., vol. 53, 4:183-186.*

Rossman A.Y., Adams G.C., Cannon P.F., Castlebury L.A., Crous P.W., Gryzenhout M., Jaklitsch M., Mejia L.C., Stoykov D., Udayanga D., Voglmayr H., Walker D.M., 2015 - *Recommenda-tions of generic names in Diaporthales competing for protection or use.* IMA Fungus 6(1): 145–154. https://doi.org/10.5598/imafungus.2015.06.01.09

Torbati M., Asnaashari S., Heshmati A.F., 2016 - *Essential Oil from Flowers and Leaves of Elaeagnus Angustifolia (Elaeagnaceae): Composition, Radical Scavenging and General Toxicity Activities.* Advanced Pharmaceutical Bulletin, 6(2):163-169

Úrbez-Torres J. R., Leavitt G. M., Voegel T. M., and Gubler W. D. 2006 - *Identification and distribution of Botryosphaeria spp. associated with grape-vine cankers in California.* Plant Dis. 90:1490-1503.

Xu T.C., Lu Y.H., Wang J.F., Song Z.Q., Hou T.G., Liu S.S., Liu C.S., Wu S-H., 2021 - *Bioactive secondary metabolites of the genus Diaporthe and anamorph Phomopsis from terrestrial and marine habitats and endophytes: 2010–2019. Microorganisms 9(2): 1–49. https://doi.org/10.3390/microorganisms9020217*

***https://gd.eppo.int/taxon/1PHOPG *(accessed in 12.09.2024)*

ALTERNARIA HEAD ROT ON SUNFLOWER IN THE NE REGION OF ROMANIA

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Abstract

Alternaria sp. infections can produce a major disease on sunflower worldwide, with yield losses as high as 60-80%, especially in warm and humid areas of Europa, India, Australia, America and some parts of Africa. Species as *Alternaria zinniae* and *Alternariaster helianthi* are responsible for Alternaria leaf blight and stem spot, that is considered a middling frecvent foliar disease on sunflower in Romania culture conditions. During summer 2024 diseased sunflowers plants with numerous tan or light-brown, slightly sunken cankers and scattered over the bracts and the back of the receptacle were observed in the climatic conditions from Iasi county, located in the NE region of Romania. Observations from the field revealed an extremely high percentage of affected plants, over 60% of the sunflower plants showed attack symptoms on the heads and seeds. According to the carried out analyzes, both by *Alternaria zinniae and Alternariaster helianthi*, were morphologically identified and described. Considering the fact that the genus *Alternaria* is ubiquitous and abundant in the atmosphere, as well as in soil, seeds and crop residues, but also of the increasingly pronounced climate changes and the EU regulations on the reduction of pesticide use and crop rotation, a strong knowledge and constant observations on this type of phytopathogens become essential.

Key words: head rot, sunflower, *Alternaria zinnia, Alternariaster helianthi.*

Sunflower (*Helianthus annuus* L.) is one of the most important sources of vegetable oil in Romania. In 2023, Romania ranked second in the European Union in terms of sunflower production, after France, with an area of 1,089 milion ha under cultivation with a production of about 2,028 milion tonnes, according to data published by the National Institute of Statistics (INS).

The genus *Alternaria* is ubiquist and frequent in the atmosphere as well in soil, seeds, and difrent agricultural commodities. It includes both plant pathogenic and saprophytic species that may affect crops in the field or can cause harvest and postharvest decay of plant products (Udayashankar A.C. *et al*, 2012). Besides these aspects *Alternaria* has a high mycotoxicological risk in preharvest or freshly harvested plant undergoing drying (Logrieco A. *et al*, 2003).

Alternaria spp. are dematiaceous hyphomycetes belonging to the phylum *Ascomycota* and five species have been reported both as leaf blight and stem spot pathogens and for Alternaria head rot on sunflower. In warm, humid areas of central Europe, India, Australia, North and South America, and parts of Africa, Alternaria leaf blight is a major disease of sunflower and can cause severe infestations with defoliation and yield losses as high as 60-80%. In Romania, for sunflower crop are reported three species of *Alternaria*: *Alternaria helianthi, Alternaria zinniae* and the ubiquistous saprophyte *Alternaria alternata* that is an opportunistic colonizer of insect wounds and fungal lesions who may colonize the canckers and cause additional head rot. Among them, *Alternaria helianthi* (syn. *Alternariaster helianthi* (Hansford) E.G. Simmons) is the dominant species in all sunflower vegetation stages (Raranciuc S., Pacureanu-Joita M., 2002). Even if it is found in the same warm and humid environments as alternaria leaf blight and steam spot, Alternaria head rot is a relatively minor disease on sunflower, caused primarly by *Alternariaster helianthi* and *Alternaria zinnia* (Harveson M.R. *et al*, 2016). Considering the climatic change characterized by a rise in temperature and absolute humidity and the fact *Alternaria* can be a seed fungus and can introduce the disease to a new location management strategies are needed to prevent further spread. Permanently worldwide, the specialized scientific literature reports new occurrences of leaf blight or head rot on sunflower caused by *Alternaria* species (Kgatle, M.G. *et al*, 2019; Hussain M. *et al*, 2023).

MATERIAL AND METHOD

The presence of *Alternaria* head rot on sunflower was observed in August 2024, to some

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commercial sunflower crops located in Tiganasi commune from the northeast of Iasi county, on the shore left of the Jijia River, Romania (GPS Coordinates 47°20′50″N 27°27′28″E).

Observed sunflower plants with symtoms of *Alternaria* head rot were collected from two plots, a plot about 72 ha cultivated with Suvex SU hybrid and another plot by 100 ha cultivated with Arnetes SU hybrid. Both hybrids are semi-late and resistant to the application of approved herbicides from the sulfonylurea family. The cultivation process followed conventional practices in irrigated systems conditions. Afectted sunflowers head were brought to the research laboratory of the Phytopathology discipline, within the "Ion Ionescu de la Brad" Iasi University of Life Sciences (IULS). In order to isolate and identify the pathogen, seeds and small pieces of infected tissues cuted from sunflower head were sterilized for 3 minutes with a NaOCl (5%) solution before being repeatedly washed with distilled water. Thus, seeds and treated tissues were transferred to potato dextrose agar (PDA) medium and cultured at 25 °C (Mathur S.B., Kongsdal O., 2003).

Thus, pathogen identification was based on sunflower head rot symptoms, on the colony characters grown on PDA medium after the fungus isolation but also on conidia and conidiophore morphology, as described by Simmons E.G. (2007) or other specialized scientific guidance.

RESULTS AND DISCUSSIONS

High temperature and increased absolute humidity during the summer of 2024 certainly represented a favorable factor in the occurance of the attack of the pathogens on sunflower crops. During August 2024, in two sunflower plots located in Tiganasi commune were observed symptoms characteristic of *Alternaria* head rod disease to over 60% of the sunflower plants (Fig. 1).

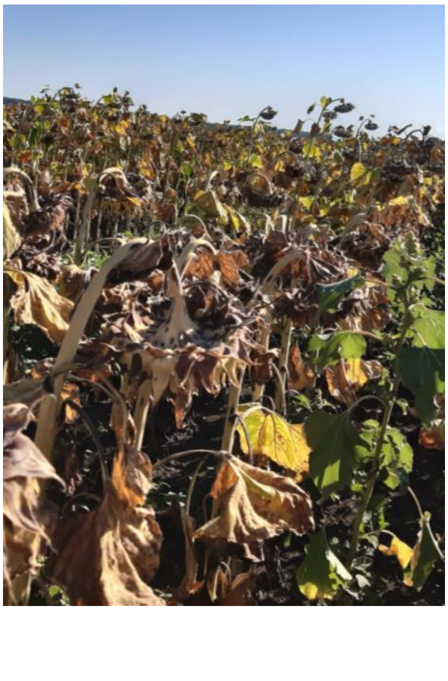

Figure 1. **Infection by *Alternaria* sp. resulting in severe head rot on sunflower (original)**

Affected sunflowers present numerous tan or light-brown, slightly suncked cankers about 0,25-1,5 cm in diameter were scattered over the bracts and the back of receptacle Continuing the observations, canckers becomed more deeply sunken in the fleshy receptacle tissues, and they darked as the pathogen sporulated on rotted tissues (Fig. 2).

Figure 2. **Suncken cankers of *Alternaria* head rot on sunflower heads (original)**

The sunflower heads were severe colonized and seeds to were infected and presented mycelia and conidia characteristic of *Alternaria* genus (Fig. 3). After the fungal isolation from infected head samples and seeds, based on grown cultures and morphology characteristics *Alternariaster helianthi* and *Alternaria zinniae* were identified.

Figure 3. **Mycelium of *Alternaria* sp. grown on sunflower seeds (original)**

Alternariaster helianthi (Hansf.) E.G. Simmons, syn. *Alternaria helianthi* (Hansf.) Tubaki & Nishih. isolate presented conidia about 80–160 × 18–30 µm, without oblique or transverse septa, which though rare. Fungus conidiophores were hypophyllous, solitary or in small groups, straight to slightly sinuous, 100–225 × 7.5–10 µm, simple, 3–6-septate, pale to chestnut-brown and smooth (Fig. 4). On PDA culture characteristics presented a growing about 30–40 mm diameter after 10 days, colony raised centrally, aerial mycelium felted, white, having a wide periphery of flat, sparse, olivaceous-buff to greenish glaucous mycelium, with irregular margins.

The genus *Alternariaster* was first described by Simmons (2007) with *Alternariaster helianthi* (formerly *Alternaria helianthi* and *Helminthosporium helianthi*) as type, and has hitherto been monotypic (Alves J.L. *et al*, 2013). Some phylogenetic analysis confirm Simmons's segregation of *Alternariaster* from *Alternaria*, by showing that *Alternariaster* is a well-delimited taxon belonging to the *Leptosphaeriaceae*, instead of the *Pleosporaceae* to which *Alternaria* belongs (Schoch *et al*, 2009).

Figure 4. **Hyphae and conidia of *Alternariaster helianthi* (original)**

Alternaria zinniae M. B. Ellis isolated both from infected head tissue samples and seeds, showed mostly single obclavate conidia (Fig. 3), pale to dark brown, 3-12 traverse septa, o,9 longitudinal, few oblique, body 19-105 x 9-28,5 µm with filiform beak, simple, reaches 6-160 µm with 0-3 transverse septa. Rarely a secondary conidium appeared.

Figure 5. **Conidia of *Alternaria zinniae* (original)**

Conidia of *Alternaria zinniae* isolated from sunflower infected tissues presented a club shape and either long beaks while *Altternariaster (Alternaria) helianthi* produced septate, cilindical conidia rounded at the ends, and subhyaline to midpale olivaceous brown.

CONCLUSIONS

Usually, natural infections with *Alternaria* spp. occurre each year to sunflower, in low to medium levels of disease intensity depending primarly on weather conditions. Extremely high temperature and a rise absolute humidity during the 2024 growing season conducted to the occurence of a severe disease as head rot on sunflower produced by *Alternariaster helianthi and Alternaria zinniae.*

Alternaria pathogen can be localized both out-side and inside, germination of the seeds it is definitely maintained.

This two *Alternaria* species represent a threatening pathogen of sunflower under certain conditions. Thus, more research on this disease is needed, including the effects of crop rotation, fungicides, development of genetic resistance, and other control measure.

REFERENCES

Alves J.L., Woudenberg J.H.C., Duarte L.L., Crous P.W., Barreto R.W., 2013- *Reappraisal of the genus Alternariaster (Dothideomycetes),* Persoonia- Molecular Phylogeny and Evolution of Fungi, Vol. 31: 77–85.

Harveson M.R., Markell G.S., Block C.C., Gulya T.J., 2016 - *Compendium of Sunflower Diseases and Pets,* Part I, APS Press, 978-0-89054-507-2.

Hussain M., Algam S., Baillo E., Mohamed B., Ahmed Y, 2023 - *First report of Alternariaster helianthi causing leaf blight disease of sunflower (Helianthus annus) in Sudan,* New Disease Reports: Volume 47, Issue 2, e12167.

Kgatle, M.G., Flett, B., Truter, M., Ramusi, M., Aveling, T., 2019 - *Distribution of Alternaria leaf blight of sunflowers caused by Alternaria alternata in South Africa.* Journal of Agriculture and Rural Development in the Tropics and Subtropics, 120, 71–77.

Logrieco A., Bottalico A., Mul'eG., Moretti A., Perrone G., 2003 - *Epidemiologgy* **o**f *toxigenic fungi and their associated mycotoxins for some Mediterranean crops,* European Journal of Plant Pathology, 109:645-667.

Mathur S.B., Kongsdal O., 2003 – *Common laboratory seed health testing methods for detecting fungi*, International Seed Testing Association, CH-Denmark, ISBN 3 -906549-35-6.

RARANCIUC S., PACUREANU-JOITA M., 2002 - *Evaluation of some sunflower genotypes concerning the reaction to Alternaria spp. pathogen.* Romanian Agricultural Research, 17-18, 29-40.

Schoch CL, Crous PW, Groenewald JZ, Boehm EWA, Burgess TI, et al, 2009 - *A class-wide phylogenetic assessment of Dothidiomycetes. Studies*, Mycology, 64: 1–15.

Simmons E.G., 2007 - *Alternaria- An identification Manual.* Utrecht Netherlands: CBS Fungal Biodiversity Centre.

Udayashankar A.C., Chandra Nayaka S., Archana B., Anjana G., Niranjana S.R., Mortensen C.N., Lund O.S., Prakash H.S., 2012 - *Specific PCR-based detection of Alternaria helianthi: the cause of blight and leaf spot in sunflower.* Arch Microbiol.;194(11):923-32.

***** Institutul National de Statistica, 2024 -** *Producția vegetală la principalele culturi în anul 2023, Comunicat de presa, nr. 78/ 29. 03. 2024.*

THE INFLUENCE OF TREATMENTS WITH VARIOUS PHYTOSANITARY PRODUCTS (FUNGICIDES) ON THE ATTACK OF SOME PHYTOPATHOGENIC FUNGI ON WHEAT HARVEST – GLOSA VARIETY - IN 2023 PEDOCLIMATIC CONDITIONS OF THE EASTERN BARAGAN

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Abstract

This study aims at monitoring the dynamics of the occurrence and evolution of the attack of some pathogens to Glosa Romanian wheat variety, among which we mention: *Puccinia recondita* f. sp. tritici (sin. *Puccinia triticina*) which produces wheat's brown rust and *Septoria* sp. which produces wheat's brown leaf spotting (septoriosis). The influence of applying these fungicides on the harvest, as compared to the untreated control variant, has also been monitored. One experiment with 5 variants (4 variants with phytosanitary treatment, plus one control variant not treated) was taken into consideration for this study, for which the following phytosanitary products were used, as follows: NATIVO PRO 325 SC (prothioconazole 175 g/l + trifloxystrobin 150 g/l) and RETENGO (Pyraclostrobin 200 g/l). The treatment variants were the following: V1 – NATIVO PRO 325 SC 0.7 L/HA, 1 treatment applied at booting – flowering phase; V2 - RETENGO 0.5 /L/HA, 1 treatment applied at booting – flowering phase, V3 - NATIVO PRO 325 SC – 0.7 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel filling; V4 - RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel filling and V5 – Control variant not treated. The experiment was placed in Latin square, the 5 variants being placed in 5 repetitions. The year 2023 was a year with a relatively wet spring and early summer. The experiment was irrigated in the spring of 2023 with the norm of 600 m^2 of water / ha. The experiment was established after rapeseed. The climatic conditions were favorable to the attacks of some wheat pathogens, at higher values than in 2022, year which was very dry. The yields of the variants were as follows: V1 – 7,056 t/ha, V2 – 7,287 t/ha, V3– 6,783 t/ha, V4 – 6,783 t/ha and V5 (control variant not treated) – 6,720 t/ha.

Key words: *Puccinia, Septoria*, Latin square

The wheat, *Triticum aestivum*, is attacked by many pathogenic agents, such as: mildew - *Blumeria graminis* f.sp. *tritici*, brown rust - *Puccinia recondita* f. sp. *tritici*, brown leaf spotting - *Septoria tritici*, *Septoria nodorum*, stem's fusariosis and ear's rot *Giberella zeae*, *Giberella avenacea* (Iacob V. *et al*, 1998). The first half of 2023 was, for wheat, more favorable in terms of climatic conditions, compared to the first half of 2022. The first half of 2023 was richer in rainfall than the similar period of 2022. During this period, rainfall was recorded in relatively moderate quantities. Average temperatures were lower than in the same period of 2022. In February, the average temperature was 2.5^{0}C and rainfall totaled 9.3 l/m² and the average relative humidity was 71%. In March, the average temperature was 9^{0}C, the average relative humidity was 60% and rainfall totaled 24 l/m². In April, the average temperature was 14.5^{0}C, precipitation totaled 53 l/m² and the average relative humidity was 70%. In May, the average temperature recorded was 16.5^{0}C, precipitation totaled 41 l/m² and the average relative humidity was 59%. In June, the average temperature recorded was 21^{0}C, rainfall totaled 20.5 l/m^2 and the average relative humidity was 46%. Under these conditions, *Septoria* sp. fungus, which produces, in wheat, diseases known as brown leaf spotting (septoriosis), made its presence felt. We emphasize that this phytopathogenic fungus has made its appearance in some years with rainier and cooler springs to a greater extent than the *Puccinia recondita* f. sp. *tritici* phytopathogenic fungus. The attack of the *Gibberella* genus fungi was practically absent, probably due to the fact that June came with high temperatures and an air humidity of only 46%. The 20.5 l/m^2 of rainfall accumulated in June resulted from light rains of 2-5 l/m^2, which were staggered during this month.

The experiment received a watering in May 2023 to complete the amount of water from rainfall. This watering contributed substantially to obtaining a good wheat production, especially since June turned out to be poorer in rainfall than April and May 2023.

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Table 1

The results of the experiment with fungicide products (4 variants of treatment + 1 untreated control variant) in what concerns the attack (D.A.%) of *Septoria* sp. fungus ("flag" leaf and the next leaf). The observations had been made on 12th June 2023

	"Flag" leaf			Second leaf		
Variant	D.A. %	Difference as compared to the control variant	Significance	D.A. %	Difference as compared to the control variant	Significance
V1 - NATIVO PRO 325 SC 0.7 L/HA, 1 treatment applied at booting – flowering phase	34.76	38.24	**	90.00	7.50	**
V2 - RETENGO 0.5 L/HA, 1 treatment applied at booting – flowering phase	35.76	37.24	**	85.50	12.00	**
V3 - NATIVO PRO 325 SC – 0.7 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel filling	36.26	36.74	**	89.00	8.50	**
V4 - RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel filling	34.00	39.00	**	89.50	8.00	**
V5 - Untreated control variant	73.00	-	-	97.50	-	-

LD D.A. % for "flag" leaf
LD 5%= 5.68%
LD 1%= 7.83%

LD D.A. % for the second leaf
LD 5%= 5.26%
LD 1%= 7.24%

Table 2

The results of the experiment with fungicide products (4 variants of treatment + 1 untreated control variant) in what concerns the yield (t/ha) obtained at the treated variants, as compared to the untreated control variant

Variant	Yield (t/ha)	Difference as compared to the control variant (t/ha)	Significance
V1 - NATIVO PRO 325 SC 0.7 L/HA, 1 treatment applied at booting – flowering phase	7.056	0.420	*
V2 - RETENGO 0.5 /L/HA, 1 treatment applied at booting – flowering phase	7.287	0.567	**
V3 - NATIVO PRO 325 SC – 0.7 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel filling	6.783	0.063	Not significant
V4 - RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel filling	7.035	0.315	Not significant
V5 - Untreated control variant	6.720	-	-

LD 5% =0.345 t/ha
LD 1% =0.475 t/ha

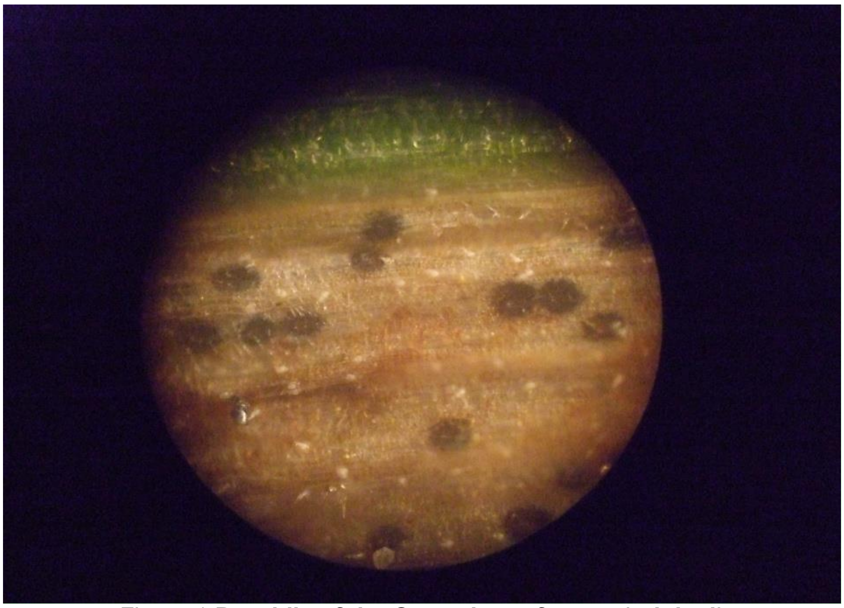

Figure 1 **Pycnidia of the *Septoria* sp. fungus (original)**

Figure 2 **Aspects from the experimental field (original)**

MATERIAL AND METHOD

1 experiment with 5 study variants each had been conceived for performing the observations. This experiment comprised 4 phytosanitary treatment variants (fungicide products containing various active substances) and one untreated control variant. The variants of the experiment were the following:

- V1: NATIVO PRO 325 SC 0.7 L/HA, 1 treatment applied at booting – flowering phase;
- V2: RETENGO 0.5 /L/HA, 1 treatment applied at booting – flowering phase;
- V3: NATIVO PRO 325 SC – 0.7 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel filling;
- V4: RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel filling;
- V5: Untreated control variant.

The experiment was placed in Latin square; the 5 variants were placed in 5 repetitions. Each experimental plot had an area of 15 m^2 (5 x 3m). The total number of experimental plots was 25. The surface of an experimental variant was of 15 m^2 x 5 repetitions = 75 m^2. The total area of the experiment was of 75 m^2 x 5 = 375 m^2. The treatments had been performed manually, with a "Vermorel" type of equipment. Weed control was achieved with the help of Mustang herbicide (6.25 g / l florasulam + 300 g / l 2.4-D EHE acid) at a dosage of 0.6 l / ha applied, separately, with the vermorel. The experiment has shown the effectiveness of the above-mentioned phytosanitary products in relation to their price. The efficiency and, respectively, the profitability of applying a single treatment to a product with a fungicidal effect or two phytosanitary treatments with a product with a fungicidal effect were also monitored during wheat's vegetation period. It was taken into account that the spring of 2023 was rainier and cooler than the spring of 2022.

The assessment of the attack's frequency (F%), of attack's intensity (I%) and respectively of the degree of attack (D.A.%) was done separately, on each and every experimental plot, being analyzed 10 plants / experimental plot. The degree of affectation (attack intensity, I%) of the last two leaves was assessed, especially of the "flag" leaf which has the greatest contribution to the ear's production at strawy cereals. The phytosanitary analyses on the plants' samples had been done with the help of the stereo-microscope and of the optic microscope at the laboratory of Braila's Phytosanitary Office – National Phytosanitary Authority, institution subordinated to the Ministry of Agriculture and Rural Development. These analyses have revealed in the analyzed samples the presence of *Septoria* fungus which produces in wheat the disease known as septoriosis. Other pathogenic agents specific to wheat (*Blumeria* sp. *Puccinia* sp.) were signaled in the climatic conditions of the first half of the year 2023, but in a smaller percentage.

For assessing the yield of each variant under study, samples of kernels from each experimental plot, 5 samples each / plot, had been analyzed by spot check. Each sample contained 20 plants, so 100 plants had been taken from each experimental plot, for which the yield was weighted manually. The delimitation of each sample was done with a metric frame with an area of 0.25 m^2 (0.5/0.5m). The average of the samples from the experimental plots was used for calculating the yield of each experimental parcel. The statistic interpretation was executed with the help of limit differences (LD %) (Săulescu N., 1967).

The used variety, Glosa, is a Romanian variety created by the Fundulea National Agricultural Research & Development Institute. Glosa variety is an early variety. It has good resistance to falling, resistance to wintering, drought and heat and it has a good resistance at sprouting into ear. It has average resistance to brown rust and is resistant to mildew and to the actual strains of yellow rust (Fundulea Seeds Company, 2021).

The assessment of pest attack can be done with the help of the following values (Methods of Prognosis and Warning 1980):

- Frequency of attack (F%);
- Intensity of attack (I %);
- Degree of attack (D.A %).

- The frequency of attack represents the relative value of the number of plants or organs of the plant under attack (n) reported to the number of observed plants or organs (N). The value of the frequency is established by direct observation on a number of plants or organs, according to the case and to the conditions, existing different methods of sample taking and for performing the observations. In the case of our observations, for the foliar diseases, the number of attacked plant organs out of the total of observed plant organs (leaves) was taken into consideration, being thus established the attack's frequency expressed in percentages %. In the case of blights (*Ustilago* sp), it is used the number of wheat's attacked ears, as reported to the total number of observed ears. The frequency is calculated with the formula F%= nx100/N.

- The intensity of the attack represents the degree or percentage whereby a plant or a plant's organ is attacked and how much from the surface of the plant or of the organ analyzed (leaf, fruit) is covered by the disease under study.

- The assessment of the surface under attack is done with the naked eye or with the magnifying glass, assessing the percentage occupied by spots or burns caused by the pathogenic agent. The affectation percentages can be noted or grades can be given for each plant or organ attacked by the disease and/or by the pest. The usage of grades can make easier data summarization in a great extent. It can be used a scale with 6 degrees of intensity, as follows:

- Grade 0 no attack
- Grade 1 attack between 1 and 3%
- Grade 2 attack between 3 and 10%
- Grade 3 attack between 11 and 25%
- Grade 4 attack between 26 and 50%
- Grade 5 attack between 51 and 75%
- Grade 6 attack between 76 and 100%

After data's summarization, the attack's intensity is determined by the formula:

$$I\% = \frac{\Sigma (i \times f)}{n}$$

Where:

I% – attack's intensity (in %);

i – intensity according to the grade given to the organ or plant under attack;

f – number of cases (plants, organs) attacked;

n – number of plants attacked.

Grades from 1 to 6, separately, to the "flag" leaf and to the next leaf situated beneath it, had been awarded in our experiment.

- The degree of attack is the expression of the extension of the severity of the attack onto the crop or onto the total number of plants on which we perform the observations. The following relation gives the value expression of D.A.:

$$D.A\ (\%). = \frac{F \times I}{100}$$

In most cases, there is a negative correlation between the degree of attack of a pathogenic agent or pest and the quantitative and/or qualitative level of production

RESULTS AND DISCUSSIONS

The first half of 2023 was more favorable to the onset of the attack of the wheat-specific pathogen complex compared to the similar period of 2022, which was particularly dry. Unlike the previous year, the months of February, March, April and May were richer in rainfall than in 2022. These months were also a little cooler than in 2022. In the autumn of 2022, relatively richer rainfall fell than in the autumn of 2021. Under these conditions, the plants sprang up in time to get through the winter of 2022-2023. This winter was relatively warm compared to the average of previous years. The crop was irrigated in the spring of 2023 with 600 m^2 of water per ha.

Regarding the dynamics of the occurrence of pathogen attacks on wheat, we mention that the pathogen that appeared in the experiment in 2023 was the *Septoria* sp. fungus which produces wheat septoriosis at values of the degree of attack (D.A%) much higher than in 2022.

If we analyze the data in table 1, we notice that the degree of attack of the pathogens monitored, on each treatment variant, was as follows:

- V1 determined a degree of attack (D.A.) of the *Septoria* sp fungus of **34.76**% in the "flag" leaf, and 90.00% in the second leaf, therefore lower by **38.24**% and, respectively, by **7.50**% than the untreated control variant (V5).
- V2 determined a degree of attack (D.A.) of the *Septoria* sp fungus of **35.76**% in the "flag" leaf, and 85.50% in the second leaf, therefore lower by **37.24**% and, respectively, by **12.00**% than the untreated control variant (V5).
- V3 determined a degree of attack (D.A.) of the *Septoria* sp. fungus of **36.26**% in the "flag" leaf, and of 89.00% in the second leaf,

therefore lower by **36.74**% and, respectively, by **8.50**% than the untreated control variant (V5).

- V4 determined a degree of attack (D.A.%) of the *Septoria* sp. fungus of **34.00**% for the "flag" leaf, and 89.50% for the second leaf, therefore lower by **39.00**% and, respectively, by **8.00**% than the untreated control variant (V5).
- V5 untreated control variant showed a degree of attack (D.A.%) of the *Septoria* sp. fungus of **73.00**% on the "flag" leaf, and 97.50% on the second leaf.

All differences in the degree of attack (D.A.%) are statistically assured, according to Table 1.

From the analysis of table 2, the yield differences compared to the untreated control variant V5 can be observed, as follows:

- V1 achieved a yield of 7.056 t/ha, so 0.420 t/ha lower than the control variant.
- V2 achieved a yield of 7.287 t/ha, so 0.567 t/ha higher than the control variant.
- V3 achieved a yield of 6.783 t/ha, so 0.063 t/ha higher than the control variant.
- V4 achieved a yield of 7.035 t/ha, so 0.315 t/ha lower than the control variant.
- V5 - The untreated control variant achieved a yield of 6,720 t/ha.

The yield increases of the variants V1 NATIVO PRO 325 SC 0.7 L/HA 1 treatment applied to booting – flowering phase and V2 RETENGO 0.5 L/HA, 1 treatment applied to the booting – flowering phase present statistical assurance, compared to the V5 - untreated control variant.

CONCLUSIONS

The observations made in the summer of 2023 on the experiment with the Romanian wheat-variety Glosa, led to the following conclusions and recommendations:

1 - The attacks of some pathogens were higher than in 2022. Among these, *Septoria* sp, which produces, in wheat, diseases known as septoriosis, has mainly appeared. The values of the degrees of attack of this phytopathogenic fungus, both in the "flag" leaf and in the second leaf had significantly higher values than in the untreated control variant.

2 - For a good protection of the wheat crop, in case of using the Romanian variety Glosa, we recommend performing, especially in years with moderately humid and cool springs, a single treatment with fungicides, applied in the booting - flowering phase of the wheat plants.

3 – In the years with springs with rainfalls, higher atmospheric humidity and lower temperatures, we recommend performing two treatments with fungicidal plant protection products.

4 - The prices (2024) of the products with fungicide effect used in 2023 are as follows:

- NATIVO PRO 35 SC costs about 212 lei/l (42.5 €/l)
- RETENGO costs about 200 lei/l (40 €/l)

For the V1 variant, 1 treatment with NATIVO PRO 35 SC 0.7 l/ha was applied, i.e. the total cost with the phytosanitary product/ha was 148 lei/ha (approx. 29.6 €/ha)

For the V2 variant, 1 treatment with RETENGO 0.5 l/ha was applied, i.e. the total cost with the phytosanitary product/ha was 100 lei/ha (approx. 20€/ha).

For the V3 variant, 2 NATIVO PRO 325 SC 0.7 l/ha treatments were applied, the total cost with the fungicide product/ha was 296 lei/ha (approx. 59.2 €/ha)

For the V4 variant, 2 treatments with RETENGO 0.5 l/ha were applied, the total cost with the fungicide product/ha was 200 lei/ha (approx. 40 €/ha)

The differences in yield, expressed value wise (lei) compared to the untreated control variant (V5), were as follows:

- For V1, the difference was of 0.420 t/ha, amounting to 420 lei/ha (84 €/ha);
- For V2, it was of 0.567 t/ha, amounting to 567 lei/ha lei/ha (113 €/ha);
- For V3, it was of 0.063 t/ha, amounting to 63 lei/ha (12.6 €/ha);
- For V4, it was of 0.315 t/ha, amounting to 315 lei/ha (63€/ha);

The yield of the untreated control variant was 6,720 t/ha.

We emphasize that the V3 and V4 variants do not present statistical assurance.

4 - From the analysis of the economic profitability, in the climatic conditions of 2023, which was rainier and cooler in the first half, compared to the similar period of 2022, the most cost-effective turned out to be the variants V1 NATIVO PRO 325 SC 0.7 L/HA, 1 treatment applied to the booting - flowering phase and V2. RETENGO 0.5 L/HA, 1 treatment applied to the booting – flowering phase. Under these conditions, we recommend, in years with relatively wet and cool springs, to carry out a single treatment, in the wheat's vegetation phase of booting - flowering, a treatment with a more performant fungicidal product, such as one of those used in this experiment. In the years with springs when rainfall

falls above the multi-year average of the area and temperatures are lower than usual, we recommend two treatments with more performing fungicide products.

5 – In the years with dry and hot winters and springs, a single treatment with products with a fungicidal effect, cheaper, such as those based only on tebuconazole, can be applied to wheat. Here we mention: ARMADA (250 g/l tebuconazole) at a dosage of 0.5 l/ha, ORIUS 25 EW (SALVATOR 25 EW - second trade name) 0.5 l/ha, MYSTIC GOLD -1.0 l/ha according to the Pest-Expert website of the National Phytosanitary Authority, a structure subordinated to the Ministry of Agriculture and Rural Development of Romania.

6- The price of wheat, quoted for export, was, in Romania, on 1st August 2024, about 1.0 lei/kg - about 200€/to (Cereal Exchange 2024).

7-The average leu/€ exchange rate, in the months of April, May and June of 2024 was 4.9751 lei/€1, according to the National Bank of Romania's website.

REFERENCES

Iacob Viorica, Hatman M., Ulea E., Puiu I., 1998 – *Agricultural phytopathology,* **"**Ion Ionescu de la Brad" Publishing House, p. 16-18, 26-28, 31-33.

Săulescu N., 1967 - *Experiment field*, Agro-Silvică (Agro–Sylvan) Publishing House, Bucharest, p. 217, 311.

Velichi E., 2012 - *General and special phytopathology*, Universitară (University) Publishing House, Bucharest, p. 136-137.

*** *National Bank of Romania* 2024 (web page).

******* *Cereal Exchange 2024* (web page)

*** *Fundulea Seeds Company 2021* (web page).

*** 1980 *Methods of Prognosis and Warning*, 1980 M.A.I.A., Bucharest, p. 7-9.

*** *Pest – Expert website*, the National Phytosanitary Authority, Ministry of Agriculture and Rural Development.

THE INFLUENCE OF TREATMENTS WITH VARIOUS PHYTOSANITARY PRODUCTS (FUNGICIDES) ON THE ATTACK OF SOME PHYTOPATHOGENIC FUNGI ON BARLEY HARVEST, DONAU VARIETY, IN 2023 PEDOCLIMATIC CONDITIONS OF THE EASTERN BARAGAN

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Abstract

This study aims at monitoring the dynamics of the occurrence and evolution of the attack of some pathogens to barley, among which we mention: mildew (*Blumeria graminis* f.sp. *hordei*), leaf stripe (*Pyrenophora graminea*) and barley's rust (*Puccinia hordei*). Also, the influence of applying these fungicides on the harvest, as well as of the number of treatments/ha as compared to the untreated control variant, has been monitored. For this study, an experiment with 6 treatment variants was created, being used the following phytosanitary products: EVALIA (azoxystrobin 250 g/l), RETENGO (200 g/l pyraclostrobin) and ORIUS 25 EW (250 g/l tebuconazole). The treatment variants were the following: V1- ORIUS 25 EW 0.5 L/HA, 1 treatment applied at booting – flowering phase; V2 – EVALIA 1/L/HA, 1 treatment applied at booting – flowering phase, V3 - RETENGO 0.5 L/HA, 1 treatment applied at booting – flowering phase, V4 - ORIUS 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling, V5- EVALIA 1L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling, V6-RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling, V7 – Control variant not treated. The experiment was placed in Latin square, the 7 variants being placed in 7 repetitions. The year 2023 was a year with a relatively wet spring and early summer. The climatic conditions were favorable to the attacks of barley-specific pathogens, earlier than in 2022, year which was very dry. The experiment was not irrigated. The experiment was established after rapeseed. Among the pathogens followed, attacks produced by the *Pyrenophora graminea* fungus, which produces, in barley, the disease known as leaf stripe, were observed. Between the untreated control variant and some of the variants that were treated with fungicides, there were significant yield differences in the climatic conditions of 2023. The variant's yields were: V1- 7335 t/ha, V2–7165 t/ha, V3-7505 t/ha, V4–7305 t/ha, V5–7496 t/ha, V6 - 7622 t/ha and V7–7275 t/ha. The presence of the phytopathogenic fungus *Blumeria graminis* f.sp. *hordei,* which produces barley's mildew, was slightly higher than in 2022.

Key words: (*Pyrenophora, Blumeria,* Latin square)

Hordeum vulgare barley is attacked by many pathogenic agents, such as: mildew - *Blumeria graminis* f.sp. *hordei*, leaf stripe - *Pyrenophora graminea*, leaf blotch - *Rhyncosporium secalis*, rust - *Puccinia hordei* (Iacob Viorica, Hatman, M., Ulea, E., Puiu, I. 1998). The first half of 2023 was favorable for obtaining good barley yields. Rainfall was recorded quantitatively higher than the previous year, which was particularly dry. For example, in February, the average temperature was 2.5⁰C, the rainfall totaled 9.3 l/m² and the average relative humidity was 71%. In March, the average temperature was 9⁰C and the average relative humidity was 60%, the rainfall totaled 24 l/m². In April, the average temperature was 14.5⁰C, rainfall totaled 53 l/m² and the average relative humidity was 70%. In May, the average temperature recorded was 16.5⁰C, rainfall totaled 41 l/m² and the average relative humidity was 59%. The emergence of barley in the autumn of 2022 was relatively good. The winter between 2022 and 2023 was quite warm, as it was the previous winter, which allowed the plants not to freeze, barley being a more sensitive species to cold than wheat. The rainfall between February and May 2023 was higher than that of the previous year, leading to a higher yield of barley compared to the yield obtained in the previous year. Among the pathogens that have appeared, we mention the *Pyrenophora graminea* fungus which produces, in barley, the disease called leaf stripe. This pathogen attacks barley crops every year at attack intensities that vary from year to year.

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Figure 1. **Atack of *Pyrenophora graminea* fungus on the date of 8th April 2023 (original)**

Figure 2. **Aspects from the experimental field (original)**

Table 1

The results of the experiment with fungicide products (6 variants of treatment + 1 untreated control variant) in what concerns the attack (D.A. %) of *Pyrenophora graminea* fungus on barley (“flag” leaf and the next leaf). The observations were performed on the date of 20th May 2023

	The “flag” leaf			The second leaf		
Variant	D.A %	Difference as compared to the control variant	Significance	D.A %	Difference as compared to the control variant	Significance
V1-ORIUS 25 EW 0.5 L/HA, 1 treatment applied at booting – flowering phase	30.66	21.26	**	76.21	20.93	*
V2- EVALIA 1/L/HA, 1 treatment applied at booting – flowering phase	20.27	31.65	**	84.43	12.71	_
V3-RETENGO 0.5 L/HA, 1 treatment applied at booting – flowering phase	16.06	35.86	**	66.93	30.21	**
V4- ORIUS 0.5 L/HA, 1 treatment applied at straw’s extension + 1 treatment applied at kernel’s filling	24.90	27.02	**	90.36	6.78	_
V5- EVALIA 1/L/HA, 1 treatment applied at straw’s extension + 1 treatment applied at kernel’s filling	11.71	40.21	**	73.50	23.64	*
V6- RETENGO 0.5 L/HA, 1 treatment applied at straw’s extension + 1 treatment applied at kernel’s filling	4.20	47.72	**	57.07	40.07	**
V7 – Control variant not treated	51.92	-	-	97.14	-	-

LD D.A.% for the „flag” leaf
LD 5% =10.71%
LD 1% =14.58%

LD D.A.% for the second leaf:
LD 5% =19.17%
LD 1% =25.85%

Table 2

The results of the experiment with fungicide products (6 variants of treatment + untreated control variant) in what concerns the yield (t/ha) obtained at the treated variants as compared to the untreated control variant

Variant	Yield (t/ha)	Difference as compared to the control variant (t/ha)	Significance
V1-ORIUS 25 EW 0.5 L/HA, 1 treatment applied at booting – flowering phase	7.335	0.060	-
V2-EVALIA 1/L/HA, 1 treatment applied at booting – flowering phase	7.165	-0.110	-
V3-RETENGO 0.5 L/HA, 1 treatment applied at booting – flowering phase	7.505	0.230	*
V4-ORIUS 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling	7.305	0.030	-
V5- EVALIA 1/L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling	7.496	0.221	*
V6--RETENGO 0,5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling	7.622	0.347	**
V7 – Control variant not treated	7.275	_	_

LD 5% = 0.191 t/ha

LD 1% = 0.258 t/ha

MATERIAL AND METHOD

An experiment with 7 study variants was designed in order to make the observations. This experience included 6 phytosanitary treatment variants (fungicidal products, their combinations, no. of treatments) and an untreated control variant. The variants of the experiment were as follows (Table 1):

- V1 - ORIUS 25 EW 0.5 L/HA, 1 treatment applied at booting – flowering phase
- V2 - EVALIA 1L/HA, 1 treatment applied at booting – flowering phase
- V3 - RETENGO 0.5 L/HA, 1 treatment applied at booting – flowering phase
- V4 - ORIUS 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling
- V5 - EVALIA 1L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling
- V6 - RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling
- V7 – Control variant not treated

The experiment was placed in Latin square. These 7 variants were placed in 7 repetitions. Each experimental plot had an area of 15 m^2 (5 x 3 m). The total number of the experiment plots was 49. The area of an experimental variant was of 15 m^2 x 7 repetitions = 105 m^2. The total area of the experiment was of 105 m^2 x 7 = 735 m^2. The treatments were performed manually, with a machine of "Vermorel" type. Weed control was achieved with the help of Mustang herbicide (6.25 g / l florasulam + 300 g / l 2,4-D EHE acid) at a dosage of 0.5 l / ha applied, separately, with the vermorel. The experiment has shown the effectiveness of these phytosanitary products, in relation to their price, as well as the efficiency and, respectively, the profitability of applying one or two phytosanitary treatments during barley's vegetation period.

The evaluation of the attack's frequency (F%), of the attack's intensity (I%) and respectively, of the degree of attack (D.A.%) was done separately, on each and every experimental plot, analyzing 10 plants / experimental plot. Their degree of affectation (the intensity of the attack I %) of the last 2 leaves, especially of the "flag" leaf which has the biggest contribution to the ear's yield at cereals, had been assessed. The phytosanitary analyses of the plant's samples were done with the help of the stereomicroscope and optic microscope at Brăila Phytosanitary Office's laboratory – Phytosanitary National Authority, institution subordinated to the Ministry of Agriculture and Rural Development. These analyses had revealed the presence of *Pyrenophora graminea* in the samples analyzed, fungus which produces barley's leaf stripe.

In order to assess the yield of each variant under study, kernel samples from each experimental plot, 5 samples / plot, had been analyzed by sampling. Each sample comprised 20 plants, so, from each experimental plot, 100 plants were taken over, from which the yield was manually weighted. The demarcation of each sample was performed with a metric frame with the area of 0.25 m^2 (0.5/0.5m). The average of the experimental plot samples had served for calculating the production of each and every experimental plot. The statistic interpretation had been done with the help of the limit differences (LD %) (Săulescu N., 1967).

Donau variety was used. This is a new German variety of barley for beer, traded by Soufflet French Company. The variety is early-flowering. It has a good resistance to falling, cold and barley's specific diseases (Soufflet Agro Romania, 2020).

Assessing the pest attack can be done with the help of the following values (Prognosis and Warning Methods, 1980):

- Attack frequency (F %);
- Attack intensity (I %);
- Degree of attack (D.A %).

- Attack frequency represents the relative value of the number of plants or organs of the plant under attack (n) reported to the number of plants or organs observed (N). The value of the frequency is established through direct observations on a number of plants or organs, according to the case and to the conditions, existing different methods of collecting the samples and for performing the observations. In the case of our observations regarding the foliar diseases, the number of attacked plant organs from the total of observed plant organs (leaves) had been taken into consideration, establishing thus the frequency of the attack expressed in percentages %. In case of blights, the number of attacked ears reported to the total number of observed ears had been used. The frequency was calculated with the help of the F%= nx100/N formula.

- Attack intensity represents the degree or percentage where a plant or an organ of the plant is attacked and how much from the area of the plant or of the organ analyzed (leaf, fruit) is covered by the disease under study.

The assessment of the area attacked had been done with the naked eye or with the magnifying glass, assessing the percentage occupied by spots or burns caused by the pathogenic agent. The damage percentage can be recorded or grades can be awarded for each plant or organ attacked by the disease or/and by the pest. Grades usage can ease up greatly data summarizing. It can be used a scale with 6 degrees of intensity, as follows:

- Grade 0 no attack
- Grade 1 attack 1 – 3%
- Grade 2 attack 3 – 10%
- Grade 3 attack 11 – 25%
- Grade 4 attack 26 – 50%
- Grade 5 attack 51 – 75%
- Grade 6 attack 76 – 100%

After summarizing the data, the attack intensity had been determined with the following formula:

$$I\% = \frac{\Sigma (i \times f)}{N}$$

Where:

I% – Attack intensity (in %);

i – The intensity according to the grade awarded to the organ or plant attacked;

f – The number of cases (plants, organs) attacked;

n – The number of plants attacked.

In our experiment, grades from 1 to 6 had been separately awarded to the "flag" leaf and to the next leaf situated below it.

- The Degree of Attack is the expression of the attack severity's extension on the crop or of the total number of plants for which we are making the observations. D.A.'s value expression is given by the ratio:

$$D.A. (\%) = \frac{F \times I}{100}$$

In most of the cases, there is a negative correlation between the degree of attack of a pathogenic agent or pest and the quantitative and/or qualitative level of a crop's yield.

RESULTS AND DISCUSSIONS

The agricultural year 2022 – 2023 was relatively favorable for barley crop. It must be underlined the very important fact that barley (*Hordeum vulgare*) is a variety more sensitive to disease attack and to wintering than wheat. Contrary to last year, February, March, April and May months were richer in rainfalls compared to 2022. Those months were also cooler compared to the same months in 2022. The autumn of 2022 had been relatively richer in rainfalls than the autumn of 2021. In these conditions, the plants emerged in time in order to go through the winter of 2022-2023 in good conditions. This winter was relatively warm compared to the average of the previous years.

In what concerns the occurrence dynamic of the pathogens' attacks on barley, we mention the following aspects: - *Pyrenophora graminea* had affected barley to a greater extent in 2023, as compared to 2022. The degree of attack (D.A.%) was of 51.92% at V7 - untreated control variant, at the "flag" leaf - on the date of 26th May 2023. This degree of attack on the "flag" leaf of the untreated control variant was higher than in the previous year, 2022, which was very dry.

If we analyze the data from Table 1, we observe that the degree of attack of *Pyrenophora graminea* fungus was differentiated, as follows:

- V1 determined a degree of attack of the *Pyrenophora graminea* fungus of 30.66% in the "flag" leaf, and of 76.21 % in the second leaf, therefore lower by 21.26%, and, respectively, by 20.93% than the untreated control variant (V7).

- V2 determined a degree of attack of the *Pyrenophora graminea* fungus of 20.27% in the “flag” leaf, and of 84.43% in the second leaf, therefore lower by 31.6%, and, respectively, by 12.71% than the untreated control variant (V7).
- V3 determined a degree of attack of the *Pyrenophora graminea* fungus of 16.06% in the “flag” leaf and of 66.93% in the second leaf, therefore lower by 35.86% and, respectively, by 30.21% than the untreated control variant (V7).
- V4 determined a degree of attack of the *Pyrenophora graminea* fungus of 24.90% in the “flag” leaf and of 90.36% in the second leaf, therefore lower by 27.02% and, respectively, by 6.78% than the untreated control variant (V7).
- V5 determined a degree of attack of the *Pyrenophora graminea* fungus of 11.71% in the “flag” leaf, and of 73.50% in the second leaf, therefore lower by 40.21% and, respectively, by 23.64% than the untreated control variant (V7).
- V6 determined a degree of attack of the *Pyrenophora graminea* fungus of 4.20% in the “flag” leaf and of 57.07% in the second leaf, therefore lower by 47.72% and, respectively, by 40.07% than the untreated control variant (V7).
- V7 – The untreated control variant was affected by *Pyrenophora graminis* at a degree of attack (D.A.) values of 51.92% in the “flag” leaf and of 97.14% in the second leaf.

From the analysis of table 2, the yield differences compared to the untreated control variant, V7, can be observed, as follows:

- V1 achieved a yield of 7.335 t/ha, respectively 0.060 t/ha higher than the untreated control variant (V7).
- V2 achieved a yield of 7.165 t/ha, respectively 0.110 t/ha lower than the untreated control variant (V7).
- V3 achieved a yield of 7.505 t/ha, respectively 0.230 t/ha higher than the untreated control variant (V7).
- V4 achieved a yield of 7.305 t/ha, respectively 0.030 t/ha higher than the untreated control variant (V7).
- V5 achieved a yield of 7.496 t/ha respectively an increase of 0.221 t/ha compared to the untreated control variant (V7).
- V6 achieved a yield of 7.622 t/ha respectively an increase of 0.347 t/ha. compared to the untreated control variant (V7).
- V7 untreated control variant achieved a yield of 7,275 t/ha.

CONCLUSIONS

The observations made in the spring of 2023 on barley crop, in the pedoclimatic conditions of the Eastern Bărăgan, led to the following conclusions and recommendations:

1-The attack of the *Pyrenophora graminea* fungus, which causes the disease popularly known as “leaf stripe”, also made its presence in 2023. The attack of this fungus was, this year, stronger than in 2022 and started earlier. This was caused by: the relatively higher amount of rainfalls, slightly lower average temperatures and higher average air humidity, recorded in the first 5 months of 2023, compared to the first 5 months of 2022. The yield differences between the treated variants and the untreated control variant were very small and even negative for V1- ORIUS 25 EW 0.5 L/HA, 1 treatment applied at booting-flowering phase, V2-EVALIA 1L/HA, 1 treatment applied at booting-flowering phase and V4- ORIUS 0.5 L/HA, 1 treatment applied at straw’s extension + 1 treatment applied at kernel’s filling.

2-Variants: V3-RETENGO 0.5 L/HA; 1 treatment applied at booting-flowering phase, V5-EVALIA 1L/HA, 1 treatment applied at straw’s extension + 1 treatment applied at kernel’s filling and V6 RETENGO 0.5 LHA, 1 treatment applied at straw’s extension + 1 treatment applied at kernel’s filling achieved higher yields compared to the untreated control variant, statistically assured.

3-Compared to previous years, slightly higher attacks of the *Blumeria graminis* f. sp. *hordei* fungus, producing barley’s mildew, have been reported.

4-The Donau beer barley variety has proven to be quite resistant to the attack of phytopathogenic fungi of the genera *Pyrenophora* and *Blumeria* in the climatic conditions of the spring of 2023. V7 (untreated control variant) achieved a relatively good production (7.275 t/ha) in the climatic conditions of 2023, which were favorable to the attacks of phytopathogenic fungi of the mentioned genera.

5-The experiment was placed on a plot of land that was cultivated with rapeseed in the previous year. As a result, the inoculum reserve of the *Pyrenophora graminea* fungus left in the soil from the previous year was practically zero. Under these conditions, we appreciate that the general vegetation condition of the crop where the experiment was located was also very good due to the rapeseed that preceded the barley.

6-The price of barley, in mid-2024, stands at approximately 0.85 lei (approx. 0.17 €)/kg (Cereal Exchange 2024)

7-The yields obtained for the studied variants were significantly higher than those achieved in 2022. In 2023, the untreated control variant (V7) achieved 7.275 t/ha compared to 2022, when it achieved 5.508 t/ha.

8-As for the costs/ha of some plant protection products, they vary, in 2023, as follows:

- RETENGO costs about 200 lei/l – about 40 €/l. A single treatment was applied with 0.5 l/ha (100 lei/ha – 20 €/ha) to V3. 2 treatments were applied to V6, with 0.5 l/ha, i.e. a total of 1 l/ha (200 lei/ha – 40 €/ha).
- EVALIA costs 210 lei/l - 44 €/l. 1 l/ha (210 lei/ha - 44 €/ha) was applied to V2. 2 treatments were applied to V5, with 1.0 l/ha, i.e. 420 lei/ha - 88 €/ha.
- ORIUS 25 EW costs 100 lei/l - 20€/l. 0.5 l/ha (1 treatment) was applied to V1, i.e. 50 lei/ha - 20 €/ha. 2 treatments were applied to V4, with 0.5 l/ha, i.e. a total of 1 l/ha (100 lei/ha – 20 €/ha.

7-From the analysis of the economic profitability, it seems that, in the climatic conditions of 2023, which was rainier and cooler in the first 5 months, compared to 2022, the V3 variant turned out to be the most cost-effective (RETENGO 0.5 L/HA-; 1 treatment applied at booting-flowering phase) which at a yield increase of 230 kg compared to V7 (untreated control variant), offered a financial plus of 96 lei/ha, at a barley price of 0.85 lei/kg-0.17 €/kg. A similar financial addition was offered by V6 (RETENGO 0.5 L/HA, 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling) of 95 lei/ha. But, in the case of V6, two treatments were applied and we have an additional cost, compared to V3, in terms of the expense of applying the second treatment.

The variants: V1-ORIUS 25 EW 0.5 L/HA, 1 treatment applied to booting-flowering phase, V2-EVALIA, 1L/HA, 1 treatment applied at booting-flowering phase and V4-ORIUS 0.5 L/HA, , 1 treatment applied at straw's extension + 1 treatment applied at kernel's filling did not prove to be economically profitable

8-Barley grown after rapeseed, even in the conditions of a year more favorable to the attack of specific pathogens, behaves relatively well in terms of general phytosanitary status.

9-The average leu/€ exchange rate in April, May and June 2024 was 4.9751 lei/1€, according to the National Bank of Romania's website.

REFERENCES

Iacob Viorica, Hatman M., Ulea E., Puiu I., 1998 – *Agricultural phytopathology*, "Ion Ionescu de la Brad" Publishing House, p. 37-39.

Săulescu N., 1967 - *Experiment field*, Agro-Silvică (Agro–Sylvan) Publishing House, Bucharest, p. 217, 311

Velichi E., 2012 - *General and special phytopathology*, Universitară (University) Publishing House, Bucharest, p. 151 -153.

*** *National Bank of Romania 2024* (web page).

*** *Methods of Prognosis and Warning*, 1980 M.A.I.A., Bucharest, p. 7-9.

****Soufflet Agro Romania*, 2020 (web page).

******* *Cereal Exchange 2024* (web page)

THE QUALITY OF INDICES OF GREEN MASS AND HAY FROM *ARRHENATHERUM ELATIUS* AND *FESTUCA ARUNDINACEA*, IN MOLDOVA

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Abstract
We studied the quality indices of the of green mass and hay from tall oatgrass *Arrhenatherum elatius* and tall fescue *Festuca arundinacea* which grow in the experimental sector of the "Alexandru Ciubotaru" National Botanical Garden (Institute) MSU. It was determined that the biochemical composition and nutritive value of the dry matter of the harvested plants were: 9.6-11.2% CP, 8.2-8.7% ash, 35.4-37.5% CF, 37.9-39.9% ADF, 65.3-68.4% NDF, 3.3-3.7 % ADL, 12.0-12.4% TSS, 34.6-36.2% Cel, 27.4-28.5% HC, 590-629 g/kg DMD, 538-572g/kg OMD, 11.48-11.76 MJ/kg DE, 9.43-9.66 MJ/kg ME and 5.45-5.67 MJ/kg NEl. The quality indices of the prepared hays were: 10.0-11.4% CP, 9.4-10.0% ash, 36.7-39.9% CF, 39.4-41.4% ADF, 64.6-68.3% NDF, 3.7-3.8 % ADL, 3.7-3.8% TSS, 35.7-38.0% Cel, 25.2-26.5% HC, 515-567 g/kg DMD, 471-527g/kg OMD, 11.21-11.55 MJ/kg DE, 9.20-9.48 MJ/kg ME and 5.3-5.5.50 MJ/kg NEl. The biochemical methane potential of the studied substrates varied from 343 to 354 l/kg ODM. The *Arrhenatherum elatius* and *Festuca arundinacea* species can be used to restore permanent grasslands or to create temporary grasslands, and the harvested green mass and prepared hays can be used as forages for farm animals or as substrates for biomethane production.

Key words: *Arrhenatherum elatius, biochemical composition, biomethane potential, Festuca arundinacea, nutritive value*

The ecosystems with herbaceous perennials play a part in water conservation, protecting the soil from erosion and enriching it with humus. Traditionally, perennial plants of the family *Poaceae* Barnhart are known to provide food and shelter for various species of animals, birds and insects, and are of high socio-economic value, being used to produce building materials and handicrafts, and, in recent years, they have been more commonly used as a source of different types of biofuels, raw material for the circular economy, and as cover crops and ornamental plants in open spaces in vineyards, orchards and recreational land.

On a global and regional level, the species of grasses in the genera *Arrhenatherum* P. Beauv. and *Festuca* L. are quite common in the floristic composition of permanent and temporary grasslands. The native flora of the Republic of Moldova includes only 1 species of genus *Arrhenatherum* and 8 species of genus *Festuca* (Negru A., 2007). In Romania, the genus *Festuca* is represented by 32 species and the genus *Arrhenatherum* – by 1 species (Marușca T., 1999).

The goal of this study was to evaluate the quality indices of the green mass and prepared hay from tall oatgrass (*Arrhenatherum elatius*) and tall fescue (*Festuca arundinacea*) grown under the climatic conditions of the Republic of Moldova, as feed for livestock and as substrates for biogas production.

MATERIALS AND METHODS

The local ecotype of tall oatgrass, *Arrhenatherum elatius*, and the romanian cultivar 'Măgurele 5' of tall fescue, *Festuca arundinacea*, grown in monoculture in the experimental sector of the National Botanical Garden (Institute) of Moldova, Chişinău, served as research subjects.

The experimental design was a randomized complete block design with four replications, and the experimental plots measured 10 m^2. The samples were collected in the third growing season and the first cut was done in the pre-flowering stage.

The harvested plants were chopped into 1.5-2.0 cm small pieces, with a laboratory forage chopper; the dry matter content was detected by drying the samples to a constant weight, at 105°C. The prepared hay was dried directly in the field. For chemical analyses, the plant samples were dried in a forced-air oven at 60 °C, then milled in a beater mill equipped with a sieve with mesh diameter of 1 mm. Some of the main biochemical parameters were assessed: crude protein (CP), ash, acid detergent fiber (ADF), neutral detergent fiber (NDF) and acid detergent lignin (ADL), total soluble sugars (TSS), digestible dry matter (DDM) and digestible organic matter (DOM) were determined by the near infrared spectroscopy (NIRS) technique using the

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PERTEN DA 7200 NIR analyzer, at the Research and Development Institute for Grasslands, Braşov, Romania. The concentration of hemicellulose (HC), cellulose (Cel), digestible energy (DE), metabolizable energy (ME), net energy for lactation (NEl) and relative feed value (RFV) were calculated according to standard procedures. The mass samples were collected in the early flowering stage. The carbon content of the substrates was determined using an empirical equation according to Badger C.M. *et al*, (1979). The biochemical methane potential was calculated according to Dandikas V. *et al*, (2015).

RESULTS AND DISCUSSIONS

As a result of our research, we found out that at the time when the green mass was harvested, the *Arrhenatherum elatius* plants contained 268.5 g/kg dry matter, but the *Festuca arundinacea* plants – 246.9 g/kg dry matter. The *Festuca arundinacea* green mass was characterized by a higher content of dry leaves (64%) as compared with *Arrhenatherum elatius* (58%).

Analyzing the results of the determination of the quality indices of the of harvested whole plants, Table 1, we would like to mention that the nutrient content varied within the following limits: 9.6-11.2% CP, 8.2-8.7% ash, 35.4-37.5% CF, 37.9-39.9% ADF, 65.3-68.4% NDF, 3.3-3.7 % ADL, 12.0-12.4% TSS, 34.6-36.2% Cel, 27.4-28.5% HC.

A higher concentration of crude protein, total soluble sugars, ash and a lower content of structural carbohydrates was found in the fodder from *Festuca arundinacea* plants. The concentration of nutrients influences the forage value of harvested green mass. Thus, the green fodder from *Festuca arundinacea* plants contained 629 g/kg DMD, 572g/kg OMD, 11.76 MJ/kg DE, 9.66 MJ/kg ME and 5.67 MJ/kg NEl, but – from *Arrhenatherum elatius* plants – 590g/kg DMD, 538g/kg OMD, 11.48 MJ/kg DE, 9.66 MJ/kg ME and 5.67 MJ/kg NEl. Some authors mentioned various findings about the nutrient quality of the green mass of the studied grasses.

According to Tomić Z. *et al*, (2005), the grass quality of *Arrhenatherum elatius* pasture associations was 6.28 % CP, 30.07 % CF, 8.11 % ash, but in *Festuca* pasture associations – 6.57-9.53 % CP, 27.63-29.55 % CF and 6.00-8.00 % ash. Skládanka J. *et al*, (2008) reported that the forage dry matter from *Arrhenatherum elatius* plants contained 30.2 % CF, 60.5 % NDF, 35.9% ADF, 5.46 MJ/kg NEl; *Dactylis glomerata* plants – 28.9 % CF, 57.1 % NDF, 35.1% ADF, 5.54 MJ/kg NEl; *Festulolium* plants contained 26.9 % CF, 58.9 % NDF, 32.3% ADF, 5.84 MJ/kg NEl. Bulokhov A.D., (2014) revealed that the biochemical composition of the dry matter in the green mass of *Festuca arundinacea* was 12.0 % CP, 2.7% EE, 32.6% CF, 45.2% NFE, 9.8% ash and the nutritive value 0.37 fodder units/kg green mass and 78g DP/ fodder units. Ţîţei V. *et al*, (2019) mentioned the quality of dry matter contained in the green fodder from the studied tall fescue cultivars: 114-136 g/kg CP, 74-89 g/kg CA, 582-593 g/kg NDF, 392-396 g/kg ADF, 34-41 g/kg ADL, 322- 329 g/kg Cel, 226-229 g/kg HC, 60.3- 63.8% DDM and 57.2-62.2% OMD, 9.12-9.62 MJ/kg ME and 5.69-5.86 MJ/kg NEl. Reiné R. *et al,* (2020) reported that *Arrhenatherum elatius* plants had 421 g/kg DM with 7.6% CP, 4.5% ash, 1.6% EE, 66.5 % NDF, 35.2% ADF, 3.0% ADL, 61.5% DDM, 0.13% P, 0.50 % Ca, but *Festuca arundinacea* plants contained 455 g/kg DM with 7.2% CP, 4.4% ash, 2.0% EE, 73.3% NDF,41.1% ADF, 4.0% ADL, 56.8% DDM, 0.12% P, 0.35% Ca.

Hay is a key element in the diet of ruminant animals, mostly in the autumn-spring season but also throughout the year, providing a considerable amount of nutrients, vitamins and minerals, especially for young breeding animals, pregnant females and reproductive males, supports the motor functions of the rumen, i.e. the muscular activity of the digestive system, and rumination, an indispensable activity for a proper utilization of food.

The results concerning the biochemical composition of the hay prepared from the researched grasses are presented in Table 2. The prepared hays contained 10.0-11.4% CP, 9.4-10.0% ash, 36.7-39.9% CF, 39.4-41.4% ADF, 64.6-68.3% NDF, 3.7-3.8 % ADL, 3.7-3.8% TSS, 35.7-38.0% Cel, 25.2-26.5% HC with 515-567 g/kg DMD, 471-527g/kg OMD, 11.21-11.55 MJ/kg DE, 9.20-9.48 MJ/kg ME and 5.3-5.5.50 MJ/kg NEl. *Festuca arundinacea* hay contains higher amounts of crude protein and total soluble sugars than *Arrhenatherum elatius* hay. According to Medvedev P.F.& Smetannikova A.I., (1981), *Arrhenatherum elatius* hay contained 7.6-12.7% CP, 1.6-3.4% EE, 23.2-32.0% CF, 36.0-50.0 % NFE, 7.0-10.0 % ash. Angima S.D.& Kallenbach R.L., (2008) mentioned that the quality of hay from *Festuca arundinacea* ‘Kentucky 31’ was 6.37-7.85% CP and RFV= 96-98. Akdeniz H. *et al.* (2019) described the quality of the *Festuca arundinacea* hay as being characterized by the following indices: 9.86% CP, 9.54% ash, 1.15% EE, 44.85% CF, 64.05% NDF, 47.64% ADF and RFV=75.22.

A recent study has shown that anaerobic digestion is likely to be one of the most promising technologies for biomass energy recovery. Perennial grass biomass have been largely used as organics substrates in the production of biogas via an anaerobic digestion. The results regarding the quality indices of studied grass substrates and the potential for obtaining biomethane are shown in Table 3.

Table 1.
The biochemical composition and the feed value of the green mass of the studied grasses

Indices	*Arrhenatherum elatius*	*Festuca arundinacea*
Crude protein, g/kg DM	96.00	112.00
Crude fibre, g/kg DM	375.00	354.00
Ash, g/kg DM	82.00	87.00
Acid detergent fibre, g/kg DM	399.00	379.00
Neutral detergent fibre, g/kg DM	684.00	653.00
Acid detergent lignin, g/kg DM	37.00	33.00
Total soluble sugars, g/kg DM	120.00	124.00
Cellulose, g/kg DM	362.00	346.00
Digestible dry matter, g/kg DM	590.00	629.00
Digestible organic matter, g/kg DM	538.00	572.00
Relative feed value	77	85
Metabolizable energy, MJ/kg DM	11.48	11.76
Net energy for lactation, MJ/kg DM	9.43	9.66
Digestible energy, MJ/kg DM	5.45	5.67

Table 2.
The biochemical composition and the nutritive value of the hay from the studied grasses

Indices	*Arrhenatherum elatius*	*Festuca arundinacea*
Crude protein, g/kg DM	100.00	114.00
Crude fibre, g/kg DM	399.00	367.00
Ash, g/kg DM	94.00	100.00
Acid detergent fibre, g/kg DM	418.00	394.00
Neutral detergent fibre, g/kg DM	683.00	646.00
Acid detergent lignin, g/kg DM	38.00	37.00
Total soluble sugars, g/kg DM	78.00	83.00
Cellulose, g/kg DM	380.00	357.00
Digestible dry matter, g/kg DM	515.00	567.00
Digestible organic matter, g/kg DM	471.00	527.00
Relative feed value	77	84
Metabolizable energy, MJ/kg DM	11.21	11.55
Net energy for lactation, MJ/kg DM	9.20	9.48
Digestible energy, MJ/kg DM	5.23	5.50

Table 3.
The biochemical composition and biomethane production potential of the substrates from the studied grasses

Indices	*Arrhenatherum elatius*		*Festuca arundinacea*	
	green mass	hay	green mass	hay
Crude protein, g/kg DM	96.00	100.00	112.00	114.00
Nitrogen, g/kg DM	15.36	16.00	17.92	18.25
Carbon, g/kg DM	510.00	503.33	507.22	500.00
Ratio carbon/nitrogen	33.33	31.46	28.30	27.40
Acid detergent lignin, g/kg DM	37.00	38.00	33.00	37.00
Hemicellulose , g/kg DM	285.00	265.00	274.00	252.00
Biomethane potential, L/kg VS	344.00	343.00	354.00	346.00

We found that in the investigated substrates, according to the C/N ratio, which constituted 27-33, the amount of acid detergent lignin (33-37 g/kg) and hemicellulose (252-285 g/kg) met the established standards; the biochemical methane potential of studied substrates varied from 343 to 354 l/kg ODM. High biochemical methane potential was also characteristic of *Festuca arundinacea* substrates. There are different results reported in research studies conducted by other authors. Ebeling D. *et al.* (2013) found that, depending on the harvest dates and the amounts of fertilizer applied, the specific methane yield of *Arrhenatherum elatius* biomass substrates ranged between 311 and 347 l/kg VS. Goliński T. & Goliński P., (2013) reported that the harvested biomass from the semi-natural grasslands that were mainly represented by *Arrhenatherion* alliance contained 308 g/kg dry matter, 10.35 % CP, 6.36 % ash, 50.98% NDF, 31.61 % ADF and methane productivity was 338 l/kg VS. Boob et al. (2019)

remarked that the methane yield of the biomass from *Arrhenatherion* grasslands was 300 l/kg VS. Ţîţei V. *et al,* (2019) revealed that biomethane production potential of green mass substrates from *Festuca arundinacea* cultivars varied inessentially from 349 to 354 l/kg VS. Von Cossel M. *et al,* (2019) mentioned that the first-cut biomass substrate from *Arrhenatherion* grasslands were characterized by 240-297 g/kg DM, 7.0-8.1 % ash, 4.7-5.7% lignin, 29.3-31.9% Cel, 20.7-25.2 % HC, 1.4-1.7 % N and the methane yield ranged from 289 to 297 l/kg VS. Amaleviciute-Volunge K. *et al,* (2021) reported that tall fescue substrates contained 15.02 % CP, 7.52 % ash, 4.7-5.7% ADL, 27.3% Cel, 20.9 % HC and the methane yield was 191 l/kg VS. Meserszmit M. *et al,* (2021) mentioned that the herbage from the *Arrhenatherum elatius* and *Dactylis glomerata* plant community contained 8.00 % CP, 3.17% EE, 57.30 % NDF, 16.56 % HC, 29.47% Cel, 11.24 % lignin, 7.73 % ash, and methane yield was 249 l/kg VS. Zhang Y. *et al,* (2021) revealed that the methane potential of *Festuca arundinacea* herbage varied from 259 to 446 l/kg VS.

CONCLUSIONS

The local ecotype of *Arrhenatherum elatius* and the cultivar 'Măgurele 5' of *Festuca arundinacea* are suitable for grassland restoration, the creation of temporary grasslands and the harvested mass may be used as fodder for livestock, and also as substrate for biomethane production as a source of renewable energy.

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REFERENCES

Akdeniz H., Hosaflioğlu I., Koç A., Hossain A., Islam M.S., Iqbal M. A., Imtiaz H., Gharib H., El Sabagh A., 2019 - *Evaluation of herbage yield and nutritive value of eight forage crop species*. Applied Ecology and Environmental Research, 17(3):5571-5581.

Amaleviciute-Volunge K., Slepetiene A., Butkute B., 2020 - *Methane yield of perennial grasses as affected by the chemical composition of their biomass.* Zemdirbyste-Agriculture, 107 (3):243–248.

Angima S.D., Kallenbach R.L., 2008 - *Relative feed value and crude protein of selected cool and warm season forages in response to varying rates of nitrogen.* Journal of the NACAA. 2008. https://www.nacaa.com › journal › angima-PAPER

Badger C.M., Bogue M.J., Stewart D.J., 1979 - *Biogas production from crops and organic wastes.* New Zealand Journal of Science, 22:11-20.

Boob M., Elsaesser M., Thumm U., Hartung J., Lewandowski I., 2019 - *Harvest time determines quality and usability of biomass from lowland hay meadows.* Agriculture, 9(9), 198. https://doi.org/10.3390/agriculture9090198.

Bulokhov A.D., 2014 - *Assessment of the quality of forage of natural and sown meadows of the Iput River basin in radiation-contaminated areas of the Bryansk and Gomel regions.* The Bryansk State University Herald, 4:61-65. [in Russian]

Dandikas V., Heuwinkel H., Lichti F., Drewes J.E., Koch K., 2015 - *Correlation between biogas yield and chemical composition of grassland plant species.* Energy Fuels, 29 (11): 7221-7229.

Ebeling D., Breitsameter L., Bugdahl B., Janssen E., Isselstein J., 2013 - *Herbage from extensively managed grasslands for biogas production: methane yield of stands and individual species.* Grassland Science in Europe, 18:560-562.

Goliński T., Goliński P., 2013 - *Integrating the bioenergy production with biodiversity conservation on semi-natural and riparian grasslands.* In. Proceedings of the 22nd International Grassland Congress, 1699-1700.

Marusca T., 1999 - *Genetic resources of grasses and legumes in Romania.* In Report of a Working Group on Forages. Elvas, Portugal, 132-136.

Medvedev P.F., Smetannikova A.I., 1981 - *The forage crops of European part of the USSR.* Leningrad, Kolos.

Meserszmit M., Swacha G., Pavlů L., Pavlů V., Trojanowska-Olichwer A., Kącki Z., 2021 - *Species composition of semi-natural mesic grasslands as a factor influencing the methane yield of plant biomass (Central Europe).* Global Change Biology Bioenergy, 14:54–64.

Negru A., 2007 - *Determinator de plante din flora Republicii Moldova*. Chişinău, 391 p.

Reiné R., Ascaso J., Barrantes O., 2020 - *Nutritional quality of plant species in Pyrenean hay meadows of high diversity.* Agronomy, 10, 883. https://doi.org/10.3390/agronomy10060883

Skládanka J., Adam V., Ryant P., Doležal P., Havlíček Z., 2010 - *Can Festulolium, Dactylis glomerata and Arrhenatherum elatius be used for extension of the autumn grazing season in Central Europe?* Plant, Soil and Environment, 56(10): 488-498.

Temel S., Keskin B., Şimşek U., Yilmaz I., 2015 - Performance of some forage grass species in halomorphic soil. *Turkish Journal of Field Crops*, 20(2), p. 131-14120. 10.17557/tjfc.82860

Ţîţei V., Blaj V.A., Maruşca T., 2019 - *The productivity and the quality of green mass and hay from romanian cultivars of Festuca arundinacea, grown in the Republic of Moldova.* Journal of Plant Development, 26: 189-196.

Tomić Z., Nešić Z., Mrfat V.S., Žujović M., 2005 - *Quality and plant association structure of grasslands on Stara Planina Mountain.* Biotechnology in Animal Husbandry, 21(5-6): 253-257.

Von Cossel M., Bauerle A., Boob M., Thumm U., Elsaesser M., Lewandowski I., 2019 - *The performance of mesotrophic Arrhenatheretum grassland under different cutting frequency regimes for biomass production in Southwest Germany.* Agriculture, 199(9).

Zhang Y., Kusch-Brandt S., Salter A.M., Heaven S., 2021 - *Estimating the methane potential of energy crops: an overview on types of data sources and their limitations.* Processes 9, 1565. https://doi.org/10.3390/pr909156.

CANNABIS SATIVA L. A NATURAL, LOCAL SOURCE OF CANNABINOIDS IN STRENGTHENING HUMAN HEALTH

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Abstract

This article provides a bibliographic synthesis regarding the importance of endocannabinoids from the species Cannabis sativa. Cannabinoids are the most intensively studied group of compounds, particularly because of their wide range of pharmacological effects on humans, including psychotropic activities. Most of the biological properties associated with cannabinoids are related to their interactions with the human endocannabinoid system. Endocannabinoids regulate or modulate a variety of physiological processes, including appetite, pain perception, mood, memory, inflammation, insulin sensitivity, and fat and energy metabolism. CBD (cannabidiol) exhibits anti-anxiety, anti-nausea, anti-arthritis, antipsychotic, anti-inflammatory, and immunomodulatory properties. In preclinical models of central nervous system diseases (such as epilepsy, neurodegenerative diseases, schizophrenia, multiple sclerosis), mood disorders, and central modulation of feeding behavior, CBD has also demonstrated strong antifungal and antibacterial properties, including remarkable efficacy against methicillin-resistant Staphylococcus aureus (MRSA). Additionally, cannabidiol possesses anti-inflammatory and anticancer properties. We believe that Cannabis sativa holds particular interest for cultivation and utilization aimed at enhancing human health.

Key words: *Cannabis sativa,* endocannabinoids, human health

Hemp, *Cannabis sativa* L. is an herbaceous species that belongs to the genus *Cannabis*, family *Cannabaceae*, and is native to Central Asia, used by humans for over 4,000 years. The plant has been utilized in ancient folk medicine for treating or alleviating various diseases (Alexander S., 2016). This fast-growing plant has recently experienced a resurgence of interest due to its multifunctional applications: it is indeed a treasure trove of phytochemicals and a rich source of both cellulose and woody fibers, energy biomass (Tabără V., 2009; Kreuger E. *et al,* 2011; Alexander S.P., 2016; Kraszkiewicz A. *et al,* 2019; Wawro A. *et al,* 2019; Ţîţei V., 2022; Melnic V. *et al*, 2023; Ţîţei V. *et al,* 2023; Visković J. *et al,* 2023).

Cannabinoids are biologically active substances derived from cannabinol. These substances are found naturally in plants from the hemp family. Endogenous cannabinoids are often referred to as anandamides—neurotransmitters with a different chemical structure but a similar impact on the body. The inflorescences and leaves of cannabis contain over 60 different cannabinoids. As the plant develops, cannabidiol (CBD) predominates, which is then converted into tetrahydrocannabinols (THC), and as the plant matures, these break down into cannabinols (CBN). All cannabinoids are fat-soluble substances. When they enter the body, they accumulate in lipid-rich tissues (brain, lungs, internal reproductive organs) and are gradually released into the circulatory system.

Cannabidiol (CBD) is one of the main cannabinoids present in Cannabis sativa. It is found in the inflorescences and leaves of hemp, partially in the form of butyl analogs, cannabidivarin, and cannabidiolic acid. Its maximum concentration is reached before flowering, after which it transforms into tetrahydrocannabinols (THC). Cannabidiols does not have psychotropic properties and can block some of the unpleasant effects of tetrahydrocannabinols (particularly the so-called "paranoia"). Recent experiments have shown that cannabidiol and cannabidiolic acid are responsible for the antibacterial effect of freshly pressed hemp juice, known since ancient times. These substances can effectively suppress a range of microorganisms, including penicillin-resistant staphylococci and other antibiotics. Additionally, there is a very high probability that cannabidiol

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may significantly help with motor disorders, epilepsy, multiple sclerosis, and more. One of the main biologically active substances in the biomass of *Cannabis sativa* L. is cannabinol (CBN). It is found in the inflorescences and leaves of hemp, partially in the form of butyl analogs and cannabivarin. Cannabinol reaches its maximum concentration during seed ripening as tetrahydrocannabinols and its analogs break down. Cannabinol has a moderate psychotropic effect (ten times weaker than tetrahydrocannabinols); products with a dominance of cannabinols are considered low quality (Melnic V. *et al,* 2023).

Scientific interest in cannabinoids arose after the discovery of the main psychoactive component, Δ9-tetrahydrocannabinol. Subsequently, receptors in the brain were identified that interact with cannabinoids, as well as endogenous cannabinoid ligands (EC), along with the enzymes responsible for their synthesis, transport, and degradation, forming the endocannabinoid system (ECS).

Interest in endogenous cannabinoid ligands has steadily increased in recent years, especially after discovering their important role in cognitive functions. They regulate synaptic transmission in the brain, mediate numerous forms of plasticity, and control neuronal energy metabolism. ECs exert their effects through a variety of mechanisms and interactions with neurotransmitters, neurotrophic factors, and neuropeptides.

The main functions of ECs in the brain are retrograde synaptic signaling and neuromodulation, which help maintain cellular homeostasis. There is extensive literature indicating a protective effect of ECS activation in human neurodegenerative diseases and in animal models of cognitive deficits. This analysis examines the evidence demonstrating the effects of cannabinoid medications and ECS activation on cognitive function in normal brains and in neurodegenerative diseases, Alzheimer's disease, and temporal lobe epilepsy (Kichigina V.F., 2021; Shubina L.V., 2015; Bossong M.G. *et al,* 2013).

Anti-Anxiety Effect

The first scientific studies demonstrating that CBD + THC from *Cannabis sativa* has an anti-anxiety effect were conducted in 1982. Experiments on a sample of eight individuals with an average age of 27 highlighted that administration of CBD + THC significantly alleviated anxiety, establishing scientifically that *Cannabis sativa* has an anti-anxiety effect on humans (Zuardi A.W. *et al,* 2006).

Subsequent research revealed that CBD has beneficial effects in cases of social anxiety disorders. Specifically, administration of CBD resulted in a significant reduction in anxiety levels, somatic symptoms, and negative self-evaluation among the participants (Bergamaschi M.M. *et al,* 2011).

In another study, administration of a single 400 mg dose of CBD to individuals suffering from social anxiety disorders contributed to a subjective reduction in anxiety, reduced activity in the left parahippocampal gyrus, hippocampus, and inferior temporal gyrus, and increased activity in the right posterior cingulate gyrus. These results suggest that CBD reduces anxiety in social anxiety disorders and that this is related to its effects on activity in the limbic and paralimbic brain areas (Crippa J.A.S. *et al,* 2011). Research involving the administration of 600 mg of CBD to patients with anxiety demonstrated a trend toward reduced anxiety (fear in patients), showing a distinct effect on neural responses, acting on activation in limbic and paralimbic regions, and contributing to reduced autonomic arousal and subjective anxiety. Additionally, it was established that the anxiolytic action of CBD occurs through modulation of prefrontal-subcortical connectivity via the amygdala and anterior cingulate (Fusar-Poli P. *et al,* 2009).

Anti-Nausea and Vomiting Effect

Nausea and vomiting are among the most distressing symptoms reported by cancer patients undergoing treatment. With currently available treatments, vomiting and especially nausea remain problematic, highlighting the need for alternative therapies. In vitro and in vivo research has demonstrated the efficacy of CBD in managing nausea and vomiting, showing significant potential for evaluation in clinical studies due to its enhanced ability to reduce nausea and/or vomiting (Rock E.M. *et al,* 2021).

Considerable evidence indicates that manipulating the endocannabinoid system regulates nausea and vomiting in humans and other animals. The anti-emetic effect of cannabinoids has been demonstrated in a wide variety of animals capable of vomiting in response to toxic challenges. Animal experiments suggest that cannabinoids may be particularly useful in treating nausea and anticipatory nausea symptoms, which are more difficult to control in chemotherapy patients and are less managed by currently available conventional pharmaceutical agents. The primary non-psychoactive compound in cannabis, cannabidiol (CBD), also suppresses nausea and vomiting within a limited dosage range. The anti-nausea/anti-emetic effects of CBD may be mediated by the indirect activation of 5-HT1A somatodendritic receptors in the dorsal raphe nucleus; activation of these autoreceptors reduces the release of 5-HT in terminal regions of the forebrain. Preclinical research indicates that cannabinoids, including CBD, may be clinically effective for treating both chemotherapy-induced nausea and vomiting or other therapeutic treatments (Parker L.A. *et al,* 2011).

Anti-Arthritic and Anti-Inflammatory Effect

Arthritis and inflammatory conditions require effective therapies, but conventional medications often have side effects. Recent research has highlighted that essential oil from *Cannabis sativa* administered in models with induced inflammatory conditions (in the ear and paw) resulted in a significant reduction in ear weight in the xylene-induced ear swelling test, indicating a potential inhibition of neutrophil accumulation. In the carrageenan-induced paw inflammation test, it reduced paw volume, suggesting interference with edema formation and leukocyte migration. Additionally, in the paw inflammation test, a decrease in the volume of the contralateral paw was observed, along with restored body weight and reduced levels of C-reactive protein (Kabdy H. *et al,* 2024).

Recent studies indicate that cannabinoids exhibit anti-inflammatory effects by activating cannabinoid receptor type 2 (CB2), which decreases cytokine production and immune cell mobilization. Conversely, activation of cannabinoid receptor type 1 (CB1) on immune cells is pro-inflammatory, while CB1 antagonism provides anti-inflammatory effects by enhancing β2-adrenergic signaling in joints and secondary lymphoid organs. Furthermore, the non-psychoactive cannabinoid cannabidiol (CBD) has demonstrated anti-arthritic effects independent of cannabinoid receptors. In addition to controlling inflammation, cannabinoids reduce pain by activating central and peripheral CB1 receptors, peripheral CB2 receptors, and non-cannabinoid receptor targets sensitive to CBD (Lowin T. *et al*, 2019).

Antipsychotic Action

The primary antipsychotic effects of Cannabis sativa plants are attributed to CBD, which has demonstrated antipsychotic properties in both rodents and rhesus monkeys. Following several individual treatment trials, the first randomized, double-blind, controlled clinical study showed that in acute schizophrenia, cannabidiol exhibits antipsychotic properties comparable to the antipsychotic medication amisulpride, with a superior side effect profile resembling that of a placebo. As the clinical improvement with cannabidiol was significantly associated with increased levels of anandamide, it appears that its antipsychotic action is based on mechanisms related to elevated anandamide concentrations (Rohleder C. *et al,* 2016). Further research involving volunteers indicated that CBD from Cannabis sativa has antipsychotic effects, suggesting that CBD has a pharmacological profile similar to that of atypical antipsychotic medications. Additionally, reports from schizophrenia patients treated with CBD and preliminary findings from a controlled clinical study comparing CBD to an atypical antipsychotic have confirmed that this cannabinoid may serve as a safe and well-tolerated alternative treatment for schizophrenia (Zuardi A.W. *et al,* 2006).

Effects in Metabolic Syndromes

CBD may have beneficial effects for individuals with obesity, impaired glucose and lipid metabolism, hypertension, and non-alcoholic fatty liver disease (NAFLD). It appears that CBD helps maintain insulin sensitivity in adipose tissue and reduces glucose levels, making it a potential target in this type of metabolic disorder, although some research findings are inconclusive. CBD shows promising results in treating various lipid disorders, with some studies demonstrating its positive effects by lowering LDL and increasing HDL levels. Despite their likely efficacy, CBD and its derivatives will probably remain adjunctive treatments rather than primary therapeutic options.
Studies have also shown that CBD has positive effects in patients with hypertension, even though its hypotensive properties are modest. However, CBD may be used to prevent increases in blood pressure, stabilize it, and provide a protective effect on blood vessels. Preclinical studies have indicated that cannabidiol's effects on NAFLD may be potentially beneficial in treating metabolic syndrome and its components (Wiciński M. *et al,* 2023).

Neuropathic Pain

Neuropathic pain is a clinical condition resulting from an identifiable injury or disease of the somatosensory nervous system, which can be caused by certain abnormalities, trauma, or underlying conditions such as stroke or diabetes.

According to WSIB policy, cannabis can be prescribed for cases of neuropathic pain that are refractory to standard pharmaceutical and non-pharmaceutical treatments. An acceptable pharmaceutical treatment must involve at least three first-line and/or second-line medications along with a pharmaceutical cannabinoid.

Numerous systematic reviews have reported the efficacy of medical cannabis preparations (Cannabis sativa) for the treatment of neuropathic pain in general, and particularly in patients with HIV/AIDS. Furthermore, one of these reviews reported the effective use of THC and FAAH inhibitors for neuropathic pain and in cancer chemotherapy. Research indicated that median pain was reduced twice as much (34% compared to 17%) in the cannabis group versus the placebo group. A recent major systematic review reported a reduction in neuropathic pain (odds ratio of 1.37, p-value <0.05) with cannabinoids (combining pharmaceutical and non-pharmaceutical formulations), corresponding to achieving at least a 30% reduction in symptoms. Three recent clinical guidelines have reported strong, reasonable, and consistent evidence for the use of medical cannabis and cannabinoids in treating patients with neuropathic pain.

It is well known that *Cannabis sativa* exhibits pronounced beneficial effects in conditions such as schizophrenia, epilepsy, multiple sclerosis, Parkinson's disease, Alzheimer's disease, dementia, insomnia, diabetes, anorexia, and more (Workplace Safety Insurance Board, 2021).

Antifungal and Antibacterial Effects

Research on five different strains of cannabis has revealed that all cannabis varieties were effective to varying degrees against both Gram-positive and Gram-negative bacteria, as well as against the germination of spores and vegetative growth of pathogenic fungi. These effects were not correlated with the content of major cannabinoids such as CBD or THC, but rather with the presence of a complex terpene profile. The efficacy of the extracts allowed for a reduction in the doses required for a widely used commercial antifungal to prevent fungal spore development (Vozza Berardo M.E. *et al*, 2024).

Other studies indicate that extracts obtained from Cannabis sativa exhibit pronounced effects against Gram-positive bacteria (such as *Staphylococcus aureus, Streptococcus alpha hemolyticus, Streptococcus beta hemolyticus, Enterococcus, Diplococcus pneumoniae, Bacillus subtilis, Bacillus anthracis, Bacillus pumilus, Corynebacterium diphtheriae, Corynebacterium cutis, Erysipelothrix rhusiopathiae, Clostridium perfringens, Mycobacterium tuberculosis, Micrococcus flavus, Listeria monocytogenes, and T. mentagrophytes*), Gram-negative bacteria (such as P. *vulgaris, Bordetella bronchiseptica, Helicobacter pylori*, and *E. coli*), and fungi (such as *Candida albicans, Aspergillus niger, A. parasiticus, and A. oryzae*) (Schofs L. *et al,* 2021).

CONCLUSIONS

The present literature review study highlights the importance of hemp crops, *Cannabis sativa* as a valuable source of endocannabinoids, emphasizing the remarkable therapeutic potential of these compounds for human health. Cannabinoids, particularly CBD (cannabidiol), have demonstrated a wide range of pharmacological effects, including anti-inflammatory, antipsychotic, anticancer, and antibacterial properties. The interactions of cannabinoids with the human endocannabinoid system regulate essential physiological processes, making hemp crops a major resource of interest for research and utilization aimed at improving public health.

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REFERENCES

Alexander S.P., 2016 - *Therapeutic potential of cannabis-related drugs*. Progress in Neuro-Psychopharmacology & Biological Psychiatry, 64: 157–166.

Bergamaschi M., Queiroz R., Chagas M., Oliveira D., Martinis B., Kapczinski F., Quevedo J., Roesler R., Schröder N., Nardi A., Martín-Santos R., Hallak J., Zuardi A., Crippa J., 2011 - *Cannabidiol reduces the anxiety induced by simulated public speaking in treatment-naive social phobia patients*. Neuropsychopharmacology, 36. 1219-26. 10.1038/npp.2011.6.

Bossong M.G., van Hell H.H., Jager G., Kahn R.S., Ramsey N.F., Jansma J.M., 2013 - *The endocannabinoid system and emotional processing: a pharmacological fMRI study with (increment)9-tetrahydrocannabinol.* European Neuropsychopharmacology; 23: 1687–1697.

Crippa J.A., Derenusson G.N., Ferrari T.B., Wichert-Ana L., Duran F.L., Martin-Santos R., Simões M.V., Bhattacharyya S., Fusar-Poli P., Atakan Z., Santos Filho A., Freitas-Ferrari M.C., McGuire P.K., Zuardi A.W., Busatto G.F., Hallak J.E., 2011 -

Neural basis of anxiolytic effects of cannabidiol (CBD) in generalized social anxiety disorder: a preliminary report. Journal of Psychopharmacology 25(1):121-30. doi: 10.1177/0269881110379283.

Fusar-Poli P., Allen P., Bhattacharyya S., Crippa J.A., Mechelli A., Borgwardt S., Martin-Santos R., Seal M.L., O'Carrol C., Atakan Z., Zuardi A.W., 2010 - *Modulation of effective connectivity during emotional processing by Δ9-tetrahydrocannabinol and cannabidiol*. International Journal of Neuropsychopharmacology, 13(4):421-432.

Kabdy H., Azraida H., Agouram F., Oufquir S., Laadraoui J., Baslam A., Aitbaba A., Ouazzani M.E., Elyazouli L., Aboufatima R., Garzoli S., Chait A.,2023 - *Antiarthritic and anti-inflammatory properties of Cannabis sativa essential oil in an animal model*. Pharmaceuticals (Basel), 22;17(1):20. doi: 10.3390/ph17010020.

Kitchigina V.F., 2021 - *Cannabinoids, endocannabinoid system and cognitive functions: foes or friends?* IP Pavlov Journal of Higher Nervous Activity, 71(1): 3–38. DOI: 10.31857/S0044467721010068. https://www.sciencejournals.ru/cgi/getPDF.pl?jid=jourvnd&year=2021&vol=71&iss=1&file=JourVND2101006Kichigina.pdf

Kraszkiewicz A., Kachel M., Parafiniuk S., Zaj G., Niedziółka I., Sprawka M., 2019 - *Assessment of the possibility of using hemp biomass (Cannabis sativa L.) for energy purposes: a case study.* Applied Sciences, 9, 4437; doi:10.3390/app9204437

Kreuger E., Sipos B., Zacchi G., Svensson S-E., Björnsson, L., 2011 - *Bioconversion of industrial hemp to ethanol and methane: The benefits of steam pretreatment and coproduction.* Bioresource Technology, 102: 3457–3465

Lowin T., Schneider M., Pongratz G., 2019 - *Joints for joints: cannabinoids in the treatment of rheumatoid arthritis.* Current Opinion in Rheumatology, 31(3):271-278.

Melnic V., Dobrojan S., Bîrsan A., Buracinschi N., Melnic A., 2023 - *Cannabis sativa L. plantă de perspectivă ce poate deveni cultură în circuitul agricol al Republicii Moldova* In. Conferinţa Ştiinţifică Naţională, consacrată jubileului de 95 ani din ziua naşterii academicianului Boris Melnic, 172-181. https://ibn.idsi.md/sites/default/files/imag_file/172-181_9.pdf

Parker L.A., Rock E.M., Limebeer C.L., 2011 - *Regulation of nausea and vomiting by cannabinoids.* British Journal of Pharmacology, 163(7):1411-22. doi: 10.1111/j.1476-5381.2010.01176.x

Rock E.M., Limebeer C.L., Pertwee R.G., Mechoulam R., Parker L.A., 2021 - *Therapeutic potential of cannabidiol, cannabidiolic acid, and cannabidiolic acid methyl ester as treatments for nausea and vomiting.* Cannabis and Cannabinoid Research, 6(4):266-274. doi: 10.1089/can.2021.0041.

Rohleder C., Müller J.K., Lange B., Leweke F.M., 2016 -*Cannabidiol as a potential new type of an antipsychotic. a critical review of the evidence.* Frontiers in Pharmacology, 7:422. doi: 10.3389/fphar.2016.00422

Schofs L., Sparo M.D., Sánchez Bruni S.F., 2021 - *The antimicrobial effect behind Cannabis sativa.* Pharmacology Research & Perspectives, 1-7.

Shubina L.V., 2015 - *Modulation of seizure activity by endogenous cannabinoids in a temporal epilepsy model.* Doctoral thesis, Pushchino, 2015. https://www.dissercat.com/content/modulyatsiya-sudorozhnoi-aktivnosti-endogennymi-kannabinoidami-v-modeli-visochnoi-epilepsii

Tabără V., 2009 - *Cânepa (Cannabis sativa L.) – o importantă plantă tehnică.* https://www.revistaferma.ro/articole/tehnologii-agricole/canepacannabis-sativa-l

Ţîţei V., 2022 - *The evaluation of the quality of the energy phytomass from industrial hemp Cannabis sativa grown in Moldova.* Lucrări Ştiinţifice, seria Agronomie, 65 (1):123-128. *https://www.uaiasi.ro/revagrois/volum/Volum-65-1_2022.pdf*

Ţîţei V., Gadibadi M., Gutu A., Daraduda N., Mazare V., Armas A., Cerempel V., 2020 - *Biomass quality of hemp, Cannabis sativa L., and prospects of its use for various energy purposes.* Scientific Papers. Series A. Agronomy, 63 (2): 330-335.

Visković J., Zheljazkov V.D., Sikora V., Noller J., Latković D., Ocamb C.M., Koren A., 2023 - *Industrial hemp (Cannabis sativa L.) agronomy and utilization: A Review*. Agronomy 2023,*13*, 931. *https://doi.org/10.3390/agronomy13030931*

Vozza Berardo M.E., Mendieta J.R., Villamonte M.D., 2024 - *Antifungal and antibacterial activities of Cannabis sativa L. resins*. Journal of Ethnopharmacology, 2024, https://www.sciencedirect.com/science/article/abs/pii/S0378874123007079#:~:text=Cannabis%20sativa%20extracts%20have%20antifungal,antimicrobial%20activity%20of%20cannabis%20extract.

Wawro A., Batog J., Gieparda W., 2019 - *Chemical and enzymatic treatment of hemp biomass for bioethanol production.* Applied Sciences, 9, 5348; doi:10.3390/app9245348

Wiciński M., Fajkiel-Madajczyk A., Kurant Z., Gryczka K., Kurant D., Szambelan M., Malinowski B., Falkowski M., Zabrzynski J., Slupski M., 2023 - *The use of cannabidiol in metabolic syndrome—an opportunity to improve the patient's health or much ado about nothing?.* Journal of Clinical Medicine. 12. 4620. 10.3390/jcm12144620. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10380672.

Workplace Safety Insurance Board, 2021 - *Review on use of cannabis for medical purposes*. Risk Sciences International, 2021. 203 p. https://www.wsib.ca/sites/default/files/2022-02/medical_cannabis_final_report_jan_20_2021.pdf

Zuardi A.W., Crippa J.A., Hallak J.E., Moreira F.A., Guimaraes F.S., 2006 - *Cannabidiol, a Cannabis sativa constituent, as an antipsychotic drug*. Brazilian Journal of Medical and Biological Research 39(4):421-429. *https://www.scielo.br/j/bjmbr/a/5sGSHxqFkYHxCYhRZh6fWKH/?format=pdf&lang=en*

THE QUALITY INDICES OF THE BIOMASS OF SOME *TRIFOLIUM* SPECIES UNDER THE CONDITIONS OF THE REPUBLIC OF MOLDOVA

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Abstract

We studied the quality indices of the biomass of the local ecotypes of *Trifolium alpestre, Trifolium hibridum, Trifolium pannonicum, Trifolium pretense, Trifolium repens*. It was determined that the nutrient content and energy value of the dry matter of whole plants of the studied Trifolium species were characterized by the following indices: 144.9-206.9 g/kg CP, 25.8-31.7 g/kg EE, 224.4 -312.9 g/kg CF, 352.7-492.9 g/kg NFE, 85.6-125.0 g/kg ash, 11.4-22.9 g/kg Ca, 1.6-2.6 g/kg P, 17.86-18.43 MJ/kg GE, 8.31-9.96 MJ/kg ME and 4.63-5.76 MJ/kg NEl. The quality indices of the prepared hays were: 168.4-196.9 g/kg CP, 15.8-2.51 g/kg EE, 269.0-339.6 g/kg CF, 350.8-424.0 g/kg NFE, 94.2-124.6 g/kg ash, 12.6-22.6 g/kg Ca, 1.6-2.8g/kg P and 7.80-8.58 MJ/kg ME. The green mass substrates from the studied Trifolium species have C/N=14.89-21.10 and the biochemical methane potential varied from 260 to 271 l/kg ODM. The local ecotype of the studied Trifolium species can be used for the restoration of permanent grasslands and degraded lands, as a component of the mix of grasses and legumes for the creation of temporary grasslands. The harvested clover biomass can be used as forages for farm animals or as substrates in biogas generators for biomethane production.

Key words: biochemical composition, biomethane potential, green mass, hay, nutritive value, Trifolium species

The interest in agricultural systems based on crops of the *Fabaceae* family has increased regularly over the recent years due to their ability to form symbiotic relationship with nitrogen fixing bacteria, thus, they improve the physical properties of soil, form a large amount of organic raw material for circular economy and, besides, they are an important source of proteins, beneficial to human and animal nutrition (European Parliament Resolution, 2018).

Considering the limited natural and technical resources in the Republic of Moldova, the efficient use of the biological potential of the *Fabaceae* plants that are adapted to the local climatic conditions becomes more and more relevant. In the spontaneous flora of Basarabia, the family *Fabaceae* Lindl. is represented by 146 species of 35 genera, including 20 species of the genus *Trifolium* L. (Izverscaia T., 2020).

Members of the genus *Trifolium* include fodder crops, medicinal plant, honey plants, cover crops, energy biomass crops, ornamentals, soil nitrifiers, dune stabilizers, important agricultural weeds. In this context, the plants of the genus *Trifolium* have gained a lot of attention, being studied in many research centres (Ates E., 2011; Kiraz A.B., 2011; Lang J.&Vejražka K., 2012; Zvereva G.K., 2016; Tambara A.A.C. *et al,* 2017; Stinner W. *et al,* 2017; Egan L.M. *et al,* 2021; Hunady I. *et al,* 2021; Ţîţei V., 2023; Belashova O.V. *et al,* 2024).

The aim of this study was to evaluate the quality indices of the biomass from the local ecotype of *Trifolium alpestre* L., *Trifolium hibridum*, *Trifolium pannonicum* Jacq., *Trifolium pretense* L., *Trifolium repens* L., as forages for farm animals or as substrates in biogas generators for biomethane production.

MATERIALS AND METHODS

The local ecotypes of *Trifolium* species: *Trifolium alpestre*, *Trifolium hibridum*, *Trifolium pannonicum*, *Trifolium pratense* and *Trifolium repens* maintained in monoculture in collections of the National Botanical Garden (Institute) of Moldova, Chişinău, served as research subjects. The green mass samples were collected in in the third growing season and the first cut was done in the early flowering stage. The harvested plants were chopped into 1.5-2.0 cm small pieces, with a laboratory forage chopper; the dry matter content was detected by drying the samples to a constant weight, at 105°C. The prepared hay was dried directly in the field. For chemical analyses, the plant samples were dried in a forced-air oven at 60 °C, at the end of the fixation, the biological material was finely ground in a laboratory ball mill. The quality of the biomass was evaluated by analyzing such indices as: crude protein (CP) – by Kjeldahl method; crude fat (EE) – by Soxhlet method, crude cellulose (CF)– by Van Soest method; ash – in muffle furnace at 550°C and the nitrogen-free extract (NFE) was mathematically appreciated. The calcium (Ca) concentration of the samples was determined by using the atomic absorption spectrometry method, phosphorus (P) concentration – by spectrophotometric method.

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The gross energy (GE), metabolizable energy (ME), net energy for lactation (NEl) were calculated according to standard procedures:

GE= 23.9 xCP+39.8 xEE+ 20.1 xCF+17.5x NFE;

ME=14.07+0.0206 xEE-0.0147xCF - 0.0114 xCP;

NEl= 9.10+0.0098 xEE-0.0109 xCF-0.073xCP.

The carbon content of the substrates was determined using an empirical equation according to Badger C.M. *et al,* (1979). The biogas (BP) and the biomethane potential (MP), litre per kg of volatile solid matter (VS), were calculated using the gas forming potential of nutrients according to Baserga U. (1998), corrected by the nutrient digestibility.

RESULTS AND DISCUSSIONS

Providing high quality feed to meet the nutritional needs of farm animals is important for their growth and development, maintaining their health and wellbeing, as well as obtaining high quality animal products, which would increase their market value and would generate higher income for farmers, being an essential component of sustainable agriculture, food safety and security.

The biochemical composition and the fodder value of the green mass from the studied *Trifolium* species are shown in Table 1. We would like to mention that the nutrient content of the dry matter of whole plants of the studied *Trifolium* species was: 144.9-206.9 g/kg CP, 25.8-31.7 g/kg EE, 224.4 -312.9 g/kg CF, 352.7-492.9 g/kg NFE, 85.6-125.0 g/kg ash, 11.4-22.9 g/kg Ca, 1.6-2.6 g/kg P. A higher content of crude protein was found in the fodder from *Trifolium pretense* and *Trifolium pannonicum*. The green fodder of *Trifolium hybridum* and *Trifolium pretense* is characterized by higher content of fats, nitrogen-free extract and low content of crude cellulose as compared with *Trifolium pannonicum* and *Trifolium repens*. The green fodder of *Trifolium alpestre* has optimal concentration of crude cellulose and nitrogen free extract and lower – of crude protein and ash. The green fodder from *Trifolium hybridum, Trifolium pretense, Trifolium alpestre* have higher content of phosphorus, metabolizable energy and net energy for lactation as compared with *Trifolium pannonicum* and *Trifolium repens* green fodder.

Some authors mentioned various findings about the dry matter nutrient concentration of the green mass from *Trifolium* species. According to Acar Z. *et al*, (2001) the *Trifolium hybridum* plants contained 18.92% CP, 12.08 % ash, 1.34% Ca; *Trifolium pratense* – 17.74% CP, 13.70 % ash, 1.91% Ca and *Trifolium repens* 18.93% CP, 13.64 % ash, 1.39% Ca. Burlacu G. *et al,* (2002) revealed that the *Trifolium pratense* plants contained 183 g/kg DM, 90.8% OM, 18.6 % CP, 3.8% EE, 24.0% CF, 44.4% NFE, 9.0% sugars, 4% starch and 18.1 MJ/kg GE. Dewhurst R.J. *et al.* (2009) mentioned that *Trifolium pratense* plants contained 900 g/kg OM, 16.6% CP, 47.6 % NDF, 31.2% ADF with 69% OMD, 0.74 UFL/ kg, 86g/kg PDIE and 106 g/kg PDIN, but *Trifolium repens*, respectively, 887 g/kg OM, 22.9% CP, 32.0% NDF, 19.3% ADF with 80% OMD, 1.03 UFL/ kg, 102 g/kg PDIE and 147 g/kg PDIN. Tavlas A. *et al.,* (2009) reported that the *Trifolium pratense* genotypes contained 13.24 % CP, 32.15 % ADF, 42.97 % NDF with 63.86 % DDM, 59.39% TDN, RFV =139.6 and 0.61 Mcal/lb NEl. Ates E. (2011) mentioned that chemical content of dry matter from *Trifolium arvense* plants was 18.40-19.27% CP, 27.37-28.23% CF, 2.87-3.13% Ca, 0.27-0.28% P; from *Trifolium hybridum* plants – 18.97-19.57% CP, 23.83-24.67% CF, 1.92-2.13% Ca, 0.38-0.39% P; from *Trifolium medium* plants – 18.90-20.00% CP, 26.03-27.33% CF, 1.63-1.67% Ca, 0.43-0.44% P; from *Trifolium dubium* plants – 15.00-15.77% CP, 23.50-24.33% CF, 1.60-1.72% Ca, 0.35% P; from *Trifolium campestre* plants – 17.07-1.90% CP, 24.20-28.07% CF, 2.10-2.63% Ca, 0.36-0.37% P, respectively.

Homolka P. *et al,* (2012) found that the dry matter content, the concentrations of nutrients and energy of the red clover plants were 172.9 g/kg DM, 89.20% OM, 17.74% CP, 2.13% EE, 23.71 % CF, 41.80% NDF, 29.39% ADF, 4.95% ADL, 27.60% NSC with 75.4% *in vitro* digestibility of organic matter, 70.7% *in vivo* digestibility of organic matter, 17.74 MJ/kg GE, 11.84 MJ/kg DE, 9.57 MJ/kg ME and 5.67 MJ/kg NEl, but in lucerne forage, there was 237.1 g/kg DM, 89.03% OM, 14.55% CP, 2.06 % EE, 31.34% CF, 44.41% NDF, 34.48% ADF, 8.37% ADL, 28.01% NSC with 70.3% *in vitro* digestibility of organic matter, 65.6% *in vivo* digestibility of organic matter, 17.89 MJ/kg GE, 11.86 MJ/kg DE, 9.75 MJ/kg ME and 5.82 MJ/kg NEl. Lang J.& Vejražka K. (2012) mentioned that *Trifolium hybridum* yield was 9.19 t/ha DM with 21.8 % CP, 19.95% CF and 6.65 MJ/kg NEl; *Trifolium pratense* cultivars 2.75-16.42 t/ha DM with 17.35-21.26 % CP, 21.25-29.53% CF and 5.51- 6.14 MJ/kg NEl; *Trifolium repens* cultivars 1.89-8.35 t/ha DM with 22.72-24.06 % CP, 19.10-26.48% CF and 5.91- 6.6.56 MJ/kg NEl; *Trifolium ambiguum* yield was 2.73-3.17 t/ha DM with 17.28-18.38 % CP, 21.78-27.88% CF and 5.85-6.38 MJ/kg NEl. Küchenmeister K. (2013) reported that the nutrient content of *Trifolium repens* plants was: 24.0-254.4% CP, 31.5-36.6% NDF, 26.3-27.4% ADF, 6.1-6.7% WSC. Dandikas V. *et al,* (2015) mentioned that the nutrient composition of the tested red clover mass was 80.5-85.1% OM, 13.3-23.3% CP, 1.5-2.7 % EE, 18.4-27.7% CF, 4.5-6.2% starch, 6.3-10.6% reducing sugars, 33.6-53.6% NDF, 27.9-39.8% ADF, 5.2-7.2% ADL.

Heuze V. *et al,* (2015, 2019), reported the average feed value of *Trifolium pratense* aerial part was: 190 g/kg dry matter, 19.7% CP, 3.5% EE, 22.4% CF, 36.4% NDF, 26.6% ADF, 4.1% lignin, 8.3% WSC, 10.4% ash, 14.4 g/kg Ca and 3.4 g/kg P, 74.1% DOM, 18.4 MJ/kg GE, 13.1 MJ/kg DE and 10.4 MJ/kg ME, but *Trifolium repens* 168 g/kg dry matter, 24.8% CP, 2.7% EE, 19.6% CF, 27.5% NDF, 22.1% ADF, 3.9% lignin, 9.2% WSC, 11.3% ash, 10.1 g/kg Ca and 3.3 g/kg P, 80.9% DOM, 18.3 MJ/kg GE, 14.2 MJ/kg DE and 11.1 MJ/kg ME. Golubeva O.A *et al,* (2016) mentioned that *Trifolium pratense* plants contained 12.0-15.0% CP, 22.2-27.8 % CF, 0.5-0.8 nutritive units/kg with 9.5-9.8 MJ/kg ME and 89-120 g digestible protein/ nutritive units, *Trifolium hybridum* – 16.0% CP, 25.8% CF, 0.7 nutritive units/kg with 9.1 MJ/kg ME and 114 g digestible protein/ nutritive units, but *Trifolium repens*, respectively, 20.8% CP, 32.1% CF, 0.8 nutritive units/kg with 9.9 MJ/kg ME and 118 g digestible protein/ nutritive units.

Teleuță A. & Ţîţei V. (2016) established that the biochemical composition and energy concentration of *Trifolium repens* plants was: 11.38% CP, 2.10% EE, 42.00% CF, 38.44% NFE, 6.08% ash and 8.05 MJ/kg ME.

Ergon A. *et al,* (2017) mentioned that the nutritive value of dry matter from *Trifolium pratense* was 17.8-20.6% CP, 34.2-39.5% NDF, 29.1-30.5% ADF, 14.9-17.0% WSC, 32.5-35.2% NFC, 5.89-6.31 MJ/kg NEl and from *Trifolium repens* 16.3-22.6% CP, 36.9-43.8% NDF, 27.6-29.3% ADF, 14.1-18.7% WSC, 30.7-32.3% NFC, 5.93-6.24 MJ/kg NEl. Tambara A.A.C. *et al.* (2017) reported that the nutrient content of dry matter from *Trifolium pratense* was 24.08% CP, 33.72% NDF and 19.97% ADF, but from *Trifolium repens* 23.94% CP, 30.75% NDF and 18.91% ADF.

Sheaffer C.C. *et al*, (2018) mentioned that *Trifolium hibridum* contained 17.1-24.4% CP, 28.8-42.0% NDF, 62.9-70.1% *in vitro* DM. Shamanin A.A. *et al.* (2019) revealed that the quality indices of the dry matter from *Trifolium pannonicum* was 111.49 g/kg protein, 221.92 g/kg fibres, 168.10 g/kg sugars and the energy value 9.01 MJ/kg ME.

Wróbel B. & Zielewicz W. (2019) reported that the nutritional value of red clover was: 16.37-17.61% CP, 36.67-38.02% NDF, 27.84-28.77% ADF, 4.47-4.64% ADL, 12.84-13.08% WSC, 23.20-24.30% Cel, 8.53-9.25% HC, 66.49-67.21% DDM. Nechaeva T. *et al,* (2020) mentioned that *Trifolium pannonicum* plants contained 190-230 g/kg dry matter with 14.8-18.5 % CP, 2.1-2.7% EE, 26.0-28.9% CF, 9.7-12.5% ash, 24.9 g/kg Ca, 2.0 g/kg P, 0.88-0.90 fodder units/kg and 10.5-10.7 MJ/kg ME. Hunady I. *et al,* (2021) found that *Trifolium alpestre* dry matter contained 92.57 % OM, 15.08% CP, 4.04 % EE, 24.74% CF, 41.69% NDF, 32.09% ADF; *Trifolium pannonicum* – 94.86 % OM, 13.57% CP, 3.81 % EE, 26.87% CF, 48.18% NDF, 37.98% ADF; *Trifolium rubens* – 96.06 % OM, 15.21% CP, 2.78 % EE, 26.62% CF, 42.98% NDF, 33.82% ADF. Belashova O.V. *et al,* (2024) mentioned that the nutrient concentration in dry matter from *Trifolium hibridum* plants was 216.4 g/kg CP, 6.99 g/kg P; from *Trifolium pratense* plants – 238.8 g/kg CP, 6.48 g/kg P; from *Trifolium repens* plants – 277.3 g/kg CP and 6.52 g/kg P, respectively.

Fodder conservation is necessary in most parts of Earth to maintain feed supply, particularly in autumn and winter seasons. Hay is a valuable fodder for different species of animals, and the nutritional value of hay depends on the plant species, the period and method of harvesting the plants, the drying and storage system of the hay. As a result of the research carried out, Table 2, it was established that the hay from the investigated species is characterized by an optimal concentration of nutrients. *Trifolium hibridum* hay has higher content of crude protein, nitrogen free extract, phosphorus and lower amount of fats and crude cellulose, with higher energy value than other species. *Trifolium pratense* hay has higher content of fats, and *Trifolium repens* contains higher amounts fats and crude cellulose, ash and calcium and lower energy value. *Trifolium pannonicum* hay has higher concentration of crude protein and nitrogen free extract as compared with *Trifolium pratense* and *Trifolium repens* hay.

Several literature sources describe the biochemical composition and nutritional performance of hay from *Trifolium* species. According to Medvedev P.F.& Smetannikova A.I. (1981), *Trifolium hybridum* hay contained 19.0% CP, 1.26 % EE, 26.7% CF, 35.5 % NFE, 7.2- % ash and *Trifolium repens* hay 17.9-23.7% CP. Kiraz A.B. (2011) reported that *Trifolium repens* hay contained 15.08% CP, 9.77% ash, 3.29% EE, 41.06 % NDF, 33.15% ADF, 63.07% DMD, 2.435 Mcal/kg ME and RFV=143, but *Trifolium incarnarium* hay – 16.74% CP, 10.69% ash, 1.95% EE, 38.48 % NDF, 36.40% ADF, 60.54% DMD, 2.346 Mcal/kg ME and RFV=146, respectively. Heuze V. *et al,* (2015, 2019) mentioned that red clover hay contained 18.3% CP, 2.5% EE, 27.4% CF, 37.7% NDF, 28.3% ADF, 6.0% lignin, 6.5% ash, 13.5 g/kg Ca, 9.0 g/kg P, 67.2% DOM, 19.0 MJ/kg GE, 11.9 MJ/kg DE and 9.5 MJ/kg ME, but white clover hay – 22.7% CP, 23.4% CF, 29.4% NDF, 28.8% ADF, 3.5% lignin, 12.3% ash, 65.1% DOM, 17.4 MJ/kg GE, 10.7 MJ/kg DE and 8.4 MJ/kg ME. Zvereva G.K. (2016) in a comparative study on the loss of aerial organs and their parts during haymaking and the wilting intensity of cut shoots in perennial legume plants, found that in *Galega orientalis*, *Trifolium pratense* and *Trifolium pannonicum* leaves are larger, the intensity of shedding of vegetative organs in hay is lower (9-13%), the amount of shed leaves in the leaf mass reached 2-6%, after mowing, their leaves lose moisture more quickly than petioles, but more intense loss of vegetative and generative organs was observed in *Medicago* and *Melilotus* plant species (22-30% of the total weight); the process of drying of shoots and leaves of legume grasses was uneven, *Medicago varia*, *Melilotus albus* and *Melilotus officinalis* plants had smaller leaves; the loss of their vegetative organs at drying was greater; their petioles dried out faster than the leaf blades. Nechaeva T. *et al,* (2020) mentioned that Hungarian clover hay had 11.2-15.9 % CP, 1.5-3.2% EE, 25.2-35.6% CF, 8.8-11.1% ash.

Table 1.

The biochemical composition and the fodder value of the green mass from the studied *Trifolium* species

Indices	*Trifolium hibridum*	*Trifolium pratense*	*Trifolium repens*	*Trifolium pannonicum*	*Trifolium alpestre*
Crude protein, % DM	*16.54*	*20.68*	*18.23*	*19.15*	*14.99*
Crude fats, % DM	*3.17*	*2.98*	*2.71*	*2.56*	*2.72*
Crude cellulose, % DM	*22.44*	*23.79*	*31.29*	*29.74*	*26.78*
Nitrogen free extract, % DM	*49.29*	*41.23*	*35.27*	*37.77*	*46.58*
Ash, % DM	*8.56*	*11.32*	*12.50*	*10.78*	*8.93*
Calcium, % DM	*1.14*	*1.48*	*2.28*	*1.72*	*1.16*
Phosphorus, %	*0.26*	*0.23*	*0.18*	*0.16*	*0.24*
Gross energy, MJ/ kg	*18.43*	*18.09*	*17.86*	*18.15*	*17.96*
Metabolizable energy, MJ/ kg	*9.96*	*9.15*	*8.31*	*8.41*	*9.38*
Net energy for lactation, MJ/ kg	*5.76*	*5.29*	*4.63*	*4.71*	*5.36*

Table 2.

The biochemical composition and the fodder value of the hay from the studied *Trifolium* species

Indices	*Trifolium hibridum*	*Trifolium pratense*	*Trifolium repens*	*Trifolium pannonicum*
Crude protein, % DM	*19.69*	*16.84*	*16.87*	*17.18*
Crude fats, % DM	*1.59*	*2.51*	*1.63*	*1.58*
Crude cellulose, % DM	*26.90*	*32.15*	*33.96*	*31.24*
Nitrogen free extract, % DM	*42.40*	*38.51*	*35.08*	*39.75*
Ash, % DM	*9.42*	*9.99*	*12.46*	*10.25*
Calcium, % DM	*1.26*	*1.82*	*2.26*	*1.75*
Phosphorus, %	*0.28*	*0.17*	*0.17*	*0.16*
Gross energy, MJ/ kg	*18.17*	*18.18*	*17.61*	*18.19*
Metabolizable energy, MJ/ kg	*8.58*	*8.30*	*7.84*	*8.20*
Net energy for lactation, MJ/ kg	*4.89*	*4.62*	*4.33*	*4.59*

Table 3.

The biochemical biomethane production potential of green mass substrates from the studied *Trifolium* species

Indices	*Trifolium hibridum*	*Trifolium pratense*	*Trifolium repens*	*Trifolium pannonicum*	*Trifolium alpestre*
Carbon, g/kg DM	*508.00*	*492.66*	*486.11*	*49567*	*505.94*
Nitrogen, g/kg DM	*26.46*	*33.09*	*29.17*	*30.64*	*23.98*
Ratio carbon/nitrogen	*19.20*	*14.89*	*16.66*	*16.18*	*21.10*
Biodegradable protein, g/kg DM	*125.70*	*157.17*	*138.55*	*145.54*	*113.92*
Biodegradable fats, g/kg DM	*19.02*	*17.88*	*16.26*	*15.36*	*16.32*
Biodegradable carbohydrates, g/kg DM	*493.00*	*445.62*	*453.40*	*443.43*	*486.74*
Biogas potential, L/kg VS	*501*	*498*	*476*	*471*	*485*
Biomethane potential, L/kg VS	*271*	*266*	*261*	*260*	*262*
Methane content, % DM	*54.20*	*53.80*	*54.80*	*55.10*	*54.00*

Biogas is obtained by the anaerobic digestion of organic matter in special installations called digesters, which are designed and built in different shapes and sizes, depending on the type and quantity of raw material used as substrate. These digestion tanks contain complex bacterial cultures that break down (digest) organic matter to produce biogas, which consists of a relatively high percentage of methane (CH_4), the main component of natural gas, as well as carbon dioxide (CO_2), hydrogen sulphide (H_2S), water vapour, traces of other gases and digestate – the by-product of the anaerobic digestion process, which has many useful applications, as a nutrient-rich fertilizer. The biomethane produced from plant mass has a great importance and can successfully replace natural gas to obtain electric power and heat, can be compressed and used as vehicle fuel. The stability and the productivity of biogas digesters are mostly influenced by nutrient content and its biodegradability, and the carbon to nitrogen ratio (C/N) of the substrate. It is known the optimal C/N ratio in substrate should range from 10 to 30, which does not affect the development of bacteria involved in anaerobic digestion. The quality indices of the green mass substrates from the investigated *Trifolium* species and their biochemical methane potential are shown in Table 3. The carbon to nitrogen ratio in the investigated *Trifolium* substrates varied from 14.89 to 21.10, therefore, it met the established standards. The calculated biochemical biomethane potential of investigated substrates varied from 260 l/kg to 271 l/kg VS. The best biomethane potential was achieved in *Trifolium hybridum* substrate due to the higher content of fats and carbohydrates.

Several publications have documented the biomethane potential of *Trifolium* substrates. According to Lehtomäki A. (2006) the methane potentials of the *Trifolium pratense* substrates were 280-300 l/kg VS. Adamovics A. (2014) mentioned that the methane yield of red clover was 222.8-245.4 l/kg. Wahid R. *et al,* (2015) reported that the cumulative methane yield in red clover substrates varied from 263 to 328 l/kg VS, but grass-clover mixture – from 320 to 352 l/kg, respectively. Dandikas V. *et al.* (2015) remarked that the studied fresh mass substrates from *Trifolium pratense* contained 13.3-23.3% CP, 5.2-7.2% ADL and methane yield reached 273-346 l/kg VS, but the substrates from *Trifolium repens* plants 17.3-29.0% CP, 6.5-8.8% ADL and the methane yield was 265-320 l/kg VS, respectively. Teleuță A. &Ţîţei V. (2016) reported that the calculated gas forming potential of the fermentable organic matter of the *Trifolium repens* ecotype was 470 l/kg VS and the methane yield – 247 l/kg VS. Santamaría-Fernández M. *et al*, (2018) revealed that the methane yield of red clover residual press cake after protein extraction was 219-375 l/kg. Stinner W. *et al,* (2021) mentioned that the green mass substrate from *Trifolium alexandrinum* had 69% degradability and 308 l/kg VS methane yields, from *Trifolium pratense* 66-72% degradability and 278-316 l/kg VS methane yields. Hunady I. *et al,* (2021) calculated the theoretical methane yield and revealed that the values of biomass from *Trifolium pannonicum, Trifolium rubens* and *Trifolium alpestres*, *Trigonella foenum-graecum* and *Melilotus albus* ranged from 0.130 to 0.140 m^3/kg VS, the methane yield of the biomass from *Onobrychis viciifolia*, *Astragalus cicer*, *Dorycnium germanicum* and *Vicia sylvatica* ranged from 0.141 to 0.160 m^3/kg VS. Lallement A. *et al,* (2022) revealed that the methane potential of millet substrate was 267.9 l/kg VS, but the mix of millet and clover reached was 309.7 l/kg VS. In our previous research (Ţîţei V., 2023), we found that the biochemical methane yield of *Trifolium alexandrinum* substrates was 327-340 l/kg VS and *Trifolium pratense* substrates 364-365 l/kg VS. Li W. *et al,* (2023) remarked that the red clover substrate contained 5.96 g/kg N, 71 g/kg HC, 353 g/kg Cel, 42 g/kg ADL with practical biomethane potential 276.87 l/kg VS.

CONCLUSIONS

The studied local ecotypes of *Trifolium alpestre*, *Trifolium hibridum*, *Trifolium pannonicum*, *Trifolium pratense* and *Trifolium repens* can serve as starting material in breeding and implementing new varieties of leguminous species in the production of protein rich forages, as well as feedstock for biomethane production as a source of renewable energy.

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REFERENCES

Acar Z., Ayan I., Gülser C., 2001 - *Some morphological and nutritional properties of legumes under natural conditions.* Pakistan Journal of Biological Sciences, 4(11): 1312-1315.

Adamovics A., 2014 - *Biogas production from grasses*. In. 14th International Multidisciplinary Scientific GeoConference SGEM, 1: 65-68.

Ates E., 2011 - *Some chemical and morphological properties of five clover species (Trifolium sp.) at different aspect of pasture in Belovets village (Razgrad) Bulgaria.* International Journal of Plant Production, 5(3):255-262.

Badger C.M., Bogue M.J., Stewart D.J., 1979 - *Biogas production from crops and organic wastes.* New Zealand Journal of Science, 22:11-20.

Baserga U., 1998 - *Agricultural co-digestion biogas plants– biogas from organic residues and energy grass.*FAT Reports, 512: 1-11.

Belashova O.V., Kozlova O.V., Velichkovich N.S., Fokina A.D., Yustratov V.P., Petrov A.N., 2024 - *A phytochemical study of the clover growing in Kuzbass.* Foods and Raw Materials, 12(1):194–206.

Burlacu G., Cavache A., Burlacu R., 2002 - *Potentialul productiv al nutreturilor si utilizarea lor.* Ceres. București. 501.

Dewhurst R.J., Delaby L., Moloney A., Boland T., Lewis E., 2009 - *Nutritive value of forage legumes used for grazing and silage.* Irish Journal of Agricultural and Food Research, 48: 167–187.

Egan L.M., Hofmann R.W., Ghamkhar K., Hoyos-Villegas V., 2021 - *Prospects for Trifolium improvement through germplasm characterisation and pre-breeding in New Zealand and Beyond.* Frontiers in Plant Science, 12:653191.

European Parliament Resolution *European strategy for the promotion of protein crops*, 2018.

Ergon A., Kirwan L., Fystro G., Bleken M.A., Collins R.P., Rognli O. A., 2017 - *Species interactions in a grassland mixture under low nitrogen fertilization and two cutting frequencies. II. Nutritional quality.* Grass and Forage Science, 72(2):333-342.

Golubeva O.A., Timeyko L.V., Kholoptseva E.S., Evstratova L. P., 2016 - *Perennial plants of the legume family* (*Fabaceae or Leguminosae*) *in agrophytocenoses of Karelia.* Proceedings of Petrozavodsk State University, 6 (159):42–48.

Heuzé V., Tran G., Giger-Reverdin S., Lebas F., 2015 - *Red clover (Trifolium pratense).* Feedipedia,

Heuzé V., Tran G., Hassoun P., Lebas F., 2019 - White clover (Trifolium repens). Feedipedia,

Homolka P., Koukolová V., Podsedníček M., Hlaváčková A., 2012 - *Nutritive value of red clover and lucerne forages for ruminants estimated by in vitro and in vivo digestibility methods*. Czech Journal of Animal Science, 57(10):454-468.

Hunady I., Ondrísková V., Hutyrová H., Kubíková Z., Hammerschmiedt T., Mezera J., 2021 - *Use of wild plant species: a potential for methane production in biogas plants.* International Journal of Renewable Energy Research, 11(2):930-932.

Izverscaia T., 2020 - Familia *Fabaceae.* In: *Flora Basarabiei*. Chişinău. Vol.**3**. 388-592 pp.

Kiraz A.B., 2011 - *Determination of Relative Feed Value of Some Legume Hays Harvested at Flowering Stage.* Asian Journal of Animal and Veterinary Advances, 6: 525-530.

Küchenmeister K. 2013 - *Performance of underutilized forage legumes as an alternative to Trifolium repens under drought stress: yield, water utilization and nutritive value.* Doctoral Dissertation, Göttingen. 81p.

Lallement A., Peyrelasse C., Lagnet C., Barakat A., Schraauwers B., Maunas S., Monlau F., 2023 - A detailed database of the chemical properties and methane potential of biomasses covering a large range of common agricultural biogas plant feedstocks. *Waste*, 1:195–227.

Lang J., Vejražka K., 2012 - *Yields and quality of forage legumes under imbalanced year precipitation conditions on south Moravia.* Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 60(6): 217–224.

Lehtomäki A. 2006 - Biogas production from energy crops and crop residues. Jyväskylä, 94p.

Li W., Chai B., Lu Y., Wang M., 2023 - *Anaerobic co-digestion of grass, alfalfa, and red clover for methane production and the kinetic analysis.* BioResources, 18(1):1742-175.

Medvedev P.F., Smetannikova A.I., 1981 - *The forage crops of European part of the USSR*. Leningrad, 336p.

Nechaeva T., Yakutina O., Bogolubova, H., 2020 - *Hungarian clover (Trifollium pannonicum Jacq.) - perspective forage crop and phytomeliorant (literary review).* The Journal of Soils and Environment*. 3.* 10.31251/pos.v3i1.115. [in Russian].

Santamaría-Fernández M., Molinuevo-Salces B., Lübeck M., Uellendahl H.M, 2018 - *Biogas potential of green biomass after protein extraction in an organic biorefinery concept for feed, fuel and fertilizer production.* Renewable Energy, 129:769-775

Stinner W., Deuker A., Schmalfuß T., Brock C., Rensberg N., Denysenko V., Trainer P., Möller K., Zang J., Janke L., Mozena L.W., Oehmichen K., Popp D., Daniel-Gromke J., 2018 - *Perennial and intercrop legumes as energy crops for biogas production.* In. Legumes for Soil Health and Sustainable Management, 139-171.

Tambara A.A.C., Sippert M.R., Jauris G.C., Flores J.L.C., Henz E.L., Velho J.P., 2017 - *Production and chemical composition of grasses and legumes cultivated in pure form, mixed or in consortium.* Acta Scientiarum - Animal Sciences, 39:235-241.

Sheaffer C.C., Ehlke N.J., Albrecht K.A., Jungers J.M., Goplen J.J., 2018 - *Forage legumes clovers, birdsfoot trefoil, cicer milkvetch, crownvetch and alfalfa.* Station Bulletin 608-2018 Minnesota Agricultural Experiment Station University of Minnesota Saint Paul, Minnesota. 64p.

Shamanin A.A., Popova L.A., Gintov V.V., 2019 - Using the less widespread feed crops for forming a high quality feed agrophytocenosis in conditions of the Northern region of Russia. Agrarian Bulletin of the Urals, 4 (183):40-47.

Tavlas A., Yolcu H., Tan M., 2009 - *Yields and qualities of some red clover (Trifolium pratense L.) genotypes in crop improvement systems as livestock feed.* African Journal of Agricultural Research, *4*(7): 633-641.

Teleuţă A., Ţîţei V., 2016 - *Economic value of some leguminous plant species of the collections from the Botanical Garden (Institute) of the Academy of Sciences of Moldova.* Journal of Plant Development, 23:27-35.

Ţîţei V., 2023 - *The agroeconomical value of Trifolium alexandrinum and Trifolium pratense, in the Republic of Moldova.* Oltenia. Studii şi comunicări. Ştiinţele Naturii, 39 (1): 93-101.

Wahid R., Ward A., Møller H., Søegaard K., Eriksen J., 2015 - *Biogas potential from forbs and grass-clover mixture with the application of near infrared spectroscopy*. Bioresource Technology,198:124-132.

Wróbel B., Zielewicz W., 2019 - *Nutritional value of red clover (Trifolium pratense L.) and birdsfoot trefoil (Lotus corniculatus L.) harvested in different maturity stages*. Journal of Research and Applications in Agricultural Engineering, 64(4):14-19.

Zvereva G.K., 2016 - *Leaf shedding in hay and cut shoot wilting intensity of perennial legume grasses.* Bulletin of the Altai State Agrarian University, 3(137): 35-41.

THE BIOMASS QUALITY OF *EPILOBIUM ANGUSTIFOLIUM* L. AND PROSPECTS OF ITS USE IN MOLDOVA

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Abstract

This research was aimed at evaluating the quality indices of green mass forage and the substrates for the biomethane production from rosebay willowherb – Epilobium angustifolium. The local ecotypes of Epilobium angustifolium which grow in the experimental sector of the "Alexandru Ciubotaru" National Botanical Garden (Institute) MSU Chişinău served as subject of the research. The results revealed that the dry matter of Epilobium angustifolium whole plants contained: 12.99% crude protein, 5.83% crude fats, 28.33% crude cellulose, 44.92% nitrogen free extract, 5.23% sugars, 1.74% starch, 7.92 % ash, 1.11% calcium, 0.28% phosphorus with 10.06 MJ/kg ME and 5.64 MJ/kg NEl. The Epilobium angustifolium substrate for anaerobic digestion and biomethane production had optimal carbon to nitrogen ratio and the estimated biochemical methane potential reached 288 l/kg VS. Epilobium angustifolium can be used as an alternative source of nutrients in livestock nutrition, or as a source of biomass for biomethane production in renewable energy production and as organic fertilizer.

Key words: biochemical composition, biomethane potential, Epilobium angustifolium, green mass, nutritive value

Climate change-associated environmental stresses, such as extreme temperatures, lack of precipitation or erratic rainfall during the growing season will compromise the ability of agriculture to meet the food demands of an increasing global population. The mobilization and domestication of new plant species would promote agricultural diversity and would provide a solution to many of the problems associated with climate change resilience, food security, forage production, feedstock energy biomass and other industrial needs.

Rosebay willowherb or fireweed, *Epilobium angustifolium* L., is an herbaceous perennial plant from *Onagraceae* family, native to Eurasia, North America. In the European literature, the species is frequently referred to as *Chamaeneion angustifolium* (L.) Scop., *Chamerion angustifolium* (L.) Holub. The plants grow each spring from buds formed the previous year on lateral roots. The green stems, frequently reddish, usually unbranched and usually glabrous below and pubescent above with small white hairs, glabrous below and pubescent above, are erect, up to 2 m tall. The willow-like leaves are alternate, entire, 3-20 cm long and 1.0-2.5 cm wide, green above, pale and reticulate-veiny beneath, acuminate with a narrowed, sessile, to obscurely petiolate base.

Leaves are minutely and distantly toothed, or nearly entire, the lower ones are narrowed into short petioles. The inflorescence is a raceme, 15-35 cm long with 8 to 80 flowers, foliated at the base. The flower peduncles are 0.4-1.3 cm long, with small, linear bracts at the base. The calyx is incised down to the base, with the tube reaching 1 mm long, with lanceolate or linear, acute lobes, with small hairs on the outside, 10 mm long and 2 mm wide. The corolla is slightly zygomorphic, reddish-purple; the petals are 15 mm long and 7 mm wide. The seed capsules are canescent, 2.5-8.0 cm in length, and each may contain many small light brown seed, 0.8-1.3 mm in length, capped with a tuft of hairs up to 13 mm long. Flowers are pollinated by insects, the honey production 600-900 kg/ ha. It reproduces by seeds and vegetatively by rhizomes, and so it may be propagated from cuttings (Broderick D.H., 1990; Pavek D.S., 1992; Adamczak A. *et al,* 2019).

Rosebay willowherb *Epilobium angustifolium* it occurs sporadically throughout the entire territory of Bessarabia, in meadows along creeks, on sandy riverbanks, in forest glades, on roadsides and in deforested areas.

Epilobium angustifolium has gained a lot of attention, being studied as medicinal plant, honey plant, fodder crop, energy biomass crop, ornamental, soil stabilizer and agricultural weed in many research centres (Medvedev P.F. & Smetannikova A.I., 1981; Robbins C.T. *et al,* 1987; Broderick D.H., 1990; Hanley T.A. *et al,* 1992; Pavek D.S., 1992; Starkovsky B.N., 2003; Erhardt A. *et al,* 2005; Kshnikatkina A.N. *et al,* 2005; Polezhaeva I.V. *et al,* 2007; Guil-Guerrero J.L. *et al,* 2016; Bushueva G.R. *et al,* 2016; Tsarev V.N. *et al,* 2016; Adamczak A. *et al,* 2019; Smuga-Kogut M. *et al,* 2020; Irinina

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This research was aimed at evaluating the quality indices of green mass forage and the substrates for the biomethane production from rosebay willowherb, *Epilobium angustifolium*.

MATERIALS AND METHODS

The local ecotypes of rosebay willowherb *Epilobium angustifolium* that grow in the experimental sector of the "Alexandru Ciubotaru" National Botanical Garden (Institute) Chişinău served as subjects of the research. The traditional forage crops: common millet – *Panicum miliaceum* 'Marius', the sorghum and Sudan grass hybrid – *Sorghum bicolor* × *Sorghum sudanense "SAȘM-4,* the corn hybrid – *Zea mays 'Porumbeni 374'* and alfalfa – *Medicago sativa* were used as control variants. The *Epilobium angustifolium* plant samples were collected in the flowering stage. The dry matter content was detected by drying the samples up to constant weight at 105°C. For biochemical analysis, the samples were dried in a forced air oven at 60°C, milled in a beater mill equipped with a sieve with diameter of openings of 1 mm. The quality of the biomass was evaluated by analyzing such indices as: crude protein (CP) – by Kjeldahl method; crude fat (EE) – by Soxhlet method, crude cellulose (CF)– by Van Soest method; ash – in muffle furnace at 550°C and the nitrogen-free extract (NFE) was mathematically appreciated. The calcium (Ca) concentration of the samples was determined by using the atomic absorption spectrometry method, phosphorus (P) concentration – by spectrophotometric method. The gross energy (GE), metabolizable energy (ME), net energy for lactation (NEl) were calculated according to standard procedures:

$$GE= 23.9 \times CP+39.8 \times EE+ 20.1 \times CF+17.5 \times NFE;$$

$$ME=14.07+0.0206 \times EE-0.0147 \times CF - 0.0114 \times CP;$$

$$NEl= 9.10+0.0098 \times EE-0.0109 \times CF-0.073 \times CP.$$

The carbon content of the substrates was determined using an empirical equation according to Badger C.M. *et al,* (1979). The biochemical methane potential was calculated using the gas forming potential of nutrients according to Baserga U., (1998), corrected by the nutrient digestibility.

RESULTS AND DISCUSSIONS

As a result of our observations, we found that at the flowering stage the local ecotypes of *Epilobium angustifolium* reached 132-148 cm in height. In the harvested mass of *Epilobium angustifolium*, the stems made up 59.5% and the leaves 40.5%. The dry matter content varied considerably, from 23.96% in leaves to 28.81% in stems. The biochemical composition, nutritive and energy value of the green mass from the *Epilobium angustifolium* are presented in Table 1. The comparative analysis of the nutrient composition of whole plants showed that *Epilobium angustifolium* natural fodder was characterized by a significantly higher content of crude protein than *Sorghum bicolor* × *Sorghum sudanense* and *Zea mays* green mass, but lower than in *Medicago sativa* fodder.

The concentration of crude fats in *Epilobium angustifolium* whole plants differed significantly as compared with traditional forage crops, reaching 58.3 g/kg dry matter. The content of crude cellulose in rosebay willowherb green fodder was lower than in sorghum x Sudan grass, alfalfa and common millet, but higher than in corn green fodder. The *Epilobium angustifolium* green fodder is characterized by optimal amount of nitrogen free extract (449.2 g/kg dry matter), but much lower than in corn and common millet green fodder. The concentration of soluble sugars in *Epilobium angustifolium* green fodder was higher than in *Medicago sativa* fodder, but lower than in *Sorghum bicolor* × *Sorghum sudanense, Panicum miliaceum* and *Zea mays* green mass. The starch concentration in rosebay willowherb green fodder was lower than in corn and sorghum x Sudan grass hybrids. The ash content in rosebay willowherb natural fodder was much higher than in corn and sorghum x Sudan grass fodder, and did not differ significantly as compared with alfalfa and common millet fodder.

The rosebay willowherb natural fodder was characterized by much higher concentration of calcium and phosphorus than in sorghum x Sudan grass, common millet and corn fodder. The energy supply of the feed from whole *Epilobium angustifolium* plants reached 10.06 MJ/kg metabolizable energy and 5.64 MJ/kg net energy for lactation, being higher than in the forage produced from sorghum x Sudan grass, common millet and alfalfa plants, but lower than in corn plants. It was found that the level of carotene in *Epilobium angustifolium* green mass was significantly higher as compared with controls forage crops.

Different results regarding the biochemical composition and the nutritive value of the harvested mass from *Epilobium angustifolium* species are given in the specialized literature. According to Medvedev P.F. & Smetannikova A.I., (1981) the harvested rosebay willowherb whole plants contained 10.5-14.0 % CP, 2.0-3.2 % EE, 18.2-20.2% CF, 4.3-9.9% ash. Robbins C.T *et al*, (1987) mentioned that the *Epilobium angustifolium* flowers had 13.7% CP. Hanley T.A. *et al,* (1992) remarked that *Epilobium angustifolium* plants contained 13.4% CP, 2.0% lignin, 1.2% cutin and 65.4% digestible dry matter. Pavek D.S. (1992)

revealed that the nutritional value of fireweed *Epilobium angustifolium* varied depending on season and site: 4-20% CP and 28-80% dry matter digestibility. Starkovsky B.N. (2003) found that the dry matter quality indices of *Epilobium angustifolium* whole plants were 170 g/kg DM, 18.3 % CP, 4.92% EE, 19.7% CF, 50.3 % NFE, 10.02% sugars, 2.03 % starch, 8.17% ash, 9.54 g/kg Ca, 6.01 g/kg P, 214 mg/kg carotene with 10.2 MJ/kg ME and 0.88 nutritive units. MJ/kg ME Kshnikatkina A.N. *et al*, (2005) reported that the forage quality of *Epilobium angustifolium* green mass harvested in the flowering period was 269.5 g/kg DM, 14.98 % CP, 3.05% EE, 26.61% CF, 7.47% ash, 11.00 g/kg Ca, 7.00 g/kg P, but *Medicago varia* – 154.5 g/kg DM, 24.47 % CP, 2.59% EE, 22.87% CF, 10.25% ash, 5.00 g/kg Ca, 1.80 g/kg P, respectively. Guil-Guerrero J.L. *et al*, (2014) remarked that the proximate composition and energy content of *Epilobium angustifolium* shoots was 18.8% CP, 55.0% carbohydrates, 10.0% fibre, 7.5% lipids, 5.0 % ash and 18.39 MJ/kg GE, but *Sorghum bicolor* inflorescence with seeds contained 9.0% CP, 72.0% carbohydrates, 3.0% lipids, 2.0 % ash, and 15.64 MJ/kg GE. Terranova M. (2018, 2011) found that the nutrient content and the fodder value of green mass from *Epilobium angustifolium* was 937-938 g/kg organic matter with 12.1-12.5 % CP, 1.5-1.9% EE, 40.2-47.3% NDF, 33.8-40.6% ADF, 9.4-10.8 % ADL, 61.6%IVOMD, 4.56 MJ/kg NEl and from *Lotus corniculatus* 912-914 g/kg organic matter with 13.5-13.9 % CP, 0.7-1.0% EE, 57.0-58.8% NDF, 43.4-46.0% ADF, 10.4-11.2% ADL, 64.9% IVOMD, 4.96 MJ/kg NEl, respectively. Irinina O.I.& Eliseeva S.A. (2021) reported that the above-ground mass of *Epilobium angustifolium* contained 16.4% CP and 13.13-26.01 % CF. Starkovsky B.N. *et al*, (2020) revealed that the forage produced from *Epilobium angustifolium* whole plants, in the first year of growth, contained 16.00 % CP, 4.29% EE, 8.75% sugars, 10.17 MJ/kg ME and 0.77 nutritive units/kg DM, while second-year forage – 15.27 % CP, 4.11% EE, 8.35% sugars, 10.19MJ/kg ME and 0.88 nutritive units/kg DM, respectively.

Table 1.

The biochemical composition and the fodder value of *Epilobium angustifolium* green mass

Indices	*Epilobium angustifolium*	*Panicum miliaceum*	*Sorghum bicolor × Sorghum sudanense*	*Zea mays*	*Medicago sativa*
Crude protein, % DM	*12.99*	*10.62*	*8.47*	*7.26*	*16.28*
Crude fats, % DM	*5.83*	*2.81*	*2.75*	*2.83*	*2.75*
Crude cellulose, % DM	*28.33*	*30.69*	*37.61*	*18.40*	*33.25*
Nitrogen free extract, % DM	*44.92*	*47.60*	*45.19*	*67.92*	*39.50*
Soluble sugars, % DM	*5.23*	*7.31*	*10.56*	*7.55*	*4.28*
Starch, % DM	*1.74*	*2.67*	*1.50*	*22.79*	*1.65*
Ash, % DM	*7.92*	*8.01*	*5.99*	*3.59*	*8.22*
Calcium, % DM	*1.11*	*0.30*	*0.20*	*0.24*	*1.43*
Phosphorus, %	*0.28*	*0.23*	*0.13*	*0.22*	*0.22*
Gross energy, MJ/ kg	*18.94*	*18.21*	*18.27*	*18.46*	*18.56*
Metabolizable energy, MJ/ kg	*10.06*	*9.29*	*8.13*	*11.13*	*8.26*
Net energy for lactation, MJ/ kg	*5.64*	*5.23*	*4.63*	*6.34*	*4.57*
Carotene, mg/kg	*174.0*	*32.92*	*32.92*	*14.30*	-

Table 2

The biochemical methane production potential of green mass substrate from *Epilobium angustifolium*

Indices	*Epilobium angustifolium*	*Panicum miliaceum*	*Sorghum bicolor × Sorghum sudanense*	*Zea mays*	*Medicago sativa*
Organic dry matter, g/kg	*920.8*	919.0	894.4	964.1	917.8
Digestible matter, g/kg	*662.7*	662.3	640.5	678.0	580.9
Digestible proteins, g/kg	*101.2*	80.7	59.2	42.1	122.1
Digestible fats, g/kg	*36.7*	17.4	12.3	19.2	12.7
Digestible carbohydrates, g/kg	*524.8*	564.2	569.0	616.7	446.1
Carbon, g/kg	*511.6*	510.6	496.9	535.6	509.8
Nitrogen, g/kg	*20.8*	17.0	13.6	11.6	26.0
Ratio carbon/nitrogen	*24.6*	30.0	36.5	46.2	19.6
Biochemical methane potential, L/kg OM	*288*	303	296	291	268

Biomass plays a key role in the development and utilization of renewable energy resources and has become a major component of sustainable global energy strategies, energy security and climate change mitigation. Biogas production is receiving growing attention in the circular economy aspects, may appear on a variety of markets, including electricity, heat and transportation fuels.

The results of the determination of the quality indices and biochemical methane production potential of green mass substrate from the *Epilobium angustifolium* are presented in Table 1. The digestible organic matter concentration in the *Epilobium angustifolium* substrate reaches 662.7 g/kg dry matter, being higher than in *Medicago sativa* substrate but lower than in *Zea mays* substrate. The C/N ratio in the *Epilobium angustifolium* substrate is more favourable as compared with *Sorghum bicolor* × *Sorghum sudanense* and *Zea mays* substrates. The biochemical methane potential of the studied *Epilobium angustifolium* substrate was 288 l/kg organic matter, being about the same as in corn and sorghum x Sudan grass substrates, but lower than in common millet substrate.

CONCLUSIONS

The green mass from the local ecotypes of *Epilobium angustifolium* can be used as an alternative source of nutrients in livestock nutrition, or as a source of biomass for biomethane production in renewable energy production and as organic fertilizer.

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REFERENCES

Adamczak A., Dreger M., Seidler-Łożykowska K., Wielgus K. 2019 - *Fireweed (Epilobium angustifolium L.): botany, phytochemistry and traditional uses. A review.* Herba Polonica, 65: 51 - 63.

Antonenko M.S., Malankina E.L., 2022 - *Prospects for the use of leaves and inflorescences of fireweed (Chamaenerion angustifolium (L.) Scop.) as a medicinal plant material (review).* Vegetable Crops of Russia, (1):72-78. [in Russian].

Badger C.M., Bogue M.J., Stewart D.J., 1979 - *Biogas production from crops and organic wastes.* New Zealand Journal of Science, 22:11-20.

Baserga U., 1998 - *Agricultural co-digestion biogas plants– biogas from organic residues and energy grass.*FAT Reports, 512: 1-11

Broderick D. H., 1990 - *The biology of Canadian weeds. 93. Epilobium angustfolium L. (Onagraceae).* Canadian Journal of Plant Science, 70: 24'7-259

Bushueva G.R. Syroeshkin A.V. Maksimova T.V., Skalny A.V., 2016 - *Chamaenerion angustifolium – a promising source of biologically active compounds.* Trace Elements in Medicine, 17(2):15-23.

Erhardt A., Rusterholz H-P., Stöcklin J., 2005 - *Elevated carbon dioxide increases nectar production in Epilobium angustifolium L.* Oecologia, 146: 311-317.

Guil-Guerrero J.L., Guil-Laynez J.L., Guil-Laynez A., 2014 - *Assessment of several weeds for bioenergy production.* Journal of Biobased Materials and Bioenergy, *8*(3): 358-362.

Hanley T.A., Robbins C.T., Hagerman A.E., Mcarthur, C., 1992 - *Predicting digestible protein and digestible dry matter in tannin-containing forages consumed by ruminants*. Ecology,73(2):537-541

Irinina O.I., Eliseeva S.A., 2021 - *The study of biochemical composition and medicinal properties of the plant Epilobium angustifolium (fireweed).* Polzunovskiy vestnik, (2):44-54.

Kamkin V.A., Shalabaev B.A., Kamarova A.N., 2023 - *Prospects of cultivation and production of fireweed in the north-east of Kazakhstan.* Bulletin of the L.N. Gumilyov Eurasian National University. Bioscience Series, 1(142):6-16. DOI: 10.32523/2616-7034-2023-142-1-6-16.

Kshnikatkina A.N., Gushchina V.A., Galiullin A.A., Varlamov V.A., Kshnikatkin S.A., 2005 - *Nontraditional fodder crops*. Penza, RIO PGSKHA.

Medvedev P.F., Smetannikova A.I., 1981 - *The forage crops of European part of the USSR.* Leningrad, Kolos. 336p.

Polezhaeva I.V., Polezhaeva N.I., Menyajlo L.N., 2007 - *Amino acid and mineral composition of the vegetative part of Chamaenerion angustifolium (L.) Holub*. Chemical Pharmaceutical Journal, 3: 27-29.

Pavek D.S., 1992 - Chamerion angustifolium. In: Fire Effects Information System. *https://www.fs.usda.gov/database/feis/plants/forb/chaang/all.html*

Robbins C.T., Hanley T.A., Hagerman A.E., Hjeljord O., Baker D.L., Schwartz C.C., Mautz W. W., 1987 - *Role of tannins in defending plants against ruminants: reduction in protein availability.* Ecology. 68(1): 98-107.

Smuga-Kogut M., Szymanowska D., Markiewicz R., Piskier T., Kobus-Cisowska J., Cielecka-Piontek J., Schöne H., 2020 - *Evaluation of the potential of fireweed (*Epilobium angustifolium *L.), European goldenrod (*Solidago virgaurea *L.), and common broom (*Cytisus scoparius *L.) stems in bioethanol production.* Energy Science & Engineering, 8:3244–3254.

Starkovsky B.N., 2003 - *Development of agricultural practices for cultivation narrow-leaved fireweed for feed purpose.* Dissertion for an academic degree candidate of agricultural sciences, 157p.

Starkovsky B.N., Simonov G.A., Vakhrusheva V.V., 2020 - *Cultlvation of narrow-leaved fireweed (Chamaenerion angustifolium) together with maral root (Rhaponticum carthamoides) (Willd) Jlin.* Dairy Farming Journal, 3 (39):83-93.

Terranova M., 2018 - *Potential of forages from temperate-climate woody and herbaceous plants to mitigate methane and ammonia in ruminants. Doctoral thesis, University of Hohenheim, 135*

Tsarev V.N., Bazarnova N.G., Dubenskii M.M., 2016 - *Chamerion angustifolium L. chemical composition, biological activity* (Reviews). Chemistry of Plant Raw Material, 4: 15–26.

VALORIZATION OF WASTEWATER FROM *SPIRULINA PLATENSIS* CULTIVATION AS A BIOLOGICAL STIMULANT FOR THE GERMINATION OF *GALEGA ORIENTALIS* L. SEEDS PRESERVED IN COLLECTIONS

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Abstract
The article presents the experimental results obtained from applying a biostimulant based on residual water from the cultivation of the alga Spirulina platensis on the germination of *Galega orientalis* seeds maintained in collection conditions for 2, 3, and 4 years. The results show that seeds treated with biostimulants exhibit a higher germination capacity than those in the control group, where germination ranged between 27-33%. The highest germination rates were obtained for the 4-year-old seeds (60%) and 3-year-old seeds (47%) treated with biostimulant concentrations of 2% and 4% for 2-4 hours. Moreover, the germination index is significantly higher in the treated seeds, reaching maximum values of 12 and 8.6 for the 4- and 3-year-old seeds, respectively, compared to the control group values (5,4-6,6). The relative root elongation was greater in the 2-year-old seeds treated with a 1% biostimulant, but for the older seeds (3-4 years), the 2% concentration applied for 4 hours yielded the best results. The 4% concentration showed stability, although with a smaller root elongation compared to the lower concentrations. In conclusion, the 2% biostimulant applied for 2-4 hours is the most effective for stimulating germination and root growth in the older seeds of *Galega orientalis*.

Key words*:* biostimulants, *Galega orientalis, Spirulina platensis,* wastewater.

INTRODUCTION

Cultivation of spirulina *(Spirulina platensis*) has gained increasing interest due to its nutritional value and applicability in various fields. According to recent estimates, global spirulina production is around 1,5 million tons of dry biomass, a significantly higher amount than chlorella, which stands at approximately 1 million tons of dry biomass (Market Watch, 2024; Global Algae Market Report, 2024). To meet these biomass quantities, algae are cultivated on an industrial scale, and as a result, large amounts of wastewater, primarily consisting of the cultural liquid, accumulate. Managing this wastewater requires significant resources, especially for the maintenance of treatment systems. It is important to note that this wastewater is rich in nutrients, biologically active substances, and other compounds that need recovery and utilization, presenting a real opportunity to apply the environmental protection principles of "R-R-R" (recovery - reuse - recycling). Thus, recent research has begun to explore the potential of this wastewater for reuse, recycling, and recovery, offering innovative solutions that could contribute to the ecological sustainability of spirulina cultivation.

Research conducted by Li and co-authors demonstrated that wastewater from spirulina cultivation can be successfully used as a fertilizer for various crops, including for stimulating seed germination, showing a pronounced positive effect (Li X. *et al,* 2021). In a similar study, Zhang and co-authors used wastewater from spirulina cultivation as a soil fertilizer, which improved soil quality and increased the productivity of agricultural crops (Zhang Y. *et al,* 2022). Kumar and co-authors developed an advanced technology that involves using spirulina for wastewater treatment to recover nutrients, thus reducing environmental impact and turning waste into valuable resources (Kumar P. *et al,* 2023). Based on this, we believe that wastewater from spirulina cultivation can not only be recycled, recovered, and reused, but also significantly contribute to the development of more sustainable agricultural practices.

Therefore, we aimed to utilize this wastewater as a biostimulant for the germination of *Galega orientalis* seeds stored under collection conditions.

The *Galega orientalis* Lam. Fabaceae family is known commonly as eastern galega or fodder galega - is a perennial herbaceous plant native to the North Caucasus area. The Fabaceae speces are of interest in agriculture due to its

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ability to fix atmospheric nitrogen in the soil through symbiosis with bacteria from the *Rhizobium* genus (Giller K., 2001). *Galega orientalis* develops a branched tap root system that reaches a depth of 50-135 cm, forming a dense network of roots with adventitious bristles, on which there may be up to 1500 nodules containing *Rhizobium galegae* bacteria. This species had a multipurpose utility, including the early beginning of vegetation, fast growth, optimal capacity for regeneration after mowing, so that they can be cut 2-3 times per year with high protein yield.

Galega orientalis has been researched in several university and scientific centers as fodder crops, medicinal plant, honey plant, energy crops (Skerman P.J. *et al*, 1988; Koleva I.I., 2002; Dubrovskis V. *et al,* 2008; Adamovics A. *et al,* 2011; Avetisyan A.T., 2013; Domash V.I. *et al*, 2013; Povilaitis V. *et al,* 2016; Skórko-Sajko H. *et al,* 2016; Meripold H. *et al,* 2017; Darmohray L.M. *et al,* 2018, 2021; Shymanska O. *et al,* 2018; Aizman R.I. *et al,* 2019; Cherniavskih V.I. *et al,* 2020; Khasanov E. *et al,* 2020; Starkovskiy B. *et al,* 2020; Vergun O. et al, 2020; Hunady I. *et al,* 2021; Rakhmetov J. *et al,* 2021; Żarczyński P.J. *et al*, 2021; Ignaczak S *et al,* 2022; Biligetu B. *et al,* 2024; Moiseeva E.A. *et al,* 2024).

At the "Alexandru Ciubotaru" National Botanical Garden (Institute) of Moldova State University, the species *Galega orientalis* it has been researched the ‘80s of the past century, being identified valuable forms and created local cultivars, evaluated the quality of green mass, hay and haylage, also the quality indices of biomass for renewable energy production (Teleuţă A. & Ţîţei V. 2011, 2012; Teleuţă A. *et al,* 2015; Coşman S. *et al,* 2017; Ţîţei V. & Coşman S., 2019; Cerempei V. *et al,* 2023; Ţîţei V., 2024).

To preserve the gene pool of *Galega orientalis* Lam., its seeds are stored under collection conditions for several years, a process that affects their germination. Therefore, it is important to develop new, affordable, and efficient biostimulants to stimulate the germination of dormant plant seeds.

MATERIALS AND METHODS

In the experiments, the *Spirulina platensis* cyanobacteria strain, selected in culture by corresponding member Prof. Vasile Șalaru, academician Prof. Valeriu Rudic, and co-authors, was used. The *Spirulina platensis* strain, stored in the Sceintific Laboratory "Algology Vasile Șalaru" collection of the Moldova State University, was cultivated on modified Zarrouk liquid medium with the following composition (g/L): $NaHCO_3$ – 8; K_3HPO_4 – 0,5; $NaNO_3$ – 2,5; K_2SO_4 – 1; NaCl – 1; $MgSO_4$ – 0,2; $CaCl_2$ – 0,04; $FeSO_4$ – 0,01; NaEDTA – 0,08; potable water – 1 L. The inoculum was 0,5 g/L (absolute dry biomass). On the 20th day of cultivating the *Spirulina platensis* cyanobacteria, the algal biomass was separated from the cultural liquid by centrifugation (at 6000 rpm), and the cultural liquid (wastewater) was used to obtain the biostimulant applied in the experiments. The cyanobacterial biostimulant was obtained by thermal activation of the separated cultural liquid.

Solutions with concentrations of 1-4% were used in the experiments, obtained by diluting the cultural liquid from *Spirulina platensis* cultivation with distilled water. Seeds of *Galega orientalis* L., maintained in collection conditions for 2-4 years, numbering 100 for each experimental group, were exposed to the prepared solutions for 1-4 hours, while the control group consisted of the same seeds exposed to distilled water for the same duration.

The experimental *Galega orientalis* cultivar ‘Sofia’ seeds were provided by "Alexandru Ciubotaru" National Botanical Garden (Institute) of the Moldova State University.

To study the germination process, the seeds were placed in Petri dishes on filter paper moistened with distilled water, under natural light and at a temperature of 22°C. In the research, the following indicators were determined:

Germination capacity of the seeds (GC), according to the formula: $GC = Nsg/Nts * 100$, where Nsg = number of germinated seeds; Nts = total number of seeds.

Germination index (GI) calculated on the 5th day of the experiment, according to the formula: $GI = \sum(Gt/Tt)$, where Gt = number of seeds germinated at time t, and Tt = number of days.

Relative root elongation (RRE), calculated on the 7th day of germination, according to the formula: $RRE = (Le/Lc) * 100$, where Le = root length in the experimental group, and Lc = root length in the control group.

RESULTS AND DISCUSSIONS

Stimulating the germination of seeds maintained in collections is crucial for both scientific research in the field and for individuals interested in agriculture, such as breeders. To ensure effective stimulation, it is essential that the products used are of biological origin and, at the same time, cost-effective. The valorization of wastewater from the cultivation of spirulina presents a significant opportunity for obtaining cheap, accessible, and efficient biostimulants.

As a result of our research, we found that the use of the experimental cyanobacterial biostimulant significantly enhanced the germination process of *Galega orientalis* ‘Sofia’ seeds maintained in collection conditions. This was demonstrated by the increased germination capacity of the seeds (*Table 1)*.

As observed from the data presented in Table 1, in general, the seeds treated with biostimulants show a higher germination capacity compared to the control group. The highest germination capacity is noted in the seeds of *Galega orientalis* 'Sofia'., maintained in collection conditions for 4 years (60%) and 3 years (47%), compared to the control variants, where the germination capacity of these seeds reached a maximum of 27-33%. The most beneficial biostimulant concentrations were 2% and 4%, with exposure periods of 2 and 4 hours. The seeds of *Galega orientalis* 'Sofia'. stored in collection conditions for 2 years exhibited a reduced germination capacity, reaching a maximum of 9% in the variant treated with 2% biostimulant for 1 hour, while in the control variant, this value reached a maximum of 4% (*Table 1).* Accordingly, we conclude that the application of the biostimulant obtained from the recycling of wastewater from spirulina cultivation shows a pronounced germination effect on the seeds of *Galega orientalis* 'Sofia'. maintained in collection conditions The germination index values of *Galega orientalis* 'Sofia' seeds are significantly higher in the treated seed variants with biostimulant. The most notable results are observed in seeds maintained in collection conditions for 4 years (12) and 3 years (8,6), when treated with a 2% biostimulant and exposed for 2 hours. In the control variant, the highest values of this index were recorded for seeds of 3 and 4 years (germination index ranging from 5,4 to 6,6). These results support the efficacy of the obtained biostimulant for the germination of seeds maintained in collection conditions for 3-4 years *(Table 2).*

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Table 1.

Germination capacity of *Galega orientalis* 'Sofia' seeds treated with biostimulant obtained from the cultural liquid resulting from the cultivation of cyanobacterium *Spirulina platensis*, %

Seed treatment period, hours	Experimental variants											
	1%			2%			4%			Control		
	2 years	3 years	4 years	2 years	3 years	4 years	2 years	3 years	4 years	2 years	3 years	4 years
1st day												
1	4,00	20,00	30,00	2,00	20,00	33,00	0,00	17,00	27,00	0,00	3,00	7,00
2	0,00	20,00	20,00	2,00	23,00	20,00	0,00	13,00	27,00	0,00	10,00	10,00
4	0,00	17,00	10,00	2,00	13,00	23,00	0,00	13,00	20,00	0,00	3,00	10,00
2nd day												
1	6,00	27,00	37,00	6,00	27,00	34,00	4,00	27,00	30,00	0,00	27,00	7,00
2	2,00	23,00	40,00	4,00	40,00	60,00	2,00	33,00	37,00	2,00	20,00	23,00
4	2,00	37,00	43,00	2,00	27,00	37,00	2,00	47,00	43,00	0,00	30,00	17,00
3rd day												
1	6,00	27,00	37,00	6,00	30,00	34,00	6,00	33,00	30,00	4,00	33,00	7,00
2	2,00	23,00	40,00	8,00	43,00	60,00	2,00	43,00	37,00	2,00	27,00	27,00
4	4,00	37,00	43,00	4,00	30,00	37,00	2,00	50,00	43,00	2,00	33,00	20,00
4th day												
1	6,00	27,00	37,00	9,00	30,00	34,00	6,00	33,00	30,00	4,00	33,00	7,00
2	4,00	23,00	40,00	8,00	43,00	60,00	2,00	43,00	37,00	2,00	27,00	27,00
4	4,00	37,00	43,00	4,00	30,00	37,00	6,00	50,00	43,00	2,00	33,00	20,00
5th day												
1	6,00	27,00	37,00	9,00	30,00	34,00	6,00	33,00	30,00	4,00	33,00	7,00
2	4,00	23,00	40,00	8,00	43,00	60,00	2,00	43,00	37,00	2,00	27,00	27,00

Table 2.

Germination index values of *Galega orientalis* 'Sofia 'seeds treated with biostimulant obtained from the cultural liquid resulting from the cultivation of cyanobacterium *Spirulina platensis*

Seed treatment period, hours	Experimental variants											
	1%			2%			4%			Control		
	2 years	3 years	4 years	2 years	3 years	4 years	2 years	3 years	4 years	2 years	3 years	4 years
1	1,20	5,4	7,4	1,80	6,0	6,8	1,20	6,6	6,0	0,80	6,6	1,4
2	0,80	4,6	8,0	1,60	8,6	12,0	0,40	8,6	7,4	0,40	5,4	5,4
4	0,80	7,5	8,6	0,80	6,0	7,4	1,20	10,0	8,6	0,40	6,6	4,0

Table 3.

Relative root elongation of *Galega orientalis* L. treated with biostimulant from the cultural liquid of the cyanobacterium *Spirulina platensis*, %

Seed treatment period, hours	Experimental variants								
	1%			2%			4%		
	2 years	3 years	4 years	2 years	3 years	4 years	2 years	3 years	4 years
1	158,0	153,33	83,33	150,0	115,78	126,43	125,0	117,64	129,31
2	100,0	100,00	90,00	75,0	126,32	229,88	100,0	129,41	126,44
4	200,0	133,33	97,14	175,00	136,83	240,00	125,0	117,67	114,94

The results of the relative root elongation of *Galega orientalis* 'Sofia' plants indicate that for a 1% biostimulant concentration, root elongation is maximal in seeds stored for 2 years, with a gradual decrease observed in seeds stored for 3 and 4 years. For a 2% biostimulant concentration, a more pronounced elongation is seen in seeds of 3 and 4 years, especially for longer exposure periods (4 hours), suggesting increased efficacy on older seeds. The 4% biostimulant concentration shows stable values, with no major variations between seed groups, but root elongation is less than at lower concentrations for extended treatment periods. Thus, we conclude that the 2% biostimulant applied for 2-4 hours has the most effective impact on root elongation, particularly for older seeds (*Table 3).*

RESULTS AND DISCUSSIONS

Seeds of *Galega orientalis* generally, feature a water-impermeable coating, which contributes to maintaining a dormant state. To initiate germination, the seed coat must be treated, with classic methods including scarification or chemical treatments (Laman N.A. *et al*, 2004). Additionally, research in this area highlights that prolonged seed storage reduces their ability to absorb water and delays germination. This condition, known as dormancy, is commonly observed in species with a thick or hard seed coat (Solberg S.Ø. *et al*, 2020). Long-term storage of *Galega orientalis* seeds results in a reduction in seed coat thickness. Although germination is slower in prolonged storage variants, this reduction in seed coat thickness allows biostimulatory substances to penetrate more easily to the embryo. Our results show that the highest germination rates were observed in seeds stored for longer periods, such as 3-4 years, across all experimental variants *(Table 1).* This is attributed to both the easier access of water to the seed cotyledon and the more efficient penetration of germination biostimulants.

Numerous studies have demonstrated that treating plant seeds with microalgae accelerates the germination process and significantly increases the percentage of seeds germinated across various plant species (Runshi X. *et al,* 2022; Dobrojan S. *et al,* 2023). This is because algae contain phytohormones and growth regulators, such as cytokinins, auxins, gibberellins, betaines, abscisic acid, and brassinosteroids, as well as matrix and reserve polysaccharides (alginate, carrageenan, agar, ulvan, mucopolysaccharides, oligosaccharides, fucoidan, laminaran, starch, and fluoride). These compounds have a biostimulatory effect on seed germination in various plants (Khan W. *et al*, 2009; Hong Y.P. *et al,* 1995; López B.C., 2001; Stirk W.A. *et al*, 2014). Many of these biostimulatory substances are eliminated or accumulated in the residual water (cultural liquid) resulting from the cultivation of *Spirulina platensis*. Consequently, in our experiments, the biostimulant obtained from the residual water generated by cultivating *Spirulina platensis* had a pronounced germinative effect on seeds of *Galega orientalis* L. stored under collection conditions for 3-4 years *(Tables 1-2).*

Plant hormones and other biologically active substances produced by *Spirulina platensis*, when used in optimal concentrations, promote root development and elongation (Thet N.H. *et al*, 2009).

Our research found that *Galega orientalis* 'Sofia' seeds, stored in collections and treated with the biostimulant, showed a 14-140% increase in root length compared to untreated variants. These results suggest that the residual waters from cultivating *Spirulina platensis* are rich in phytohormones and other biologically active substances that stimulate the germination of *Galega orientalis* seeds stored under collection conditions and present significant interest for applying circular economy principles.

CONCLUSIONS

Our study results demonstrated the effectiveness of applying a biostimulant based on residual water from the cultivation of *Spirulina platensis* on the germination of *Galega orientalis* 'Sofia'. seeds stored under collection conditions for 2, 3, and 4 years. Seeds treated with biostimulants showed significantly higher germinative capacity compared to the control group, where germination ranged from 27% to 33%.

The highest germination rates were observed in 4-year-old seeds (60%) and 3-year-old seeds (47%) treated with biostimulant concentrations of 2% and 4%, applied for 2-4 hours.

The germination index was significantly higher in treated seeds, reaching maximum values of 12 and 8,6 for 4-year-old and 3-year-old seeds, respectively, compared to the control group values (5,4-6,6). Regarding root elongation, 2-year-old seeds treated with a 1% biostimulant showed the greatest relative root elongation. For older seeds (3-4 years), the 2% concentration applied for 4 hours was most effective in stimulating root elongation, while the 4% concentration was stable but resulted in less elongation compared to the lower concentrations. Thus, the 2% biostimulant applied for 2-4 hours appears optimal for stimulating germination and root development in older *Galega orientalis* 'Sofia' L. seeds, positively impacting seed germination and plant growth under collection conditions. These results suggest significant potential for applying circular economy principles in managing residual water and improving agricultural production.

ACKNOWLEDGEMENTS

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REFERENCES

Adamovics A., Dubrovskis V., Plime I., Adamovicsa O., 2011 - *Biogas production from Galega orientalis Lam. and galega-grass biomass*. Grassland Science in Europe, 16: 416-418.

Avetisyan A.T., 2013 - *Introduction of new, rare fodder crops in the forest-steppe conditions*. Bull. KrasGAU, 7: 72-74. [In Russian].

Aizman R.I., Kozlov, A.P., Gordeeva E.I., Lomovsky, I.O., 2019 - *Effects of Curcuma longa and Galega orientalis herbal remedies on homeostatic renal functions in rats with diabetes mellitus and acute renal failure.* Advancements in Journal of Urology and Nephrology, 1(1): 1-6. www.opastonline.com

Biligetu B., Bainard J., Khanal N., Wang H., 2024 - *A comparative study of fodder Galega (Galega orientalis LAM.) and common forage legumes in monoculture and grass–legume binary mixture in Canadian Prairies.* Canadian Journal of Plant Science. 104. 10.1139/CJPS-2023-0089.

Cerempei V., Țiței V., Vlăduț V., Moiceanu G.A., 2023- Comparative study on the characteristics of seeds and phytomass of new high-potential fodder and energy crops. Agriculture 2023, 13, 1112. *https://doi.org/10.3390/agriculture13061112*

Cherniavskih V.I., Dumacheva E.V., Lisetskii F.N., Tsugkieva V.B., Gagieva L.C., 2020 - *Productivity of galega (Galega orientalis) in single-species and binary crops with sainfoin (Onobrychis arenaria): A case study of forest-steppe of European Russia.* Bioscience Biotechnology Research Communications, 13(1): 15-22.

Coşman S., Ciopată A.C., Coşman V., Bahcivanji M., Ţîţei V., 2017 - *Study on the chemical composition and nutritional value of the Galega orientalis Lam. and the prospects of its valorification in the Republic of Moldova.* Scientific Papers, series D, Animal Science, 60: 75-80.

Darmohray L.M., Gutyj B.V., Darmohray O.O., 2018 - *Antimicrobic activity concept of water extract of plants Galega orientalis (Lam.).* Scientific Messenger of Lviv National University of Veterinary Medicine and Biotechnologies, 20 (87):122-125.

Darmohray L., Luchyn I., Perih M., 2021 - *Sustenance, the safety of plants and feed of Galega orientalis (Lam.).* AgroLife Scientific Journal, 10(1): 91-100.

Dobrojan S., Jigău Gh., Dobrojan G., Melnic Cr., Ciolacu T., Ciobanu E., 2023 - *Perspectiva utilizării algelor în tratarea seminţelor de plante.* Studia Universitatis Moldaviae, 1(171): 139-145.

Domash V.I., Prokhorov V.N., Kandelinskaya O.L., Sharpio T.P., Zabreiko S.A., Grischenko E.R., 2013 - *Biochemical peculiarities of Galega orientalis Lam. genotypes in Belorussia.* Agricultural Biology, 6: 105-111. 10.15389/agrobiology.2013.6.105eng

Dubrovskis V., Plume I., Adamovics A., Auzins V., Straume I., 2008 - *Galega biomass for biogas production.* Engineering for Rural Development: Proceedings of the 7th International Scientific Conference, Jelgava: 61-65.

Fattakhova Z.F., Shakirov S.K., Bikchantaev I.T., 2021 - *Influence of biological preparations on conservation of Galega orientalis* Lam. Vestnik of Kazan State Agrarian University, 1(61): 62-65.

Giller K. E., 2001 - *Nitrogen Fixation in Tropical Cropping Systems* 2 nd edition. CABI Publishing, 423 p.

Grand View Research, 2024 - *Global Algae Market Report 2024*, *https://www.grandviewresearch.com.*

Hong Y.P., Chen C.C., Cheng H.L., Lin C.H., 1995 - *Analysis of auxin and cytoknin activity of commercial aqueous seaweed extract*. Gartenbauwissenschaft: Germany, 60(4): 191-194.

Hunady I., Ondrísková V., Hutyrová H., Kubíková Z., Hammerschmiedt T., Mezera J., 2021- *Use of wild plant species: a potential for methane production in biogas plants*. International Journal of Renewable Energy Research, 11(2): 920-932. *https://doi.org/10.20508/ijrer.v11i2.11990.g8216*

Ignaczak S., Andrzejewska J., Sadowska K., Albrecht K.A., 2022 - *Fodder galega vs. alfalfa: yield and feed value of leaves, stems, and whole plants.* Agronomy, 12, 1687. *https://doi.org/10.3390/agronomy12071687*

Khan W., Menon U., Subramanian S., Jithesh M.N., Rayorath P., Hodges D.M., Critchley AT., Craigie J.S., Norrie J., Prithiviraj B., 2009- *Seaweed extracts as biostimulants of plant growth and development.* Journal of Plant Growth Regulation, 28(4):386–99.

Khasanov E., Mudarisov S., Khamaletdinov R., Mukhametdinov A., Maskulov D., Musin R., 2020 - *Substantiation of work quality indicators of the universal seeds scarificator of the eastern galega Galega orientalis).* Journal of Agricultural Engineering, 51(3):169–175. doi: 10.4081/jae.2020.1034.

Koleva I.I., Van Beek, T.A., Linssen J.P., De Groot A., Evstatieva L.N., 2002 - *Screening of plant extracts for antioxidant activity: a comparative study on three testing methods.* Phytochemical Analysis, 13(1): 8-17.

Kumar P., et al., 2023 - *Advanced treatment technologies for spirulina cultivation wastewater: nutrient recovery and environmental benefits.* Water Research, 212:118-128.

Laman N.A., Prokhorov V.N., Morozova I.M., 2004 - Recommendations for cultivation eastern galleys for fodder and seeds Minsk.44.

Li X., et al., 2021 - *Utilization of Spirulina platensis wastewater as a fertilizer for seed germination*. Journal of Agricultural Science and Technology, 23, 3, 235-245.

López BC., 2001 - *Uso de derivados de algas marinas en la producción de tomate, papa, chile y tomatillo. Coahuila*, Palau: Bioquím S.A, 24.

Market Watch, 2024 - *Algae Industry Market Research Report 2024*, https://www.marketwatch.com.

Meripõld H., Tamm U., Tamm S., Võsa T., Edesi L., 2017 - *Fodder galega (Galega orientalis Lam) grass potential as a forage and bioenergy crop*. Agronomy Research, 15: 1693-1699. 10.15159/AR.17.021

Moiseeva E.A., Shepeleva L.F., Bordey R.Kh., 2024 - *Features of the development of Galega orientalis Lam. in the conditions of the middle taiga of Western Siberia*. Acta Biologica Sibirica 10: 601–610.

Rakhmetov D.B., Shymanska O.V., Bondarchuk O.P., Vergun O.M., Korablova O.A., Rakhmetova S.O., Fishchenko V.V., 2021 - *Productivity of plant varieties of species of the genus Galega L. in the Right-Bank Forest-Steppe of Ukraine.* Plant Varieties Studying and protection, 17: 274-281.

Runshi X., Kevin D., Sonya K., Jakob S., Johnson R., Clay M., Jessup R., Qin H., 2022 - *The effects of microalgae as a biostimulant on seed germination.* Combined Proceedings IPPS, 72:119-126.

Shymanska O., Vergun O., Rakhmetov D., Brindza J., Ivanišová E., 2018 - *Total content of phenolic compounds in the ethanol extracts of Galega officinalis L. and Galega orientalis Lam.* Agrobiodiversity for Improving Nutrition, Health and Life Quality, 2: 140-145.

Skerman P.J., Cameron D.G., Riveros F., 1988 - *Tropical forage legumes.* FAO Plant Production and Protection Series No. 2. FAO. 609 p.

Skórko-Sajko H., Lipinski K., Tywonczuk J., Minakowski D., 2016 - *Amino acids profile of protein and nutritional value of fodder galega (Galega orientalis Lam.) depending on the phenological stage.* Zeszyty Naukowe Uniwersytetu Przyrodniczego we Wrocławiu. Biologia i hodowla zwierząt, 618: 19-26.

Solberg S.O., Yndgaard F., Andreasen C., von Bothmer R., Loskutov I.G., Asdal Å., 2020 - *Long-term storage and longevity of orthodox seeds: a systematic review.* Frontiers in Plant Science, 11:1007. https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2020.01007/full.

Starkovskiy B., Simonov G., Malinovskaya Y., Simonov A., 2020 - *The influence of the vegetative stage of Galega orientalis on the quality of haylage prepared from it.* DAIC, E3S Web of Conferences, doi:10.1051/e3sconf/202022202019

Stirk WA., Tarkowská D., Turečová V., Miroslav S., Staden J., 2014 - *Abscisic acid, gibberellins and brassinosteroids in Kelpak®, a commercial seaweed extract made from Ecklonia maxima.* Journal of Applied Phycology, 26(1):561–567. DOI 10.1007/s10811-013-0062-z

Teleuţă A., Ţîţei V., 2011 - *Particularitățile biologice și calitatea furajului la ciumărea orientală în condițiile Republicii Moldova.* Realizări și Perspective În Zootehnie, Biotehnologii și Medicină Veterinară, Chișinău: 253-257.

Teleuţă A., Ţîţei V., 2012 - *Species of Galega orientalis, Polygonum sachalinense, Silphium perfoliatum and their agrobiological pecularities in Republic Moldova's conditions.* Acta Horti Botanici Bucurestiensis, 39: 95-100.

Teleuţă A., Ţîţei V., Coşman S., Lupan A., 2015 - *Forage value of the species Galega orientalis Lam. under the conditions of the Republic of Moldova.* Research Journal of Agricultural Science, 47(2): 226-231.

Thet N.H., Moat W.D.N., Min Th., 2009 - *Effect of spirulina on the germination and growth of Cicer arietinum L.* University Research Journal, 2(4): 1-9.

Ţîţei V., 2024 - *Progress in the breeding of eastern galega, Galega orientalis, for productivity and quality in the Republic of Moldova*. Romanian Agricultural Research, 41:363-373. https://www.incda-fundulea.ro/rar/nr41fol/rar41.34.pdf

Ţîţei V., Coşman S., 2019 - *Some agro biological features and hay quality of fodder galega, Galega orientalis.* Romanian Journal of Grassland and Forage Crops, 19: 79-86.

Vergun O., Shymanska O., Rakhmetov D., Grygorieva O., Ivanišová E., Brindza J., 2020 - *Parameters of antioxidant activity of Galega officinalis L and Galega orientalis Lam. (Fabaceae Lindl.) plant raw material.* Potravinarstvo, 14: 125-134.

Żarczyński P.J., Sienkiewicz S., Wierzbowska J., Krzebietke S.J., 2021 - *Fodder galega - a versatile plant.* Agronomy, 11, 1797 https://doi.org/10.3390/agronomy1109179

Zhang Y., et al., 2022 - *The effects of Spirulina wastewater on soil quality and crop yield.* Environmental Science and Pollution Research, 29(4), 3480-3490.

DEVELOPMENT OF AN ANEMOMETER FOR MEASURING AIR FLOW VELOCITY IN AGRICULTURE

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Abstract

This paper presents the construction and calibration steps of a hot-wire airflow sensor (anemometer) using an incandescent filament as the sensor. Due to the properties of the filament, its high melting point and the materials from which it is made, the light bulb filament allows the filament to heat up when electric current is passed through it without the filament oxidising rapidly. The paper also describes the aerodynamic calibration of the filament sensor using a calibrated anemometer (testo 405i) as a reference point. The experimental results following the calibration process confirm that the electrical resistance of a conductor can be successfully used to measure airflow.

Key words: anemometer, hot wire, wind sensor, light bulb filament

Air flow velocity is an important parameter that needs to be regularly measured and monitored both in scientific research and in many fields of industry (Russo G. P., 2011). The problem with all anemometers is the certainty with which the measurement is performed (Lečić M. R., 2009).

A hot-wire anemometer is an instrument for measuring the air flow velocity with a sensor that is composed of a thin tungsten or platinum conductor of small dimensions, with a diameter of 5 µm and a length of a few millimeters. (Lundstr H., 2021). However, when an anemometer is used under conditions of high air flow velocity, due to high fragility, the sensor deteriorates (Korprasertsak N. *et al*, 2020).

There are several constructive types of hot-wire anemometers, Lia Z. et al. made a hot-wire anemometer using optical fiber. Experimental results showed that the measurement error is ±0.15 m/s in the range of 0 - 6 m/s. The hot-wire anemometer is widely used to measure air flow velocity. The working principle of the hot-wire anemometer is based on the convective heat transfer between the outdoor environment varying with the air flow velocity and the hot wire. (Khamshah N., 2011, Ardekani M.A., 2008).

Another principle of operation of hot wire anemometer is by keeping the sensor temperature constant. The electrical resistance of the sensor determines the value of the air flow velocity by means of an experimentally established relationship between the air flow velocity and the supply current. The disadvantage of such a constant-temperature hot-wire anemometer is that it can produce electromagnetic signals that influence the accuracy of measurements (Ligęza P., 2021).

The sensor of the anemometer is connected to a voltage source and is heated by the Joule effect. The sensor operates at constant temperature, so that the temperature of the sensor filament is maintained at a constant value regardless of the air flow velocity and the temperature of the outside environment. The electrical power supplied to the sensor to maintain its temperature can be correlated with the air flow velocity. This is accomplished by calibration to known air velocities. It has been shown that a 2.5 µm hot-wire sensor performs well in the velocity range 0.3 - 30 m/s and but at temperatures up to 30 ^{0}C (Lundström H., 2021). An anemometric sensor calibration method is based on moving the hot-wire sensor through air (Al-Garni A. M., 2007).

The measurement technique using the hot-wire anemometer is an indirect method to measure the air flow, on the output of the sensor is a voltage signal. Therefore, the calibration process is the most important step in the construction of an anemometer for efficient and accurate air flow velocity measurement (Özahi E. *et al*, 2022).

In this paper, the construction and steps of the calibration process of an anemometer sensor using a wind tunnel are presented. The experimental determinations of the air flow velocity being related to the results obtained with a hot-wire anemometer with calibration certificate. The measuring range of the anemometric sensor is 0 - 3 m/s.

MATERIAL AND METHOD

A Tungsten filament from a light bulb (HELLA R5W) with a supply voltage of 12V, power of 5W and a resistance of 2.4 Ω was used as an anemometric sensor (SA) for air flow velocity measurement. The filament length is

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approximately 8 mm (figure 1a). Tungsten is used because it has a high melting point and withstands high temperatures when the bulb is in operation. The SA was connected in series with a power resistor (10 W) with a value of 30 Ω. The power of the resistor is an important parameter, as it must be large enough not to allow power loss through Joule effect and not to allow measurements to be influenced by heating the resistor. The powering of the SA and the power resistor was done using a 5V voltage stabilizer (LM7805).

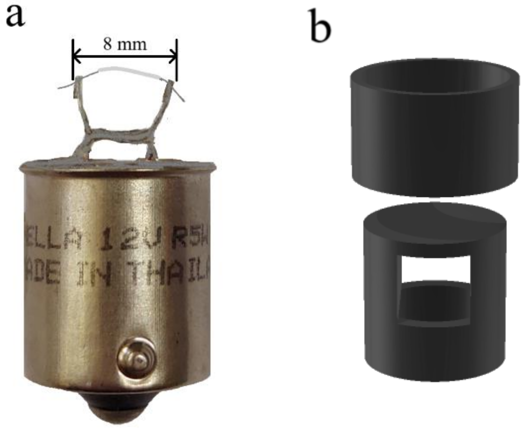


Figure 1 **Anemometric sensor**
a - bulb filament used as a sensor to determine the air flow velocity; b - body and protective cover

The airflow required for the calibration process was created by two fans with different constructive characteristics: a small V1 fan (Sunon EE92251B1) with dimensions of 92 x 92 x 25 mm and a blade diameter of 91.8 mm at a maximum flow rate of 87.5 m3/h; a large V2 fan (Sunon EEC0251) with dimensions of 120 x 120 x 25 mm, a blade diameter of 117 mm and a flow rate of 183.83 m3/h. Both fans have 12V supply voltage. Uniformization of the air flow created by the fan was achieved by a tunnel (PVC tube) with a diameter of 150 mm and a length of 1500 mm. The fans were mounted on the tunnel by means of two reducers at one end of the tunnel. The fans were powered with a ZHAXIN RXN-3050 adjustable voltage power supply unit, which allows the voltage supply to the fans to be varied.

The temperature measurement was realized with two sensors (NTC 100k), one is mounted next to the filament and measures the temperature of the airflow inside the tunnel and the other measures the ambient temperature.

To the acquisition board (Arduino Uno) are connected: two sensors for measuring temperature and SA on the analog ports, and the fan for measuring the speed is connected on one of the digital ports (figure 3).

Calibration of the anemometric SA sensor was done with the anemometer (testo 405i-calibrated) used as a reference. The measurement range of the air flow velocity is 0 - 30 m/s. In the range 0 - 2 m/s, the measurement accuracy is ± 0.1 m/s, and in the range 2 - 15 m/s the accuracy is ± 0.3 m/s according to the calibrated specifications. The testo 405i anemometer can be connected to a telephone via Bluetooth and thus acquires velocity and temperature data via the testo Smart application.

The Arduino IDE program was installed on the computer through which the data acquisition was performed during the calibration, where the program code for the microcontroller and the CoolTerm software for data acquisition was written. The CoolTerm program saves the recorded values in .txt format so that the data can be further processed, the file saving was done in .xls format. The connection between the Arduino Uno and the data acquisition computer was made via a USB 3.0 cable.

In order to protect the filament from the influence of air flows from the sides, the body and a protective cover were realized. The body is cylindrical in shape with a rectangular slit in its upper half (figure 1 b).

The tachometer (DT-2234C) was used to measure the fan speed.

Electrical resistivity underlies the principle of operation of the sensor. The scheme of operation comprises an SA connected in series with the power resistor fed to a voltage source. A voltmeter was connected in parallel with the filament to measure the voltage drop across the terminals of the SA (figure 2). When the SA is penetrated by electric current it heats up. When an air flow acts on it, its resistance changes and therefore, due to Ohm's law, the voltage also changes. The velocity of the air flow is determined on the basis of this change in voltage.

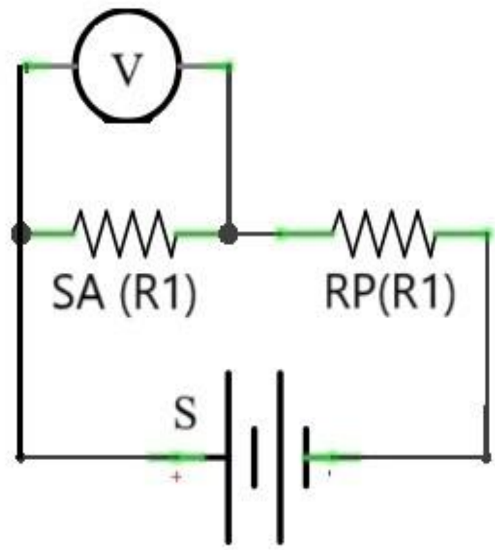


Figure 2 **Schematic diagram**
S - power supply; SA - anemometer sensor with resistor R1; RP - power resistor with resistor R2; V - voltmeter.

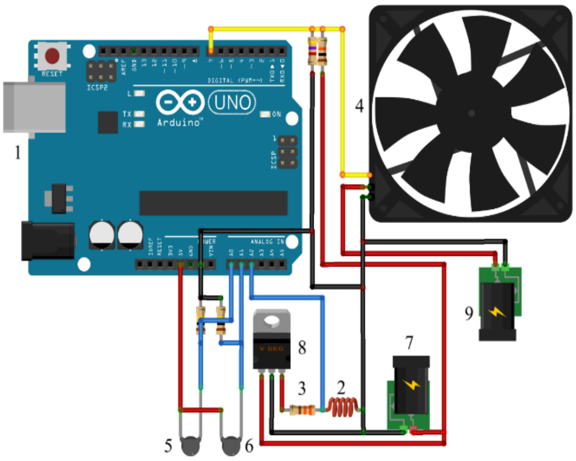


Figure 3 **Wiring diagram of the calibration stand**
1 - Arduino uno; 2 - filament (SA); 3 - resistor; 4 - fan; 5,6 - temperature sensor, 7 - 12v power supply; 8 - voltage stabilizer; 9 - adjustable voltage supply.

In order to calibrate the sensor, a stand (figure 4) consisting of a fan (4) fed from the adjustable source (5) was realized. Uniformization of the air flow created by the fan was achieved due to the length of the cylindrical tunnel (6).

The velocity profile obtained with the testo 405i anemometer (figure 5a) in the section of the air tunnel helped to position the sensor. The position of the SA (figure 5b) and the anemometer (testo 405i) at the exit of the tunnel is 2 cm vertically from the base of the tunnel.

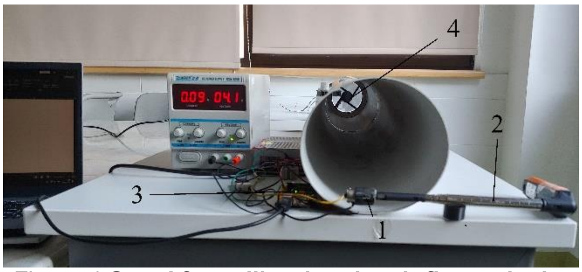
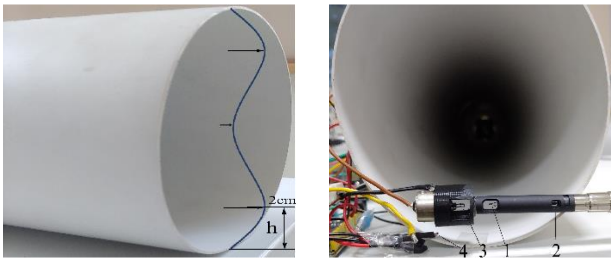


Figure 4 **Stand for calibrating the air flow velocity sensor**
1 - sensor; 2 - testo 405i anemometer; 3 - microcontroller; 4 - fan; 5 - adjustable power supply; 6 - wind tunnel.



a b

Figure 5 **Velocity profile and sensor positioning on the calibration tunnel**
1 - airflow velocity sensor (testo 405i), 2 - temperature sensor (testo 405i), 3 - SA sensor, 4 - temperature sensor; h - height; a - airflow velocity profile at the exit of the calibration wind tunnel; b - position of the sensors at the exit of the calibration wind tunnel.

The tachometer was used to measure the fan speed at different supply voltages and to compare the tachometer values with the values recorded by the microcontroller. The fan speed compensation was realized by introducing some coefficients in the relations of the programming code, thus the fan speed was accurately measured and the fan calibration was realized.

By changing the supply voltage of the fans with the adjustable voltage source, different fan speeds were obtained. The minimum speed of the fans is 900 RPM, in the case of fan V1 the maximum speed is 3300 RPM and for fan V2 the maximum speed is 3600 RPM. Fan V1 in the air tunnel produces an air flow velocity between 0 - 0,7 m/s and fan V2 in the air tunnel produces an air flow velocity between 0,7 - 3 m/s.

A microcontroller programming code was created and the following parameters are displayed in the CoolTerm program interface (figure 6): the voltage measured at the filament terminals, the fan rotation speed, the value of the temperature sensor subjected to the air flow created by the fan and the ambient temperature value.

Two temperature sensors were used in the calibration process, one encapsulated temperature sensor that was shielded from the air flow and the second one that was subjected to the air flow created by the fans. This made it possible to identify and determine the temperature difference between the environment and the temperature of the air flow created by the fans.

Calibration was performed at a temperature of 24 ^{0}C. The temperature difference between the sensor measuring the ambient temperature and the sensor measuring the air flow temperature was approximately ±0.5 ^{0}C.

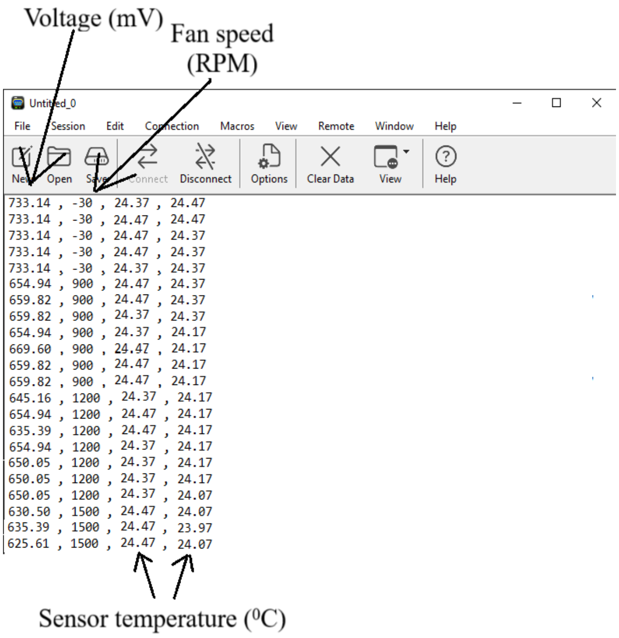


Figure 6 **Parameters displayed in the CoolTerm program interface**

Calibration started with connecting the Arduino Uno to the data acquisition computer via the CoolTerm program and the testo 405i anemometer via the testo Smart application. With the fan switched off, voltage and air flow velocity data was acquired from the testo 405i anemometer.

By changing the fan supply voltage using the adjustable source, the V1 fan speed reached 900 RPM. In parallel with the recording of the values by Arduino Uno, the air c flow velocity was measured with testo 405i anemometer. In order to increase the accuracy of the obtained values, five recordings of the same air flow with the testo 405i anemometer were made at one second intervals.

The V1 fan speed was increased by an interval of 300 RPM until the maximum speed of 3300 RPM was reached.

After performing this calibration, fan V1 was replaced with fan V2, following the calibration steps from fan V1.

Having the correlation between the electric current voltage and the air flow measured with the testo 405i anemometer, the calibration could be performed.

RESULTS AND DISCUSSIONS

After all the results were obtained, the 5 values of the air flow measured with the testo 405i anemometer were averaged with the average of the SA electric current voltages acquired by the Arduino for a given fan speed.

The plot in Figure 7 shows the results obtained after correlating the voltage with the air flow velocity.

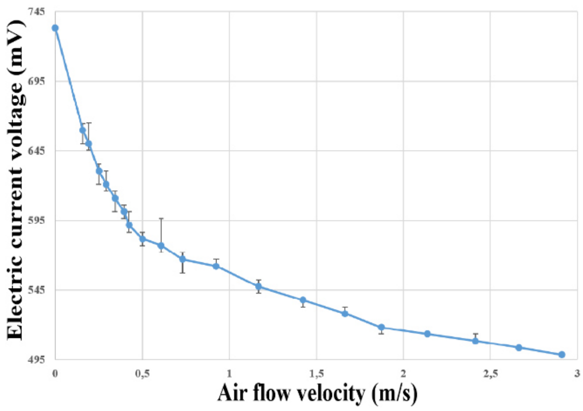


Figure 7 **Average air flow velocity - electric current voltage diagram**

The voltage values acquired by the Arduino from the SA in the range 0 - 3 m/s are about 200 mV with an accuracy of about 5 mV. In the range 0 - 1 m/s, the voltage measured by SA is about 150 mV, while in the range 1 - 3 m/s the voltage measured by SA is about 50 mV.

A polynomial relationship of order 3 between the air flow velocity measured with the testo 405i anemometer and the electric current voltage recorded by the SA was obtained by regression using the Minitab v21.4 program.

$v = - 0{,}0000005423 * (u\hat{}3) + 0{,}001082861 * (u\hat{}2) - 0{,}7215098744 * u + 160{,}6341269355$

where: v (m/s) - air flow velocity; u (mV) - electric current voltage measured at SA terminals

The diagrams in Figures 8 and 9 show the air flow velocity measured with the testo 405i anemometer and the air flow velocity at the SA obtained from the third order polynomial relationship at different fan speeds V1 and V2 respectively.

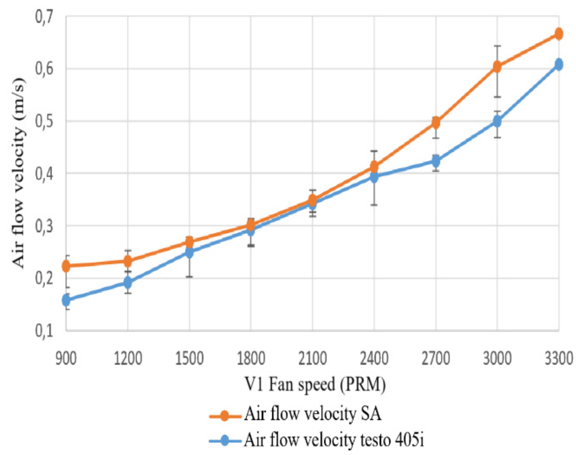


Figure 8 **Air flow velocity diagram determined by testo 405i anemometer and SA in the range 0.1 - 0.7 m/s**

The average difference between the air flow velocity measured with the testo 405i anemometer and the air flow velocity measured with the SA is

±0.04 m/s, and the largest difference in air flow velocity is about ±0.1 m/s (figure 8).

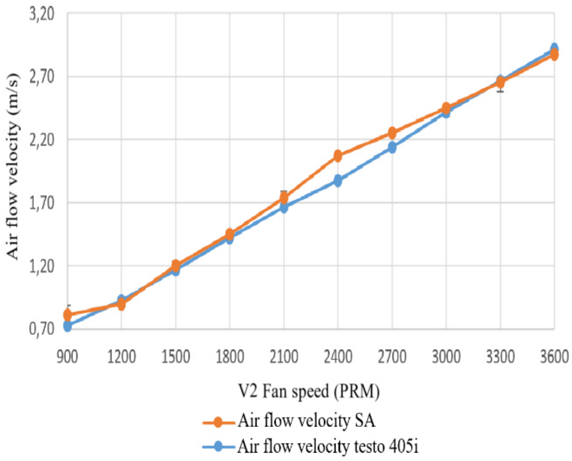


Figure 9 **Air flow velocity diagram determined by testo 405i anemometer and SA in the range 0.7 - 3 m/s**

The mean difference between the air flow velocity measured with the testo 405i anemometer and the air flow velocity measured with the SA is ±0.05 m/s, and the largest difference in air flow velocity is about ±0.2 m/s (figure 9).

The measurement sensitivity of the SA also depends on the reading accuracy of the microcontroller, and after entering the programming code, the accuracy is about 5 mV.

CONCLUSIONS

This sensor has a high sensitivity at low air stream velocities due to the size and characteristics of the filament. Therefore the SA accuracy is inversely proportional with increasing air flow velocity, so the accuracy is high at low air flow velocities and decreases with increasing air flow velocity.

The calibration process showed that the sensor is not very sensitive to temperature.

The accuracy of the sensor is related to the type and performance characteristics of the microcontroller, how it measures and reads the voltage.

REFERENCES

Al-Garni A. M., 2007 – *Low speed calibration of hot-wire anemometers.* Flow Measurement and Instrumentation, 18(2), 95–98.

Ardekani M. A., 2008 – *Hot-wire calibration using vortex shedding.* Measurement, 42(5), 722–729.

Khamshah N., Abdalla A. N., Koh S.P., Rashag H. F., 2011 – *Issues and temperature compensation techniques for hot wire thermal flow sensor.* International Journal of the Physical Sciences, 6(14), 3270 –3278

Korprasertsak N., Leephakpreeda T., 2020 – *Novel wind measurement via thermoelectric anemometer.* Measurement, 149, 107037. doi:10.1016/j.measurement.2019.107037.

Lečić M.R., 2009 – A new experimental approach to the calibration of hot-wire probes. Flow Measurement and Instrumentation, 20, 136-140, https://doi.org/10.1016/j.flowmeasinst.2009.04.00

Lia Z., Wang J., Zhong X., Liu T., Ning Y., Hou M., Zhao L., Dong G., Liu Y., Wang J., Sun T., Grattan K. T. V., 2020 – *Temperature-compensated fiber-optic gas flow speed sensor based on the 'Hot-wire' principle.* Optik, 241, 166118.

Ligęza P., Jamróz P., Ostrogórski P., 2021 – *Reduction of electromagnetic interferences in measurements of fast-changing air velocity fluctuations by means of hot-wire anemometer.* Flow Measurement and Instrumentation, 79, 101945.

Lundström H., 2021 – *Investigation of heat transfer from thin wires in air and a new method for temperature correction of hot-wire anemometers.* Experimental Thermal and Fluid Science, 128, 110403.

Özahi E., Çarpınlıoğlu M. O., Gündoğdu M.Y., 2022 – *Simple methods for low speed calibration of hot-wire anemometers.* Flow Measurement and Instrumentation, 21, 2, 166-170.

Russo G.P., 2011 – *Hot wire anemometer,* Aerodynamic Measurements, Woodhead Publishing.

STUDY OF THE AIR VELOCITY FIELD IN THE COMBINE HARVESTING CLEANING SYSTEM

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Abstract

This paper describes how a stand for measuring the air flow generated by the fan of combine harvesters for cereals and technical plants was realised. The air flow velocity at the top of the sieve and the velocity profile over the entire sieve surface are important for the design and construction of a cleaning system fan fitted to combine harvesters. The experimental results show the velocity profile of the New Holland TC5050 combine measured with the anemometer at 52 points on the upper sieve surface for different fan rotations, fan deflector positions, upper sieve positions and lower sieve positions.

Key words: centrifugal fan, cleaning system, combine haresters, air flow

The cleaning process in a combine harvester is a complex process, which is influenced by a cumulation of parameters, such as, combine settings for different crops, crop condition, harvesting moisture, etc. (Craessaerts G. *et al*, 2007).

The air flow created by the fan of the cleaning system in combine with the oscillatory motions of the sieves realizes the separation of the grains from the total material mixture passing through the cleaning system (Wang L. *et al*, 2024; Craessaertsa G. *et al*, 2008).

The use of an anemometer in measuring the air flow velocity created by the combine harvester fan is a widespread method of determining the air flow velocity profile (Gebrehiwot M.G. *et al*, 2010; Adachi T. *et al*, 2004; Kergourlay G. *et al*, 2006).

As a result of the determination of the air flow velocity generated by centrifugal fans used in combine cleaning systems, it results that the maximum air flow velocity is obtained near the side walls of the outlet duct of the fan and is minimum at the center of the fan (Pustovaya O.A. *et al*, 2024).

Due to the uneven air flow velocity distribution created by the combine fan, it is difficult to achieve homogeneous cleaning over the entire surface of the upper sieve (Liang Z. *et al*, 2019; Badretdinov I. *et al*, 2021; Gebrehiwot M.G., 2010).

Much of the research on the velocity profile of the airflow created by the fan of the cleaning system for grain and technical plant combine harvester cleaning has been based on fluid dynamics simulations (Chai X. *et al*, 2020; Gebrehiwot M. G. *et al*, 2007; Li H. *et al*, 2013).

So far, the problem of obtaining a uniform airflow distribution on the surface of the upper screen of the cleaning system arises when using a centrifugal fan. In order to eliminate a number of drawbacks of centrifugal fans, some of the high-efficiency combusters are equipped with CFF-type fans (Liang Z. *et al*, 2023).

In research conducted on the NH combine on the velocity profile of the cleaning system fan, it was found that at the outlet of the air stream from the fan the velocity profile is unevenly distributed over the sieve surface (Badretdinov I. *et al*, 2019).

The disadvantage of centrifugal fans is the high static pressure in the type of cleaning process, which leads to the creation of an unevenly distributed air flow velocity profile, which influences the performance of the grain cleaning system and consequently the performance of the combine (Chai X.Y. *et al*, 2020).

In the paper, the construction of a stand for adjusting the flow rate of the New Holland TC 5050 combine fan by controlling its speed and determining the air flow velocity profile on the surface of the upper sieve of the combine cleaning system is presented. The determination of the velocity profile on the surface of the upper sieve was carried out at different air flow rates generated by the fan, at different positions of the fan deflectors and by adjusting the opening position of the air flaps of the upper and lower sieve of the combine cleaning system.

MATERIAL AND METHOD

In the paper, a stand for operating the combine fan at different speeds in order to regulate the air flow rate, and a stand for measuring the air flow velocity at the surface of the upper screen were realized.

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Construction of the stand for operating the combine fan

For the experimental part the New Holland TC5050 combine of USV Iași was used. The cleaning system of the combine consists of an grain pan, a centrifugal fan with six blades 1000 mm long and 500 mm in diameter, two deflectors (noted A and B) with two adjustment positions (up and down) and two screens: upper with a width of 1000 mm and a length of 1580 mm, lower with a width of 1000 mm and a length of 1350 mm. The screens of the combine are of Petersen type, adjustable, allowing the opening of the screen louvers to be changed.

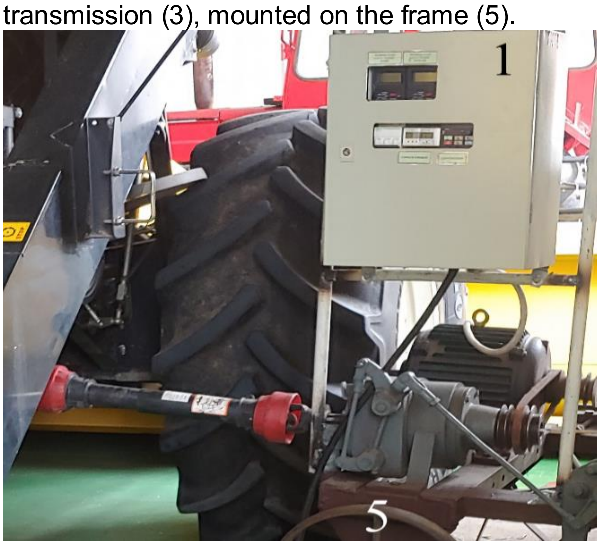
The baffles are part of the fan casing and are located at the airflow outlet of the fan to direct the airflow to the cleaning system screens.

The asynchronous electric motor was used to produce the rotational motion required to drive the combine fan. The electric motor is supplied at a voltage of 380V, with a maximum speed of 1430 RPM and power of 4.5 KW. The converter was used to change the speed of the electric motor by changing the frequency. The VFD type converter allows frequency change in the range of 0 - 60 Hz.

By using the intermediate transmission, which is driven by the electric motor through a belt drive, the speed transmission on the same axis as the axis of the fan of the combine fan was realized. The cardan coupling was used to transmit the rotational motion from the intermediate transmission to the fan shaft.

Combine fan speed measurement was performed with the DT-2234C tachometer. The tachometer uses laser technology for measurements and can measure in the range 2.5 - 99999 RPM with an accuracy of ±0.05%.

In order to start up the fan of the combination, a stand (figure 1) was realized, consisting of: frequency converter (1), asynchronous electric motor (2), intermediate transmission (3), mounted on the frame (5).



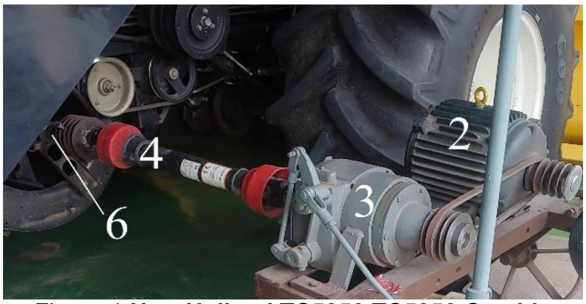


Figure 1 **New Holland TC5050 TC5050 Combine Combine Fan Drive Stand**
1 - converter; 2 - electric motor; 3 - intermediate transmission; 4 - cardan coupling; 5 - beat; 6 - combine fan shaft.

Combine cleaning system fan speeds for which the air flow velocity profile was determined were set according to the adjustments required for different crops. Using the tachometer (figure 2 a), the speed of the combine fan was measured. At speeds of 400, 500, 600, 800 RPM correlations were made between the fan speed and the electric current frequency (table 1) displayed on the converter screen (figure 2 b).

For the upper sieve, 5 positions were set in relation to the harvesting requirements of different crops (table 2): fully closed (0), open a quarter (¼), open half (½), open three quarters (¾), fully open (1), and for the lower sieve 3 positions were set: fully closed (0), open half (½), fully open (1) and for the two baffles 4 different positions were set (table 3).

Table 1
Combine fan speed and electric current frequency at the fan motor

Speed fan (RPM)	400	500	600	800
Converter frequency (Hz)	28	35	42	56

Figure 2 **Frequency setting versus fan speed**
a - fan speed measured with tachometer; b - electric current frequency displayed on the display of the converter

Table 2
Site position and site opening

Site position	0	1/4	1/2	3/4	1
Opening the site (mm)	0	6	12	18	24

Table 3 shows the four variants of positions corresponding to the two deflectors.

Table 3

Deflector positions

Positions/Variants	V1	V2	V3	V4
Deflector A	Sus	Sus	Jos	Jos
Deflector B	Sus	Jos	Jos	Sus

The stand for driving the combine fan was put into operation after the a combine belt drives through which the fan was driven were removed.

Construction of the stand for measuring the air flow velocity created by the combine fan

Four anemometric sensors, 25 cm apart, were used to measure the air flow velocity created by the combine fan. The sensors were calibrated to the testo 405i anemometer. The source supplying power to the entire stand is a 12v switching power supply, powering the stepper motor and the LM7805 type 5V voltage stabilizers to power the anemometer sensors.

The temperature difference between the ambient environment and the temperature of the air flow0 created by the combine fan was measured with two temperature sensors (NTC 100K).

The stepper motor (NEMA 17) was used to move the 4 anemometric sensors along the entire length of the upper screen of the combine by means of a belt. The driver type A4988 was used to control the stepper motor.

A computer was used to acquire the data while measuring the air flow created by the combine fan from an acquisition board (Arduino Uno). Through the Arduino Uno, anemometric sensors were connected to record the air flow velocity, two temperature sensors and the A4988 driver for controlling the stepper motor (figure 3). Arduino IDE programs for loading the microcontroller programming code and CoolTerm for data acquisition were installed on the data acquisition computer.

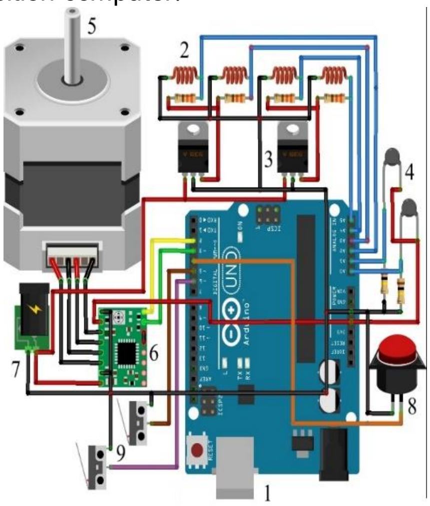


Figure 3 **Wiring diagram of the stand for measuring air flow velocity**

1 - Arduino Uno; 2 - anemometric sensor; 3 - voltage stabilizer; 4 - temperature sensors; 5 - stepper motor; 6 - motor driver; 7 - power supply; 8 - start button; 9 - limit swich 1 and 2.

Three switches were used to control the stepper motor. The first one called "start button" initializes the process of measuring the air flow created by the fan of the combine, the second one called "limit swich 1" initializes the movement of the stepper motor in the reverse direction once the process of measuring the air flow velocity over the entire working length of the combine screen is completed, and the third switch called "limit swich 2" allows the motor to be stopped and prepared for a new series of determinations.

In order to measure the air flow velocity over the entire surface of the screen, a stand (figure 4) was built, consisting of a frame positioned on the upper sieve, on which a sledge was mounted, which moved along the length of the frame by means of bearings.

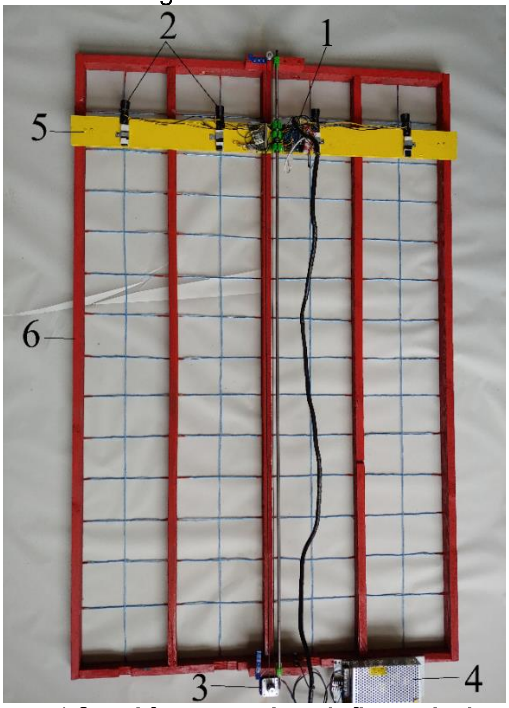


Figure 4 **Stand for measuring air flow velocity on the surface of the upper screen**

1 - Arduino Uno; 2 - anemometric sensor; 3 - stepper motor; 4 - power supply; 5 - sledge; 6 - frame.

Anemometer sensors, Adruino Uno, temperature measurement sensors, stepper motor driver and limit swich 1 and 2 were mounted on the sled (figure 5). The sled moves on the frame with the stepper motor.

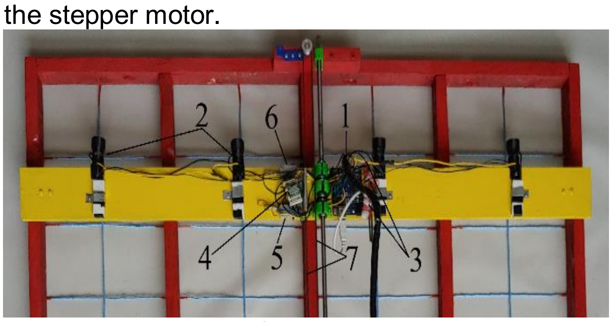


Figure 5 **Layout of components on the sled**

1 - Arduino Uno; 2 - anemometric sensors; 3 - temperature sensors; 4 - stepper motor driver; 5 - limit swich 1; 6 - limit swich 2; 7 - transmission belt.

Air flow velocity determinations were made perpendicular to the surface of the upper sieve of the combine cleaning system, with anemometer sensors mounted at an angle of 90° on the sled.
The stand was placed on the surface of the upper sieve of the cleaning system (figure 6). The process of measuring the velocity profile of the air flow created by the fan, on the surface of the upper sieve of the cleaning system, started with the adjustment of the position of the deflectors and the blinds for opening the sieves, and by means of the converter, the frequency of the electric current corresponding to a certain speed of the fan was adjusted. The connection of the Arduino Uno to the acquisition computer was realized through the CoolTerm software, in the interface of which the following parameters are displayed: the air flow velocity measured by the four sensors and the temperatures acquired from the temperature sensors.

Once the fan of the combine was put into operation, through the CoolTerm program data acquisition began, after determining the first 10 values, by pressing the "start button" switch, the motor step by step moves the anemometric sensors 100 mm, after which it stops moving and starts measuring the velocity of the flow air created by the fan of the combine. 10 air flow velocity determinations are made for the four anemometric sensors, one determination every second, after which the stepper motor moves the anemometric sensors by another 100 mm following the determination of the new airflow values. In total, the stepper motor makes 12 movements over the entire surface of the upper sieve.

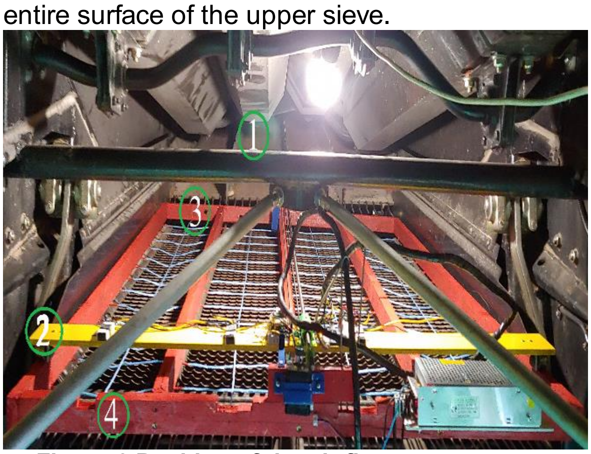


Figure 6 Position of the air flow measurement stand on the sieve surface
1 - grain pan; 2 - sled; 3 - front of upper sieve; 4 - rear of upper sieve

At limit swich 1 when the last air flow velocity measurement is performed, the stepper motor changes its direction of rotation and redirects the anemometer sensors to the starting point of the measurements, the stepper motor is stopped and the stand is prepared for a new measurement by operating limit swich 2.

In figure 7, the front side of the upper sieve, where the air flow velocity determinations started, is corresponding to number 1 and the rear side, where the last air flow velocity determination on the upper sieve surface was performed, is corresponding to number 13.

According to Figure 7 the intersection of the anemometric sensors (I, II, III, IV) and points 1, 2, 3, ..., 13, 10 cm apart, were used for the air flow velocity determinations.

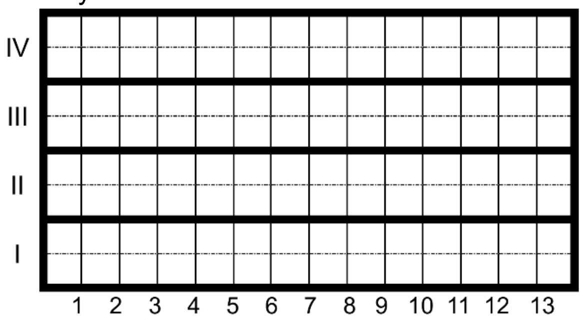


Figure 7 **Site area and points at which air flow velocity determinations were made**
I, II, III, IV - positions of the four anemometer sensors along the length of the upper sieve; 1, 2, 3, ...13 - points where air flow velocity determinations were made on the upper sieve surface.

Once the data acquisition from the anemometric sensors is done electronically on an acquisition computer, and the measurement of the air flow velocity along the entire length of the upper sieve is done automatically, the human involvement is reduced to initializing the measurement process by pressing a button and changing the parameters of fan speed, position of the deflector flaps and position of the opening flaps of the upper and lower sieve.

RESULTS AND DISCUSSIONS

The plot in Figure 8 shows the average values of the air flow velocity over the sieve surface obtained from the four anemometric sensors at a fan speed of 600RPM, with the baffles in position V1 and the air flaps opening at the upper sieve in position ¾ and at the lower sieve in position ½.

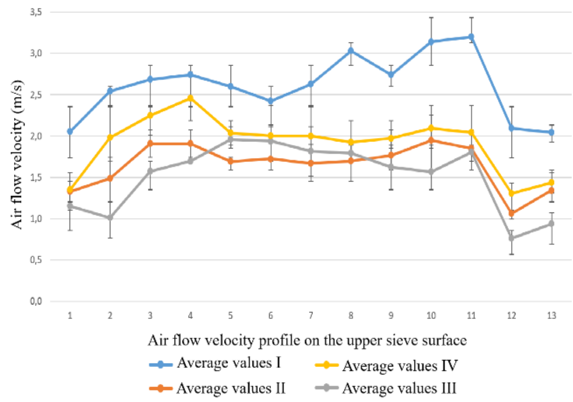


Figure 8 **Air flow velocity measured at 52 points on the surface of the upper sieve at 600 RPM fan speed, with baffles in V1 position, upper sieve ¾ and lower sieve ½.**

The red and grey velocity curves (figure 8) are the average values of the air flow velocity along the length of the upper sieve obtained from sensors II and III located in the middle of the sieve, and the blue and yellow velocity curves are the average values of the air flow velocity along the length of the sieve obtained from sensors I and IV located on the sides of the sieve.

The values of the air flow velocity generated by the fan of the combine cleaning system are higher on the sides of the upper sieve surface, as determined by sensors I and IV, than the values of the air flow velocity recorded in the middle of the upper sieve surface, as obtained from sensors II and III.

The obtained air flow velocity determinations show that the velocity profile is unevenly distributed over the surface of the upper sieve. The air flow velocity profile varies within wide limits from one anemometric sensor to another and from one measurement point to another.

During the cleaning process, the grains separate from the material mixture once they pass through the screen openings, and the air flow created by the fan, due to pneumatic transport forces, separates light particles (chaff, short straws, etc.) from the grains (Miu P., 2016).

If during the working process of the cleaning system of a combine harvester, the velocity of the air flow created by the fan is low, the grains will not be separated from the total mass of material, which leads to the appearance of impurities in the mass of clean grains.

If the air flow velocity is high, the grains will be removed along with the total mass of material (chaff, short straw, etc.), leading to grain losses (Khoshtaghaza M. H. *et al*, 2006).

The air flow velocities determined in the middle of the sieve by sensors II and III are lower than in the sides recorded by sensors I and IV which causes the grain cleaning process to be influenced due to the unevenness of the air flow velocity created by the fan.

In the case of the air flow velocities obtained at the sieve sensors I and IV, the air flow velocity is higher on the side of the sieve than in the middle of the sieve corresponding to sensors II and III, which leads either to higher grain losses on the sides of the sieve due to the grain floating velocity being exceeded or to the presence of impurities in the grain mass due to insufficient air flow velocity in the middle of the sieve.

The non-uniformity of the air flow on the surface of the upper sieve is determined by the construction characteristics of the centrifugal fan, but the non-uniformity of the air flow is also influenced by the position settings of the deflector flaps and the upper and lower sieve. The temperature at which air flow velocity determinations were made was approximately 23 ^{0}C. The temperature difference between the air stream sensor and the encapsulated sensor was approximately ±0.5 ^{0}C.

CONCLUSIONS

The determination of the air flow velocity profile created by the combine cleaning system fan, by modifying the fan speed, the position of the baffles and the flaps adjusting the position of the upper and lower sieve louver position, eliminates the involvement of the human factor in making these determinations.

Using the stand with the four anemometric sensors, the air flow velocity determinations were performed simultaneously over the entire working width of the upper screen, increasing the accuracy with which the experimental determinations were made.

The air flow velocity profile on the surface of the upper sieve is unevenly distributed. On the sides of the sieve corresponding to the mean air flow values determined by anemometer sensors I and IV, they were higher compared to the mean air flow values obtained in the middle of the sieve from anemometer sensors II and III.

The non-uniformity of the air flow velocity profile is related to the type and design parameters of the fan and the positions of the sieve adjustment flaps and baffles. Centrifugal fans are known to have high values of static pressure, which is manifested near the side walls of the fan.

REFERENCES

Adachi T., Sugita N., Yamada Y., 2004 – *Study on the performance of a sirocco fan (flow around the runner blade).* International Journal of Rotating Machinery, 10(5), 592040, 415-424.

Badretdinov I., Mudarisov S., Khasanov E., Nasyrov R., Tuktarov M., 2021 – *Operation technological process research in the cleaning system of the grain combine.* Journal of Agricultural Engineering, 52(2). doi: 10.4081/jae.2021.1129.

Badretdinov I., Mudarisov S., Lukmanov R., Permyakov V., Ibragimov R., Nasyrov R., 2019 – *Mathematical modeling and research of the work of the grain combine harvester cleaning system.* Computers and Electronics in Agriculture, 165, 104966.

Chai X., Xu L., Sun Y., Liang Z., Lu E., Li Y., 2020 – *Development of a cleaning fan for a rice combine harvester using computational fluid dynamics and response surface methodology to optimise outlet* *airflow distribution.* Biosystems Engineering, 192, 232-244.

Craessaerts G., Saeys W., Missotten B., Baerdemaeker J. D., 2007 – *A genetic input selection methodology for identification of the cleaning process on a combine harvester, Part I: Selection of relevant input variables for identification of the sieve losses*. Biosystems Engineering, 98(3), 297-303.

Craessaertsa G., Saeys W., Missotten B., Baerdemaeker J. D, 2008 – *Identification of the cleaning process on combine harvesters. Part I: A fuzzy model for prediction of the material other than grain (MOG) content in the grain bin*. Biosystems Engineering, 101(1), 42-49.

Gebrehiwot M. G., Baerdemaeker J. D., Baelmans M., 2007 – *Numerical analysis of a cross-flow fan with two outlets.*

Gebrehiwot M. G., Baerdemaeker J. D., Baelmans M., 2010 – *Effect of a cross-flow opening on the performance of a centrifugal fan in a combine harvester.* Biosystems Engineering, 105(2), 247-256.

Gebrehiwot M. G., Baerdemaeker J. D., Baelmans M., 2010 – *Numerical and experimental study of a cross-flow fan for combine cleaning shoes*. Biosystems Engineering, 106(4), 448-457.

Kergourlay, G., Kouidri, S., Rankin, G. W., & Rey, R., 2006 – *Experimental investigation of the 3D unsteady flow field downstream of axial fans.* Flow Measurement and Instrumentation, 17(5), 303-314.

Khoshtaghaza M. H. and Mehdizadeh R., 2006 – *Aerodynamic Properties of Wheat Kernel and Straw Materials.* Agricultural Engineering International: the CIGR Ejournal, 05 007.

Liang Z., Xu L., Baerdemaeker J. D., Li Y., Saeys W., 2019 – *Optimisation of a multi-duct cleaning device for rice combine harvesters utilising CFD and experiments.* Engineering, Agricultural and Food Sciences, 190, 25-40.

Liang Z., Wada M. E., 2023 – *Development of cleaning systems for combine harvesters.* Biosystems Engineering, 236, 79-102

Miu P., 2016 – *Combine harvesters (theory, modeling, and design*). 1st Edition, CRC Press, https://doi.org/10.1201/b18852.

Pustovaya O.A., Pustovoy E.A., Usanov V.S., Sakharov V.A., Lipkan A.V., Kuvshinov A.A., 2024 – *Evaluation of the operation of the fan of the combine harvester air-and-screen cleaning system when using an asynchronous electric motor as a drive.* BIO Web of Conferences 108(2).

Wang L., Chai X., Huang J., Hu J., Cui Z., 2024 – *Efficient and Low-Loss Cleaning Method for Non-Uniform Distribution of Threshed Materials Based on Multi-Wing Curved Combination Air Screen in Computational Fluid Dynamics/Discrete Element Method Simulations*. Agriculture 2024, 14, 895

CURRENT TREND IN CLIMATE PARAMETER EVOLUTION AFFECTING VINEYARDS IN BUJORU VITICULTURAL AREAL

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Abstract

Climate change caused by global warming phenomena, cause important disturbances in all types of ecosystems, including vine growing areas. The current study presents the evolution of influential climate parameters for vine varieties at Bujoru viticultural area, located in south-eastern part of Romania. Climate analysis identified important changes on main climate indices that influence vegetative development and biological production yields specific to vine varieties. Results of the study confirm the climate parameter evolution with negative influences on traditional viticultural areas. Amplification of prolonged drought phenomenon was observed with recorded precipitation values below the multi-annual averages due to current climate change trends. Depletion of soil water reserves was helped by: an increase in the number of days with temperatures exceeding 30^{0}C, a change of the interval in which the highest air temperatures are recorded. Maximum air temperatures specific to the month of July have shifted towards the month of August. In winter months average temperatures have increased above before known reference levels. This study, through its results, confirms the current trend of intensifying extreme weather phenomena that can have significant effects on vine plantations, as well as pan-European trends for replacing traditional genotypes.

Key words: climate, parameter evolution, viticultural areal

Climate change has manifested as an increase in the frequency of extreme and uncertain climate events. World Meteorological Organization and Intergovernmental Panel on Climate Change warn that global climate trends are changing, whit unprecedented climate extremes (Fisher *et al*, 2013). Viticulture and winemaking have an important socioeconomic impact in many European countries. Climate characteristics are vital in defining terroir proprieties that in turn give specificity to a certain wine region. These climate indices are responsible for vine growth, vine physiology, yield, and berry composition and in turn determine wine typicity (Shimizu *et al*, 2022). Global warming phenomena have caused many disturbances in all types of ecosystems, viticultural areals not being left out.

The European continent, according to recent studies, is an especially responsive area to temperature rise induced by climate change, particularly during summer months (Giorgi, 2006). Grapevine is recognized as one of the most important crops cultivated across Europe, with the largest wine production and vineyard area in the world, is home to some of the most important and renowned wine-making regions and wines (OIV, 2019).

Climate change scenarios predict major influence on main viticultural choices or even alteration of geographical distribution for current grapevine varieties (Santos *et al*, 2020).

Grapevines are historically cultivated on six continents, between latitudes 4° and 51° in the Northern Hemisphere (NH) and between 6° and 45° in the Southern Hemisphere (SH), and across a large diversity of climates. Vine cultivation, mostly, being specific for climate regions (Tonietto, 1999). Viticulture is a key socioeconomic and cultural sector, with a high economic for many relevant industry branches of the supply and distribution chains. Setting aside the direct income from wine sales, which benefit the whole production chain (wine and subsidiary companies, their employees, viticulturists, and property owners), there are other indirect benefits provided, spreading from landscape and ecosystem services to tourism development (Lavalle *et al*, 1999).

Many individual atmospheric factors influence vine development and grape yield but meeting the required thermal and hydrological conditions remain among the most important aspects of a healthy productive plantation (Jones *et al*, 2005).

Grapevines require both adequately cold periods for hardening and fruitfulness followed by warm periods beneficial for the ripening process.

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Temperature is a crucial factor for the thermophilic heat-demanding grapevine (Fennel, 2014).

Vine cultivars are forced to modify their characteristic vegetation cycle, with often negative consequences on grape yield and quality indices of the resulting wines (Droulia & Charalampopoulos, 2022).

MATERIAL AND METHOD

Climate change monitoring in Bujoru viticultural areal was done for general and specific climate indices using a time line from 2010 to 2019 as reference, compared to the latest 2020-2023 interval. General climate analysis followed the variation of: Global heat balance, (Σt°g); Active thermal balance, (Σt°a); Useful heat balance, (Σt°u); Σ annual precipitation (mm); Average annual temperature °C; Average temperature for the month of : July, August and September °C; Average temperature from the first and second decades/ June °C; Mean maximum temperature values specific for August, °C; Relative air humidity (%); No. days with maximum temp. > 30°C; Bioactive period length (days); Real heliothermic; Hydrothermal coefficient index; "de Martonne" aridity index. Specific climatic vine indices were monitored: vine bioclimatic index; Oenoclimatic aptitude index (IAOe); Huglin helio thermic index (IH); Night cooling index (IF), in order to have a correct image of current climate influence on vine plantation.

RESULTS AND DISCUSSIONS

I.General climate indices analysis

Heat balance parameters: Global heat balance, (Σt°g); Active thermal balance, (Σt°a); Useful heat balance, (Σt°u) registered increases for 2020-2023 when compared to multiannual values.

Figure 1 **Heat balance variation**

A Global heat value of 3483 was specific for 2022 representing an increase of 39 units but the maximum value of 3492 with an increase by 48 units was specific to 2023. Specific for temperate climate condition and Romanian vineyards global values are naturally situated in the rage of 2700-4000 Σt°g (Enache, 2013). Latest average values situated at the far end of the scale. Active thermal balance (Σt°a) values ranged from 3337(2020) to 3245(2023), highest value recorded was specific to 2020. An increase by 0.8% for active thermal balance parameter. Values of 1702 units for useful heat balance (Σt°u), seen in 2023, surpassed multiannual data situated at 1697 maximum values.

Temperature indices revealed important variations whit annual average temperatures registering increases compared to multiannual means. Data analysis revealed a 0.7^0 increase in 2022 and a more significant 1.5^0 increase for 2023. Although average temperatures reached 12.4 °C (2020), near the value of 2023, average temperatures decreased the following year below multiannual values.

Figure 2 **Average annual temperature variation**

Latest temperature values describe a change in before known trends whit the absence of colder years between hotter ones. Temperature changes associated with climate change are not homogeneous. Studies show that temperatures are currently 1 °C higher on average compared to pre-industrial revolution (IPCC, 2014)

Figure 3 **Average temperature indices in summer months**

Average temperatures for summer months show a developing trend of maximum average temperatures increases whit the same trend development as seen in average annual temperature values. Beside the fact that new average air temperatures are achieved, data analysis shows a consecutive yearly increase in temperature. Most noticeable increase in temperature was specific to the month of August 2023 whit a maximum of 32.9^0C, 2.9^0C higher than 2010-2019 maximum values. July and August average temperatures also increased by 1.1 and 1.6^0C. June temperatures suffered declines from average values of 21^0C to a minimum of 17.8^0C (2021). European data show shifting climatic conditions due to climate change whit possible great impact on viticulture worldwide (Schultz *et al*, 2000).

Synergistic effects between projected precipitation decrease, and higher rates of evapotranspiration due to a warmer climate will likely increase water requirements, particularly during summer, in southern Europe (Cardell *et al*, 2019).

Figure 4 **Number of days with maximum temp. > 30°C, air humidity and bioactive period length**

Optimum photosynthetic temperature for the grapevine is between 25 and 35 °C (Kun *et al*, 2018). Increases in the length of bioactive periods have been especially characteristic for 2023 whit an extra 6 days longer than multiannual averages and 21 days more compared de 2022. These values are corroborated whit a rise in days that exceed average temperatures of 30^0C. Data has shown 55 days whit average values over 30^0C in 2022 whit a surge to 61 days in 2023.

Photosynthetic rates in grape leaves do not decrease significantly at 35 °C, but these processes are limited at temperatures of over 40 °C (Luo *et al*, 2011). A consecutive amplification of the number of days whit these values is starting to emerge. Air humidity is dropping whit latest data below mean values. 2022 registering a drop by 20.1 % and the lowest value for the time interval analyzed.

Figure 5 **Real heliothermic index and Hydrothermal coefficient values**

Important reductions of hydrothermal coefficient values were observed, lowest value being specific for 2023 (0.72), 0.23 units less compared to multiannual averages. Analysis of real heliothermic index show variations between 2.2 and 2.75 whit a value of 2.69 (2022) and 2.47 (2023) near multiannual values. Following climatic trend provided by other indices. New registered values surpassed known benchmarks for this specific climate region. A minimum of 0.44 unites compared to 2.25 value specific for late ripening varieties and maximum value of 1.44 unites compared to 1.25 value for early ripening varieties.

Figure 6 **Rainfall values**

A gradual decline of rainfall is emerging as a trend in the latest years. When compared to multiannual average values for 2010-2019 (526 mm), total amount for 2022 and 2023 of precipitation did not exceed 347 mm. The two consecutive years that registered the lowest precipitation values for the analyzed time line were also preceded by years whit declining inputs of water, 2020 (490.2 mm) and 2021 (447 mm).

Multiannual precipitation values of 526 mm were by 34 % higher compared to 2022 and 2023.

Precipitation ratios remain marginally close; 33% rainfall during vegetative periods for 2023 compared to 39% rainfall during vegetative resulted from multiannual data. Total soil water reserve is severely affected, whit lowering values for precipitations during vegetative periods, of 233 mm compared to multiannual values of 316 mm.

Annual precipitation and its distribution are critical. High soil water reserves are used during vine vegetative stages followed by dry and stable atmospheric conditions from flowering to berry ripening (Ramos *et al*, 2008). "De Martonne" aridity index suffered modification according to precipitation and temperature values. 2010-2019 average values of 24.9 were higher by 10 units, whit low values of 15.9 (2022) and 15.3 (2023). Values <22 are characteristic for extreme aridity areas and were characteristic to eastern periphery of Romanian Plain and Danube wetlands, which corresponds to the smallest annual quantity of rainfall <450 mm (Zaldea *et al*, 2021).

II. SPECIFIC VINE CLIMATE INDICES ANALYSIS

Specific vine climate indices offer hints on the health and suitability of the viticultural area (Fraga *et al*, 2013).

One of the most important parameters is cool night Index which represent the average of minimum night temperatures during ripening periods in order to improve evaluation of the qualitative potentials of wine in relation to the secondary metabolite accumulation in grapes (Piña-Rey *et al*, 2020).

Figure 7 **Vine bioclimatic and Night cooling index**

Both specific indices registered modifications according to previous general climate indices. Night cooling index was by 16.7% higher at its maximum value, 12.6-2023, than baseline values. Vine bioclimatic followed an ascending trend for the last two monitored years whit values of 10.67 and 10.96. Studies conducted in the Mediterranean wine making basin showed significant night cooling index variations, whit a developing trend for increasing values (Biasi *et al*, 2019). Other results Portugal vine growing centers also report higher night cooling indices (Blanco-Ward *et al*, 2019), confirming current trend at Bujoru viticultural area.

Oenoclimate aptitude index (IAOe) is another revealing climate suitability factor important in wine production under temperate climate conditions. In Romanian wine regions, IAOe is traditionally quite stable assuring certain types of wine production practices. In the last decades the IAOe values have increased (Irimia *et al*, 2017).

Bujoru multiannual values 2010-2019 show an average IAOe of 4758. According to data analysis 2020-2023, oenoclimate aptitude index has varied between 4950(2020) and 4460 (2021) whit consecutive increases for this index in 2022 and 2023 to 4856 respectively 4710. Values reflecting the impact of global warming phenomena when compared to previous measurements (Halbac-Cotoara-Zamfir *et al*, 2021).

Figure 8 **Oenoclimate aptitude and Huglin heliotermic index**

Huglin heliotermic index variations registered important variations between 2020-2023 whit a max of 2469 in 2020 followed by 2023 (2324) whit possible future ascending values. Higher huglin index, situates the territory as warm with cultivation possibilities suitable for late varieties situated in the $2100 < HI \leq 2400$ classification (Vizitiu *et al*, 2019).

CONCLUSIONS

Significant warming trends have been observed globally, with substantial implications for various sectors, including viticulture. Future warming phenomena will probably result in an eventual overall loss of viticultural suitability in the Mediterranean-like climatic areas of southern Europe, while in central and northern Europe, warming conditions will potentially benefit late ripening grapevine cultivation. Romania's diverse climate and varying geography mean that the impacts of climate change will be region-specific.

Low relative humidity combined with high temperatures can increase water stress in grapevines. This stress can affect the vines' ability to produce quality fruit and maintain overall health.

New climate parameters determine a raise in the number of dry years whit an interplay between reduced rainfall, higher maximum temperatures, and relative humidity having serious effects on vine plantations gown at Bujoru viticulture and winemaking research - development facility. Sustainable viticulture strategies are being developed in order to adapt and mitigate the effects of climate change seen in Bujoru viticultural areal.

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REFERENCES

Sanz-Sáez Á., Erice G., Aguirreolea J., Muñoz F., Sánchez-Diaz M., Irigoyen J.J., 2012 - *Alfalfa forage digestibility, quality and yield under future climate change scenarios vary with Sinorhizobium meliloti strain*. Journal of Plant Physiology, 169:782-788.

Shimizu H., Akamatsu F., Kamada A., Koyama K., Iwashita K. & Goto-Yamamoto N., 2022 - *Effects of variety and vintage on the minerals of grape juice from a single vineyard*. Journal of Food Composition and Analysis, 107:304-377.

Santos J. A., Fraga H., Malheiro A. C., Moutinho-Pereira J., Dinis L. T., Correia C. & Schultz H. R., 2020 - *A review of the potential climate change impacts and adaptation options for European viticulture*. Applied Sciences, 10(9) : 30-92.

Tonietto J., 1999 - Les Macroclimats Viticoles Mondiaux et l'Influence du Mésoclimat sur la Typicité de la Syrah et du Muscat de Hambourg dans le sud de la France: Méthodologie de Caractérisation. Ph.D. Thesis, Ecole Nationale Supérieure Agronomique, Montpellier, France; 233p

Lavalle C., Micale F., Houston T.D., Camia A., Hiederer R., Lazar C., Conte C., Amatulli G., Genovese G., 2009 - *Climate change in Europe. 3. Impact on agriculture and forestry. A review*. Agron. Sustain. Dev. 29: 433–446.

Jones G.V., White M.A., Cooper O.R., Storchmann K., 2005 - *Climate change and global wine quality*. Clim. Change 73: 319–343.

Fennell A., 2014 - *Genomics and functional genomics of winter low temperature tolerance in temperate fruit crops*. Crit. Rev. Plant Sci. 33: 125–140.

OIV, 2019 - *Statistical Report on World Vitiviniculture*; International Organisation of Vine and Wine: Paris, France; Available online: https://www.oiv.int/public/medias/6782/oiv-2019-statistical-report-on-world- vitiviniculture.pdf

Giorgi F., 2006 - *Climate change hot-spots*. Geophys. Res. Lett., 33:87-107

Droulia F. & Charalampopoulos I., 2022 - *A review on the observed climate change in Europe and its impacts on viticulture*. Atmosphere, 13(5), 837.

IPCC, 2014 - *Climate Change Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Pachauri, R., Meyer, L., Eds.; IPCC: Geneva, Switzerland.

Schultz H.R., 2000 - *Climate change and viticulture: A European perspective on climatology, carbon dioxide and UV-B effects.* Aust. J. Grape Wine Res. 6: 2–12.

Kun Z., Bai-hong C., Yan H., Rui Y., Yu-an W., 2018 - *Effects of short-term heat stress on PSII and subsequent recovery for senescent leaves of Vitis vinifera L. cv. Red Globe*. J. Integr. Agric. 17: 2683–2693.

Luo H.B., Ma L., Xi H.F., Duan W., Li S.H., Loescher W., Wang J.F., Wang L.J., 2011 - *Photosynthetic responses to heat treatments at different temperatures and following recovery in grapevine (Vitis amurensis L.) leaves*. PLoS ONE, 6: 23-33.

Ramos M.C., Jones G.V., Martínez-Casasnovas J.A., 2008 - *Structure and trends in climate parameters affecting winegrape production in Northeast Spain*. Clim. Res., 38: 1–15.

Cardell M.F., Amengual A., Romero R., 2019 - *Future Effects of climate change on the suitability of wine grape production across Europe*. Reg. Environ. Chang. 19: 2299–2310.

Zaldea G., Nechita A., Damian D., Ghiur A. & Cotea V. V., 2021 - *Climate changes in recent decades, the evolution of the drought phenomenon and their influence on vineyards in North-Eastern Romania*. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 23:20-32

Fraga H., Malheiro A.C., Pereira J., Santos J.A., 2013 - *Future scenarios for viticultural zoning in Europe: Ensemble projections and uncertainties.* Int. J. Biometeorol. 57:909–925.

Piña-Rey A., González-Fernández E., Fernández-González M., Lorenzo M. N., & Rodríguez-Rajo F. J., 2020 - *Climate change impacts assessment on wine-growing bioclimatic transition areas.* Agriculture, 10(12): 605-615.

Biasi R., Brunori E., Ferrara C. Salvati L., 2019 - *Assessing impacts of Climate Change on phenology and quality traits of Vitis vinifera L.: The contribution of local knowledge*. Plants, 8:121-129.

Blanco-Ward Daniel A., Ribeiro David Barreales J., Castro J. Verdial M. Feliciano V., 2019 -

Climate change potential effects on grapevine bioclimatic indices: A case study for the Portuguese demarcated Douro Region (Portugal). In BIO Web of Conferences, 12: 1-13. EDP Sciences.

Irimia L. M., Patriche C. V. & Roșca B., 2017- *Changes in oenoclimate aptitude index characterizing climate suitability of Romanian wine growing regions.* Applied Ecology & Environmental Research, 15(4):10-19.

Enache V., 2013 - *Influenţa unor verigi tehnologice asupra dinamicii umidităţii solului, în condiţiile de secetă prelungită a anului 0 în Podgoria Dealu Bujorului-Romania*. In Horticultură, Viticultură şi vinificaţie, Silvicultură şi grădini publice, Protecţia plantelor, 36: 249-251.

Halbac-Cotoara-Zamfir R., Ferreira C. S. S., & Salvati L., 2021 - *Long-term urbanization dynamics and the evolution of green/blue areas in eastern europe: Insights from Romania.* Sustainability, 13(24):57-68.

Vizitiu D. E., Dinca L., Enache V., Donici A., Popa L., Cociorva D. & Murariu G., 2018 - *Identifying and describing the main climatic and stress factors that are affecting forest and viticultural ecosystems.* Horticulturae, 5:232-241.

STRUCTURE, DYNAMICS, AND ABUNDANCE OF BEETLE SPECIES FROM A CORN CROP FROM THE WESTERN AREA OF ROMANIA

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Abstract

The observations regarding the useful and harmful fauna belonging to the Coleoptera order were made in the western part of Romania in a corn crop in Arad county.

For these observations, 12 pitfall traps were used, and they were placed in the culture in two rows of 6 per row from the beginning of the emergence of the plants until harvesting at intervals of about 2 weeks per during the year 2022 on the following calendar dates: 15.05, 29.05, 12.06, 26.06, 24.07, 7.08, 21.08, 4.09, and 18.09.

Only carabid species were retained from the collected material. The experience was organized in two variants:

Variant 1 is represented by an ecological corn culture where no chemical treatment was done to combat pathogens and pests. Variant 2, represented by a corn crop grown in a conventional system where chemical treatments were applied both to the seed and to the crop to combat pathogens and pests. Among the carabid species collected, I mention *Pterostichus pubescens, Harpalus distinguendus, Ophonus azureus, Anysodactilus signatus*, etc.

In general, a greater diversity and an important number of carabids are found in the corn crop cultivated in an ecological system (variant 1).

Key words: corn, abundance, trap, carabids

Maize is one of the world's main food sources, both for human consumption and for animal feed. In many regions, maize is a staple food, being used in the form of flour, sorghum, or other food products (Staller *et al*, 2010).

Corn is also an important source of energy due to its high starch content. Due to the large volume of biomass produced, the corn crop plays a role in capturing carbon dioxide. It is used in the production of biofuels (ethanol), starch, corn syrup, and other industrial derivatives. It contributes to various industries, from food production to chemical and pharmaceutical (Norton *et al*, 2022).

Maize also proves to be a versatile crop that can be grown in various climatic conditions and on varied soils, making it accessible in a wide range of agricultural regions around the world, with a relatively high yield per hectare compared to other crops, offering consistent production, essential for food safety (Spînu, 2018).

Carabids are effective predators of various species of insect pests that affect maize crops, such as wireworm (*Agriotes spp*.), *Diabrotica virgifera virgifera,* etc. (Losey and Vaughan, 2006)

Due to their ability to naturally control pest populations, carabids help reduce the use of chemical pesticides. This is an essential practice for sustainable agriculture because it reduces the impact on the environment and biodiversity, maintains soil and water health by reducing contamination with substances and chemicals, and favors the development of a balanced agroecosystem (Landis *et al*, 2000).

MATERIAL AND METHOD

The observations regarding the useful and harmful fauna belonging to the order Coleoptera were made in the western part of Romania in a corn crop in Arad city.

For these observations, 12 pitfall traps were used, and they were placed in the culture in two rows of 6 per row from the beginning of the emergence of the plants until harvesting, harvesting at intervals of about 2 weeks per during the year 2022 on the following calendar dates: 15.05, 29.05, 12.06, 26.06, 24.07, 7.08, 21.08, 4.09, and 18.09.

From the collected material, only carabid species were retained.

The experience was organized in two variants:

Variant 1 is represented by an ecological corn crop where no chemical treatment was done to combat pathogens and pests.

Variant 2, represented by a corn crop grown in a conventional system where chemical

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treatments were applied both to the seed and to the crop to combat pathogens and pests.

Pitfall traps are a collection method used in the study of insects. These traps are often used in ecology to assess species diversity and abundance, particularly in biodiversity and population monitoring studies (Thorne and Williams, 1988).

Pifall traps are traps dug into the ground, designed to capture organisms that move across the surface of the land. They work on the principle that insects that move on the ground fall into the trap, where they remain captive. They can be constructed from various materials, including plastic, metal, or glass. They are shaped like a container (usually cylindrical) that is dug into the ground (Fig. 1). Sometimes the traps are covered with a lid or a net to prevent water or other plant debris from entering (Lang, 2000).

Pifall traps are an efficient and relatively simple method for collecting terrestrial organisms, with important applications in ecological research. Using this method allows ecologists to obtain data essential to understanding biodiversity and ecosystem dynamics.

Figure 1. The inventory of the entomological material collecte

RESULTS AND DISCUSSIONS

In 2022, treatments against pathogens and pests were applied to the corn crop, V2 variant:

- Premis 700 WS insecticide and Lebosol growth stimulator were used to treat corn seeds;

- during the vegetation period, the herbicides Dicopur D, Elumis, and the systemic insecticide Mospilan 20 SG were used.

On 15.05.11 carabid species (77 specimens) were collected (table 1) at the V1 variant and 1 species, *Pseudophonus pubescens* (66 specimens), at the V2 variant. The species with only one specimen collected were *Pterostichus niger, Harpalus aeneus, Ophonus azureus, Pterostichus koyi, Ophonus puncticollis,* and *Harpalus rufus*.

On May 29, 2022, 10 carabid species were collected at the V1 variant (100 specimens) and 4 species (65 specimens) at the V2 variant (table 2). The species with the highest abundance was *Pseudophonus pubescens* (58 specimens) in both variants, variant V1-58 specimens, respectively 44 specimens in variant V2. In total, a total of 165 specimens of carabids were collected in the two experimental variants

Tabel 1

The beetles collected in the corn crop on 15.05.2022

No.	Name of speccies	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Variant V1-untreated														
1.	Pseudophonus pubescens	4	4	4	3		1	3	3	3	3	6	1	**35**
2.	Pterostichus niger	1												1
3.	Pseudophonus griseus	3	2	3	2									**20**
4.	Harpalus distinguendus	1	1		1							1		**4**
5.	Nebria brevicollis	1									1			**2**
6.	Pterostichus cylindricus			1	2		1		1	2		2	1	**10**
7.	Harpalus aeneus				1									**1**
8.	Ophonus azureus							1						**1**
9.	Pterostichus koyi								1					**1**
10.	Ophonus puncticollis										1			**1**
11.	Harpalus rufus										1			**1**
Total V 1		**10**	**7**	**8**	**9**	**0**	**3**	**13**	**5**	**5**	**6**	**9**	**2**	**77**
Variant V2 - treated														
1.	Pseudophonus pubescens	5	5		9	7	11	7	12	4	4	2		**66**
Total V2		**5**	**5**	**0**	**9**	**7**	**11**	**7**	**12**	**4**	**4**	**2**	**0**	**66**

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Tabel 2

Carabids collected in the corn crop on 29.05.2022

No.	Name of speccies	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Variant V1- untreated														
1.	Carabus coriaceus	1												1
2.	Carabus intricatus	1												1
3.	Pterostichus cylindricus	3	1					7						10
4.	Harpalus aeneus	1							1					2
5.	Pseudophonus pubescens	15	5	5	10	3		8	3	3	2	2	1	58
6.	Ophonus azureus		2		1									3
7.	Pseudophonus griseus		4	2			2	2	2	2	7	1		22
8.	Harpalus distinguendus				1									1
9.	Ophonus puncticollis				1									1
10.	Pterostichus vulgaris								1					1
Total V1		**21**	**12**	**7**	**13**	**3**	**2**	**17**	**7**	**5**	**9**	**3**	**1**	**100**
Variant V2 - treated														
1.	Pterostichus cylindricus								4				1	5
2.	Pseudophonus pubescens	3	4	2	6	6	8	5	6	2	1		1	44
3.	Pseudophonus griseus	4				3	3		3		1		1	15
4.	Harpalus distinguendus	1												1
Total V2		**8**	**4**	**2**	**6**	**9**	**11**	**5**	**13**	**2**	**2**	**0**	**3**	**65**

On 12.06.2022, 55 carabid specimens belonging to 11 species were collected in the V1 variant using pitfall traps (table 3), and in the V2 variant a number of 64 specimens belonging to 2 carabid species: *Pseudophonus griseus* (25 specimens) and *Pseudophonus pubescens* (39 specimens). In total, in the two experimental variants, a total of 119 carabid specimens were collected.

Tabel 3

The beetles collected in the corn crop on 12.06.2022

No.	Name of speccies	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Variant V1-untreated														
1.	Pterostichus melas	1												1
2.	Harpalus distinguendus	1							2					3
3.	Pterostichus vulgaris	1												1
4.	Pseudophonus griseus	3		1	3			3						10
5.	Pseudophonus pubescens	9	2	4	6			2			2	6		31
6.	Amara crenata	1												1
7.	Harpalus aeneus				1									1
8.	Abax carrinatus				1									1
9.	Pterostichus cylindricus					1								1
10.	Calatus fuscipes							1						1
11.	Pterostichus niger								1					1
Total V1		**16**	**2**	**5**	**11**	**1**	**0**	**8**	**2**	**1**	**3**	**6**	**0**	**55**
Variant V2 - treated														
1.	Pseudophonus griseus	4	3		2	2	5	1	2	2	2	1	1	25
2.	Pseudophonus pubescens		5	2	2	2	4	4	6	4	5			39
Total V2		**9**	**8**	**2**	**4**	**4**	**9**	**5**	**8**	**6**	**7**	**1**	**1**	**64**

On 26.06.2022 (table 4), in the untreated variant (V1) 13 carabid species (73 specimens) were collected, the most abundant species being *Pseudophonus pubescens* with 39 specimens, representing 53.42% of the total, and in V2 only 2 species (39 specimens) - *Pseudophonus pubescens* and *Pseudophonus griseus.*

Tabel 4.

The beetles collected in the corn crop on 26.06.2022

No.	Name of speccies	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Variant V 1- untreated														
1.	Pterostichus niger	1												1
2.	Pseudophonus pubescens	6	4	4	5	4	5	4		1		5	1	39
3.	Harpalus distinguendus	1			2									3

4.	Ophonus azureus	1						1						2
5.	Ophonus puncticollis	1						1						2
6.	Harpalus aeneus	1						1						2
7.	Amara aenea	1												1
8.	Pseudophonus griseus		2		2		2	3				3		12
9.	Pterostichus cylindricus			1				3		1	1		1	7
10.	Carabus cancellatus							1						1
11.	Amara apricaria							1						1
12.	Harpalus tardus							1						1
13.	Calatus fuscipes											1		1
Total V 1		**12**	**6**	**5**	**9**	**4**	**7**	**16**	**0**	**2**	**1**	**9**	**2**	**73**
Variant V 2 - treated														
1.	Pseudophonus pubescens	1			2	2	7	2	5	4	2			**25**
2.	Pseudophonus griseus	1	1	1	2	1	4			3	1			**14**
Total V 2		**2**	**1**	**1**	**4**	**3**	**11**	**2**	**5**	**7**	**3**	**0**	**0**	**39**

On 10.07, 56 carabid specimens were collected in the V1 variant and 63 specimens in the V2 variant belonging to the species *Pterostichus cylindricus, Pseudophonus pubescens* and *Pseudophonus griseus* (table 5). The species with the largest number of specimens collected was *Pseudophonus pubescens* (27 specimens) in the V1 variant, respectively *Pseudophonus griseus* (36 specimens) in the V2 variant.

Tabel 5

Carabids collected in the corn crop on 10.07.2022

No.	Name of speccies	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Variant V1- untreated														
1.	Pterostichus cylindricus	1			2		1		2	1	1	2	1	**11**
2.	Harpalus distinguendus	2	1					2						**5**
3.	Pseudophonus pubescens	2	3	4	2	0	1	5	2	1	3	3	1	**27**
4.	Pseudophonus griseus		2	3								1		**6**
5.	Harpalus aeneus		1											**1**
6.	Ophonus puncticollis			1										**1**
7.	Harpalus tardus			1										**1**
8.	Aniysodactylus signatus			1										**1**
9.	Calatus fuscipes							1						**1**
10.	Pterostichus niger									1				**1**
11.	Amara aenea										1			**1**
Total V1		**5**	**7**	**10**	**4**	**0**	**2**	**8**	**4**	**3**	**5**	**6**	**2**	**56**
Variant V2 - utreated														
1.	Pterostichus cylindricus								2					**2**
2.	Pseudophonus pubescens		1	1	2	3	2		4	6	4	2		**25**
3.	Pseudophonus griseus		2	2	4	1	7	2	8	4	3	1	2	**36**
Total V2		**0**	**3**	**3**	**6**	**4**	**9**	**2**	**14**	**10**	**7**	**3**	**2**	**63**

On 24.07.2022, 12 carabid species (62 specimens) were collected with the help of the pitfall traps at the V1 variant and 7 species (53 specimens) at the V2 variant (table 6). The species with the highest abundance were *Pseudophonus pubescens* for both variants: 17 specimens at V1, respectively 44 specimens at V2.

Tabel 6

The beetles collected in the corn crop on 24.07.2022

No.	Name of speccies	Capcana												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Variant V1- untreated														
1.	Pterostichus cylindricus	2	2	1	1	1		2		1	1	2		**13**
2.	Pterostichus niger	1	1											**2**
3.	Abax carrinatus	1				1								**2**
4.	Amara aenea	1												**1**
5.	Bembidion properans	1			3									**4**
6.	Nebria brevicollis	1			0									**1**
7.	Pseudophonus griseus	3			4	3		2						**12**
8.	Pseudophonus pubescens	4	1			3	1	2	1	2	1	2		**17**
9.	Harpalus distinguendus		2	1	1	1		1				1		**7**
10.	Pterostichus marginalis			1										**1**
11.	Ophonus azureus				1									**1**
12.	Pterostichus vulgaris							1						**1**
Total V1		**14**	**6**	**3**	**10**	**9**	**1**	**8**	**1**	**3**	**2**	**5**	**0**	**62**
Variant V2 - treated														

1.	Pterostichus cylindricus						3							**3**
2.	Pterostichus niger						1							**1**
3.	Pseudophonus griseus								1					**1**
4.	Pseudophonus pubescens	2	2	1	9	2	9	3	8	4	2	1	1	**44**
5.	Pterostichus marginalis						1							**1**
6.	Ophonus azureus						1							1
7.	Calatus fuscipes								2					**2**
Total V2		**2**	**2**	**1**	**9**	**2**	**15**	**3**	**11**	**4**	**2**	**1**	**1**	**53**

On 07.08.2022 (table 7), 37 specimens of carabids were collected in the V1 variant and 25 specimens in the V2 variant belonging to the species *Pterostichus cylindricus, Pseudophonus pubescens* and *Pseudophonus griseus*. The species with the largest number of specimens collected was *Pseudophonus griseus* in both variants, with 15 specimens in the V1 variant, and 17 specimens in the V2 variant.

Tabel 7

Carabids collected in the corn crop on 07.08.2022

No.	Name of speccies	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Variant V1- untreated														
1.	Pterostichus cylindricus	1			2			1	2		1	2		**9**
2.	Harpalus aeneus	1			1									2
3.	Pseudophonus griseus	1	4	1	2	1	1	3	1		1			**15**
4.	Pterostichus niger		1	1			1				1			**4**
5.	Pseudophonus pubescens				1				1	1		1		**4**
6.	Harpalus distinguendus				1			1	1					**3**
Total V1		**3**	**5**	**2**	**7**	**1**	**2**	**5**	**5**	**1**	**3**	**3**	**0**	**37**
Variant V2 - treated														
1.	Pterostichus cylindricus			1	1									**2**
2.	Pseudophonus griseus	1		1	5		2	2	3		2		1	**17**
3.	Pseudophonus pubescens				2		1	2	1					**6**
Total V2		**1**	**0**	**2**	**8**	**0**	**3**	**4**	**4**	**0**	**2**	**0**	**1**	**25**

On 21.08.2022, 5 carabid species (29 specimens) were collected at the V1 variant and 4 species (22 specimens) at the V2 variant (table 8). The species with the highest abundance were *Pterostichus cylindricus* with 10 specimens collected at V1 and *Pseudophonus griseus* with 14 specimens at V2.

Tabel 8

Carabids collected in the corn crop on 21.08.2022

No.	Name of speccies	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Variant V1- untreated														
1.	Pterostichus cylindricus	1	1		2		1	2	1		1	1		**10**
2.	Pseudophonus griseus	2			1		1		1	1	1	1	1	**9**
3.	Harpalus distinguendus	1	1											**2**
4.	Pseudophonus pubescens		1	1	1		2		1					**6**
5.	Pterostichus niger						1		1					**2**
Total V1		**4**	**3**	**1**	**4**	**0**	**5**	**2**	**4**	**1**	**2**	**2**	**1**	**29**
Variant V2 - treated														
1.	Pterostichus cylindricus				2									**2**
2.	Pseudophonus griseus		1	2	1	1		2	3	1	1	1	1	**14**
3.	Pseudophonus pubescens	1		1	1		2							**5**
4.	Pterostichus niger				1									**1**
Total V2		**1**	**1**	**3**	**5**	**1**	**2**	**2**	**3**	**1**	**1**	**1**	**1**	**22**

On 04.09.2022, 17 carabid specimens were collected belonging to 5 species in the V1 variant and 15 specimens in the V2 variant, belonging to 3 species (table 9). The species that recorded only one specimen were *Pseudophonus pubescens* (V 1) and *Pterostichus cylindricus* (V2). In total, 32 specimens of carabids were collected; the untreated variant (V1) recorded the highest abundance with 17 specimens.

Tabel 9

Carabids collected in the corn crop on 04.09.2022

No.	Name of speccies	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Variant V1- untreated														
1.	Pseudophonus griseus	2								3		1	1	**7**
2.	Pterostichus cylindricus				1				1			1		**3**
3.	Pterostichus niger	1							2		1			**4**
4.	Harpalus distinguendus								1	1				**2**
5.	Pseudophonus pubescens									1				**1**
Total V1		**3**	**0**	**0**	**1**	**0**	**0**	**0**	**4**	**5**	**1**	**2**	**1**	**17**
Variant V2 - treated														
1.	Pseudophonus griseus		2		2		2				3			**9**
2.	Pterostichus cylindricus				1									**1**
3.	Pseudophonus pubescens	1			1					1	2		1	**5**
Total V2		**1**	**2**	**0**	**4**	**0**	**2**	**0**	**0**	**1**	**5**	**0**	**1**	**15**

On 18.09.2022, 5 carabid species (14 specimens) were collected at the V1 variant and one species, *Pseudophonus pubescens* (7 specimens), at the V2 variant. A total of 21 specimens of carabids were collected in the two experimental variants (table 10), the V1 variant representing 66.7% of the total specimens.

Tabel 10

The beetles collected in the corn crop on 18.09.2022

No.	Name of speccies	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Variant V1- untreated														
1.	Pterostichus cylindricus	1			1				1	1				**4**
2.	Pseudophonus pubescens	2			1				2					**7**
3.	Pseudophonus griseus				1									**1**
4.	Harpalus distinguendus								1					**1**
5.	Brachynus crepitans								1					**1**
Total V1		**3**	**0**	**0**	**3**	**0**	**0**	**0**	**5**	**1**	**0**	**0**	**2**	**14**
Variant V2 - treated														
1.	Pseudophonus pubescens	1	1					1		2			2	**7**
Total V2		**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**0**	**0**	**2**	**7**

The most specimens collected were of the species *Pseudophonus pubescens* (484 specimens), *Pseudophonus griseus* (235 specimens), *Pterostichus cylindricus* (94 specimens), *Harpalus distinguendus* (32 specimens), and *Pterostichus niger* (188 specimens); nine carabid species recorded only one specimen (Tabel 11).

Tabel 11

Carabid species collected in the corn crop in 2022

No.	Name of speccies	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
1.	Pseudophonus pubescens	56	38	29	63	32	54	48	55	39	31	30	9	**484**
2.	Pseudophonus griseus	24	23	16	31	12	29	20	24	16	22	10	8	**235**
3.	Pterostichus cylindricus	9	4	4	15	2	6	15	14	6	5	10	4	**94**
4.	Harpalus distinguendus	7	5	1	6	1		4	5	1		2		**32**
5.	Pterostichus niger	4	2	1	1		3		4	1	2			**18**
6.	Harpalus aeneus	3	1		3			1	1					**9**
7.	Ophonus azureus	1	2		2		1	2						**8**
8.	Calatus fuscipes							2	2			1		**5**
9.	Ophonus puncticollis	1		1	1			1			1			**5**
10.	Bembidion properans	1			3									**4**
11.	Abax carrinatus	1			1	1								**3**
12.	Amara aenea	2									1			**3**
13.	Nebria brevicollis	2									1			**3**
14.	Pterostichus vulgaris	1						1	1					**3**
15.	Harpalus tardus			1				1						**2**
16.	Pterostichus marginalis			1			1		1					**3**
17.	Amara apricaria							1						**1**
18.	Amara crenata	1												**1**

19.	Aniysodactylus signatus			1										**1**
20.	Brachynus crepitans								1					**1**
21.	Carabus cancellatus							1						**1**
22.	Carabus coriaceus	1												**1**
23.	Carabus intricatus	1												**1**
24.	Harpalus rufus										1			**1**
25.	Pterostichus melas	1												**1**
TOTAL		**116**	**75**	**54**	**126**	**48**	**94**	**97**	**108**	**61**	**64**	**53**	**21**	**917**

CONCLUSIONS

In the treated variant (V2), the treatments with insecticides and herbicides had a significant impact on the carabid biodiversity. Compared to the untreated variant (V1), the treated variant recorded a lower number of carabid species, but a higher abundance of some dominant species.

The species *Pseudophonus pubescens* dominated the collections in both variants, but in the treated variant it was less abundant than in the untreated variant.

In the untreated variant, species diversity was significantly higher, with between 10 and 13 species recorded in several stages of the experiment (for example, 13 species on 26.06 and 12 species on 24.07). Instead, in the treated variant, only two or three species were frequently recorded (except for 24.07, when 7 species were collected). Also, species collected in small numbers, such as *Pterostichus niger* or *Harpalus distinguendus*, have were present especially in the untreated version, indicating their sensitivity to the chemical treatments applied in V2.

Although the treated variant had a lower diversity of species, certain species recorded a large number of specimens. For example, the species *Pseudophonus griseus* was the most abundant in the treated variant at the end of the experiment (36 specimens at 10.07 and 14 specimens at 21.08). In the untreated variant, the species *Pseudophonus pubescens* was frequently the most abundant (with a peak of 58 specimens at 29.05).

In both variants, the number of carabids collected fluctuated throughout the experiment. At the beginning of the collection period, the treated variant had fewer specimens collected, but from 24.07 until August, the treated variant began to record an increasing number of carabids, especially from the species *Pseudophonus pubescens* and *Pseudophonus griseus*.

In general, species diversity was lower in the treated variant (V2) compared to the untreated variant (V1), suggesting that the use of chemical treatments negatively affected the presence of more sensitive carabid species.

In conclusion, the treatments applied in variant V2 led to a reduction in carabid diversity, favoring the presence of dominant species, such as *Pseudophonus pubescens* and *Pseudophonus griseus,* at the expense of other species less tolerant to chemical interventions.

REFERENCES

Landis D.A., Wratten S.D., & Gurr G.M., 2000 - *Habitat Management to Conserve Natural Enemies of Arthropod Pests in Agriculture*, Annual Review of Entomology, 45, 175-201.

Lang A., 2000 - *Use of pitfall traps for monitoring ground-dwelling arthropods in agricultural ecosystems*. Journal of Applied Ecology, 37(1), 158-167.

Losey J. E., & Vaughan M., 2006 - *The Economic Value of Ecological Services Provided by Insects*. Bioscience, 56(4), 311-323.

Norton G.W., Alwang J., Masters W.A., 2022 - *Economics of Agricultural Development: WorldFood Systems and Resource Use, AgrekonAgricultural Economics Research*, Policy and Practice in Southern Africa

Spînu A., 2018 - The study of corn hybrids according to some morphological and biometric characters. In: Agronomy and agroecology.52(1), Chişinău, Centrul editorial UASM, 296-299. ISBN 978.

Staller J.E., Tykot R. H., Benz B. F., 2010 - Maize: Origin, Domestication, and Its Role in the Development of Culture.

Thorne J. H., & Williams M. C., 1988 - *Pitfall traps: a methodology for collecting ground-dwelling invertebrates*. In: Ecological Entomology, 13(1), 1-9.

STRUCTURE, DYNAMICS, AND ABUNDANCE OF BEETLE SPECIES FROM A SUNFLOWER CROP FROM THE WESTERN AREA OF ROMANIA

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Abstract

The observations were made in the western part of Romania in the town of Aldea, Arad County, in a sunflower crop. For these observations, were used 12 pitfall traps ground traps. These were placed in the culture in two rows of six per row from the beginning of the plants' emergence until harvesting, harvesting at intervals of about 2 weeks throughout the year 2022 on the following calendar dates: 15.05, 29.05, 12.06, 26.06, 24.07, 7.08, 21.08, 4.09, and 18.09. Carabid species were retained from the collected material. Two variants were used: Variant 1 is represented by an ecological sunflower culture where no chemical treatment was done to combat pathogens and pests and Variant 2, represented by a sunflower crop cultivated in a conventional system where chemical treatments were applied both to the seed and to the crop to combat pathogens and pests. In general, a greater diversity and an important number of carabids are found in the sunflower culture cultivated in an ecological system (variant 1).

Key words: carabids, sunflower, crop, traps

The Carabidae family presents an objective of great attraction for coleopterological specialists and amateurs; thus, interest in the study of this group has increased greatly in the last decades (Neculiseanu, 2004).

Carabids are very diverse and well represented in the epigean arthropod fauna (Tălmaciu M. *et al*, 2022). They are very important in ecological studies due to the ecological roles they fulfill, such as prey, predator, detritivore, and necrophage (Sakine, 2006), but in addition to this role, the special value of carabids has been established in recent years also as bioindicators for the evaluation of the state of health of ecosystems (Varvara & Cîrlan, 1990).

Studying the structure, dynamics, and abundance of carabid species in a sunflower crop is important to understand the interaction between various biotic agents and agricultural systems. Coleoptera constitute a major group of insects that can have a significant impact on crops, having both beneficial-predatory and harmful species (Bărbulescu P., 2002).

Dominant species are those that appear in large numbers and have a significant impact on ecosystem dynamics (Chițimia, 2010). In a sunflower crop, the dominant species can be harmful or predatory species (*Adalia bipunctata*) with a role of biological regulation on pests.

Ecological agricultural practices or biological pest control can support a more diversified and balanced population of beetles (Eyre and Leifert, 2011).

The abundance of carabids species in a sunflower crop can vary according to various ecological and agricultural factors: temperature, humidity, and precipitation; application of pesticides that can reduce populations of harmful coleopterans but also of beneficial predators (Stork and Eggleton, 1992).

Studying beetles in a sunflower crop is essential for integrated pest management and maximizing the ecological benefits of natural predators, thus promoting sustainable agriculture (Schowalter, 2016).

MATERIAL AND METHOD

Samples were collected using pitfall traps, this method being effective for capturing species with high abundance and mobility (Stoyenoff, 2001; Spungis, 2008).

The entomological material was collected by means of 24 pitfall traps soil traps in each crop, more precisely 12 traps for each variant, during the entire vegetation period. The traps were made of plastic containers filled with a solution of acetic acid, a solution also used in other studies (Magura *et al*, 2005; Balog *et al*, 2012). The traps were buried to ground level (Figure 1). The location of the traps was made in the shape of a circle at a distance of 10 m between them.

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Plastic jars with a volume of 1000 ml, 13.5 cm wide, and 12.0 cm high were used to collect the entomological material. As a fixative-preservative liquid, 50% diluted acetic acid was used, in which a few drops of detergent were added to reduce the surface tension.

A hole is dug in the ground with suitable dimensions for the container so that it is inserted at ground level. The upper edge of the container must be perfectly aligned with the surface of the soil so that the insects enter the container.

The specimens captured there were collected and tagged. Labeled samples were protected from sunlight and transported to the laboratory for analysis and determination.

In the 2022 research year, using the pitfall trap method, a total of 10 periodic collections of biological material were carried out on the following dates: 15.05, 29.05, 12.06, 26.06, 10.07, 24.07, 07.08, 21.08, 04.09, and 18.09.

In order to achieve the research objectives, two work variants located in the same location were studied for each culture:

V1-Untreated crops;

V2-Crops to which treatments against pathogens and pests have been applied.

Treatments used on seeds:

- the following chemicals were used to treat wheat seeds: Permis 700 WS and Bariton Super 97.5 FS;
- the following chemicals were used to treat sunflower seeds: Permis 700 WS and Apron XL;
- the following chemicals were used to treat corn seeds: Permis 700 WS and Lebosol.

Treatments used on vegetation:

- the following substances were used to treat the corn crop: Mospilan 20 SG, Dicopur D and Elumis.
- the following substances were used to treat the sunflower crop: Karate Zeon, Mirage 45 EC and Pyrus 400;
- the following substances were used to treat the wheat crop: Attribut 70 and Hussar Activ OD.

Figure 1. **The inventory of the entomological material collected**

RESULTS AND DISCUSSIONS

In 2022, 16 distinct species of beetles were identified in the V1 version, which totaled a *similata* and *Bembidion ruficorne*, each being captured only once. *Pseudophonus pubescens* is the best represented species, with a total of 235 captured specimens being predominant number of 491 specimens (table 1). The species captured in very small numbers were *Amara* over the other species. *Pseudophonus griseus* and *Pterostichus cylindricus* are also well represented, with 96 and 114 specimens captured, respectively.

Tabel 1

Carabid species collected in the sunflower crop in V1 at 2022

No.	Species name	Trap												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
1.	Amara familiaris		3											3
2.	Amara similata		1											1
3.	Bembidion ruficorne		1											1
4.	Calatus fuscipes	3	1			1								5
5.	Carabus coriaceus		1					1				1		3
6.	Harpalus aeneus											1		1
7.	Harpalus distinguendus	1	1	3	1			3	1		1			11
8.	Harpalus tardus							1	1			1		3
9.	Leistus ferrugineus											1		1
10.	Ophonus puncticollis		1			1								2
11.	Platynus assimilis											1		1

12.	Pseudophonus griseus	5	12	2	6	15		9	14	2	12	13	6	96
13.	Pseudophonus pubescens	19	34	14	37	26	7	18	31	8	7	27	7	235
14.	Pterostichus cylindricus	11	16	7	5	9	5	20	14	4	9	8	6	114
15.	Pterostichus lepidus		1	1	1			1						4
16.	Pterostichus niger		1	1		2		1	2			2	1	10
TOTAL V1		**39**	**73**	**28**	**50**	**54**	**12**	**54**	**63**	**14**	**29**	**55**	**20**	**491**

In the V2 variant, 8 distinct species of carabids were collected (table 2). The best represented species is *Pterostichus cylindricus*, with 127 specimens caught, which represents over half of the total catches.

Other significantly represented species are *Pseudophonus pubescens* (63 specimens) and *Pseudophonus griseus* (17 specimens). Species such *as Zabrus tenebrioides* and *Nebria brevicollis* were very rarely encountered, each being captured only once.

Tabel 2

Carabid species collected in the sunflower crop in V2 at 2022

No.	**Species name**	**Trap**												**Total**
		1	2	3	4	5	6	7	8	9	10	11	12	
	Calatus fuscipes								2					2
2.	Harpalus distinguendus							2	1					3
3.	Nebria brevicollis							1						1
4.	Pseudophonus griseus	3					1	8	3		1		1	17
5.	Pseudophonus pubescens	12	6	1	5		3	18	8	1	4	4	1	63
6.	Pterostichus cylindricus	12	9	10	11	12	9	18	14	5	7	14	6	127
7.	Pterostichus niger	3		1	3		1	2	3	1				14
8.	Zabrus tenebrioides								1					1
TOTAL V2		**30**	**15**	**12**	**19**	**12**	**14**	**49**	**32**	**7**	**12**	**18**	**8**	**228**

In 2022, 18 carabid species were collected from the sunflower crop, which totaled 716 specimens (Fig. 1).

The most specimens collected were of the species *Pseudophonus pubescens* (298 specimens), *Pterostichus cylindricus* (241 specimens), *Pseudophonus griseus* (113 specimens), and *Pterostichus niger* (21 specimens); 7 carabid species recorded only one specimen.

These were: *Amara similata, Bembidion ruficorne, Harpalus aeneus, Leistus ferrugineus, Nebria brevicollis, Platynus assimilis*, and *Zabrus tenebrioides.*

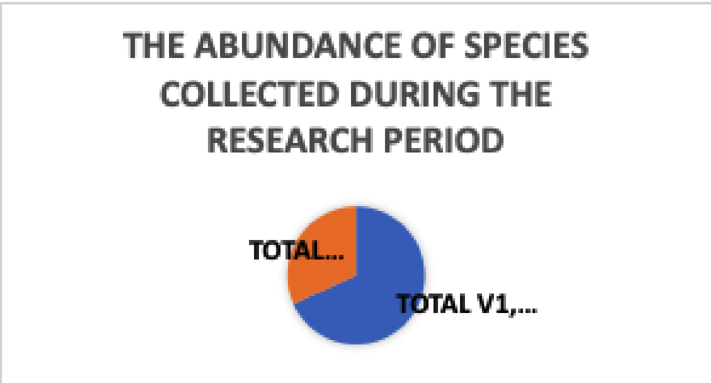

Figure 2. **Graphic representation of the structure of carabid species collected in 2022**

In the sunflower crop, in 2022, 6 common carabid species were identified with a total of 697 specimens, the species with the highest abundance being *Pterostichus pubescens* (298 specimens) and *Pterostichus cylindricus* (241 specimens), which represents 77 .33% of the total common species (table 3).

Tabel 3

Carabids species common to the sunflower crop in the two variants in 2022

No.	Species name	Variant		Total
		treated	untreated	
1.	Calatus fuscipes	5	2	**7**
2.	Harpalus distinguendus	11	3	**14**

3.	Pseudophonus griseus	96	17	**113**
4.	Pseudophonus pubescens	235	63	**298**
5.	Pterostichus cylindricus	114	127	**241**
6.	Pterostichus niger	10	14	**24**
TOTAL 6 species		471	226	**697**

CONCLUSIONS

The use of pitfall traps proved to be effective in capturing the carbids species with high abundance and mobility, as shown by the total number of specimens collected (716 in total). This confirms the specialized literature, according to which this method is suitable for such insects.

The best represented species were *Pseudophonus pubescens* (298 specimens) and *Pterostichus cylindricus* (241 specimens), contributing to 77.33% of the total catches from sunflower crops. This dominance indicates an effective adaptation of these species to the specific habitat and conditions in the studied crops.

In the untreated variant (V1), 471 specimens from 16 species were collected, while in the treated variant (V2), 226 specimens from 8 species were collected. This suggests that phytosanitary treatments applied in variant V2 had an impact on the abundance and diversity of carabids, reducing the number of species and specimens captured. However, the species *Pterostichus cylindricus* was more abundant in the treated variant, which indicates the possibility of greater resistance to the treatments.

A small number of species (7 in number), such as *Amara similata, Bembidion ruficorne*, and *Zabrus tenebrioides*, were found, only one specimen each. These rare species may indicate either a greater sensitivity to the treatments applied or a reduced natural presence in the respective agro-systems.

The treated variant of the sunflower crop had a reduced biodiversity, capturing only 8 species compared to 16 in the untreated variant. This shows that the application of pest and pathogen treatments can negatively affect the biodiversity of beneficial insects such as carabids.

Periodic captures throughout the entire growing season provide a detailed picture of carabid population dynamics, highlighting seasonal fluctuations in diversity and abundance. Thus, long-term monitoring is essential to understanding the impact of agricultural factors on these species.

In conclusion, the research highlighted the significant impact of agricultural practices on carabid communities, with their involvement in natural pest control and maintaining the balance of agricultural ecosystems.

REFERENCES

Bărbulescu A., Popov C., 2002 - *Agricultural entomology*, Ceres Publishing House.

Chițimia L., 2010 - *Dynamics and control of harmful insect populations in agroecosystems,* University Press.

Eyre M. D., Leifert C., 2011 - *Crop management factors and pest and beneficial Coleoptera associated with organically and conventionally managed wheat*, Annals of Applied Biology, 158(2), 142-154.

Ionescu M., 2005 - *Coleoptera in agricultural crops: Case study on sunflower crops*, Editura Academiei Române.

Neculiseanu Z., 2004 - *Ground-beetles (Coleoptera: Carabidae) in the Republic of Moldova.* Bul.inf. Entomol, 14-15: 21-32. ISSN 1221 – 5244.

Pălăgeșiu I., Botău D., 2007 - *Entomofauna from sunflower crops in western Romania*, Annales of the University of Oradea, Environmental Protection Fascicula, 12(2), 89-96.

Sakine S.V., 2006 - *Distribution and diversity of ground beetles in Baskonus mountain National Park of Turkey*, Journal of Environmental Biology, 27(3), p.515-521.

Schowalter T. D., 2016 - *Insect Ecology: An Ecosystem Approach* (4th ed.), Academic Press.

Stork N.E., Eggleton P., 1992 - *Insects and biodiversity.* In Groombridge, B. (Ed.), Global Biodiversity: Status of the Earth's Living Resources (pp. 105-124). Chapman & Hall.

Szénási Á., Jászai, V. E., 2014 - *Sunflower pests and their natural enemies in Hungary*, Journal of Plant Diseases and Protection, 121(1), 34-42.

Tălmaciu M., Tălmaciu N., Herea M., Croitoru N., 2022 - *Comparative research on the structure, abundance and dynamics of coccinellid species (Coleoptera Coccinellidae) from some agricultural crops in the Northern Zone of Moldova-Romania*, Universitatea Tehnică a Moldovei, Chișinău, 2023, ISBN 978-9975-165-51-8, p. 39-42

Varvara M., Cîrlam V., 1990 - *Observation on the dynamics of the main species of Carabidae in the sugar beet crop from Moldavia (Romania).* Analele Științifice ale Universității Al. I. Cuza din Iași, 36(2).

RESEARCH ON THE EXPLOITATION WATER AND CLIMATIC FACTORS BY MAIZE HYBRIDS OF DIFFERENT FAO GROUPS AND THEIR ADAPTATION TO CLIMATE CHANGE

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Abstract

The researches and observations proposed by the presented paper aim to identify those corn hybrids that make superior use of rainwater and that lend themselves to the local climate conditions specific to the south-western area of Romania. The research was carried out by testing 18 maize hybrids from different FAO maturity groups, from FAO-350 to FAO-500 (6 hybrids from FAO group 350-400, 6 hybrids from FAO group 400-500, 6 hybrids from FAO group 450-500), in 2021 and 2022. Determining the Water use efficiency (WUE) resulted in values between 0.09 – 0.29 m^3/kg, thus hybrids that can make superior use of water. Comparing the total volume of precipitation recorded in the period April-September of 2021-2022 with the water consumption (ET) for that period, the appearance of the moisture deficit (550.38 mm in 2021 and 594.51 mm in 2022, respectively), a deficit that has values higher than the multiannual average (506.17 mm) is observed. Precipitation between April and September of 2021-2022 is lower than the sum of the multiannual average, 301.40 mm (2021) and 272.20 mm (2022) respectively compared to 318.70 mm (multiannual average).

Key words: climate, water, maize, production

INTRODUCTION

Globally, climate change issues are frequently researched.

Weather predictions show clear increases in temperatures and implicitly a concomitant increase in evapotranspiration, but also frequent episodes of climatic anomalies, such as droughts that are frequent in the southwestern area of Romania (Cioboată *et al*, 2012).

Recently, a study was published (Șumuleac *et al*, 2020) on the evolution of the weather in Romania, in the Banat Chamber with data for a period of 122 years for temperature, and for precipitation with data for 146 years. The study showed that the average temperature increased throughout the agricultural year, but also during the vegetation period, and precipitation tends to decrease values, especially during the vegetation period (Șumuleac *et al*, 2020).

Crop productivity fluctuates from one year to another, being significantly influenced by the variability of climatic conditions and especially by extreme climatic events (Nițu Alina *et al*, 2010).

In case of an increase in average temperatures by 2^0C, the water requirement for irrigation in maize will be 61% above the current requirement, and in the case of a 5^0C increase in temperature, the water requirement will be 74% above the current requirement (Nițu Alina *et al*, 2023).

Of all-natural resources, water is the most limiting natural resource for the agricultural system, however, it is well known that the need for water varies depending on the species, but it must also be known how it varies depending on the variety and hybrid.

Evapotranspiration, grain yield, biomass, water use efficiency, and crop yield index are all affected by soil water content during the growing season.

The scientific interest in research on the efficiency of water use in crops has focused on the evaluation of new irrigation techniques but also on the genetic variation of water use efficiency in rootstocks or varieties (Amitav Bhattacharya, 2019).

One way to interpret climate data over time, and the correlations between them, is to use climate charts. A prominent example is the Walter-Lieth climate diagram (Walter H. *et al*, 1967). One advantage of the Walter-Lieth climate chart is that it graphically highlights wet or arid periods during the year. This is a simple, but very distinguished and useful classification method for estimating the

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growing conditions of vegetation at first glance (Zepner L. *et al*, 2020).

MATERIAL AND METHOD

The research and observations were carried out based on data recorded in the central area of the south-west region of Romania, at the Agricultural Research and Development Station Caracal (ARDS-Caracal), part of the University of Craiova. ARDS-Caracal (latitude - $44^{0}6'$ N, longitude - $24^{0}21'25''$ E) it is located in a plain area (altitude 91 m), on a soil with good fertility (argic chernozem), and the climate is temperate continental, with particularly hot summers and mild winters in general.

The studied material was represented by a number of 18 maize hybrids from different FAO groups, from FAO-350 to FAO-500. Those hybrids that have been tested for 2 consecutive years (2021 and 2022) in the independent testing and analysis network of the Romanian Corn Producers Association were analyzed (APPR).

The weather data recorded at the Caracal weather station, data for the multiannual average and data for the years 2021 and 2022 were used. And for the interpretation of climatic conditions, Walter-Lieth climate diagrams were made. This diagram provides a generalized representation of temperature and precipitation values for the time of year. The temperature and precipitation scales are fixed in the chart in a ratio of 1:2 and 1:3, making it easy to compare different periods.

With the help of climatic data, water consumption (evapotranspiration - ET) was indirectly determined according to the modified Blaney-Criddle method (Popescu et al. 1994), A method that uses the direct link between evapotranspiration and the average monthly temperature, on the one hand, and the monthly percentage of the annual duration of daylight hours, on the other hand, using a seasonal correction coefficient specific to different agricultural crops. The calculation formula used is:

$ET_o = K\,p \cdot (0.457 \cdot T_{mean} + 8.13)$ mm zi^{-1}

where: K = empirical coefficient for evapotranspiration according to plant and type of climate; p = percentage of daylight hours in the year; t = average monthly temperature in ^{0}C, (values for K and p were obtained from the literature).

With the help of the production data obtained, the water use efficiency (WUE) in the two years of analysis was determined.

WUE represents the ratio between the amount of total water consumed (ET) and the production obtained, m^3 of water/kg production per ha. Low WUE values indicate a higher water recovery. The better use of water is due, on the one hand, to a lower total water consumption, as a result of lower evaporative losses, and on the other hand, to an increased production per hectare as a result of the overall environmental conditions and the adaptability of hybrids.

RESULTS AND DISCUSSIONS

The investigated maize hybrids were divided for the analysis of production into 3 maturity groups, 6 hybrids in each group (Table 1.).

From the comparative analysis of the FAO 450-500 group, we can see that the average of the group had a production in 2021 of 8060.33 kg/ha, and in 2022 the production was 4354.83 kg/ha (*Table 1*). It is found that the hybrids Sy Carioca, Persic and KWS Advisio exceeded the average of the group in the reference years (2021 and 2022), which means a stability of these hybrids and their recommendation for intensive cultivation. The other hybrids analyzed achieved values between 89.72 and 99.24% of the average maturity in 2021 and respectively between 71.00 and 90.61% of the average maturity in 2022.

From the analysis of the FAO 400-450 group, we can see that the average of the group had a production in 2021 of 8092.33 kg/ha, and in 2022 the production was 4509.50 kg/ha (Table 1). It is noted that the performing hybrids were, in 2021, LG 31415 (9006 kg/ha) and Sy Minerva (8714 kg/ha) respectively and in 2022 KWS Donjuan (4952 kg/ha) and KWS Inteligens (4521 kg/ha). With one exception (KWS Inteligens in 2021), the other hybrids recorded a percentage of the average maturity value of over 95% in both reference years (2021-2022).

In the third group FAO 350-400 we can see that the average of the group had a production in 2021 of 8142.67 kg/ha and respectively 4300.00 kg/ha in 2022. The most productive hybrids in both reference periods were: KWS Kashmir (8380 kg/ha in 2021 and 4529 kg/ha in 2022), DM 3330 (8832 kg/ha in 2021 and 4759 kg/ha in 2022) and Sy Premo (8524 kg/ha in 2021 and 4535 kg/ha in 2022). With values close to % of the average maturity are the hybrids Ajovan (99.01% in 2021 and 92.26% in 2022) and RGT Texero (93.08% in 2021 and 97.37% in 2022).

Examining the climatic temperature and precipitation data (Table 2), for the years 2021, 2022 and the multiannual average (My.a), the following is found:

- the average air temperature values are increasing between May and August, for the years 2021, 2022 compared to the multiannual average.

Table 1

Results regarding production per hectar, kh/ha at H=15% humidity

Group	Hybrid		Production (kg/ha) at U=15%		% of average maturity	
			2021	2022	2021	2022
FAO 450 - 500	**FAO**	**Average**	**8060,33**	**4354,83**	**100**	**100**
	460	FELIX	7999	3946	99.24	90.61
	460	SY CARIOCA	8668	4643	107.54	106.62
	460	PERSIC	8602	5010	106.72	115.04
	470	F423	6991	3679	86.73	84.48
	480	KWS ADVISIO	8870	5759	110.05	132.24
	490	SY ANDROMEDA	7232	3092	89.72	71.00
FAO 400 - 450	**FAO**	**Average**	**8092,33**	**4509,5**	**100**	**100**
	400	KWS DONJUAN	8070	4952	99,72	109.81
	410	LG 31.415	9006	4420	111,29	98.02
	420	KWS INTELIGENS	6786	4521	83,86	100.26
	420	RGT URBANIXX	7910	4294	97,75	95.22
	430	MAS 440D	8068	4436	99,70	98.37
	440	SY MINERVA	8714	4434	107.68	98.33
FAO 350 – 400	**FAO**	**Average**	**8142,66**	**4300**	**100**	**100**
	360	AJOVAN	8062	3967	99.01	92.26
	360	RGT TEXERO	7579	4187	93.08	97.37
	370	KWS KASHMIR	8380	4529	102.91	105.33
	380	DM3330	8832	4759	108.47	110.67
	380	LG 31.390	7479	3823	91.85	88.91
	390	SY PREMO	8524	4535	104.68	105.47

Table 2

Weather data

Year / month		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average Total
Temperature (0C)	2021	1,5	3,2	5,0	9,7	17,4	21,4	25,6	24,8	18,4	10,18	7,32	2,57	12,25
	2022	1,96	4,13	4,48	11,11	18,17	23,03	25,42	24,8	18	13,69	2,62	1,7	13,37
	My.a	-3,0	-0,6	4,8	11,2	16,6	20,5	22,7	21,9	17,6	11,3	4,9	-0,5	10.6
Precipitation (mm)	2021	98,0	29,6	92,4	32,6	55,6	103,2	92,0	13,4	4,6	101,4	28,0	60,8	711,6
	2022	19,2	4,8	13,2	77,8	44,6	14,2	30	50,2	55,4	15	34,8	10,8	370
	My.a	33,3	30,4	34,9	43,6	64,9	67,0	52,9	50,7	39,6	40,4	40,3	39,4	537.4

- In the months of corn vegetation (2021, 2022) average temperatures were recorded even 3 degrees above the multiannual average.
- in 2021, 2022, precipitation is spatio-temporally fluctuating and unevenly distributed, thus values of 32.6 mm (April 2021), 77.8 mm (April 2022), 14.2 mm (June 2022), 103.2 mm (June 2021), 92.0 mm (July 2021), 30.0 mm (July 2022) and 13.4 mm (August 2021), 50.2 mm (August 2022) were recorded.
- the total amounts of precipitation between April and September of the years 2021-2022 are lower than the sum of the multiannual average (301.40 mm-2021 and 272.20 mm-2022 respectively compared to 318.70 mm-My.a).
- the rainfall related to the multiannual average does not show monthly extremes.

Climatic factors have a major influence on the vegetation of cultivated plants, influencing their growth and development process.

By transposing these climatic data into Walter-Lieth charts (figures 1,2,3) it is possible to identify the periods of the year that can pose problems in the development of vegetation and fruiting of corn, as follows:

- From the study of multiannual data with the help of the climate diagram (Figure 1), it can be seen that the January-June and October-December intervals are wet periods, and the July-September interval presents a risk of drought.
- The climate chart for 2021 (Figure 2) indicates a suitable climate for corn, with a wet period from January to early August, and drought set in in August and September.
- From the examination of the climate chart for 2022 (Figure 3), there is a dry period in February and the onset of drought in June, July and August, which also influenced the low level of production this year.

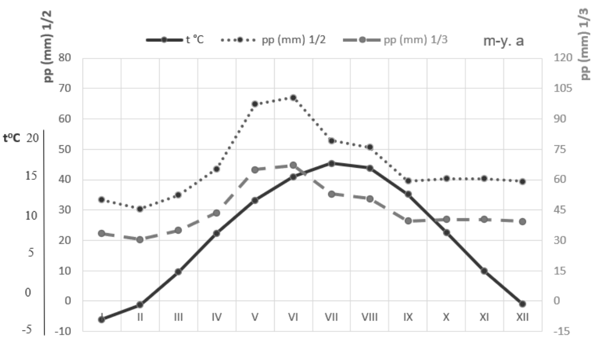

Figure 1. **Multiannual average climate diagram**

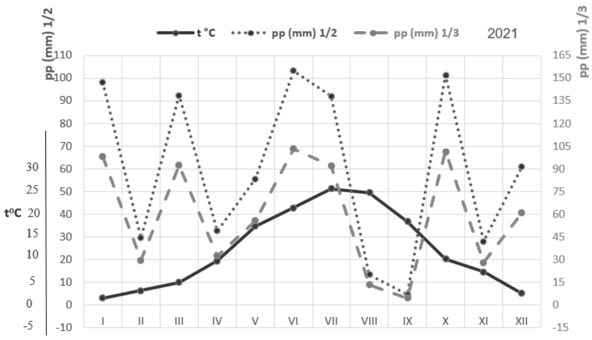

Figure 2. **Climate diagram of 2021**

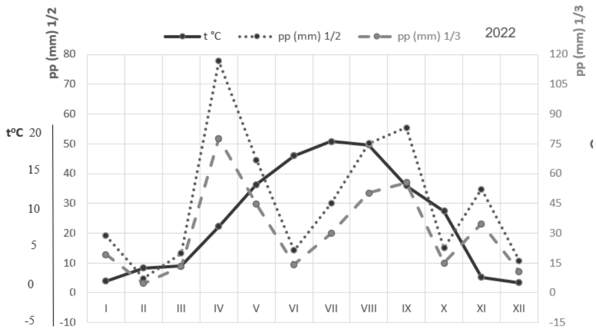

Figure 3. **Climate diagram of 2021**

From the determination of the water consumption (ET) for 2021, (table 3) it is found:

Tabelul 3

Water consumption in 2021

Month	*Average temp. (0C)*	*Precipitation (mm)*	*ET Blaney-Criddle (mm)*	*Deficit (mm/ha)*
April	9,7	32,6	96,80	64,20
May	17,4	55,6	140,73	85,13
June	21,4	103,2	159,24	56,04
July	25,6	92,0	178,32	86,32
August	24,8	13,4	158,74	145,34
September	18,4	4,6	117,95	113,35
Total	19,6	301,40	851,78	550,38
My.a	18,42	318,70	824,87	506,17

- the indirectly estimated water consumption has increasing values starting with April and including July (from 96.80 mm to 178.32 mm), remaining high in the following months (158.74 mm in August and 117.95 mm in September); The total period ET is 851.78 mm.
- comparing the total volume of precipitation recorded in the period April-September (301.40 mm) with the ET for that period (851.78 mm), a total moisture deficit of the period of 550.38 mm is found.

Analyzing the ET data for 2022 (Table 4) it can be seen:

- the indirectly estimated water consumption has increased values starting with April and including July (from 101.77 mm to 177.58 mm), remaining high in the following months (161.05

mm in August and 116.64 mm in September); The total ET of the period is 866.71 mm.

- comparing the total volume of precipitation recorded in the April-September period (272.20 mm) with the ET for that period (866.71 mm) there is a total moisture deficit of 594.51 mm for the period.

The values of the moisture deficit are variable and with an increasing trend throughout the analysis period and are due to the combined action of climatic factors with the needs of the plant.

Tabelul 4

Water consumption in 2022

Month	*Average temp. (0C)*	*Precipitation (mm)*	*ET Blaney-Criddle (mm)*	*Deficit (mm/ha)*
April	11.11	77.8	101,77	23,97
May	18.17	44.6	143,81	99,21
June	23.03	14.2	165,86	151,66
July	25.42	30,0	177,58	147,58
August	25.42	50.2	161,05	110,85
September	18,00	55.4	116,64	61,24
Total	20,19	272,20	866,71	594,51
My.a	18,42	318,70	824,87	506,17

Comparing the total volume of precipitation recorded in the period April-September of 2021-2022 with the ET for that period, the appearance of the moisture deficit (550.38 mm in 2021 and 594.51 mm in 2022, respectively), a deficit that has values higher than the multiannual average (506.17 mm) is observed.

From the point of view of water consumption, they are hybrids with very high potential in optimal humidity conditions, but which have unsatisfactory results if they are no longer ensured, or those optimal conditions no longer exist. The Water Use Efficiency Analysis (WUE) gives us indications on the amount of water consumed by hybrids to achieve one kg of production, thus identifying hybrids that have a high capacity for superior water recovery in irrigated and non-irrigated conditions.

This parameter also helps us to identify hybrids that have stability in terms of water availability and hybrids that are more drought tolerant.

The WUE value must be as small as possible, ideally subunitary, the value of this index being greatly influenced by the hybrid, soil, applied technology, etc.

Analysing the WUE values obtained for the 18 hybrids between 2021 and 2022 (Figure 4), it follows:

1) Comparing the WUE according to the maturity group, we find similar efficiency values for 2021 (on average 0,11 m^3/kg), and in 2022 there are values between 0,15-0,28 m^3/kg).

2) For cultivation in a non-irrigated regime, hybrids with high yields have been obtained in correlation with the efficiency of using water with the lowest possible value are recommended:

a) for the FAO 450-500 group, it stands out,: Sy Carioca (8668 kg/ha with 0,10 m^3/kg), Persic (8602 kg/ha with 0,10 m^3/kg) and KWS Advisio (8870 kg/ha with 0,10 m^3/kg), results in 2021. In 2022, the results were: KWS Advisio (5759 kg/ha with 0,15 m^3/kg), Persic (5010 kg/ha with 0,17 m^3/kg), Sy Carioca (4643 kg/ha with 0,19 m^3/kg).

b) for the FAO 400-450 group, it stands out: LG 31415 (9006 kg/ha with 0,09 m^3/kg), Sy Minerva (8714 kg/ha with 0,10 m^3/kg) and KWS Donjuan (8670 kg/ha with 0,11 m^3/kg), results in 2021, and in 2022 there were: KWS Donjuan (4952 kg/ha with 0,18 m^3/kg) and Sy Minerva (4434 kg/ha with 0,20 m^3/kg).

c) for the FAO 350-400 group, it stands out: DM 3330 (8832 kg/ha with 0,10 m^3/kg), Sy Premo (8524 kg/ha with 0,10 m^3/kg) și KWS Kashmir (8380 kg/ha with 0,10 m^3/kg), results recorded in 2021, and in 2022 there were: DM 3330 (4759 kg/ha with 0,18 m^3/kg), Sy Premo (4535 kg/ha with 0,19 m^3/kg) and KWS Kashmir (4529 kg/ha with 0,19 m^3/kg).

3) The lowest WUE values were recorded in the LG 31415 hybrid of the FAO 400-450 group (0,09 m^3/kg in 2021) and KWS Advisio from the FAO 450-500 group (0,15 m^3/kg in 2022).

4) The highest WUE values were recorded in the KWS Inteligens hybrid of the FAO 400-450 group (0,13 m^3/kg in 2021) and Sy Andromeda respectively from the FAO 450-500 group (0,28 m^3/kg in 2022).

5) The lowest average values of the WUE were recorded in the FAO 350-400 group (0,10 m^3/kg in 2021) and FAO Group 400-450 (0,19 m^3/kg in 2022).

Figure 4. **Water Use Efficiency Analysis (WUE) (mc kg^{-1})**

Water use efficiency can be analyzed from several points of view: economic, transport, mode of application, etc., but more specifically, water use efficiency (WUE) refers to the response of crops to the availability of water in the soil. While crops face some degree of stress caused by drought, water use efficiency is improved. In non-irrigated conditions, the distribution of precipitation during the vegetation period is decisive in achieving productions and directly influences the WUE. Water is used better if it is available during critical plant periods. For the years 2021 and 2022, the decisive rainfall in establishing the productions were those recorded during the months of May, June and July (Figure 5).

In the case of maize, the water reserve formed by the accumulation of precipitation in the soil during winter and early spring can ensure the living conditions of maize in the first two months of May-June (Şimon *et al*, 2023).

Figura 5. **Distribution of rainfall in 2021**

CONCLUSIONS

From the analysis of the average values of the air temperature, it is found to increase by even +3^{0}C, between May and August, for the years 2021, 2022 compared to the multiannual average.

In 2021, 2022, precipitation fluctuates spatio-temporally and unevenly distributed, the total amounts of precipitation in the April-September period of 2021-2022 are lower than the sum of the multiannual average.

From the study of climate data with the help of the Walter-Lieth chart, those wet, dry or dry periods can be observed. And according to the multiannual average, the July-September interval presents a risk of drought, phenomena encountered in 2021 and 2022.

The decisive rainfall in establishing the productions (±) are those recorded during the months of May, June and July.

Hybrids recommended for non-irrigated cultivation, in the South-West area of Romania, are those in which high yields have been obtained in correlation with the efficiency of water use with the lowest possible value (*a, b, c*), described in the paper.

The low WUE values recorded in the FAO 350-400 group in 2021 and in the FAO 400-450 group in 2022, recommend as suitable for cultivation in this area hybrids with FAO up to 450.

REFERENCES

Amitav Bhattacharya, 2019 - *Changing Climate and Resource Use Efficiency in Plants*, Academic Press, ISBN 9780128162095, https://doi.org/10.1016/B978-0-12-816209-5.00019-2.

Cioboata M., Brumar D., **2012 -** Study on the evolution of the dryness and drought in the south of the Dolj county. Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series, 42(2), p 321-326.

Niţu O.A., Ivan E. Ş., Niţu D.S., 2023 - *Climate change and its impact on water consumption in the main agricultural crops of the Romanian plain and Dobrogea*, Scientific Papers. Series A. Agronomy, Vol. LXVI, No. 1, https://agronomyjournal.usamv.ro/pdf/2023/issue_1/Art62.pdf

Niţu A., Jinga I., Niţu D.S., VRINCEANU A., 2010 - *Climatic changes and their possible impact on water consumption, in main crops of Romania*, Research Journal of Agricultural Science, 42 (1).

Popescu I., 1994 – *Îndrumător lucrări practice la culturi irigate*. Repr. Universităţii din Craiova.

Şmuleac L.; Rujescu C.; Șmuleac A.; Imbrea F.; Radulov I.; Manea D.; Ienciu A.; Adamov T.; Paşcalău R., 2020 - *Impact of Climate Change in the Banat Plain, Western Romania, on the Accessibility of Water for Crop Production in Agriculture*. Agriculture 2020, 10, 437. https://doi.org/10.3390/agriculture10100437.

Șimon A., Moraru Pl., Ceclan A., Russu F., Chețan F., Bărdaș M., Popa A., Rusu T., Pop Al., Bogdan I., 2023 - *The Impact of Climatic Factors on the Development Stages of Maize Crop in the Transylvanian Plain.* Agronomy, 13(6):1612. https://doi.org/10.3390/agronomy13061612.

Zepner L., Karrasch P., Wiemann F., Bernard L., 2020 - *ClimateCharts.net – an interactive climate analysis web platform*. International Journal of Digital Earth, *14(3), 338–356. https://doi.org/10.1080/17538947.2020.1829112*

Walter H., Lieth H., Rehder H., & Harnickell E., 1960 - *Klimadiagramm-weltatlas* (p. 103). Jena: G. Fischer.

***Catalog - Raport annual APPR, 2021, 2022 -** *Results of the Independent Field Test and Analysis Network.* Association of Corn Producers in Romania.

THE IMPACT OF DIFFERENT TILLAGE SYSTEMS USED IN VINEYARDS ON SOIL PHYSICAL PROPERTIES

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Abstract

It is well known that global climate change represents one of the greatest threats to the environment social and economic sector. Current trends in adopting sustainable agriculture are increasingly based on the implementation of agricultural practices designed to protect the environment and ensure the food needs of a growing population. Vineyards are among the oldest crops in the world, with the highest level of soil degradation. In vineyards there are several different cultivation technologies with different soil management systems, but all of them have the common objectives of creating optimal, favorable conditions for the growth and development of vines while maintaining or even improving soil health. Protecting the physico-chemical properties of the soil as well as conserving its productive capacity is a permanent concern of mankind, and the success of well-defined development clearly depends on it. In order to identify the stability patterns, this research assesses the protecting impact of grass cover, conventional and minimum-tillage system on physical soil properties in traditional vineyards. The study was carried out at the Vasile Adamachi Student Research and Practice Station of the "Ion Ionescu de la Brad" University of Life Sciences in Iasi, from the north-eastern part of Romania. To maintain environmental quality, vineyard yields and grape quality at a high level, as a response to an increased awareness of the value of soil health, the adoption of sustainable soil management practices is becoming increasingly common in wine-growing regions worldwide.

Key words: grass cover, tillage systems, vineyard, climate change.

Viticulture is of high economic value, with approximately 7 million hectares of grapevines planted worldwide, of which 50% are located in Europe (OIV, 2020).

Vineyards are recognized as an agricultural land use vulnerable to soil degradation, mainly because they are typically located on steep slopes and managed with heavy machinery and agrochemicals (Prosdocimi *et al.*, 2016).

Although vineyards are intensively managed agro-ecosystems, they can host a large biodiversity (Bruggisser *et al.*, 2010; Fernandez-Mena *et al.*, 2021; Geldenhuys *et al.*, 2021), can provide a range of ecosystem services due to their perennial nature, and form landscapes rich in high quality natural and semi-natural areas and special habitat structures (Winkler *et al.*, 2017; Garcia *et al.*, 2018).

In viticulture, management is commonly done in a trellis system with different degrees of management intensity in inter-rows between the vines, depending on local environmental conditions and the wine grower's attitudes, knowledge and experience (Chen *et al.*, 2022).

Several studies have highlighted that frequent tillage, machinery traffic, and agrochemical use in vineyards are responsible for the increase on soil compaction (Biddoccu *et al.*, 2016) and the decrease in aggregate stability, soil organic matter (SOM), and nutrient content (Catania *et al.*, 2018; Mondini *et al.*, 2018).

Vineyard inter-rows can support sustainability in viticulture by allowing a management system which supports a permanent or temporary vegetation cover with non-crop plant species, either as sown cover crop mixture or spontaneous vegetation. The positive effect of cover crops on different biodiversity levels and the associated ecosystem services has been demonstrated by many studies (Geldenhuys *et al.*, 2021; Zanettin *et al.*, 2021).

Cover crops stabilize soil aggregates by enhancing root networks in soils and thereby

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allow a higher soil porosity and connectivity supporting a better water infiltration, retention and refilling of soil water reservoirs (Abad *et al.*, 2021; Novara *et al.*, 2021).

The effect of cover cropping on vine growth and grape quality might vary with the intensity of vegetation cover, plant species composition, pedo-climatic conditions and the timing of disturbance by mulching or tillage (Blanco-Canqui H., Wortmann C.S., 2020).

The quality of the grapes grown in vineyards depends on climate, crop management, soil properties and cultural practices such as tillage, protection and others (Abu-Hamdes, 2000).

Soil in vineyards is subject to frequent tractor traffic associated with soil tillage, the application of chemicals and grape harvesting. In highly mechanized viticulture, the number of tractor passes per year can be up to 22 in traditionally cultivated and 20% less in grass covered vineyards (Lisa *et al.*, 1995).

Soil aeration is another important physical property of the soil which is very dynamic and varies substantially with a range of factors, in particular, with water content and bulk density (Bhandral *et al.*, 2007).

Soil erosion is the major drawback of soil tillage which is amplified by gravel soils, low soil organic matter contents and the usage of hillslopes as vineyards (Biddoccu *et al.*, 2016; Garcia *et al.*, 2018).

Farmers decisions for these different soil management strategies in inter-rows largely depend on viticulture traditions, pedo-climatic conditions, vineyard inclination, available machinery and very often personal preferences (Steenwerth and Belina, 2008).

MATERIAL AND METHOD

The study was carried out at the Vasile Adamachi Research and Student Practice Station, belonging to the University for Life Sciences "Ion Ion Ionescu de la Brad" of Iasi, located in Iasi, in the north-eastern part of Romania.

In terms of viticultural placing, the plantations within the Station are part of the viticultural zone C1, the wine-growing region of Dealurile Moldovei, Iași Vineyard, Copou Viticultural Center.

The exploited land is drained, on the N-S direction, by the Podgorenilor stream, a left tributary of the Bahlui river, contouring through its slopes the shape of an amphitheater with a southern opening. The slopes, which are approximately symmetrical in the transverse plane, have a gradient of between 8 and 25%, and the altitude varies between 80 and 170 m. The area is characterized by a temperate continental climate with predominantly drought conditions.

The average air temperature in 2023 was 12.2 °C, registering a positive deviation of +2.4 °C compared to the multiannual average, a value that confirms the gradual increase in the mean annual temperature values, a phenomenon that indicates we are in a process of global warming. The precipitation amount of about 510 mm, with a deficit of 70 mm compared to the multiannual amount, with an uneven distribution of precipitation, mainly accumulated due to heavy rainfall. In the experimental field of the Pinot Noir vineyard, a soil profile, according to the Romanian System of Soil Taxonomy 2012, was identified as an cerno-cambic aric anthrosol.

Figure 1 **Soil profile – cerno-cambic aric anthrosol**

In the experimental plot, 3 variants of management inter row spacing of vine-yard were implemented: grass cover (GC), conventional tillage (CT) and minimum-tillage (MT).

In GC system, the natural vegetation and plant debris are chopped and mulched on the surface using a vineyard shredder, without soil mobilization.

For the minimum tillage system we used the chisel plow, mobilizing the soil without turning the furrow.

Also, the plow and rotary harrow was used for the conventional tillage.

The differences between soil management practices on the inter-row spacing were evaluated and compared during the growing season and soil sampling/determination depths.

As an indicator that provides information on soil compaction, bulk density (BD) was determined in undisturbed soil samples, taken from different depths (0-10, 10-20, 20-30 and 30-40 cm) using stainless steel cylinders with 100 cm^3 volume.

For BD determination, soil samples were dried at 105 °C to a constant weight. Bulk density (g/cm^3) = (weight of oven dried soil)/(volume of the soil).

Also, as an indicator of compaction, the penetration resistance of soil was determined to a depth of 80 cm using the Eijkelkamp Penetrologger in 10 replicates on each plot (expressed in MPa).

RESULTS AND DISCUSSIONS

For all variants of inter-row management, the values of soil penetration resistance are within normal limits throughout the growing season, values that have no impact on the growth and development of the root system.

However, under CT and MT, due to soil mobilization, the penetration resistance (PR) decreases in the soil surface horizon, compared to the grassed variant, where it remains constant throughout the growing season *(figure 2)*.

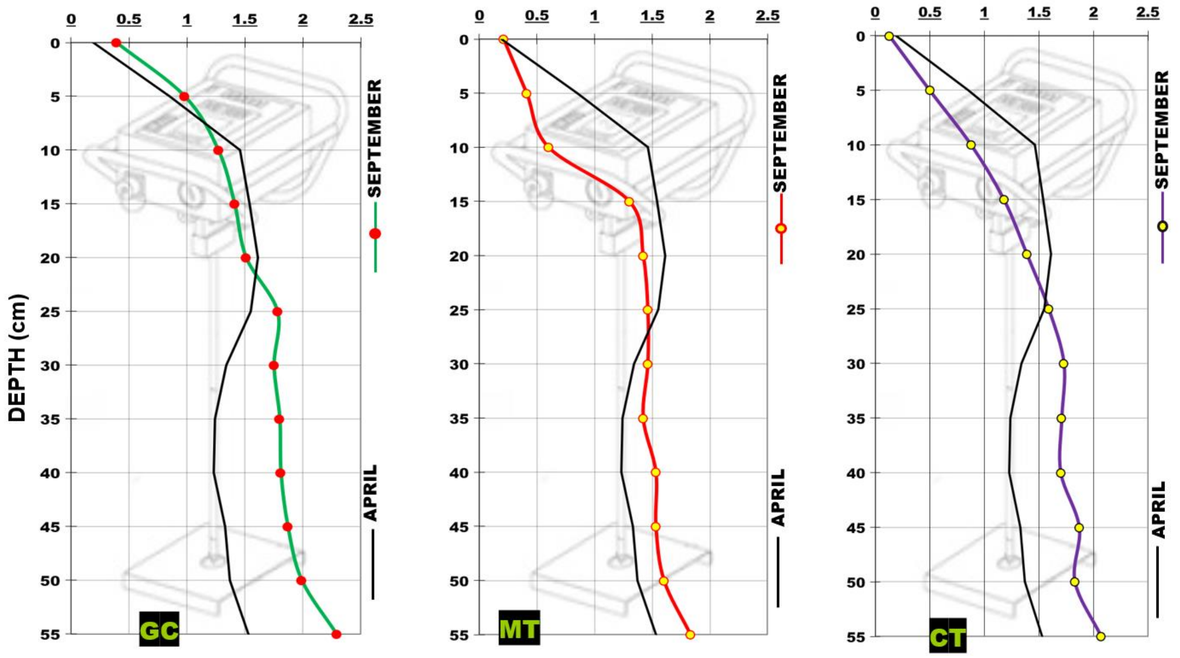

Figure 2 **Mean values of penetration resistance (MPa)**

In the GC system, from the beginning of the growing season (in April) until the grapes were harvested (in September), the BD values were not significantly modified due to the lack of soil mobilization tillage, with values ranging from 1.23 to 1.35 g/cm^3 *(table 1)*.

The significant difference is observed in chisel plow tilled variant (MT), in the zone of action of the active bodies, where from early spring until harvesting, the values decrease to 1 g/cm^3, indicating a very loose soil. This change also occurs in the conventional tillage, but with a downward trend in the soil depth.

Table 1

Mean values of bulk density (g/cm^3) registered in 2023 growing season on the 3 systems of management inter-row of vineyard

SYSTEM / DEPTH (cm)	Spring	GRASS COVER (GC)		MINIMUM TILLAGE (MT)		CONVENTIONAL TILLAGE (CT)	
		Vegetation	Harvesting	Vegetation	Harvesting	Vegetation	Harvesting
0-10	1.23	1.26	1.27	1.09	1.01	1.01	1.09
10-20	1.27	1.26	1.23	1.27	1.29	1.2	1.23
20-30	1.33	1.32	1.23	1.3	1.32	1.33	1.27
30-40	1.35	1.3	1.27	1.37	1.36	1.35	1.3

CONCLUSIONS

Soil management systems between the rows of vines have both advantages and disadvantages, but these need to be adapted to the eco-pedoclimatic conditions of the vineyard area. The lack of a plant debris layer reduces trafficability in rainy periods and can increase the compaction of the topsoil from the tracks of agricultural machinery. Tillage in soil mobilization systems reduces bulk density values but amplifies water evaporation, with negative effects also on soil structure.

In summary, many factors influence grape yield, grape quality and wine styles worldwide and therefore vineyard management decisions may be different depending on the local conditions.

REFERENCES

Abad J., Mendoza I.H., Marin D., Orcaray L., Santesteban L.G., 2021 - *Cover crops in viticulture. A systematic review* (1): Implications on soil characteristics and biodiversity in vineyard Oeno One, 55 (2021), pp. 295-312.

Abu-Hamdeh N.H., 2000 – *Effect of tillage treatments on soil thermal conductivity for some Jordanian clay loam and loam soils.* Soil Tillage Research, 56 (2000), pp. 145-151.

Bhandral R., Saggar S., Bolan N.S., Hedley M.J., 2007 – *Transformation of nitrogen and nitrous oxide emission from grassland soils as affected by compaction.* Soil Tillage Research, 94 (2007), pp. 482-492.

Biddoccu M., Ferraris S., Opsi F., Cavallo E., 2016 - *Long-term monitoring of soil management effects on runoff and soil erosion in sloping vineyards in Alto Monferrato (North-West Italy).* Soil Tillage Management., 155 (2016), pp. 176-189.

Blanco-Canqui H., Wortmann C.S., 2020 - *Does occasional tillage undo the ecosystem services gained with no-till? A review*. Soil. Res (2020), p. 198.

Bruggisser O.T., Schmidt - Entling M.H., Bacher S., 2010 - *Effects of vineyard management on biodiversity at three trophic levels*. Biol. Conserv., 143 (2010), pp. 1521-1528.

Catania P., Badalucco L., Laudicina V.A., Vallone M., 2018 - *Effects of tilling methods on soil penetration resistance, organic carbon and water-stable aggregates in a vineyard of semiarid Mediterranean environment*. Environment Earth Science, 77 (2018), p. 348.

Chen Y., Herrera R.A., Benitez E., Hoffmann E., Moth C., Paredes S., Plaas D., Popescu E., Rascher D., Willemen P., Winter L., Schwarz S., 2022 – *Winegrowers' decision-making: A pan-European perspective on pesticide use and inter-row management.* Journal of Rural Studies, 2022 (94), 37-53.

Fernandez - Mena H., Frey H., Celette F., Garcia L., Barkaoui K., Hossard L., Naulleau A., Metral R., Gary C., Metay A., 2021 - *Spatial and temporal diversity of service plant management strategies across vineyards in the south of France*. Analysis through the Coverage Index. Eur. J. Agron. (2021), p. 123.

Garcia L., Celette F., Gary C., Ripoche A., Valdes-Gomez H., Metay A., 2018 - *Management of service crops for the provision of ecosystem services in vineyards: A review.* Agr. Ecosyst. Environ., 251 (2018), pp. 158-170.

Geldenhuys M., Gaigher R., Pryke J.S, Samways M.J., 2021 - *Diverse herbaceous cover crops promote vineyard arthropod diversity across different management regimes*. Agr. Ecosyst. Environ. (2021), p. 307.

Griesser M., Steiner M., Pingel M., Uzman D., Preda C., Giffard B., 2022 - *General trends of different inter-row vegetation management affecting vine vigor and grape quality across European vineyards*. *Agric. Ecosyst.*

Lisa L., Parena S., 1995 - *Working times and production cost of grapes in grass covered or tilled vineyards of Piedmont.* Proceedings of the VIII GESCO Meeting, Vairão, Portugal, 3–5 July 2000 (1995), pp. 325-330.

Mondini C., Fornasier F., Sinicco T., Sivilotti P., Gaiotti F., Mosetti D., 2018 - *Organic amendment effectively recovers soil functionality in degraded vineyards*. Eur. J. Agron., 101 (2018), pp. 210-221.

Novara A., Cerda A., Barone E., Gristina L., 2021 - *Cover crop management and water conservation in vineyard and olive orchards*. Soil . Res (2021), p. 20.

OIV, 2020 – *Statistical Report on World Vitiviniculture*. International Organisation of Vine and Wine, rue d'Aguesseau 75008 May Paris, France.

Prosdocimi M., Cerdá A., Tarolli P., 2016 - *Soil water erosion on Mediterranean vineyards: a review* Catena, 141 (2016), pp. 1-21.

Steenwerth K., Belina K.M., 2008 - *Cover crops and cultivation: Impacts on soil N dynamics and microbiological function in a Mediterranean vineyard agroecosystem*. Appl. Soil Ecol., 40 (2008), pp. 370-380.

Winkler K.J., Viers J.H., Nicholas K.A., 2017 - *Assessing Ecosystem Services and Multifunctionality for Vineyard Systems*. Front Env. Sci. -Switz., 5 (2017).

Zanettin G., Bullo A., Pozzebon A., Burgio G., Duso C., 2021 - *Influence of Vineyard inter-row groundcover vegetation management on arthropod assemblages in the Vineyards of North-Eastern Italy* Insects, 12 (4) (2021), p. 349.

VEGETABLES IN IDIOMATIC REALMS: A CONTRASTIVE APPROACH

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Abstract

This study explores the use of vegetables in idiomatic expressions across four languages—English, French, Italian, and Romanian—employing a contrastive approach to highlight both similarities and divergences. Idiomatic expressions involving vegetables provide a rich field for examining how cultural contexts shape language and meaning. By analyzing idioms from each of these languages, the research reveals how vegetables symbolize various cultural values, social norms, and emotional states.

In English, idioms such as "cool as a cucumber illustrate how vegetables can convey composure and status. Similarly, French idioms like "*tomber dans les pommes*" (to fall into the apples, meaning to faint) and "*être dans le pétrin*" (to be in the kneading trough, meaning to be in trouble) reflect a blend of humor and traditional imagery. Italian expressions, such as "*essere un cetriolo*" (to be a cucumber, meaning to be calm), further demonstrate the role of vegetables in conveying personal traits and social actions. Romanian idioms, including "*a fi în pom*" (meaning to be in a difficult situation) and "*a se face roșu ca un ardei iute*" (to turn red as a hot pepper, meaning to blush), offer insights into how vegetables are used metaphorically to express emotional states and social interactions.

This contrastive analysis highlights how idiomatic expressions involving vegetables are deeply rooted in cultural practices and perceptions. The study underscores the importance of understanding these idiomatic nuances for more effective cross-cultural communication and translation. By examining the metaphorical use of vegetables across languages, this research contributes to a deeper understanding of how language reflects and shapes cultural attitudes and practices.

Key words: idiomatic expressions, contrastive linguistics, vegetables, cross-cultural analysis, English, French, Italian, Romanian

Idiomatic expressions are deeply embedded in the cultural fabric of a language, often reflecting unique social norms, historical contexts, and shared human experiences. They carry meanings that are not always transparent to non-native speakers, making them fascinating subjects for linguistic studies. One particularly rich area of idiomatic expression involves vegetables, which serve as metaphors for human traits, social situations, and emotional states across various languages. This study undertakes a contrastive analysis of idiomatic expressions involving vegetables in English, French, Italian, and Romanian, aiming to uncover both the cultural similarities and differences that shape these expressions.

In recent years, studies on idiomatic expressions and metaphors have increasingly focused on the cultural and cognitive aspects of language, emphasizing the importance of cross-linguistic analysis. Idioms involving food, particularly vegetables, provide a unique window into the interplay between language and culture. For example, Kövecses (2015) highlights the significance of metaphors in different cultural contexts, demonstrating how idiomatic expressions reflect cultural attitudes and values. This idea is further supported by Wierzbicka (2014), who explores the role of cultural scripts in shaping metaphorical language, arguing that understanding idiomatic expressions requires a deep understanding of the cultural context from which they arise.

Recent studies also emphasize the challenges of translating idiomatic expressions across languages (Petrea E., 2017). Baker (2018) points out that the figurative nature of idioms often makes them difficult to translate directly, requiring a nuanced understanding of both the source and target cultures. This challenge is particularly evident in idioms related to food, where cultural connotations of certain vegetables can vary significantly between languages. Fernández and Cairns (2015) add that understanding the psycholinguistic processing of idiomatic expressions is crucial for accurate translation, particularly in bilingual and multilingual contexts.

Moreover, Johansson (2020) examines sound symbolism and its role in metaphorical expressions, offering insights into how idioms can carry both literal and figurative meanings. Her

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work suggests that metaphors involving vegetables are often linked to sensory experiences, further complicating their translation across linguistic boundaries.

Overall, recent research underscores the importance of cultural and cognitive factors in understanding idiomatic expressions. These insights contribute to a deeper understanding of cross-cultural communication and the complexities involved in translating metaphorical language. The study of vegetable-based idioms provides a valuable case for exploring these broader linguistic phenomena.

Vegetables, being a fundamental part of human existence across all cultures, have naturally found their way into language as symbols for various concepts. For example, the English idiom *cool as a cucumber* uses a vegetable to convey a sense of calmness and composure, while the Romanian idiom *a se face roșu ca un ardei iute* (to turn red as a hot pepper) refers to blushing, a common emotional reaction. This research seeks to investigate these idiomatic uses of vegetables in order to gain a deeper understanding of how language and culture intertwine to reflect human behavior and societal norms.

The study will focus on the following research questions: How do idiomatic expressions involving vegetables differ across English, French, Italian, and Romanian? What cultural factors contribute to the specific use of vegetables in these idioms? And finally, how can these differences inform cross-cultural communication and translation efforts? By addressing these questions, the research aims to contribute to the fields of linguistics, translation studies, and cultural anthropology.

MATERIAL AND METHOD

Selection of Languages

The four languages selected for this study—English, French, Italian, and Romanian—represent different linguistic and cultural traditions within Europe. English, as a global lingua franca, has a rich repertoire of idiomatic expressions influenced by diverse cultural interactions. French, known for its precision and tradition of literary expression, offers a glimpse into a culture where gastronomy plays a central role. Italian, deeply influenced by its agrarian roots, reflects a culture where food metaphors are prevalent. Romanian, a Romance language with significant Slavic influences, offers a unique perspective due to its cultural and historical context in Eastern Europe.

Data Collection

Idiomatic expressions involving vegetables were collected from a variety of sources, including dictionaries of idioms, linguistic corpora, and native speakers of each language. Online resources such as linguistic databases and idiom websites were also consulted. For the purpose of this study, only idiomatic expressions that specifically involve vegetables were selected. Examples include *cool as a cucumber* (English), *tomber dans les pommes* (French), *essere un cetriolo* (Italian), and *a fi în pom* (Romanian). All the idiomatic expressions that were gathered from each language ensure a diverse representation of cultural metaphors involving vegetables.

Contrastive Analysis

The selected idioms were analyzed using a contrastive approach, which involves comparing idiomatic expressions across languages to identify similarities and differences. This method is particularly useful in highlighting how different cultures use language to express similar or divergent ideas. Each idiom was examined for its literal meaning, figurative meaning, and cultural significance. The findings were then categorized based on the cultural themes they reflect, such as emotional states, personal traits, and social situations.

Sociocultural Contextualization

In order to understand the cultural significance of each idiom, a sociocultural framework was applied. This framework considers factors such as historical context, agricultural practices, and culinary traditions, which may influence the choice of vegetables in idiomatic expressions. For example, in cultures where cucumbers are associated with coolness (as in English and Italian), this vegetable is used metaphorically to represent calmness. In contrast, cultures where certain vegetables are linked to labor or hardship may use them in idioms to express difficulty or trouble, as seen in the French idiom *être dans le pétrin* (to be in the kneading trough).

Translation Challenges

A secondary objective of this study was to explore the challenges of translating idiomatic expressions involving vegetables. Idioms often pose difficulties for translators due to their figurative nature and cultural specificity. For each idiom, potential translation strategies were discussed, including direct translation, adaptation, and paraphrasing. The aim was to identify the most effective methods for conveying the cultural nuances of idiomatic expressions in cross-linguistic contexts.

RESULTS AND DISCUSSIONS

English Idiomatic Expressions Involving Vegetables

In English, vegetables are often used in idiomatic expressions to describe personal traits and social situations. One of the most well-known examples is "cool as a cucumber," which suggests composure and emotional control. The cucumber's association with coolness in English may stem from its physical properties, as cucumbers are often served cold and are believed to have cooling effects. This idiom reflects a cultural value placed on maintaining calmness under pressure.

Another interesting English idiom is "small potatoes," which refers to something insignificant or unimportant. Potatoes, being a staple food, are often viewed as ordinary and unremarkable, making them an apt metaphor for trivial matters. This idiom illustrates how common, everyday vegetables can be used to express ideas about social status and importance.

French Idiomatic Expressions Involving Vegetables

French idiomatic expressions involving vegetables often carry humorous or ironic undertones. For example, *tomber dans les pommes* (to fall into the apples) means to faint, a phrase that likely developed as a playful way of describing a sudden loss of consciousness. The idiom *être dans le pétrin* (to be in the kneading trough) is another example of a food-related expression, where being in a difficult situation is likened to the hard work of kneading dough. This reflects the French culture's deep connection to bread-making, an essential part of the national identity.

Vegetables in French idioms often serve as metaphors for common life experiences, with a focus on humor and tradition. The use of apples and bread in these idioms demonstrates how everyday foods can be used to convey complex social meanings, while also revealing the French cultural tendency toward witty, food-based metaphors.

Italian Idiomatic Expressions Involving Vegetables

Italian idiomatic expressions involving vegetables frequently reflect personal traits and social actions. One such expression is *essere un cetriolo* (to be a cucumber), which, like the English *cool as a cucumber*, conveys a sense of calmness and emotional stability. The similarity between the English and Italian use of cucumbers to symbolize calmness suggests a shared cultural perception of this vegetable as a symbol of composure.

Italian idioms involving vegetables often center on physical characteristics and human emotions. For example, *fare il fagiolo* (to act like a bean) refers to someone who is acting foolishly, reflecting how vegetables are used to personify human behavior.

Romanian Idiomatic Expressions Involving Vegetables

Romanian idiomatic expressions offer a unique perspective due to the country's agricultural history and its blend of Eastern and Western influences. One such idiom is *a fi în pom* (to be in the tree), which means to be in a difficult situation. While this expression does not explicitly mention vegetables, it reflects the Romanian cultural connection to nature and agriculture. Another expression, *a se face roșu ca un ardei iute* (to turn red as a hot pepper), vividly illustrates the use of vegetables to describe emotional states, such as embarrassment or anger.

Vegetables in Romanian idioms often symbolize strong emotions, with a focus on physical sensations like blushing or sweating. This suggests that Romanian culture values direct, visceral expressions of emotion, in contrast to the more restrained metaphors found in English or Italian idioms.

Cross-Linguistic Comparisons

The contrastive analysis reveals both similarities and divergences in how vegetables are used metaphorically across the four languages. English and Italian share common themes of calmness and composure, as seen in the idioms involving cucumbers. French and Romanian, on the other hand, tend to use vegetables to express emotional states and social situations, with a focus on humor and physical sensations.

Cultural factors play a significant role in shaping these idioms. For example, the French use of bread-related metaphors reflects the country's long-standing culinary traditions, while the Romanian focus on nature and agriculture is rooted in its rural history. These cultural differences offer insights into how each society views food, emotions, and social interactions.

CONCLUSIONS

This study highlights the rich cultural tapestry that underpins idiomatic expressions involving vegetables in English, French, Italian, and Romanian. While some idioms reflect universal human experiences—such as the use of cucumbers to symbolize calmness—others are deeply rooted in specific cultural practices, such as the French association with bread-making or the Romanian connection to agriculture.

The findings underscore the importance of understanding idiomatic expressions in their cultural contexts, particularly for translators and language learners. Idioms often carry meanings that cannot be easily conveyed through direct translation, requiring careful consideration of the cultural nuances behind each expression.

In conclusion, idiomatic expressions involving vegetables offer a unique window into the ways in which language and culture shape human perception and behavior. By exploring these expressions across multiple languages, this study contributes to a deeper understanding of cross-cultural communication and the role of food in metaphorical language.

REFERENCES

Baker M., 2018 - *In Other Words: A Coursebook on Translation*. Routledge.

.

Fernández E. M., & Cairns H. S., 2015 - *Fundamentals of Psycholinguistics.* Wiley-Blackwell.

Kövecses Z., 2005 - *Metaphor in Culture: Universality and Variation*. Cambridge University Press.

Petrea E., 2017 - *Degrés d'équivalence en traduction: Les Misérables de Victor Hugo en version roumaine,* Journal: Buletinul Institutului Politehnic din Iași secția Științe Socio-Umane, no.63, vol 2. Pp. 47-57.

Johansson E., Anikin A., Carling G., Holmer A. 2020 - *The typology of sound symbolism: Defining macro-concepts via their semantic and phonetic features.* Linguistic Typology. No.24. Vol. 2, DOI: 10.1515/lingty-2020-2034

Wierzbicka A., 2003 - *Cross-Cultural Pragmatics: The Semantics of Human Interaction*. Mouton de Gruyter.

GAEC STANDARDS-COEFFICIENTS FOR MEASURING THE SUSTAINABILITY AND DURABILITY OF THE EUROPEAN AGRICULTURAL POLICY

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Abstract

The GAEC standards are derived from the code for good agricultural and environmental conditions, which refers to the definition of the standards or conditions that farmers must meet in order for the subsidy application, regardless of the scheme they opt for, to be eligible; the concept has been developed and debated since the 70s, but was introduced into EU policy in 2003 through the publication of Council Regulation EC 1782/2003. Currently we can talk about 8 GAEC standards as a way of evaluating compliance with eco-conditionality for the following specific areas, namely climate and environment, including water, soil and ecosystem biodiversity, public health and plant health, animal welfare.
Thus, the GAEC standards applicable for the purpose of sustainability and durability of the agricultural policy implemented at the Union level at the moment are:
GAEC 1: Maintenance of permanent grasslands
GAEC 2: new from 2023. Protecting wetlands and peatlands
GAEC 3: Prohibition of burning stubble, dry vegetation and plant debris on arable land
GAEC 4: Creation of buffer strips (strips of protection) along watercourses
GAEC 5: Management of earthworks, reducing the risk of soil degradation and erosion, including consideration of slope.
GAEC 6: Minimum ground cover to avoid bare ground during the most sensitive periods
GAEC 7 Crop rotation on arable land, excluding crops growing under water
GAEC 8: Minimum proportion of agricultural area dedicated to non-productive areas or features and on all agricultural areas, maintaining landscape features and prohibiting the cutting of hedges and trees during the breeding and rearing period of birds.
GAEC 9: introduced in 2023. Prohibition of conversion or plowing of permanent grassland designated as ecologically sensitive permanent grassland within the perimeter of Natura 2000 sites.

Key words: public agricultural policy, GAEC standards, protectionist standard, sustainable development

INTRODUCTION

The public agricultural policy on subsidies in the agricultural-zootechnical and fisheries sector represents the creation of a payment scheme strategy regarded as state aid with a double financing, European and national, to support national producers.

The scheme of financial support for producers has presented various variables over time, which signify in the more than 100 years of a Europe free of wars and famines, an initial plan on basic products for any European to have what is necessary for a subsistence existence in a first phase. The changes in consumer behavior, which is ultimately the guarantor of the demand for products on the market, also led to the change of the guvenamental policies on subsidies in the agri-food field, Europeans not considering flour as basic products, the potato, the oil, etc.

The change in consumer behavior was determined by the diversification of the labor market, the majority of the population having no occupation in the agricultural rural area; sedantarism and implicitly more sedentary occupations, they generated the phenomenon of obesity and other diseases associated with it; at the same time, industrialization was an element that caused the changing habits of the consumer, the trend of industrial production strategies being long-term food preservation, which involved the introduction of stabilizers and emulsifiers into the diet. Their introduction did not take into account the impact on the health of the population in the short, medium and long term, the legislation in the food industry being permissive in this respect.

Currently, the CAP 2023-2027 strategic plan is the government instrument on state subsidies granted in the agrarian field.

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MATERIAL AND METHOD

This paper involved studying the legislation at national and european level on public policies for financing agricultural producers in the field of vegetation, analyzing the importance of the gaec standards regarded as a benchmark of analysis regarding the eligibility of the financing application regardless of the payment system on which it was applied.the reference normative act remains the Eu Regulation 2021/2015 and the government decision 1571/2022.

RESULTS AND DISCUSSIONS

GAEC 1

GAEC 1 is a new, protectionist standard which, through the administrative sanction provided for in Article 91 of Regulation (EU) No 1306/2013, prevents the conversion of permanent grassland to other agricultural uses and aims at preserving carbon stocks.

Prior to this standard, the maintenance of permanent grassland was achievable by imposing, as an eligibility condition "for greening payments", the fulfillment of a mathematically calculated coefficient by carrying out a proportionality ratio between permanent grassland and agricultural land, the reference year being 2015.

This standard applies to schemes that include payment per pasture and aims to maintain permanent grassland with a reference criterion of a proportional ratio between permanent grassland and agricultural area at national level, based on 2019 figures; given the previous reference, a deficit of -5% at most is accepted.

The obligations at farm level, closely linked to the requirements imposed by the GAEC 1 standard, are governed by the provisions of GEO 34/2013.

GAEC standard 1 is mandatory as an eligibility criterion for farmers and other beneficiaries receiving direct payments or annual payments through interventions in the form of direct payments as well as rural development interventions provided for in Art. 16 paras. 2 and 3 Articles 70, 71, 72 of Regulation (EU) No 2021/2115.

At the same time, this type of standard was also taken into account for farmers who applied for area payments, direct payments and compensatory payments through rural development measures applied on agricultural land under the NRDP 2014-2020, the reference year being 2018, their declaration being for permanent grassland.

GAEC 2

This is a new standard, applicable from 2023, aiming to protect carbon-rich soils; the standard imposes a number of environmental obligations on farmers who own or manage agricultural land and carry out specific agricultural activities in these areas.

Therefore, farmers, in order to be eligible under the GAEC 2 standard, have a number of obligations to respect for agricultural land in wetlands and peatlands designated as protected sites, which includes Ramsar sites:

- the application of agricultural technologies and management methods developed using specific techniques in line with environmental legislation;
- the use of phytosanitary or organic products, with the approval of the protected area manager, is obligatory for pest control work specific to the agricultural crop;
- seeds treated with banned chemical products must not be used in the protected natural area; it is obligatory to take all necessary measures against pollution or environmental degradation;
- soil fertilization works must be carried out with organic fertilizers and, in the case of chemical fertilizers, in monitored quantities, in order to avoid contamination of water resources;
- all measures to protect agricultural crops from wild animals must be approved by the protected area administration;
- the use of polluted water sources for irrigating crops is prohibited and, by implication, all necessary measures to prevent soil deterioration;
- the maintenance of dykes, the protection of agricultural enclosures, as well as irrigation and drainage systems, must be carried out in the protected area;
- the cultivation of genetically modified plants, narcotics or any other plants harmful to health is prohibited;
- the construction of land protection fences erected for the purpose of preventing the free movement of wild animals is prohibited;
- it is prohibited to set fire to dry vegetation, as well as to waste resulting from technological operations;
- it is forbidden to work the soil deeper than 25 cm;
- tillage of permanent grassland in wetlands and peat bogs is prohibited;
- the conversion of wetlands and peatlands and any change in land use and watercourse is prohibited

- the deliberate introduction of non-native species into wetlands and peatlands is prohibited;
- the depositing of waste in wetlands and peat bogs, as well as in agricultural areas within the perimeter of wetlands and peat bogs, is prohibited.

GAEC 3

This standard was applicable in the period 2014-2020 and aimed to reduce GHG greenhouse gas emissions and land cover during the most sensitive periods.

The prohibition imposed by this standard covered all arable land on the national territory as well as fallow land.

The myth of fertilizing agricultural land by burning has been dispelled, as the establishment of GAEC 3 standard established the scientific truth that it does not represent

GAEC 4

This standard is, de facto, a continuation of the implementation of GAEC 1 requirements on the creation/maintenance of buffer strips along watercourses from 2014-2020.

As additional requirements to the GAEC 1 standard, it is required:

- introduction of a ban on the use of plant protection products on buffer strips along watercourses, including fertilizers;
- the minimum width of the buffer strips should be increased to 3 m (from 1 m in the previous version) for land with a slope of 12% and to 5 m (3 m in the previous version) for land with a slope of more than 12%.

GAEC Standard 4 is applicable throughout the national territory for all farmers who own or manage agricultural land located in the vicinity of watercourses, adjacent to their protection zones, as established by the Water Law No. 107/1996, as amended.

It follows from the way the legislator expressed it that the GAEC 4 standard is binding, by establishing a joint and several legal liability between the owner of the land and the person who has a precarious form of holding of the land, regardless of the nature of the title resulting from it, lease contract, concession contract, rental contract, joint venture contract.

GAEC 5

Compared to the 2014-2020 version, GAEC 5 standard requires that all tillage carried out on land with slopes of more than 12%, regardless of the crop planted, including sowing, must be carried out along the contour lines. The standard considers the average slope of the agricultural parcel used by the farmer. At the same time, this standard completely prohibits tillage (plowing, scarifying, harrowing, rotary hoeing, mechanical harrowing) on very poorly fertile land unsuitable for arable use included in the land improvement plans in the 5th quality class.

GAEC 6

This standard is the continuation of the eco-conditionality requirement of GAEC 4 for the period 2014-2022, when the percentage of uncultivated land after harvest of the total arable area of the farm was at least 20%.

Currently, GAEC Standard 6 requires farmers to keep at least 80% of the arable area of the farm and at least 50% of the area of permanent crops on the farm covered.

The most sensitive period for our territory in terms of soil remains the summer period from 15 June to 30 September, which is usually characterized by very high temperatures, lack of rainfall, soil and atmospheric drought and other extreme weather phenomena that can lead to excessive soil tilth, erosion, degradation and desertification.

In order for the farmer to fulfill his obligation regarding the percentage of soil cover, stubble left after harvesting, secondary crops, green cover crops or newly established fall crops can be used as measures; the time during which there is an exception to these obligations is only the period of land preparation and establishment of the new crop, which may not exceed 2 weeks.

In the case of permanent crops, the minimum ground cover for the most sensitive period means grassed strips between rows, mulches or plant residues on at least 50% of the area of the permanent crops on the holding.

We therefore conclude that GAEC 6 is applicable for all farmers establishing arable and permanent crops.

GAEC 7

This is a new non-applicable standard for the year 2023 which has as its main objective the preservation of soil potential. Therefore, this new standard imposed, as a set of specific requirements, the application of agricultural practices aimed at maintaining the fertility, and therefore the production potential, of agricultural soils.

Thus, crop rotation on agricultural land, with the exception of crops grown under water, has been specifically established as a farm-level obligation.

Thus, crop rotation is now required at least once a year (taking into account the agricultural year) at plot level; multiannual crops, grasses and other herbaceous forage plants, fallow land, crops in protected areas such as greenhouses and solariums are exempted from this rule.

It is allowed that one and the same plant species may be cultivated on no more than 50% of the arable area of the holding, taking into account the following:

- permission to cultivate for 3 consecutive years is possible, provided that a secondary crop of a different species is planted between the 2 main crops;

- permission to cultivate for a maximum of 2 consecutive years for areas on which the main crop was harvested late in the autumn (after November 1) because of unfavorable weather conditions which made it impossible to establish the secondary crop under optimum conditions for plant emergence and development.

In the crop rotation plan, fall varieties and spring varieties of the same species grown for production purposes are accepted as the same crop (e.g. wheat/barley crops of fall varieties and wheat/barley crops of spring varieties). The secondary crops are considered to be those which are grown in the interval between two main crops, covering the whole period between them without a significant break, covering the ground at least 8 weeks after harvesting of the main crop, and must be different in species from the main crop. From a technological point of view, secondary crops may also include successive crops or double crops sown for either harvesting or grazing.

Single crops or mixtures of crops such as grasses, legumes, protein crops, oilseeds, oilseed crops, honey plants, etc. are recommended as possible rotations.), such as: mustard+oats, mustard+fava bean, mustard+rape, mustard+mustard, mustard+mustard, mustard+oats, mustard+oats, pea+oats, pea+oats, pea+peas, pea+mustard, pea+mustard, lupin+clover, rape+clover, rape+clover, rape+mustard, grain+oats, rye+clover, rye+clover, clover+fava bean, pea+mustard, pea+mustard, pea+camel.

According to the GAEC 7 standard, fallow land is arable land not cultivated during an agricultural year, maintained in good environmental conditions, subject to minimum maintenance; the minimum period for land to be considered as fallow is 6 months, which must cover the months of March to August.

G.A.E.C. standard 7 is an eligibility criterion for the subsidy claim, regardless of the payment scheme applied for, for agricultural holdings of 11 hectares and above.

GAEC standard 7 may not be applied as an eligibility criterion where the area for which payment is claimed is 75% permanent grassland or the land itself is used for the production of grass or other herbaceous forage crops, or the land is fallow with leguminous crops, or is subject to a combination of these uses.

The exemption from GAEC standard 7 for the year 2023 took place on the basis of Commission Implementing Regulation (EU) No 2022/1317 of July 27, 2022 laying down derogations from Regulation (EU) 2021/2115 of the European Parliament and of the Council as regards the application of standards relating to good agricultural and environmental condition of land (GAEC standards) 7 and 8 for the claim year 2023 "Member States may decide to derogate, for the claim year 2023, from the application of one or both of the GAEC standards.

GAEC 8

This standard is intended to continue the application of some of the requirements of GAEC 7, i.e. the maintenance of landscape features, including in alignment, in groups or in isolation, and existing terraces on agricultural land, the prohibition of cutting hedgerows and trees during the breeding season and the rearing of wild birds, measures which aim to avoid the establishment and spread of invasive plant species on agricultural land; existing measures and in the period 2014-2020, a set of new requirements has been added by the present standard, such as for example the obligation to ensure a minimum percentage of the agricultural area dedicated to non-productive areas or features at farm level.

The requirements imposed by GAEC 8 extend, de jure and de facto, the list of landscape elements that contribute to the protection of the landscape.

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The requirements imposed by GAEC 8 extend, de jure and de facto, the list of landscape elements contributing to the minimum percentage of non-productive areas/elements, thus clarifying the list of non-productive areas/elements for which there is an obligation to maintain. It also establishes a longer period of prohibition on cutting hedgerows and trees during the breeding and rearing period of wild birds, i.e. March 31 - August 31, which has an effect on improving agricultural biodiversity.

GAEC Standard 8 imposes the following obligations at farm level:

- at least 4% of the arable land at farm level to be dedicated to non-productive areas and features, a category which includes fallow land;
- eligibility is also maintained for 3%, provided that 7% is included in an ecological consolidation program;
- the farmer is required to have at least 7% of arable land at farm level set aside for non-productive areas and areas, including fallow land, including catch crops, including catch crops with catch crops and nitrogen fixing crops grown without the use of plant protection products, of which 3% is non-productive areas including fallow land; Member States are recommended to use a weighting factor of 0.3% for catch crops;
- prohibit the felling of hedgerows and trees during the breeding and rearing period of wild birds, during which a bird species lays eggs, hatches them and raises its young until they are able to fly; this period covers the period from March 15 to August 31, applicable both within and outside the perimeter of nature protection areas (SCIs, SPAs)
- farmers are obliged to take all necessary measures to avoid the establishment of invasive plant species on agricultural land.

GAEC standard 8 remains obligatory for all agricultural holdings, except for land up to 10 ha or where 75% of the land is permanent grassland, or grass or other herbaceous forage production, or fallow land, or land under leguminous crops, or a combination of the above.

The only year that the GAEC 8 standard has not been applied since its effective date was the 2023 application year, which is the only exemption from it.

GAEC 9

The GAEC 9 standard aims, as its main objective, to protect habitats and species, bringing in addition to the 2014-2020 period the measure prohibiting the conversion and plowing of ecologically sensitive permanent grasslands; at the same time, the standard has imposed the obligation to exploit and maintain these types of sites with the aim of protecting the natural habitats of wild flora and fauna in the areas included in Natura 2000. As obligations at farm level, this standard requires:

- the prohibition of the change of use or plowing of permanent grassland considered ecologically sensitive within the perimeter of Natura 2000 sites, approximately 764,393 ha;
- the obligation to carry out exploitation and maintenance works on permanent grassland within the perimeter of Natura 2000 sites, which include in their implementation compliance with the conservation measures outlined in the site manager's management plans;

Consequently, GAEC standard 9 is mandatory as an eligibility criterion for payment claims for farmers who own or manage permanent grassland designated as ecologically sensitive in Natura 2000 sites.

It is noted that joint and several legal liability is established both for landowners who own land which includes such grassland and for those who hold it under a concession under a concession contract, lease, etc.

CONCLUSIONS

G.A.E.C. standards become a criterion for analyzing compliance with the conditionality yardstick established by the EU Regulation 2021/2015 by A.P.I.A.A. inspectors both for the situations of assessing the eligibility of farmers' applications for payment and for those for granting state aid.

Thus, they may be subject to an administrative sanction by which they risk not receiving the subsidy or state aid for the disaster.

The sanction referred to in Article 91 of Regulation (EU) No 1306/2013 shall not apply to the small farmers scheme covered by Title V of Regulation (EU) No 1307/2013 and to the support covered by Article 28(2) of Regulation (EU) No 1307/2013. 9 of Regulation (EU) No 1305/2013 referred to as support for the conservation and sustainable use and development of genetic resources in agriculture in operations not covered by paragraphs 1 to 8 of the same Article.

The administrative sanction implemented by Art. 91 of Regulation (EU) No 1306/2013 aims at protecting, as a social value, the ecoconditionality as defined through the legal rules contained in Art. 93 of the same Regulation. In itself, the concept of cross-compliance concerns the management of the agricultural and environmental conditions of the land of agricultural holdings supported by the Union payment scheme. It is juxtaposed on the concept of sustainability, aiming at a harmonious development of agriculture while respecting environmental rules, focusing on public health, plant health, animal health and welfare.

The method of calculating this administrative penalty is laid down, as a principle of law, in Article 99 and may consist either in a reduction of the payments claimed or in the total loss of the subsidy. A maximum of 5% is accepted as standard for the reduction coefficient and a maximum of 15% for non-compliance situations. Non-compliance usually refers to farming techniques which do not pay attention to environmental standards, plant health and animal welfare.

In order to avoid such situations, Member States are obliged to provide farm advisory services. In Romania, such agricultural advice was initially provided by the County Agricultural Chambers, which were later taken over by the County Agricultural Directorates, institutions subordinate to the Ministry of Agriculture and Rural Development.

EU Regulation 2021/2015 has not repealed the provisions of art.91, 93, 99 of Regulation (EU) No 1306/2013 provisions that are found at national level in HG No.1571 of 20022 on establishing the general framework for the implementation of interventions related to the plant and livestock sectors of the CAP strategic plan 2023-2027 respectively MADR Order 80/2013, the spiritual European agricultural policy remains the same.

Thus it gravitates further around the concept of sustainable development, which had and still has in mind the legal evolution of the concept of the environment seen as a right of generations, not only present but also future, and implicitly as a halt to the trend of consumerism, renouncing to practices specific to intensive agriculture.

Therefore, in order to preserve soil quality, it is recommended to leave fallow land alternating with areas farmed, to preserve fauna and flora, not only for strictly organic farming areas, but also as an adjuvant that can combat pests specific to the various crops, with a direct impact on the quantities of pesticides used.

REFERENCES

Regulamentul (UE) nr. 1.306/2013 al Parlamentului European şi al Consiliului din 17 decembrie 2013 privind finanţarea, gestionarea şi monitorizarea politicii agricole comune şi de abrogare a Regulamentelor (CEE) nr. 352/78, (CE) nr. 165/94, (CE) nr. 2.799/98, (CE) nr. 814/2000, (CE) nr. 1.290/2005 şi (CE) nr. 485/2008 ale Consiliului;

Regulamentul (UE) nr. 1.307/2013 al Parlamentului European şi al Consiliului din 17 decembrie 2013 de stabilire a unor norme privind plăţile directe acordate fermierilor prin scheme de sprijin în cadrul politicii agricole comune şi de abrogare a Regulamentului (CE) nr. 637/2008 al Consiliului şi a Regulamentului (CE) nr. 73/2009 al Consiliului;

Regulamentul delegat (UE) nr. 639/2014 al Comisiei din 11 martie 2014 de completare a Regulamentului (UE) nr. 1.307/2013 al Parlamentului European şi al Consiliului de stabilire a unor norme privind plăţile directe acordate fermierilor prin scheme de sprijin în cadrul politicii agricole comune şi de modificare a anexei X la regulamentul menţionat;

Regulamentul delegat (UE) nr. 640/2014 din 11 martie 2014 al Comisiei de completare a Regulamentului (UE) nr. 1.306/2013 al Parlamentului European şi al Consiliului în ceea ce priveşte Sistemul Integrat de Administrare şi Control şi condiţiile pentru refuzarea sau retragerea plăţilor şi pentru sancţiunile administrative aplicabile în cazul plăţilor directe, al sprijinului pentru dezvoltare rurală şi al ecocondiţionalităţii;

Regulamentul de punere în aplicare (UE) nr. 809/2014 al Comisiei din 17 iulie 2014 de stabilire a normelor de aplicare a Regulamentului (UE) nr. 1.306/2013 al Parlamentului European şi al Consiliului în ceea ce priveşte Sistemul Integrat de Administrare şi Control, măsurile de dezvoltare rurală şi ecocondiţionalitatea, ţinând cont de faptul că prezenta ordonanţă de urgenţă creează cadrul juridic pentru alte acte normative care reglementează condiţiile implementării schemelor de plăţi menţionate, neadoptarea acesteia ar conduce la disfuncţionalităţi în procesul de accesare a formelor de sprijin financiar.

Regulamentului (UE) 2021/2.115 al Parlamentului European şi al Consiliului din 2 decembrie 2021 de stabilire a normelor privind sprijinul pentru planurile strategice care urmează a fi elaborate de statele membre în cadrul politicii agricole comune (planurile strategice PAC) şi finanţate de Fondul european de garantare agricolă (FEGA) şi de Fondul european agricol pentru dezvoltare rurală (FEADR) şi de abrogare a Regulamentelor (UE) nr. 1.305/2013 şi (UE) nr. 1.307/2013;

Regulamentului (UE) 2021/2.116 al Parlamentului European şi al Consiliului din 2 decembrie 2021 privind finanţarea, gestionarea şi monitorizarea politicii agricole comune şi de abrogare a Regulamentului (UE) nr. 1.306/2013;

Regulamentului delegat (UE) 2022/126 al Comisiei din 7 decembrie 2021 de completare a Regulamentului (UE) 2021/2.115 al Parlamentului European şi al Consiliului cu cerinţe suplimentare referitoare la anumite tipuri de intervenţii specificate de statele membre în planurile lor strategice PAC pentru perioada 2023-2027 în temeiul regulamentului respectiv, precum şi cu norme privind raportul pentru standardul GAEC 1 (bune condiţii agricole şi de mediu);

Regulamentului delegat (UE) 2022/127 al Comisiei din 7 decembrie 2021 de completare a Regulamentului (UE) 2021/2.116 al Parlamentului European şi al Consiliului cu norme privind agenţiile de plăţi şi alte organisme, gestiunea financiară, verificarea conturilor, garanţiile şi utilizarea monedei euro;

Regulamentului de punere în aplicare (UE) 2021/2.289 al Comisiei din 21 decembrie 2021 de stabilire a normelor de aplicare a Regulamentului (UE) 2021/2.115 al Parlamentului European şi al Consiliului în ceea ce priveşte prezentarea conţinutului planurilor strategice PAC şi sistemul electronic pentru schimbul securizat de informaţii;

Regulamentului de punere în aplicare (UE) 2021/2.290 al Comisiei din 21 decembrie 2021 de stabilire a normelor referitoare la metodele de calculare a indicatorilor de realizare şi de rezultat comuni stabiliţi în anexa I la Regulamentul (UE) 2021/2.115 al Parlamentului European şi al Consiliului de stabilire a normelor privind sprijinul pentru planurile strategice care urmează a fi elaborate de statele membre în cadrul politicii agricole comune (planurile strategice PAC) şi finanţate de Fondul european de garantare agricolă (FEGA) şi de Fondul european agricol pentru dezvoltare rurală (FEADR) şi de abrogare a Regulamentelor (UE) nr. 1.305/2013 şi (UE) nr. 1.307/2013;

Regulamentului delegat (UE) 2022/1.408 al Comisiei din 16 iunie 2022 de mo dificare a Regulamentului (UE) 2021/2.116 al Parlamentului European şi al Consiliului în ceea ce priveşte plata avansurilor pentru anumite intervenţii şi măsuri de sprijin prevăzute în Regulamentele (UE) 2021/2.115 şi (UE) nr. 1.308/2013 ale Parlamentului European şi ale Consiliului;

Regulamentului de punere în aplicare (UE) 2022/1.173 al Comisiei din 31 mai 2022 de stabilire a normelor de aplicare a Regulamentului (UE) 2021/2.116 al Parlamentului European şi al Consiliului în ceea ce priveşte sistemul integrat de administrare şi control din cadrul politicii agricole comune;

Regulamentului de punere în aplicare (UE) 2022/1.317 al Comisiei din 27 iulie 2022 de stabilire a unor derogări de la Regulamentul (UE) 2021/2.115 al Parlamentului European şi al Consiliului în ceea ce priveşte aplicarea standardelor privind bunele condiţii agricole şi de mediu ale terenurilor (standardele GAEC) 7 şi 8 pentru anul de cerere 2023;

Hotărârii Guvernului nr. 30/2017 privind organizarea şi funcţionarea Ministerului Agriculturii şi Dezvoltării Rurale, precum şi pentru modificarea art. 6 alin. (6) din Hotărârea Guvernului nr. 1.186/2014 privind organizarea şi funcţionarea Autorităţii pentru Administrarea Sistemului Naţional Antigrindină şi de Creştere a Precipitaţiilo

Hotărârea de Guvern nr. 1571/2022 privind stabilirea cadrului general de implementare a intervenţiilor aferente sectoarelor vegetal şi zootehnic din cadrul Planului strategic PAC 2023-2027, finanţate din Fondul european de garantare agricolă şi de la bugetul de stat.

SHARING THE LANGVET – IA PROJECT: CONCEIVING LINGUISTIC AND PEDAGOGICAL CONTENT WITH THE HELP OF ARTIFICIAL INTELLIGENCE TOOLS IN THE FIELD OF VETERINARY MEDICINE

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Abstract

This article draws on the LANGVET - IA project, "Concevoir des contenus linguistiques et pédagogiques à l'aide des outils de l'intelligence artificielle (IA) dans le domaine de la médecine vétérinaire" (Conceiving linguistic and pedagogical content with the help of artificial intelligence tools in the field of veterinary medicine), coordinated by the University of Life Sciences "Ion Ionescu de la Brad" Iași, with the financial support of the Agence Universitaire de la Francophonie and developing from July 1, 2024 to August 31, 2025. The project focuses on the study and use of artificial intelligence tools to develop educational resources designed for veterinary students, by integrating them in their formal learning and practice, and their language trainers, by applying them in their teaching and research activity. The article looks into the project's methodology and partial results for the creation of online teaching and learning resources dedicated to professional communication in the field of veterinary medicine; these include trilingual (French, English, Romanian) learning units on medical vocabulary and doctor-client communication, based on an interdisciplinary (linguistic, didactic and cultural) exploration. As the LANGVET - IA project capitalizes on artificial intelligence tools to facilitate the teaching-learning process in the specialised field of veterinary medicine, this article explores its further potential for modernizing the education system.

Key words: artificial intelligence, teaching languages, veterinary medicine, research project, learning resources

The project LANGVET – IA aims to address several key needs identified in the field of linguistic education, particularly in the context of teaching French as a foreign language, while integrating new technologies and artificial intelligence (AI). First, there is a growing demand for pedagogical tools that leverage the advantages offered by modern technological advancements. This aligns with the need to update teaching methods in order to increase student engagement by enhancing the practical application of AI in language learning. Furthermore, it is increasingly important to connect the knowledge and skills acquired by students during their academic training to the labor market, where AI is becoming more prevalent.

A second essential aspect of this project is the development of transversal skills, focusing on the interaction between specialized terminology and intercultural elements, such as the representation of animals. Another key objective is the creation of multilingual glossaries that map the linguistic domain of veterinary medicine, complemented by didactic materials that deepen students' understanding.

Despite the growing relevance of AI in language instruction, there is a notable lack of terminological studies in the veterinary field, particularly those that explore multilingualism (e.g., French, English, Romanian). Addressing these gaps requires the integration of AI into teaching methodologies, equipping instructors with the necessary tools to provide students with more engaging, autonomous learning experiences. However, current resources and strategies for training educators in the use of AI are limited.

In addition to enhancing teaching practices, this project also emphasizes the importance of linking educational activities with research. All participating educators are committed to advancing both their teaching methods, and their scientific contributions through publications and academic dissemination. The dissemination of project outcomes is crucial for maintaining high-quality French education and research, especially in the international academic and scientific arena.

By combining language education, didactics, and intercultural studies, this initiative seeks to boost the visibility of French language instruction in regional universities. It will also contribute to the development of these institutions, enrich their

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academic offerings, and improve the quality of teaching and research staff. This collaborative effort between French-language researchers and educators from various disciplines—such as French for specific purposes (FOS), linguistics, anthropology, veterinary medicine, and AI—will foster dialogue, innovation, and academic excellence.

MATERIAL AND METHOD

The proposed project introduces an innovative methodological approach to French for Specific Purposes (FSP) in veterinary medicine. This approach lies at the intersection of FSP didactics, linguistics, and training in new technologies, particularly artificial intelligence (AI), all within a framework of intercultural communication. The main objectives are to:

- Develop educational resources in veterinary terminology.
- Increase the participation of non-language specialist students and Modern Languages instructors from Central and Eastern Europe in international training and research, within a multicultural and multilingual context.
- Encourage the production and dissemination of knowledge related to teaching languages, supported by scientific cooperation missions and participation in scientific events.

To achieve these goals, the project emphasizes the following strategies:

1. **Recognition and standardization of tools**: we aim to align veterinary-related tools and skills with international project standards, facilitating student and researcher mobility and fostering free exchange between participants.
2. **Improvement of student skills**: the project seeks to improve student competencies in both clinical practice and the new AI-driven digital context, ensuring their preparedness for the labor market.
3. **Interdisciplinary language education**: we aim to enhance the teaching and learning of languages, promote linguistic diversity, and raise intercultural awareness in the field of veterinary medicine.
4. **Creation of multidisciplinary educational content**: the development of innovative and interdisciplinary teaching content will support students and instructors during their professional training.
5. **Enhancement of education quality**: through international cooperation, we aim to improve the quality, innovation, excellence, and international dimension of education and training at participating institutions.
6. **Language and specialty learning integration**: by integrating linguistic education with subject-specific learning, we encourage student autonomy and active participation in their learning process.
7. **Research on specialized terminology**: we will conduct research on specialized terminology in veterinary medicine, including the creation of glossaries, databases, and terminological indices, and we will develop practical skills for specific objectives in an engaging and interactive professional context.
8. **Teacher and learner competency development**: the project will improve teacher and learner competencies in transdisciplinary education using AI, increasing the quality of French for Specific Purposes (FSP) education through dedicated training workshops.
9. **Increased participation in international training**: we aim to strengthen the participation of students and teachers from Central and Eastern Europe in international training and research, within a multicultural and multilingual environment.
10. **Collaborative research and publication**: the project will produce a collective study based on shared reflections on the project outcomes and will develop educational materials for language and veterinary medicine instructors.
11. **Utilization of AI in language education**: despite its limitations, AI has the potential to revolutionize language teaching and learning. We have identified several ways to integrate AI tools into language education:
    - Pedagogical resource generation: AI can generate tailored exercises, games, and other activities that enhance learning effectiveness and enjoyment;
    - Error correction: AI can detect and correct grammatical, lexical, and spelling errors, helping learners improve their language mastery;
    - Text generation: AI can assist learners in producing texts in French, such as letters, articles, or stories, supporting the development of writing skills.

The project is built on a collaborative partnership between educators and researchers from diverse fields, including linguistics, didactics, information engineering, and AI. The involvement of linguists and anthropologists from "Al. Philippide" Institute of Philology (Romanian Academy), together with researchers and teachers from the Faculty of Letters of Alexandru Ioan Cuza University of Iasi (Romania) and postdoctoral researchers from the University of Rijeka (Croatia), who specialize in AI integration into language learning and teaching, adds significant interdisciplinary expertise to the project.

Work Organization

The project's workflow is structured as follows:

1. Joint reflection and task sharing: a collaborative meeting to identify and assign tasks took place in July 2024;
2. Teamwork by discipline: from July 2024 to February 2025, teams work based on their areas of specialization, with common objectives and

involvement from educators across different disciplines (linguistics, FSP, etc.);

3. Teacher mobility and collaboration: between September 2024 and June 2025, educators participate in international mobility programs, scientific cooperation missions, teaching activities, and scientific events;

4. International conference organization: in March 2025, an international conference will be held in Iași, Romania;

5. Publication and dissemination: from April to July 2025, the project outcomes will be published, communicated, promoted, and made available online.

This systematic approach ensures that the project goals are met while fostering innovation, international collaboration, and academic excellence in the field of veterinary medicine, language education, and AI integration.

RESULTS AND DISCUSSIONS

The distribution of tasks among the project partners was carried out according to their professional expertise, allowing for effective collaboration and the achievement of common specific objectives. The tasks were divided into four primary areas: (I) veterinary medicine, (II) language, terminology, and translation studies, (III) language didactics and AI integration, and (IV) intercultural studies. Each partner identified a team of researchers from their institution to mutually contribute to the project's activities, ensuring a comprehensive and interdisciplinary approach.

Key activities undertaken by each team include:

Organization and participation in team meetings: regular meetings are held to coordinate the activities, share updates, and assess progress towards the project's goals. These gatherings facilitate communication and foster synergy among the partners.

Hosting and coordination of short-term mobility programs: partners host and coordinate the participation of educators and researchers in expert short-term mobility programs, which enhance knowledge exchange and provide specialized training across disciplines.

Development and publication of educational materials: teams collaborate on the creation, analysis, correction, and publication of pedagogical resources tailored to the interdisciplinary needs of the project, ensuring high-quality and relevant content.

Project presentation and dissemination: the project's outcomes are presented at workshops, study days, and international conferences, increasing visibility and promoting the diffusion of the results within the academic community.

In terms of student involvement, participants were drawn from all partner universities. Virtual working sessions and collaborative meetings were established, starting with the first gathering in July 2024. These interactions allow students to contribute to and engage with the project while working alongside their peers and instructors from different countries.

Expected Results:

The outcomes of this collaborative effort are wide-ranging and significant. The key expected results include:

Diversification and dissemination of educational, linguistic, and cultural content: the project will create and disseminate innovative educational materials that integrate language, veterinary medicine, and cultural studies.

Pedagogical advantages: the implementation of AI tools is expected to result in more engaging and effective learning environments, enhancing student motivation and performance.

Modern and motivating teaching methods: by integrating AI and information technologies, the project will offer a contemporary and dynamic teaching approach, making learning more attractive and interactive.

Learning efficiency with AI: AI-enhanced learning methods are anticipated to significantly improve the efficiency of language acquisition and veterinary terminology mastery.

Involvement of academics at risk: the project will enable academics from countries in crisis, particularly those in the AUF network, to maintain their participation in international scientific communities, ensuring the continuity of their research activities.

Promotion of French as a language of education and research: by organizing an international conference and disseminating research outcomes, the project will enhance the visibility of French as a key language for both education and scientific inquiry.

Development of specialized French education and research in veterinary medicine: the project aims to strengthen the field of specialized French language instruction, particularly within the veterinary domain, through targeted training and research initiatives.

Technology and expertise transfer: the project will facilitate the transfer of information and communication technologies (ICT) and AI expertise to the fields of language education and veterinary medicine, promoting cutting-edge innovations in these areas.

Renewal and creation of pedagogical supports: new and updated teaching materials will be developed, enriching the resources available for both language and veterinary studies.

Through this project, we aim to develop sustainable and innovative educational practices that both enhance the learning experience and increase international research and collaboration.

CONCLUSIONS

By integrating both research and training—focused on equipping students and educators with AI tools applied to language learning and veterinary medicine—this project and its interdisciplinary team will enhance the education of future specialists in life sciences. Additionally, it will increase the international visibility of French for Specific Purposes (FSP) education in regional universities by embedding cutting-edge research into a modern and sustainable teaching framework.

Project valorization strategies:

- Publication of results: the project will generate partial and final outcomes, including scientific articles, pedagogical guides, and a collective volume, ensuring broad dissemination of findings.
- Dissemination of results: participation in conferences, study days, and the publication of articles across the region will promote the project's outputs and encourage scholarly dialogue.
- Online knowledge sharing: results and educational resources will be shared through online platforms, educational websites, and partner university portals, ensuring wide accessibility.
- Development of educational resources: pedagogical materials will be made available on the online platforms of partner institutions, enhancing teaching and learning practices. A comprehensive database on veterinary terminology will be established, providing a valuable resource for students and educators.
- AI integration in language courses: AI tools will be introduced into language courses across member universities, fostering innovation in language teaching.

Through these strategies, the project aims to ensure the long-term sustainability of language education in veterinary medicine and other related fields. By leveraging online platforms, fostering international collaboration, and integrating AI into language teaching, this initiative will position itself as a reference for innovative educational practices in both the academic and professional realms.

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REFERENCES

Chen X., Xie H., Zou D., & Hwang G.-J., 2020 - *Application and theory gaps during the rise of artificial intelligence in education*. Computers and Education: Artificial Intelligence, 1, 100002. available on-line at: https://doi.org/10.1016/j.caeai.2020.100002

Grandjean T., 2023 - *Démystifier les IA génératives*, Athena Mag, vol. 364, Novembre-Décembre 2023, pp. 12-15.

Holmes W., Bialik M., & Fadel C., 2023 - *Artificial intelligence in education*. In C. Stuckelberger & P. Duggal (Eds.), Data ethics: Building trust: How digital technologies can serve humanity(pp. 621-653) available on-line at: https://repository.globethics.net/handle/20.500.12424/4273108

Karsenti T., 2019 - *Artificial intelligence in education: The urgent need to prepare teachers for tomorrow's schools*. Formation et profession, 27(1), 105, available on-line at:. https://dx.doi.org/10.18162/fp.2019.a166

Mangiante J.-M., Parpette C., 2004 - *Le Français sur Objectif spécifique : de l'analyse des besoins à l'élaboration d'un cours*. Paris, Hachette.

Ouyang F., & Jiao P., 2021 - Artificial intelligence in education: The three paradigms. Computers and Education: Artificial Intelligence, available on-line

Velescu E., 2016 - Le français à l'usage des vétérinaires et des zootechniciens. Galaţi, Europlus.

RESEARCH ON THE CHALLENGES OF ARTIFICIAL INTELLIGENCE IN FINANCIAL AUDIT ACTIVITIES AT THE ECONOMIC ENTITY LEVEL IN AGRIBUSINESS

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Abstract

This paper examines the challenges and opportunities associated with the use of artificial intelligence (AI) in financial auditing, with a particular focus on the agribusiness sector. In the current context of digitalization, AI promises to fundamentally transform audit processes by providing advanced tools for analyzing complex data and monitoring financial compliance. However, the specificities of the agribusiness industry, characterized by diversified activities and complex financial flows, create significant challenges in implementing AI. Among the identified challenges are the high initial costs, the need for advanced technological skills, and the difficulty of managing heterogeneous data generated from agriculture and related processes. On the other hand, the benefits include improved efficiency, reduced errors, and enhanced financial transparency. The study concludes with strategic recommendations for optimizing AI integration into financial audits of agribusiness economic entities, emphasizing the importance of continuous training and technological adaptation.

Key words: Artificial Intelligence, Financial Audit, Agribusiness, Digital Transformation, Data Analysis, Audit Automation, Financial Compliance.

In the era of digital transformations, the agribusiness sector faces significant challenges in terms of streamlining and optimizing economic and financial processes. Agriculture, a field of strategic importance for global food security, encompasses a variety of complex activities, from agricultural production to industrial processing and distribution. In this context, financial auditing plays a crucial role in ensuring compliance and transparency in economic operations.

Artificial intelligence (AI) has emerged as an innovative solution for optimizing financial audit processes, providing automated methods for processing and analyzing financial data. The implementation of AI allows auditors to quickly identify discrepancies, analyze financial trends, and optimize resources, all within an agricultural sector characterized by high market volatility and a strong dependence on external factors such as weather conditions.

However, the application of AI in the financial auditing of agribusiness economic entities presents a series of specific challenges. The uneven structure of the data generated by agricultural activities, combined with the complexity of financial flows in this sector, complicates the process of automation and standardization. Furthermore, the level of digitalization among agribusiness companies varies significantly, creating additional barriers to the integration of AI solutions.

This paper explores these challenges and investigates how AI can contribute to improving the quality and efficiency of financial auditing in agribusiness. Additionally, it presents solutions to overcome the obstacles encountered in the implementation process, emphasizing the need to adapt emerging technologies to the specific requirements of the agricultural sector.

The Use of Artificial Intelligence in Financial Auditing

The literature on the use of artificial intelligence (AI) in financial auditing has significantly evolved in recent decades, as digital technologies have begun to play an increasingly important role in economic and financial processes. The studies conducted by Brown and Saunders (2015) serve as key references in understanding how AI can transform traditional financial audits. According to their findings, AI can automate repetitive tasks, such as document verification and account reconciliation, significantly reducing the time and resources required for manual audits.

More recently, the research of Jones and Smith (2020) highlights that machine learning technologies allow for large-scale financial data analysis, detecting patterns and anomalies that human auditors might overlook. These advanced

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capabilities enable auditors to focus more on risk assessment and strategic decision-making, while AI manages operational tasks. Furthermore, the implementation of AI reduces the risk of human error and enables better real-time monitoring of financial compliance.

However, the application of these technologies in agribusiness is still in its early stages, and the adaptation of AI to the specific characteristics of this sector requires further research. According to Davis (2021), integrating AI into financial auditing requires both significant financial resources and advanced digital infrastructure, which can present major challenges for many companies in the agricultural sector.

The Particularities of the Agribusiness Sector in Financial Auditing

The agribusiness sector is characterized by a series of specific challenges that make the application of AI technologies in financial auditing more complex compared to other economic sectors. Agriculture, as an economic activity, involves seasonal production cycles, a high dependency on climatic factors, and significant price volatility in agricultural markets (White & Zhou, 2019). These factors create complex and variable financial flows, which are difficult to standardize and manage using conventional auditing methods.

Moreover, the production and distribution processes within agribusiness involve a multitude of diversified activities, from agricultural production to the processing and commercialization of final products. According to research by Tran et al. (2021), this diversity generates heterogeneous data from various sources, requiring advanced processing technologies to be effectively analyzed. The lack of clear standardization of agricultural data complicates the auditing process and makes it difficult to implement efficient AI solutions.

Another important aspect is the low level of digitalization in many agricultural companies, particularly in small-scale farms. According to Jensen and Baker (2020), this reduced level of digitalization limits the possibilities for automatic collection and processing of financial data, significantly diminishing the effectiveness of AI in financial auditing. Additionally, the lack of adequate technological infrastructure and specialized personnel in using AI technologies poses major barriers to adopting these solutions in agribusiness.

Challenges and Benefits of Using AI in Agribusiness Financial Auditing

The application of AI in financial auditing within agribusiness comes with a range of challenges, but also offers significant benefits. One of the major challenges is the high cost of implementing AI technologies. Jensen and Baker (2020) emphasize that many agricultural companies lack the financial resources necessary to invest in the technological infrastructure required to use AI. This is particularly true for small and medium-sized farms, which face considerable financial and technological limitations.

On the other hand, the potential benefits of AI in financial auditing are substantial. AI can automate repetitive and time-consuming processes, such as data reconciliation and the generation of financial reports, freeing auditors from these tasks and allowing them to focus on value-added activities, such as risk assessment and ensuring compliance. Additionally, AI can identify abnormal patterns in financial data and flag potential irregularities or fraud risks before they become major issues (Lewis & Brown, 2022).

Another major advantage of AI is its ability to conduct real-time financial audits. In agribusiness, where seasonal fluctuations and volatile markets can rapidly alter financial data, the real-time analysis provided by AI can contribute to the prompt detection of problems and the timely implementation of corrective measures (Davis, 2021). Thus, AI can enhance both the efficiency and transparency of audit processes, ensuring compliance with financial standards and legal regulations.

Gaps and Future Directions in the Current Literature

While the literature on AI in financial auditing has advanced significantly in terms of understanding its benefits and challenges, there are still important gaps in research, particularly in the context of the agribusiness sector. Most studies focus on industries such as the banking or retail sectors, where data is more structured and financial flows are more predictable (Davis, 2021). In contrast, research on the application of AI in agribusiness is limited, and adapting AI technologies to the specific needs of this sector requires more attention.

One promising direction for future research is the development of AI algorithms that can manage the complexity and variability of agricultural data. This would allow for a better adaptation of AI technologies to the seasonal and climatic conditions that directly affect the economic activity of farms (Davis, 2021). Additionally, longitudinal studies are needed to evaluate the long-term impact of AI on the financial performance and sustainability of agribusiness companies.

Another underexplored area is the impact of AI implementation on small-scale farms. Tran et al. (2021) suggest that while AI can provide significant benefits to large companies, small farmers may face difficulties in accessing and implementing these technologies due to high costs and lack of technological expertise.

MATERIALS AND METHODS

This chapter describes the methodological approaches used to explore the challenges and opportunities of integrating artificial intelligence (AI) into the financial auditing of companies in the agribusiness sector. A mixed methodology was adopted, combining both quantitative and qualitative methods, to ensure a comprehensive and rigorous evaluation. This includes case studies, a detailed analysis of financial data from the agricultural sector, and semi-structured interviews with experts in AI and auditing. The chosen methodology allows for an in-depth analysis of both the benefits and the obstacles associated with AI implementation in agribusiness.

Case Study

The case study was an essential part of the applied methodology. It focused on analyzing a large company in the agribusiness sector that implemented AI-based solutions in its financial auditing processes. The selection of this method was motivated by the need to understand the complex processes through which AI influences auditing in the agricultural sector. The company selected for the study provided access to detailed financial data, allowing for a comparative evaluation of performance before and after AI integration.

This approach enabled researchers to monitor the impact of AI on critical aspects such as reducing human error in the auditing process, improving the efficiency of account verifications, and quickly identifying financial fraud. The results obtained through this method were essential in understanding the specific context of agribusiness, characterized by the seasonality and volatility of financial data.

Financial Data Analysis in Agribusiness

The financial data analysis method was used to examine in detail the complexity of financial flows in the agricultural sector. Data were collected from secondary sources, including public financial reports, market studies, internal accounting documents, and financial audit reports from representative companies in agribusiness. The analysis included an assessment of the seasonal variability of revenues, fluctuations in operating costs, and other specific factors influencing the financial performance of agricultural companies.

Furthermore, the analysis focused on understanding the challenges generated by the heterogeneous nature of financial data in agribusiness, including the combination of revenues from agricultural production, food processing, and commercial activities. The collected data were used to identify financial patterns and trends that could be optimized through the use of AI in auditing processes.

Interviews with AI and Financial Audit Experts

To gain in-depth insights into the integration of AI into financial auditing, semi-structured interviews were conducted with experts in the field. The interview participants were selected based on their expertise in AI technologies and financial auditing, including representatives from consulting firms, auditing companies, and AI solution developers. The questions addressed focused on two main areas: the technological challenges encountered in the process of implementing AI in auditing and the impact of these technologies on the efficiency of financial processes within agricultural companies.

The interviews were analyzed using thematic coding methods, which allowed the identification of key recurring themes and expert perceptions regarding the potential of AI in agribusiness. This qualitative approach provided a better understanding of the subjective perspectives on AI implementation, reflecting both the difficulties and benefits perceived by professionals in the industry.

Technological Tools Used for Evaluating AI in Auditing

To evaluate the applicability and efficiency of AI solutions in financial auditing within the agricultural sector, a series of advanced technological tools were employed. These were essential for analyzing and simulating the impact of AI on various stages of the financial auditing process.

Data Analysis Software

A central technological tool used in the research was the **Tableau** software, which facilitated the collection and visualization of financial data from agricultural companies. It was used to create interactive dashboards that allowed for real-time visualization of financial trends and the generation of detailed reports. **Tableau** also enabled comparative analysis of data, highlighting differences in financial performance before and after AI implementation.

Power BI was employed to support real-time analysis of financial flows and detect anomalies, contributing to the continuous monitoring of compliance and financial risks. The ability of these software tools to work with large volumes of data was crucial in the agribusiness context, where data are often fragmented and influenced by climatic and seasonal factors.

AI Simulations

AI-based simulations were conducted using platforms such as **Python** and **TensorFlow**, which allowed the testing of machine learning algorithms in auditing processes. The simulations involved using various financial datasets, reflecting the seasonality and volatility typical of the agribusiness sector. The algorithms were trained to detect abnormal patterns and potential fraud, providing a framework for testing the efficiency of AI in the automated auditing of agricultural companies.

Through these simulations, the research evaluated AI's ability to rapidly and accurately identify financial risks and accounting discrepancies, thereby validating the applicability of these technologies in the agricultural sector.

Natural Language Processing (NLP) Techniques

Another important technological tool was **Natural Language Processing (NLP)**, which enabled the automated analysis of unstructured financial documents. This technology was used to extract relevant information from accounting reports, commercial contracts, and invoices associated with agricultural activities. The use of NLP contributed to the automation of data reconciliation processes and improved the efficiency of financial audits, particularly in the agribusiness sector, where financial documents are often large and varied.

These technological tools facilitated an in-depth analysis of financial auditing processes in agribusiness, demonstrating that AI can significantly optimize these processes by reducing the time and resources required, while improving accuracy and efficiency.

RESEARCH RESULT

The research results were obtained through the application of the methods described earlier, highlighting the substantial impact of using artificial intelligence (AI) in the financial auditing of agribusiness entities. The studies demonstrated that AI significantly improves financial auditing processes, although this integration is not without specific challenges in the agricultural sector. These results were derived from the comparative analysis of financial data before and after AI implementation, as well as from interviews with experts.

Results Regarding the Effectiveness of AI in Financial Auditing in Agribusiness

The efficiency of AI in financial auditing was confirmed by several key aspects observed in the case study. The use of AI led to a reduction in audit time by approximately 30%, thanks to the automation of essential processes such as transaction verification and account reconciliation. This result reflects AI's ability to simplify and accelerate complex tasks, allowing auditors to focus on strategic aspects of the audit, such as risk assessment and quality control.

Moreover, AI demonstrated superior capabilities in detecting financial anomalies and potential fraud. Machine learning algorithms analyzed large volumes of data and identified unusual patterns in financial transactions, enabling the discovery of significant accounting errors that would have been overlooked in a traditional audit. This performance is particularly relevant for the agribusiness sector, where the seasonality and volatility of financial data complicate the manual audit process.

The use of Natural Language Processing (NLP) simplified the analysis of unstructured financial documents, such as accounting reports, commercial contracts, and invoices. AI enabled the automatic extraction of critical information and its comparison with accounting data, significantly reducing the manual verification workload.

Identification of the Main Technological, Organizational, and Ethical Challenges

In addition to the clear benefits identified, the research revealed a series of significant challenges that impact the implementation of AI in the financial auditing of agricultural companies.

Technological challenges were predominant, especially due to the unique characteristics of the agricultural sector. AI algorithms encountered difficulties in processing variable and seasonal financial data, characteristics specific to agribusiness. The seasonality of production and fluctuations in the agricultural market complicated the training of AI algorithms, as the data models are neither constant nor predictable.

Organizational challenges included employee resistance to change as well as the lack of adequate technological infrastructure in many agricultural companies. The integration of AI required significant investments, not only in infrastructure but also in staff training. This was a significant barrier for small and medium-sized agribusinesses, which face limited resources in terms of both capital and technological expertise.

Ethical challenges were primarily related to the protection and confidentiality of financial data. In the context of collaboration with various external partners, data confidentiality became a sensitive issue, especially considering strict data protection regulations such as GDPR. The use of AI raised questions about how sensitive data are processed and secured, particularly in the context of automated auditing.

Concrete Data and Examples Demonstrating the Impact of AI on Audit Processes

The research provided concrete examples that demonstrate the tangible impact of using AI on the efficiency and quality of audit processes in agribusiness.

Example 1: In a large agricultural company, AI was used to analyze financial flows from the past five agricultural seasons. AI algorithms identified a revenue reporting error in one of the seasons, which had been missed by traditional auditors. Correcting this error had a significant impact on the company's tax compliance.

Example 2: Another company in the sector used NLP technology to automatically analyze hundreds of commercial contracts and invoices. AI accelerated the verification process, reducing audit time by 40%, thereby allowing resources to be reallocated more efficiently to other strategic activities.

Example 3: The implementation of AI reduced the risk of fraud by approximately 25%, as AI continuously monitors financial transactions, detecting suspicious patterns in real-time and notifying auditors of potential irregularities. This contributed to increased trust in the financial data reported by agricultural companies, enhancing their reputation with investors.

RESULTS AND DISCUSSION

The research results highlight both the significant benefits and the major challenges associated with the use of artificial intelligence (AI) in financial auditing within the agribusiness sector. This chapter analyzes the implications of these findings in the context of existing literature and provides a critical perspective on how AI may shape the future of auditing in this complex sector. Furthermore, the technological, organizational, and ethical aspects identified during the research are discussed.

Interpretation of Results in the Context of Existing Literature

The results obtained in this study are consistent with trends observed in the literature, which indicate that AI can fundamentally transform financial auditing processes. According to the studies of Brown and Saunders (2015) and Jones and Smith (2020), AI automates repetitive tasks such as transaction verification and account reconciliation, contributing to the reduction of audit time. This aspect was confirmed by the current research, which showed that AI reduced audit time by up to 30%, allowing auditors to focus on risk assessment and strategic decision-making.

However, our study makes a crucial contribution to understanding the specific challenges of the agribusiness sector, which are less explored in the existing literature. Technological challenges, such as the difficulty of managing seasonal and variable financial data, were identified as a major obstacle to AI implementation in this sector. Unlike industries such as banking or retail, where financial flows are better structured and predictable, the agricultural sector faces variability caused by external factors such as weather conditions and market fluctuations, which complicates the training and application of AI algorithms (Davis, 2021).

Implications for the Agribusiness Sector and Financial Audit Professionals

The integration of AI into financial auditing in agribusiness could have profound implications for the management of agricultural companies and for financial audit professionals. For companies in the agricultural sector, AI can bring significant benefits by improving operational efficiency, reducing errors, and increasing the transparency of financial processes. AI's ability to analyze large volumes of data and detect financial anomalies in real time gives companies a competitive advantage, enabling financial decision-making in conditions of economic uncertainty and market volatility.

At the same time, the use of AI in financial auditing requires significant changes for audit professionals. This necessitates the development of new skills, particularly in the use and interpretation of AI algorithms. Auditors must be able to understand how AI processes data and integrate this information into their final evaluations. Moreover, AI can transform the role of the auditor from a manual verifier to a strategic consultant, capable of offering broader insights into the financial health of companies based on data analysis provided by AI.

However, to reap these benefits, agribusiness companies will need to make considerable investments in technological infrastructure and personnel training. This can pose a significant challenge for small and medium-sized farms, which have limited resources for such investments. Furthermore, resistance to change, both at the organizational and individual levels, may slow down the adoption of AI in the agribusiness sector.

Aspects Related to Costs, Adaptation, and Personnel Training

The implementation of AI in financial auditing comes with significant costs, which include not only investments in technology but also costs related to training and personnel adaptation. Agricultural companies, especially small and medium-sized ones, face difficulties in allocating the necessary resources to acquire advanced technologies and modernize their digital infrastructure. For these companies, integrating AI may seem like a prohibitive investment, although long-term benefits can justify the initial efforts.

Another essential aspect is the training of personnel. The efficient use of AI depends heavily on the ability of staff to understand and use these technologies correctly. Continuous training is essential to ensure that auditors and financial teams can use AI algorithms to optimize audit processes and achieve relevant results. Without adequate training, the risk of underutilizing AI's potential is significant, which could diminish the impact of this technology on auditing processes.

Moreover, companies must be prepared to adapt their organizational structures to integrate AI efficiently. This does not only involve acquiring the technology but also a cultural and organizational shift that supports the use of AI in daily activities. The long-term success of AI implementation will largely depend on the ability of companies to adopt a strategic approach, aligning new technologies with their economic and financial goals.

CONCLUSIONS

The final chapter synthesizes the main findings of the research and offers strategic recommendations for the efficient implementation of artificial intelligence (AI) in the financial auditing of agribusiness companies. Additionally, potential directions for future research are identified, which could expand the understanding of AI technologies' impact in this complex sector.

Summary of the Main Findings

This research has demonstrated that the integration of AI into financial auditing in agribusiness can bring substantial improvements in terms of operational efficiency, accuracy, and the capacity to detect financial risks. The results show that AI can reduce the time required for audits by up to 30%, due to the automation of verification processes and data reconciliation. Additionally, AI algorithms have proven effective in identifying anomalies and discrepancies in financial transactions, contributing to the prevention of fraud and the reduction of operational risks.

However, the research has also identified significant challenges related to AI implementation in the agribusiness sector, particularly due to the seasonality and variability of financial data. These technological challenges were amplified by the lack of adequate digital infrastructure and the difficulties faced by small and medium-sized companies in adopting new technologies. Furthermore, ethical aspects related to data confidentiality and security were identified as important challenges that need to be addressed with seriousness.

Recommendations for the Efficient Implementation of AI in the Financial Auditing of Agribusiness Companies

To ensure the efficient implementation of AI in the financial auditing of agribusiness companies, it is essential that these entities adopt a strategic and gradual approach, taking into account the specific challenges of this sector. Based on the research findings, the following recommendations are essential:

1. **Investments in Digital Infrastructure**: Companies must allocate resources to modernize their digital infrastructure and implement information systems that allow for the efficient collection and management of financial data. A robust infrastructure is the foundation for the successful implementation of AI.
2. **Continuous Training of Personnel**: The success of AI implementation depends largely on the skills and abilities of the personnel. It is essential for auditors and financial managers to benefit from continuous training programs, enabling them to use and correctly interpret the data generated by AI algorithms.
3. **Gradual Adoption of AI**: It is advisable to implement AI gradually, starting with repetitive and time-consuming tasks, such as document verification and account reconciliation. A phased implementation reduces the risk of malfunctions and allows personnel to adapt to the new technologies.
4. **Compliance with Data Protection Regulations**: In the context of AI implementation, companies must ensure compliance with strict regulations regarding data confidentiality and security. The use of AI technologies in financial data processing involves a high risk of violating GDPR norms, requiring additional security and control measures.

Possible Directions for Future Research

This research has opened the way to a series of questions and areas that require further exploration. Among the promising directions for future research are:

1. **Adapting AI Algorithms to the Unique Characteristics of Agribusiness**: Given that seasonality and variability in financial data are major challenges, future research should focus on developing specific

algorithms capable of managing these variables and providing accurate results in volatile conditions.

2. **Longitudinal Studies on the Impact of AI in Agribusiness**: Longitudinal research is necessary to evaluate the long-term impact of AI implementation on the financial and operational performance of companies in the agribusiness sector. These studies could provide a detailed perspective on the evolution of efficiency and economic sustainability generated by the use of AI.
3. **Evaluating the Impact of AI on Small Farms**: Another important direction for research would be evaluating the impact of AI on small farms, which face limited financial resources and difficulties in adopting new technologies. Future research should explore accessible and efficient methods through which AI can be implemented even in small-scale farms, thus contributing to an inclusive digital transformation.
4. **Integrating AI with Other Emerging Technologies**: Another interesting direction would be researching how AI can be integrated with other emerging technologies, such as blockchain or the Internet of Things (IoT), to provide complete and efficient solutions for financial management and risk management in agribusiness.

REFERENCES

Brown T., & Saunders A., 2015 - *The Future of Auditing: Integrating Artificial Intelligence into Financial Audits*. Journal of Financial Auditing, 22(3), 45-60.

Jones R., & Smith M., 2020 - *Artificial Intelligence and the Transformation of Financial Audits: A Global Perspective*. International Journal of Auditing and Accountability, 35(2), 115-130.

Lewis K., & Brown J., 2022 - *Ethical Challenges in AI-Based Auditing: A Comprehensive Review*. Journal of Business Ethics, 78(4), 415-432.

Davis M., 2021 - *Artificial Intelligence in Financial Auditing: An Overview of Current Trends and Challenges*. Technology in Finance Review, 40(1), 78-94.

Popescu M., & Ionescu A., 2020 - *The Implementation of Artificial Intelligence in Financial Auditing in Romanian Agribusiness: A Critical Assessment*. Romanian Journal of Agricultural Economics, 15(2), 95-108.

Zamfir D., & Cojocaru V., 2019 - *Challenges of Digital Agriculture: Integrating AI Technologies in Financial Management Systems*. Agribusiness and Technology Journal, 10(3), 124-139.

Tran P., White D., & Zhou M., 2021 - *Data Variability in Agribusiness and the Role of AI in Financial Auditing*. International Journal of Agribusiness Technology, 17(2), 203-218.

Georgescu I., & Barbu S., 2020 - *Financial Auditing in Agribusiness: Digital Transformations and Challenges in Romania*. Audit and Financial Control in Agricultural Economics, 12(1), 56-72

Jensen P., & Baker T., 2020 - *Implementing AI in Financial Audits: A Cost-Benefit Analysis*. Global Finance Review, 23(4), 345-362.

Vasile C., & Drăgulescu L., 2018 - *Digital Solutions for Financial Auditing in Romanian Agriculture*. Management and Innovation in Agricultural Economics, 14(4), 88-101.

Oprea C., & Munteanu M., 2019 - *Ethical and Organizational Aspects in Implementing Artificial Intelligence in Auditing*. *Financial Audit Research Journal*, 29(3), 101-120.

Pretty J., 2020 - *Sustainable Agriculture and the Role of AI in Reducing Financial Risks*. Philosophical Transactions of the Royal Society B, 375(1817), 204-217.

SUSTAINABLE AND RESILIENT FARMING SYSTEMS IN THE EUROPEAN UNION

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Abstract

Farming systems in Europe face a variety of environmental, economic, social and institutional challenges, such as volatile producer prices, extreme weather events, dependence on landowners and financial institutions, organizational changes in value chains, competing policy objectives and changing consumer preferences. Resilience theory provides an integrated framework to analyze the capacity of social-ecological systems to cope with these changes, and resilience is defined as the maintenance of essential functions of farming systems in the face of increasingly complex economic, social and environmental challenges, thus farming systems include interactions between farms, technologies, stakeholders, consumers, decision makers and the environment, and vulnerabilities such as intergenerational transfer and declining attractiveness of farming affect the demographic stability of rural areas. The paper explores the resilience of farming systems in the European Union in the face of growing economic, social, environmental and institutional challenges. The study identifies a wide range of risks to EU farming systems, from extreme weather events and price volatility to demographic and institutional changes, thus through dynamic scenarios, it provides a picture of the possible future of European agriculture, taking into account socio-economic, environmental and technological developments. The scenarios developed are used to test resilience strategies at the level of farming systems and to make recommendations for the Common Agricultural Policy and governance to support the long-term resilience of these systems.

Key words: farming systems, sustainability, resilience, adaptability, efficiency

INTRODUCTION

The concept of resilience for farming systems is based on their ability to adapt and transform to cope with external challenges, thus farming systems are exposed to risks from multiple domains including economic, environmental, social and institutional. In the face of these risks, systems go through different stages, known as adaptive cycles (Andersen E., 2017).

Adaptive cycles include phases of growth, equilibrium, collapse and reorientation, thus in the growth phase, the agricultural system grows and expands, in the equilibrium phase, it reaches stabilization after having gone through the previous phases (De Kraker J., 2017). However, under certain circumstances, the system may collapse due to major disturbances, and after a collapse, the system may go through a reorientation stage, where it restructures itself to cope with new conditions (Cabell J.F. and Oelofse M., 2012).

These adaptive cycles are influenced by interlinked processes, these include governance, which refers to the role of institutions and policies, farm demography, i.e. changes in the farm population, and agricultural production, which is the process by which agricultural products are produced (Andersen E. *et al*, 2007).

To survive and thrive, agricultural systems must maintain their essential functions, which include private goods, which provide individual benefits, and public goods, which provide benefits to society as a whole, such as environmental protection and biodiversity conservation (Fath B.D. *et al*, 2015).

Research examining the resilience of farming systems mainly focuses on agricultural production processes (Urruty N. *et al*, 2016) and generally shows that different systems are better able to cope with variability (Mathijs E., 2018). However, in practice, changes in technology, markets and policies have led to larger and more specialized farms (Andersen E., 2017; Bullock J.M. *et al*, 2017). Thus, to fully understand developments in agriculture, it is necessary to consider several simultaneous processes. In this context, we highlight three key processes of the adaptive cycle that are central to farming systems

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in the EU: agricultural production processes, farm demographics and governance.

Agricultural production is the set of agricultural and multifunctional activities carried out by farms, leading to the provision of public and private goods. These goods include food and fiber, but also regulatory services, such as climate change mitigation and provision of clean water, as well as cultural services, such as landscape creation and maintenance (Binder C.R. *et al*, 2010).

Farm demography refers to the labor force required to operate agricultural systems, including both farm populations and hired labor.

Governance is defined as the process of organizing and leading society, which is based on a mix of economic, communication and regulatory mechanisms, all aimed at achieving collective goals (Darnhofer I., 2010). Thus, governance includes elements of the Common Agricultural Policy (CAP) and its national implementations, as well as public and private regulations that influence agricultural production chains and risk management strategies in the agricultural sector. Other processes such as infrastructure and local culture, which affect the performance of farming systems, are integrated as features of the farming system.

MATERIAL AND METHOD

In this study, a farm's resilience is defined as its ability to maintain essential functions, such as the provision of private and public goods, in the face of increasingly complex economic, social, environmental and institutional shocks and pressures. This capacity is based on three essential elements: robustness, adaptability and transformability (Darnhofer I., 2010). Although other external actors such as local government, NGOs and banks play a role in ensuring the essential functions of agriculture. Thus robustness is the ability of the farm to cope with shocks and stresses (predictable or unpredictable), adaptability refers to the ability to adjust inputs, production, marketing strategy and risk management to respond to shocks and pressures without changing the fundamental structures of the farm, and transformability is the ability to radically change the structure and internal mechanisms of the farm in the face of severe shocks or persistent pressures that make it impossible to continue activities in their current form. Based on these we assess the attributes that underpin resilience, following five general principles proposed by the Resilience Alliance (Folke C. *et al*, 2010): i) diversity, ii) modularity, iii) openness, iv) robust feedbacks and v) system buffers. Diversity, both functional and response diversity, tends to support system resilience, while modularity involves the division of the system into independent but interconnected units that may have different functions. Openness refers to the connectivity of systems to each other. Robust feedbacks allow parts of a system to react quickly to changes in other parts. System buffers, such as stocks of natural, economic, and social capital, provide redundancy and function as a form of „insurance" that allows the system to cope with losses or failures (Cumming G.S., Peterson G.D., 2017). These principles provide a framework for understanding how agricultural systems can become more resilient and better prepared to cope with the complex and changing challenges in the current environment.

RESULTS AND DISCUSSIONS

Resilience of farming systems is a key concept in the current context of climate change, population growth and increasing pressure on natural resources. It refers to the ability of these systems to cope with and adapt to various risks and disturbances while maintaining essential functions such as food production and environmental protection. Agricultural systems face multiple challenges, including economic, environmental, social and institutional risks, which can take the form of sudden shocks or long-term pressures. In this context, assessing the resilience of an agricultural system involves analyzing its capacity to withstand, adapt and transform when necessary (Figure 1).

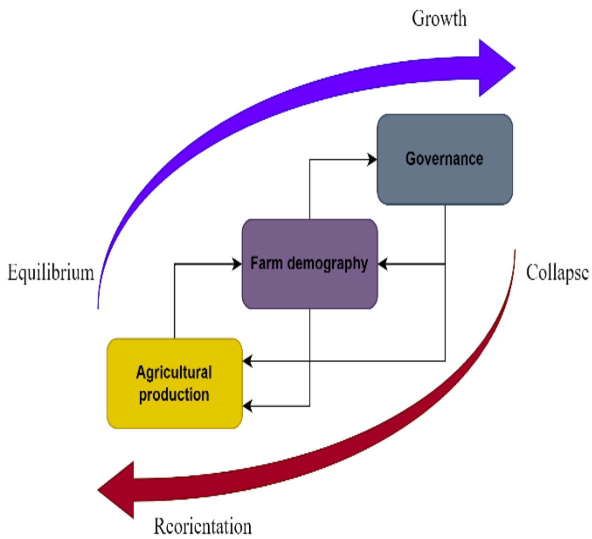

Figure 1 **The concept of resilience for farming systems**

To analyze the diversity of challenges facing farming systems, they can be classified into four main categories: economic, environmental, social and institutional risks (Giller K.E., 2013). There are also two ways in which these challenges can affect farming systems: either as sudden shocks or as long-term pressures accompanied by uncertainty (Figure 2).

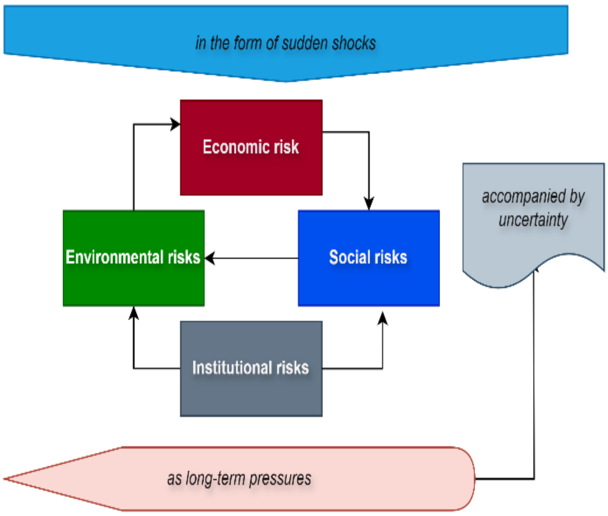

Figure 2 **Challenges facing farming systems**

Adapting the concepts proposed by Quinlan A.E. *et al*, (2016), a shock is defined as „a rapid and unexpected change in the risk environment of an agricultural system that affects part or all of the system in the short term, with negative effects on people's well-being, production levels, livelihoods or ability to cope with future shocks." Examples of shocks include price crashes (economic risk), extreme weather events (environmental risk), rapid social change at the farm level such as loss of social capital due to illness, divorce or conflicts over property or inheritance (social risk) and geopolitical crises such as embargoes (institutional risk).

Long-term pressures, on the other hand, refer to factors that slowly change the context of an agricultural system, leading to new uncertainties, e.g. reduced access to finance (economic risk), hydro-geological disturbances (environmental risk), demographic changes such as rural out-migration (social risk) and changes in public policy directions (institutional risk).

Impact studies often tend to focus on long-term pressures, such as the effects of climate change (Andersen E., 2017), while shocks can have more devastating short-term effects, such as extreme weather events (Giller K.E., 2013). Although the distinction between shocks and long-term pressures is somewhat arbitrary, this categorization can be used as a useful assessment tool, thus the main challenges are highlighted in Table 1.

Table 1

Main challenges for farming systems

Challenges	Shocks	Long-term pressures
Environmental challenges	Extreme weather events: droughts, excessive rainfall, hail, frosts, floods. Outbreaks of diseases, pests or weeds (epidemics). Food or feed security crises.	Reduced soil fertility (soil mineralization, nutrient depletion). Deforestation. Heavy metal pollution. Hydrogeological changes. Species decline, including pollinators. Antimicrobial resistance. Changes in nutrient cycling (e.g. phosphorus and nitrate cycling).
Economic challenges	Sharp falls in agricultural commodity prices. Input price volatility. Market access crises (e.g. Russian embargo or Brexit).	Reduced access to bank finance. Rising costs of hired labor. Increased competition in international markets. Reallocation of infrastructure (transportation, information technology). Increased start-up costs for new agribusiness. 'Bottleneck' situation due to resource fixity.
Social challenges	Sudden media attention on a food or safety crisis. Rapid social change on the farm, such as illness, death or divorce. Insufficient seasonal labor availability.	Rural migration, emigration and ageing rural population. Reduced access to social services (health, education). Demographic changes (urbanization, rural population decline). Changes in household structure and labor markets. Increasing gender gaps in agricultural labor. Changing consumer preferences (demand for local, organic products). Public distrust of industrial agriculture.
Institutional challenges	Sudden changes in access to international markets (e.g. embargoes). Rapid changes in food safety regulations and export markets.	Sudden changes in access to international markets (e.g. embargoes). Rapid changes in food safety regulations and export markets.

These challenges highlight the varied impact that external factors have on agriculture and provide a basis for developing resilience strategies in the face of risks and uncertainties. Thus the functions that an agricultural system performs may vary according to its geographical location (e.g. near a city or in a remote area). In addition, different institutional frameworks for sustainable development promote different principles, although a general consensus remains the Brundtland Report (1987), which defines sustainable development as „development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland G., 1987). This concept is important in agricultural systems to understand the range of „essential functions". To maintain their functionality, agricultural systems need to provide two types of essential functions: the production of private goods and public goods (Figure 3). Private goods, such as agricultural products, benefit individuals, while public goods, such as maintaining biodiversity and protecting the environment, benefit the whole community. Thus the sustainability of farming systems depends on their ability to balance these essential functions in the face of risks and change.

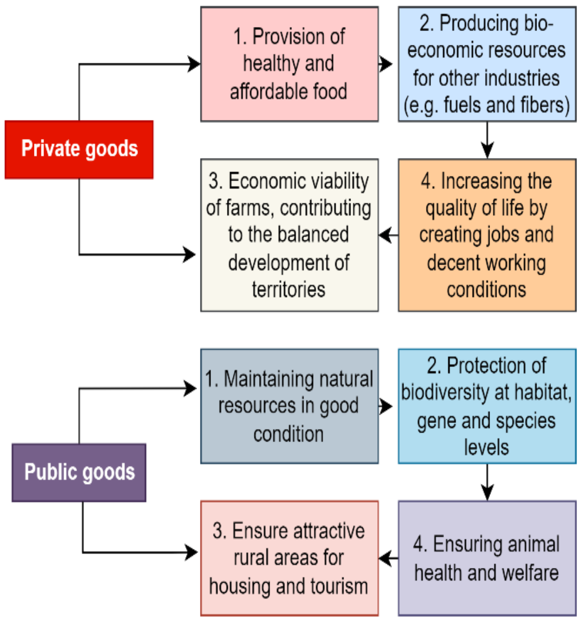

Figure 3 **Essential functions of farming systems**

These functions are defined at the farming system level, not at the individual farm level, which means that the objective is not primarily the preservation of individual farms. Although there are synergies between the provision of different functions of a farming system, not all of them are mutually supportive. Conflicts can arise between social, economic and environmental objectives, leading to trade-offs. The degree of interdependence between these functions varies according to the specificity of each farming system.

Each farming system has a level of sustainability that is linked to its specific functions and interactions within the system. For assessing the performance of an agricultural system in providing essential functions, various indicator frameworks exist (Andersen E. *et al*, 2007; Binder C.R. *et al*, 2010; Urruty N. *et al*, 2016).

The selection of indicators for assessing the performance of an agricultural system in providing essential functions is done in two steps:

1. Identification and prioritization of functions related to the provision of private and public goods.

2. Associating the functions with relevant indicators, which are specific to each agricultural system and the function they fulfill.

To select the relevant indicators, three principles can be applied:

1. The type of challenge affecting the agricultural system: different challenges can have a short- or long-term impact, and the indicators need to be tailored to measure these effects. For example, in the case of shocks such as extreme weather events, an indicator such as productivity (t/ha) would be appropriate. In contrast, for long-term pressures such as climate change, indicators such as soil erosion or water quality might be more appropriate.

2. Use of resources (human, natural and economic): each agricultural system uses different resources, and these can be assessed through specific indicators. For example, for large-scale agricultural production in the East of England, the key resources might be labor, land and technology. Indicators could include landscape maintenance (for rural attractiveness), water and soil quality (for conservation of natural resources) and percentage of land owned (as an indicator of economic viability).

3. Efficiency of agricultural system outputs: for arable crops, efficiency indicators for resilience could be the number of jobs created (quality of life), populations of key animal and plant species (biodiversity) and economic indicators such as farm liquidity and profitability.

The key functions of an agricultural system may change over time and vary according to the context. Some functions may also be taken over by other systems, depending on the interactions and specificities of each farming system.

Assessing the resilience of an agricultural system or subsystem involves a complex approach, as the stages of robustness, adaptability and transformability cannot be categorized simply (Urruty N. *et al*, 2016). An effective way to start the analysis is to explore the following elements:

1. The dynamics of the essential functions (robustness) of an agricultural system refers to its ability to maintain its essential functions, such as the production of private goods (e.g. food) and public goods (e.g. environmental protection), in the

face of disturbances. Robustness assessment focuses on how the system withstands shocks and how it recovers from disturbances

2. The relationship between risks and responses (adaptability) is the capacity of an agricultural system to respond and adjust to risks, which may be economic, environmental, social or institutional. This includes responses to sudden shocks (e.g. extreme weather events) and long-term pressures (e.g. climate change), involving adjustments in farming practices and policies.

3. Tipping points and transformation (transformability) describes the ability of an agricultural system to make fundamental changes when necessary, especially when it reaches critical points. These tipping points may force the system to transform and adapt to new conditions or evolve into a new structure in order to remain viable in the long term.

Resilience attributes play a key role in enhancing the capacity of farming systems to cope with challenges and contribute directly to improving resilience indicators. These attributes influence, for example, the rate of recovery after a shock, the diversity of responses available within a safe operating space, or the speed with which a system can transform after a collapse

Cabell and Oelofse (2012) identified 13 general attributes that support agroecosystem resilience, namely:

1. Self-organizing networks (farmers, consumers and cooperating communities).

2. Ecological self-regulation (farmers maintaining vegetation and using perennials).

3. Appropriate connectivity (polyculture and collaboration between value chain actors).

4. Functional and response diversity (heterogeneous landscapes and diverse farms).

5. Optimal redundancy (growing multiple varieties and recycling nutrients from different sources).

6. Spatial and temporal diversity (mosaics of differently managed land and varied farming practices).

7. Exposure to disturbance (pest management and positive selection).

8. Use of local natural capital (minimizing the need for imports and reducing waste exports).

9. Reflective and shared learning (record keeping and knowledge sharing between farmers).

10. Global self-reliance and local interdependence (reducing dependence on global markets and increasing local collaboration).

11. Respecting heritage (integrating traditional knowledge into modern practices).

12. Building human capital (investment in education and support for social events).

13. Reasonable profitability (farmers and laborers earn a decent income and agriculture is not overly dependent on market-distorting subsidies).

Attributes become more complex and intense when we refer to transformability versus robustness, e.g. learning is an important attribute for building resilience. Depending on the phases of the adaptive cycle, learning can range from incremental innovation („single-loop learning”) in periods of growth, to radical innovation in the face of crises („double-loop learning”) and transformation to new farming practices („three-loop learning”). Another example is related to the organization of agricultural production, here attributes may include resources for sustainable production, diversity of farms and technologies, as well as biodiversity and resource redundancy at the regional level, thus diversity and redundancy contribute to diverse and stable ecosystem services. In addition, social networks are essential for collaboration and innovation, they can support the exchange of resources between farmers and government institutions, as well as experimentation with new processes and entering new markets.

Finally, governance plays a major role in facilitating resilience, this can include financial support for farmers, access to credit and subsidies, knowledge management through dialog between formal and informal institutions, and regulatory flexibility to allow innovation and adaptation to new circumstances.

CONCLUSIONS

Farming systems are characterized by high complexity, reflected in the interaction between institutions and the agro-ecological context. Previous resilience analysis frameworks have not fully captured this complexity, and many of them have not clearly distinguished between different types of resilience, thus reducing the range of solutions available to improve resilience. In this study, we identify three main processes of adaptive cycles relevant to agricultural systems: agricultural, demographic and governance processes. We develop a framework that is based on three types of resilience: robustness, adaptability and transformability.

Exploring resilience starts with defining the spatial, functional and temporal boundaries of the system, e.g. risks and key functions vary according to the perspectives of different stakeholders and recent events, which emphasizes the need for clarity in defining the spatial, functional and temporal boundaries of the system under study.

Another challenge is to identify meaningful indicators that reflect the performance of key functions over the long term. The use of simple indicators may omit the complexity of farming systems, which may require the adoption of composite indicators or the analysis of several indicators simultaneously.

Another aspect to consider is the risk that the attributes mentioned are taken for granted without yet being empirically verified, although attribute diversity has frequently been associated with resilience to climate variability and change, this is not true in all cases. Resilience to climate change does not automatically imply resilience to technological change, thus the attributes proposed in this framework are useful for prototyping, but require further clarification and evidence in different contexts. This clarification is, however, a major challenge, as most of these attributes (especially those related to adaptability and transformability) are slow changing variables. Learning about these slow variables can take a long time, with the risk of ignoring important processes or paying attention to wrong assumptions.

ACKNOWLEGMENTS

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REFERENCES

Andersen E., 2017 - *The farming system component of European agricultural landscapes*. Eur. J. Agron.82, 282–291.

Andersen E., Elbersen B., Godeschalk F., Verhoog D., 2007 - *Farm management indicators and farm typologies as a basis for assessments in a changing policy environment*. J. Environ. Manage. 82, 353-362.

Binder C.R., Feola G., Steinberger J.K., 2010 - *Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture*. Environ. Impact Assess. Rev. 30, 71–81. available on-line at: doi:10.1016/j.eiar.2009.06.002

Brundtland G., 1987 - *Our Common Future: The World Commission on Environment and Development.* Oxford University Press, Oxford.

Bullock J.M., Dhanjal-Adams K.L., Milne A., Oliver T.H., Todman L.C., Whitmore A.P., Pywell R.F., 2017 - *Resilience and food security: rethinking an ecological concept.* Journal of Ecology, 105(4), 880-884.

Cabell J.F., Oelofse M., 2012 - *An indicator framework for assessing agroecosystem resilience*. Ecology and Society 17(1),

Cumming G.S., Peterson G.D., 2017 - *Unifying Research on Social–Ecological Resilience and Collapse.* Trends in Ecology & Evolution, 32(9), 695-713.

Darnhofer I., 2010 - *Strategies of family farms to strengthen their resilience*. Environmental policy and governance, 20(4), 212-222.

De Kraker J., 2017 - *Social learning for resilience in social-ecological systems*. Current Opinion in Environmental Sustainability, 28, 100- *107.*

Fath B.D., Dean C.A., Katzmair H., 2015 - *Navigating the adaptive cycle: an approach to managing the resilience of social systems*. Ecology and Society 20(2), 24.

Folke C., Carpenter S.R., Walker B., Scheffer M., Chapin T., Rockström J., 2010 - *Resilience thinking: integrating resilience, adaptability and transformability*. Ecology and Society, 15(4), 20.

Giller K.E., 2013 - *Guest Editorial: Can we define the term 'farming systems'? A question of scale.* Outlook on Agriculture, 42(3), 149- 153.

Mathijs E., 2018 - *Reconnecting institutions for the resilience of bio-based production systems.* Working document WUR.

Quinlan A.E., Berbés-Blázquez M., Haider L.J., Peterson G.D., 2016 - *Measuring and assessing resilience: broadening understanding through multiple disciplinary perspectives.* Journal of Applied Ecology, 53(3), 677-687.

Urruty N., Tailliez-Lefebvre D., Huyghe C., 2016 - *Stability, robustness, vulnerability and resilience of agricultural systems. A review.* Agronomy for sustainable development, 36(1).

IS THERE A REINVENTED TEACHER? NEW EDUCATIONAL PARADIGMS

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Abstract

The current paper aims to explore and analyze the challenges of today's teacher in preparing tomorrow's youth through the new paradigms of education and the impact of technologies, because we are dealing with future digital natives and teachers known as digital immigrants. We will focus on the education process but also on the product delivered for the labor market in the context of digital era. It is true that many professors have had to adapt rapidly, some of them for their own motivation, others for circumstances, but there are also many who still have a certain fear of digital technologies (hardware or software) and this is challenging for many reasons. It is not only enough the desire to implement it, but to know how to do it the right way and adapt it so that it turns out to be really functional and beneficial for students. There are many new roles that are assigned to the teacher in these new educational paradigms generated by ICT (informational and communication technologies). Teachers must stop being less police officers or/and simple information providers but become organizers, guides, generators, companions, coaches, learning managers, counselors, facilitators. In the context of a reinvented teacher with information at one click away, new paradigms have to appear, planning educational strategies inside or outside the classrooms. In the end, this paper will emphasize the role of current paradigms in shaping educational policies, understanding the close connection between them.

Key words: (digital age, educational paradigms, teachers' roles, AI tools;)

INTRODUCTION

In recent years, artificial intelligence has made remarkable advancements in various fields, from healthcare to finance, and education is no exception. AI technologies, such as machine learning algorithms and natural language processing, are being increasingly integrated into educational settings to enhance teaching and learning experiences. As AI becomes more prevalent in education, it is essential to examine how these technologies are redefining the traditional role of teachers and shaping new paradigms in education (Perrotta and Selwyn, 2019).

The rise of digital tools, online resources, and innovative teaching methods has significantly transformed the role of teachers in the classroom (Keane *et al*, 2023); (Jones *et al*, 2020). While technology has provided numerous benefits, it has also presented challenges, ultimately reshaping how educators interact with students, deliver content, and assess learning outcomes (Redecker, 2017); (Selwyn, 2020). As educators navigate this rapidly changing landscape, new paradigms are emerging that challenge traditional notions of teaching (Bondie *et al*, 2021) and redefine the roles of teachers in the classroom. The new roles of teachers in the context of evolving educational paradigms, including the integration of technology and artificial intelligence, encompass a range of responsibilities beyond traditional instructional delivery. (Kimmons and Veletsianos, 2021; Zhao, 2022).

MATERIAL AND METHOD

A systematic review of scientific literature was conducted in two phases. The initial phase involved a broad exploration of the PubMed and Google Scholar databases to assess the feasibility of the topic, guided by the following research questions: How can we identify the new roles of teachers in context of the digital age? What new tasks appear for teachers? In addition, are there any new paradigms related to this updated status of teacher? In the second phase, further searches were performed using the EBSCO, ScienceDirect, and Scopus databases, employing the keywords: digital age in education, revised status for teachers, updated educational framework.

RESULTS AND DISCUSSIONS

One of the central aspects of the changing educational landscape is the evolving role of teachers. In the past, teachers were primarily seen as knowledge providers and facilitators of learning. However, with the advent of AI technologies, teachers are now taking on new roles as learning designers, mentors, and facilitators of personalized

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learning experiences. The integration of AI in education has shifted the focus towards student-centered learning approaches, where teachers play a crucial role in guiding and supporting students as they navigate complex learning environments.

One of the most profound effects of technology on teaching is the diversification of instructional methods. Traditional lectures have been supplemented or even replaced by interactive platforms, multimedia presentations, and online discussions. Teachers can now create engaging learning environments that cater to different learning styles. For instance, tools like video conferencing and educational apps allow for real-time collaboration, enabling teachers to facilitate group work and discussions beyond the confines of the classroom. This shift empowers educators to adopt a more student-centered approach, where they act as facilitators of learning rather than mere transmitters of information.

Technology has democratized access to information. Teachers now have a wealth of resources at their fingertips, allowing them to enhance their curriculum and provide students with up-to-date content. Online databases, educational websites, and digital libraries offer a plethora of materials that can enrich lessons and foster critical thinking. Moreover, the availability of open educational resources (OER) enables teachers to share and adapt high-quality materials for their specific teaching contexts. This access not only enhances the learning experience but also encourages teachers to continuously evolve their pedagogical strategies.

Another significant impact of technology is the ability to collect and analyze data on student performance. Learning management systems (LMS) and assessment tools provide educators with valuable insights into students' strengths and weaknesses. This data-driven approach allows teachers to tailor their instruction to meet individual needs, providing targeted support where necessary. By identifying learning gaps, educators can intervene promptly, ensuring that all students have the opportunity to succeed. Consequently, teachers are increasingly taking on the role of data analysts, using technology to inform their teaching practices and improve educational outcomes.

Despite the numerous advantages, the integration of technology in education also poses challenges. Teachers must continually adapt to new tools and platforms, which can be overwhelming, especially for those who may not be tech-savvy. Professional development and training are crucial in helping educators feel comfortable with these technologies. Additionally, the digital divide—where some students lack access to technology—remains a significant concern. Teachers must navigate these disparities to ensure equitable learning opportunities for all students.

The new roles of teachers in the context of evolving educational paradigms, including the integration of technology and artificial intelligence, encompass a range of responsibilities beyond traditional instructional delivery. Some of the new roles of teachers include:

1. Facilitator of Learning: Teachers now serve as facilitators of learning, guiding students through personalized learning pathways and providing support as students engage with digital resources and tools.
2. Curator of Educational Content: Teachers curate and create educational content to meet the diverse learning needs of students, leveraging technology to access and organize a wide range of resources (Selwyn, 2020).
3. Data Analyst: Teachers analyze student data generated by educational technologies to track progress, identify learning gaps, and tailor instruction to meet individual student needs.
4. Technological Integrator: Teachers integrate technology tools and platforms into their teaching practices to enhance student engagement, collaboration, and learning outcomes (Harris *et al*, 2022).
5. Mentor and Coach: Teachers act as mentors and coaches, providing guidance, feedback, and support to students as they navigate complex learning environments and develop 21st-century skills.

In order to cover all these positions, teacher training is a critical aspect of education that directly impacts the quality of instruction and student learning outcomes. In the future, teacher training is likely to undergo significant transformations to address the evolving needs of educators and students in the 21st century. Some perspectives on the teacher training might refer to:

1. Shift towards Continuous Professional Development: In the future, teacher training is expected to move away from traditional one-time workshops or courses towards a model of continuous professional development. Educators will need ongoing support, mentoring, and opportunities for reflective practice to enhance their teaching skills, stay abreast of the latest research and pedagogical approaches, and adapt to changing educational trends (Darling-Hammond, 2020).
2. Integration of Technology: With the increasing integration of technology in education, future teacher training programs are likely to focus on equipping educators with the digital skills and

knowledge needed to effectively integrate technology into their teaching practices. This includes training on using educational apps, online resources, learning management systems, and other digital tools to enhance instruction and engage students (Darling-Hammond, 2021; Zhao, 2022).

3. Emphasis on Social-Emotional Learning (SEL): As the importance of social-emotional learning gains recognition, teacher training programs in the future may emphasize the development of educators' skills in fostering students' social and emotional well-being. Training in areas such as empathy, communication, conflict resolution, and creating a positive classroom climate will be essential for preparing teachers to support students' holistic development.

4. Culturally Responsive Teaching: Future teacher training programs are likely to place a greater emphasis on culturally responsive teaching practices to help educators create inclusive and equitable learning environments for diverse student populations. Training in cultural competency, anti-bias education, and strategies for addressing systemic inequalities in education will be integral to preparing teachers to meet the needs of all learners.

Based on these findings, several new theoretical frameworks have emerged to guide the integration of artificial inteligence in education and inform teaching practices. One prominent theory is *connectivism*, which emphasizes the importance of networks and connections in learning (Siemens, 2014). In a digital age where information is readily accessible, teachers are no longer the sole source of knowledge but rather facilitators of connections and resources for students to construct their understanding (Sîrghea, 2020). Another theory that is gaining traction in the field of educational technology is *constructionism*, which posits that learning is most effective when students actively construct knowledge through hands-on experiences and collaboration (Wang, 2022). AI technologies can support constructionist approaches by providing interactive simulations, virtual environments, and personalized learning pathways that engage students in active learning processes.

In the context of connectivism and the evolving role of technology in education, students play a crucial role as active participants in constructing knowledge, navigating digital networks, and engaging with diverse information sources. From the perspective of students, connectivism emphasizes the following key aspects:

1. Autonomous Learning: Students are encouraged to take ownership of their learning process, explore various information sources, and create connections between concepts to construct their understanding of the subject matter (Conole, 2018).

2. Digital Literacy: Students are expected to develop digital literacy skills, including the ability to critically evaluate information, navigate online resources, and collaborate effectively in digital environments (Veletsianos, 2022).

3. Networked Learning: Students engage in networked learning experiences where they connect with peers, experts, and resources to co-create knowledge, share insights, and participate in collaborative learning activities within digital networks (Popovici and Mironov, 2015).

4. Lifelong Learning: Connectivism promotes a culture of lifelong learning, where students are encouraged to adapt to changing information landscapes, continuously update their skills and knowledge, and participate in ongoing learning communities.

In the contemporary landscape of education, the integration of new technologies has ushered in a paradigm shift in teaching and learning methodologies. Central to this transformation is the theory of competencies, which underscores the mastery of specific skills and knowledge essential for success in the ever-evolving global society. Immediate feedback mechanisms facilitated by educational technologies play a crucial role in advancing competency-based education. Through online assessments, interactive quizzes, and automated grading systems, students receive timely feedback on their progress and performance, enabling them to identify areas of weakness and take corrective actions promptly. This real-time feedback loop promotes continuous improvement and empowers students to take ownership of their learning by actively engaging in the process of self-assessment and reflection (Langworthy, 2022).

Maria Langworthy's work delves into the role of technology in promoting student agency and self-directed learning. She highlights how new technologies empower students to take control of their learning journey, set goals, and monitor their progress towards mastering competencies. By leveraging digital tools and resources, students can explore diverse learning pathways, seek out personalized support, and develop a deeper understanding of complex concepts through interactive and engaging experiences.

CONCLUSIONS

In conclusion, the integration of artificial intelligence in education is leading to the emergence of new paradigms that are reshaping the role of teachers and transforming teaching practices. By embracing new theoretical frameworks and leveraging AI technologies effectively, educators can create engaging and personalized learning experiences for students. As we continue to explore the potential of AI in education, it is essential for educators to adapt to these changes, foster a culture of lifelong learning, and prioritize the human elements of teaching that are irreplaceable by technology. Even if there are transformed teaching methods, expanded access to resources, and enabled data-driven instruction, all of which enhance the learning experience. However, the challenges posed by rapid technological change and the digital divide necessitate continuous adaptation and support for educators. As technology continues to evolve, so too will the role of teachers, requiring them to embrace these changes to foster a more inclusive and effective educational environment.

In addition, the future of education is likely to see a greater focus on personalized and differentiated instruction. Advances in adaptive learning technologies, cognitive science, and data analytics are enabling educators to tailor instruction to individual learning needs, preferences, and abilities. Personalized learning approaches empower students to learn at their own pace, explore their interests, and engage with content in ways that resonate with their unique learning styles.

Further research it is needed to be conducted in order to analyze the needs for teachers training in pedagogy, technology, their well-being and retention.

REFERENCES

Bondie R., Mancenido Z., & Dede C., 2021 - *Interaction principles for digital puppeteering to promote teacher learning.* Journal of Research on Technology in Education, 53(1), 107–123. https://doi.org/10.1080/15391523.2020.1823284

Conole G., 2018 - *Learning design and open education*. The International Journal of Open Educational Resources, 1.1.

Darling-Hammond L., 2020 - *The Importance of Teacher Quality in the Age of COVID-19.* Educational Leadership, 78(1), 16-21.

Darling-Hammond L., Bransford J., 2021 - *Preparing Teachers for a Changing World: What Teachers Should Learn and Be Able to Do*. The Future of Children, 21(1), 1-16.

Harris J., Rea A., 2022 - *Teachers' Perceptions of Technology Integration in Education: A Study of Their Roles and Responsibilities.* Journal of Educational Technology Systems, 50(1), 5-25.

Jones A. L., & Kessler M. A., 2020 - *Teachers' emotion and identity work during a pandemic*. Frontiers in Education,https://doi.org/10.3389/feduc.2020.583775

Keane T., Linden T., Hernandez-Martinez P., et al., 2023 - *Digital technologies: students' expectations and experiences during their transition from high school to university*. Educ Inf Technol, 28, 857–877. https://doi.org/10.1007/s10639-022-11184-4

Langworthy M. & Hirsch-Allen J., 2022 - *Learning 3.0:* Bringing the Next Education Paradigm Into Focus. http://doi.org/10.4018/978-1-6684-3809-1.ch006

Perrotta C. & Selwyn N., 2019 - *Deep Learning goes to school: toward a relational understanding of AI in education,*https://doi.org/10.31235/osf.io/48t7e

Popovici A., & Mironov C., 2015 - *Students' perception on using eLearning technologies.* Procedia-Social and Behavioral Sciences 180, 1514–1519. https://doi.org/10.1016/j.sbspro.2015.02.300

Redecker C., 2017 - *European framework for the digital competence of educators*: DigCompEdu (JRC107466). P. O. o. t. E. Union, https://doi.org/10.2760/159770

Siemens G., 2014 - *Learning Analytics: The Emergence of a New Learning Paradigm*. In Handbook of Learning Analytics Society for Learning Analytics Research, (pp. 1-5).

Sîrghea A., 2020 - *Is Connectivism A Better Approach To Digital Age?* Proceedings of the International Conference Digital Age: Traditions, Modernity and Innovations, Series:Advances in Social Science, Education and Humanities Research, https://doi.org/10.2991/assehr.k.201212.033,

Veletsianos G., & Kimmons R., 2022 - *The Role of the Educator in Digital Education: Emerging Research.* International Journal of Educational Technology in Higher Education, 19(1), 1-14.

Wang, Y., 2022 - *Research on the Implications of Constructivism to Education*, Proceedings of the 2022 8th International Conference on Humanities and Social Science Research https://doi.org/10.2991/assehr.k.220504.507

THE IMPACT OF NITROGEN AND PHOSPHORUS FERTILIZATION ON SOIL PHYSICO-CHEMICAL INDICATORS ON SLOPED PLOTS OF WINTER WHEAT CROPS IN EASTERN ROMANIA

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Abstract

Winter wheat is one of the most important crops in Romania, ranking second in terms of cultivated area. This research investigates the influence of nitrogen and phosphorus fertilization on key soil physico-chemical indicators in a moderately eroded cambic chernozem soil in Eastern Romania. The study was conducted on sloped land at the "Mircea Moțoc" Soil Erosion Research and Development Station in Perieni, Vaslui County, located in the middle basin of the Țărnii Valley, in the Tutova Hills. Fertilization was applied in a differentiated manner, tailored to the specific growth stages of the wheat, taking into account factors such as species, variety, soil conditions, and other agronomic variables. Soil samples were collected from fertilized and unfertilized plots across three sections (upstream, middle, and downstream) at a depth of 0-10 cm to assess nutrient levels and other relevant soil characteristics. The results showed that soil pH ranged from 4.78 to 5.98, nitrogen content varied between 0.103% and 0.181%, and humus levels fluctuated between 1.97% and 3.5%. These findings highlight the direct impact of fertilization on soil quality and the importance of precise agrochemical treatments to optimize agricultural production while preserving soil resources.

Key words: slope, fertilization, soil

Matache *et al*, (2021) published data on soil degradation caused by surface and deep erosion, highlighting its impact in Romanian watersheds, such as the Alb River. This research highlights the negative effects of erosion on soil quality and agriculture, providing relevant data for areas exposed to accelerated erosion. Fertilization represents an indirect means of reducing soil erosion as plants develop a richer leaf apparatus that ensures a higher degree of coverage.

In modern agriculture, the importance of using chemical fertilizers is undeniable. In the structure of chemical fertilizers, those with nitrogen occupy the main place by their contribution in determining the yield increase, as well as by the weight with which they participate in the applied fertilization formulas (Dumitrașcu et al., 2003; Mihăilă et al., 1996; Petcu et al.., 2003).

Administering the optimal amount of nutrients contributes to maintaining or increasing soil fertility capacity, to increasing the productive potential of plants, avoiding the phenomena of plant nutritional imbalances (Axinte et al., 2008).

Dai Z. et al. (2020) investigated the impact of long-term fertilization on phosphorus cycling and microbial functionality in diverse agroecosystems. The study shows that continuous nutrient input can change microbial profiles and the carbon mineralization process, thereby influencing soil fertility and plant nutrient use.

Zhao J. et al. (2022) studied the effects of nitrogen and phosphorus combined fertilization on alfalfa, showing that a balance between these two elements significantly improves both photosynthetic characteristics and crop yield.

Zhang L. et al. (2023) performed a meta-analysis of the stability of soil aggregates following the application of nitrogen, phosphorus and organic fertilizers. It has been shown that the long-term use of organic fertilizers, in combination with chemical ones, can improve soil resistance to erosion, thus contributing to sustainable agriculture.

The role of experiments with long-term fertilizers is to provide information on the need for mineral fertilizers to obtain high yields and to establish, for the main field crops, the doses of fertilizers to maintain soil fertility at an optimal level. As is known, when harvesting any crop, large amounts of nutrients are exported from the soil; only in the case of wheat, at a production of 5000-6000 kg/ha, 100-140 kg of nitrogen, 50-60 kg of phosphorus and other nutrients, which must be returned to the soil. That is why it is important to know the need for fertilizers, which differ a lot depending on the state of soil fertility, the climate and the needs of each species of cultivated plants.

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The research carried out by Popa A. and the collaborators at Perieni, established that the losses of fertilizing elements caused by erosion, in some crops, differ according to the size of the slope, being double on lands with a slope of 24% compared to the losses on lands with a slope of 12%.

MATERIAL AND METHOD

The study was carried out at the Research and Development Station for Combating Soil Erosion "Mircea Moțoc" Perieni, Romania. The study was carried out on a cambic chernozem type soil with moderate erosion, 12% slope. This type of soil is characterized by loamy texture with loessose deposits.

This study consists of two successive stages. In the first stage, soil samples were taken from the two plots with unfertilized wheat and with wheat fertilized with nitrogen and phosphorus. The soil samples (photo 1) were taken with the help of Eijkelkamp probes (photo 2) from upstream, middle, downstream at a depth of 0-10 cm. These samples were taken to the Laboratory for various analyzes within the Soil Physics Department of the Iași Agriculture and Environment Research Institute (ICAM).

Figure 1 **Soil samples taken from the wheat plot**

Figure 2 **Eijkelkamp type soil sampling probe**

In the period preceding the sowing, manual digging with a harrow was carried out on the unfertilized wheat plot and the fertilized wheat plot. When sowing, the seedbed was prepared with a Bertolini-type motor cultivator with milling unit. Sowing of the wheat crop was done manually both in the unfertilized plot and in the fertilized plot, with the row spacing of 12.5 cm and the sowing depth of 4-7 cm.

RESULTS AND DISCUSSIONS

On sloping land, the change in physical-chemical indicators is much more pronounced and depends to a large extent on the relief, pedoclimatic conditions, the way of use and human activity. Research in this direction was done by Filiche E. (1995-2000).

The physico-chemical indicators studied were: pH, humus, nitrogen. The determinations were made in the year 2024. Therefore, as I said previously, the changes in the physico-chemical indicators of the soil can be noticed after a long period, comparisons were made between the values obtained in this period (2024) with the values obtained from the research carried out by Filiche E. (2000).

Table 1

Losses of fertilizing elements through the soil in the plots for the control of runoff in the year 2000 (Filiche E.)

Culture	Humus	Azote
	(%)	(%)
Wheat	2.26	82.96
Unfertilized wheat	4.98	94.95

Research on the influence of the fertilization system on the physico-chemical indicators was carried out on the cambic chernozem, moderately eroded with a slope of 12-13% at the Research-Development Station for Combating Soil Erosion "Mircea Moțoc", in an experience with character stationary established in 1970. In this study, the following fertilization system was applied: unfertilized (N_0P_0); fertilized with nitrogen and phosphorus in a dose of 150 N kg/ha + 150 kg P_2O_5/ha ($N_{150}P_{150}$).

On the plot with unfertilized wheat in the 3 sectors, the pH of the soil recorded values from the upstream of the plot of 5.97 to the downstream of the plot where it recorded the value of 5.98. In the case of the plot fertilized with nitrogen and phosphorus in the 3 sectors (upstream, middle, downstream), the pH of the soil shows decreasing values from the upstream of the plot with the value of 5.07 to the downstream of the plot where the pH is 4.78 (figure 1).

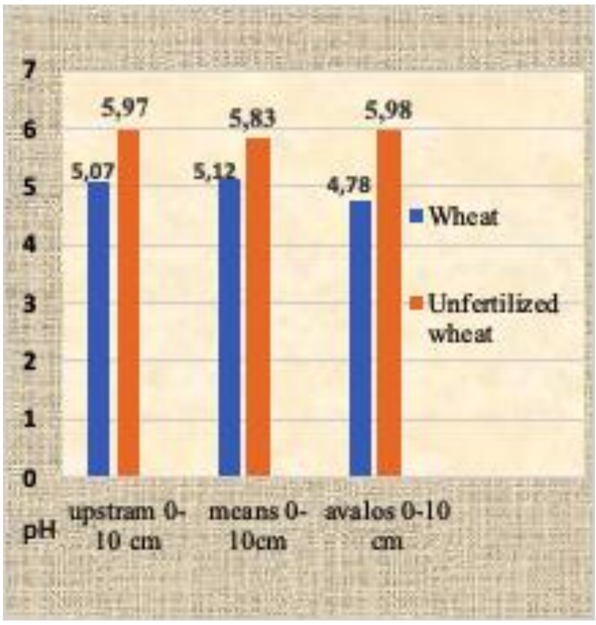

Figure 1 **Dynamics of soil pH in three sectors at a depth of 0-10 cm in the fertilized and unfertilized wheat crop**

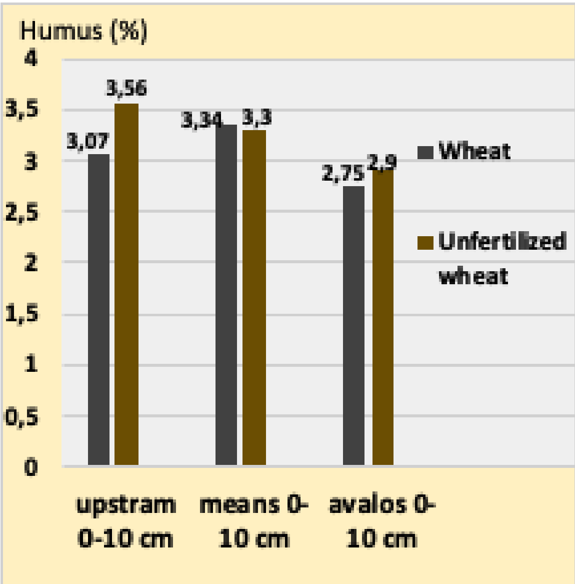

Figure 2 **Dynamics of soil humus content in three sectors at a depth of 0-10 cm in the fertilized and unfertilized wheat crop**

Humus represents the most important element of soil fertility, preservation and above all the increase of its content, which is highly dependent on agricultural production.

The humus content of the soil, on the plot with fertilized wheat, varied with values from the upstream of the plot where it indicated the value of 3.07% to the downstream of the plot where it had the value of 2.75%. In the case of the unfertilized wheat plot, the humus showed values between 3.56 % (upstream) and 2.9 % (downstream).

Comparing the humus values recorded (table 1) in the year 2000 (Filiche E.) with the current humus values (figure 2), we can see an evolution of the humus content from 2.61% to 3.34% on the plot with fertilized wheat, and in the case of the plot with unfertilized wheat, the amount of humus in the soil decreased from 4.98% in 2000 (Filiche E.) to 3.56% in 2024.

Nitrogen, being an easily soluble element, is quickly leached into the deep layers of the soil, having no possibility to quantify except the state at a given moment.

From the data represented in figure 3, significant differences can be distinguished between the fertilized and the unfertilized wheat plot in the three sectors (upstream, middle, downstream). Thus, in the fertilized plot, the amount of nitrogen varied from 0.148 % (downstream plot) to 0.181 % (upstream plot). In the case of the unfertilized plot, the nitrogen content of the soil varied from 0.139 % (downstream plot) to 0.165 % (middle plot).

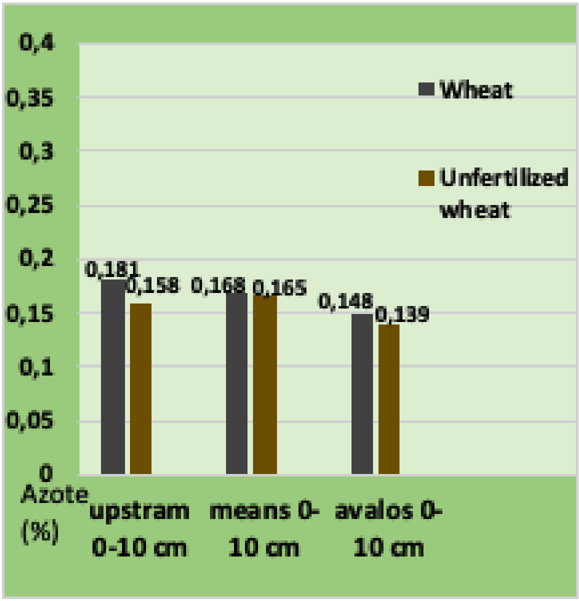

Figure 3 **Dynamics of soil nitrogen content in three sectors at the depth of 0-10 cm in the culture of fertilized and unfertilized wheat**

The nitrogen content data have the following meaning (according to I.C.P.A. Bucharest):

- at concentrations of nitrogen in the arable layer below 0.14%, it is considered that the soils are poorly supplied with nitrogen, for the cultivation of wheat and corn;
- at nitrogen concentrations in the arable layer between 0.14% and 0.27%, it is considered that the soils are moderately supplied with nitrogen;

- if the concentration of 0.27% nitrogen in the arable layer is exceeded, it is considered that the soils are well and very well supplied with this element.

If in 2000 (Filiche E.) the nitrogen content of the fertilized plot was 82.96%, the long application of chemical fertilizers led to a state of medium supply with a content of 0.148%. In the unfertilized wheat plot, the amount of nitrogen decreased in 24 years, so that in the year 2000 it was 94.95% reaching in the year 2024 a content of 0.139%, which constitutes a state of medium nitrogen supply.

CONCLUSIONS

The pH of the soil at the plot fertilized with nitrogen and phosphorus in the 3 sectors (upstream, middle, downstream) shows values from 4.78 (downstream plot) to 5.07 (upstream plot). In the case of the unfertilized wheat plot, the soil pH indicated values between 5.97 (upstream plot) and 5.98 (downstream plot).

The humus content in the soil of the fertilized plot, recorded in 2000, is 2.61% evolving after 24 years to 3.34%. In the unfertilized wheat plot, the amount of humus in the soil decreased from 4.98% in 2000 to 3.56% in 2024, constituting an average state of soil supply.

REFERENCES

Axinte M., Moglan C., Zaharia M., 2008 - *The influence of nitrogen and phosphorus fertilization on the protein content of winter wheat*, vol.51, Agronomie, U.S.A.M.V. IASI

Ciocan, F.; Manu, C.; Matache, A.; Petrescu, N.; Muratoreanu G., 2021- *Soil fertility in the central-southern part of Romania expressed by soil reaction and nutrient content: a case study from the Raul Alb catchment*, Dambovita County. Journal of Applied Life Sciences and Environment 2021, 54(4), 377-388. https://doi.org/10.46909/journalalse - 2021-033.

Dai, Z., Liu, G., Chen, H. et al., 2020 - *Long-term nutrient inputs shift soil microbial functional profiles of phosphorus cycling in diverse agroecosystems*. ISME J 14, 757–770. https://doi.org/10.1038/s41396-019-0567-9.

Deac V., Kadar R., Chețan F., Chețan C., 2009 – *Reaction of winter wheat to nitrogen and phosphorus fertilization according to the preceding plant at S.C.D.A Turda during 2009-2016*, I.N.C.D.A Funduea, Vol. LXXXV.

Dumitraşcu N., Povarnă F., Voica M., Nicola C., Mihăilescu D., 2003 - *The effect of organomineral fertilization on the evolution of the main agrochemical indices of the soil*. Annales INCDA Fundulea, LXX: 91-105.

Liu, X.; Liu, J.; Huang, J.; Chen, Y.; Zhang, L.; Qi, Y.; Li, W.; Zhu, Y., 2023 - *Response of Soil Aggregate Stability to Phosphorus, Nitrogen, and Organic Fertilizer Addition:* A Meta-Analysis. *Sustainability*, *15*, 10601.

Lupu C., Pochişcanu S., Druțu C., 2015 - *The influence of nitrogen fertilizers on corn production, under the conditions of S.C.D.A. Secuians,* Vol LXXXIII.

Mihăilă V., Brlacu Gh., Hera C., 1996 - *Results obtained in the long-term experiments with fertilizers on cambic chernozem from Fundulea*. ICCPT Fundulea, LXII: 91-105.

Năstasă V., Dumitru N., Năstasă E., 2008 - *Crop rotation and fertilization on sloping land*, Alfa Publishing House, Iasi.

Petcu Gh., Sin Gh., Ioniță S., 2003 - *The evolution of wheat and corn production in long-term experiments under the influence of rotation and fertilization*., INCDA Fundulea, LXX: 181-191.

Rusu C. et al., 2001- *The effect of fertilization on wheat production on a typical chernoziom and a brown luvic soil from the Moldavian Plateau*, Cerc.agronom. in Moldova, Vol. LVII.

Zhao, J.; Huang, R.; Yang, K.; Ma, C.; Zhang Q., **2022** - *Effects of Nitrogen and Phosphorus Fertilization on Photosynthetic Properties of Leaves and Agronomic Characters of Alfalfa over Three Consecutive Years*. Agriculture, 12, 1187. https://doi.org/10.3390/agriculture12081187.

WINE LEES – CHARACTERISTCS AND POTENTIAL OF VALORISATION

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Abstract

The circular economy's primary goals are reducing and recycling food waste, which are still problems in the agro-industrial sector. Waste reduction is one of the potential strategies that can be used to increase the sustainability of food production. So, the best method to transform these wastes into useful products that also reduce environmental issues is to feed nutritious by-products to animals. One of the guiding principles of the circular economy and one of the most significant challenges in food engineering, with implications for the strategic fields of bioeconomy, health, and environment, is the identification and establishment of new directions for utilizing the nutritional and functional potential of wine lees produced as a by-product from the wine industry. Wine lees composition varies widely due to a multitude of factors, primarily connected to the varieties of yeast and grapes utilised as well as the vinification process, as evidenced by data published in the literature. This paper proposes a review of the specialised literature regarding the valorisation of wine lees from the wine industries, in the context of the circular economy and the promotion of "green technologies", in order to obtain food and feed with high nutritional value and antioxidant potential. Future research areas are outlined, along with other strategies for valuing this especially valuable by-product.

Key words: by-product, circular economy, environmental impact, functional food, sustainable management

The population of the globe is predicted to consume three times as much food as there is on Earth by the year 2050. The European Union intends to put into place mechanisms that can counteract this effect, such as the circular economy, in order to prevent such a situation. The circular economy's primary goals are reducing and recycling food waste, which are still problems in the agro-industrial sector (Dabija D., & Năstase C., 2024).

One of the major sources of waste in the world is agro-industrial residue, which, if improperly managed, can have detrimental effects on the ecosystem, including the release of greenhouse gases and oxygen depletion (de Andrade Bulos R.B. *et al.,* 2023). Developing sustainable techniques for waste valorisation is imperative in this scenario. This method emphasises the necessity of switching from a linear (make/take/dispose) to a circular (take/make/use) economy model, which aligns with the EU aim of reaching zero food waste by 2030 (Medana C. *et al*, 2024).

By-products and waste from the food industry can be recycled and used again, which benefits both the industry and the environment. According to EUROSTAT, 179 kg of food are wasted per person per year in Europe, or around 90 million tons (Van Raamsdonk L.W.D. *et al*, 2023). The current state of the world compels us to look for options for valuing these by-products with excellent nutritional and practical potential. Adopting a sustainable management strategy for food by-products is crucial because they are key resources from a nutritional, economic, or environmental standpoint and are crucial to the implementation of systemic solutions based on the principles of a circular economy.

Regulations in the European Union promote the extraction of important components from food industry secondary products to produce functional foods and feeds (Turcu R.P. *et al,* 2020). Alternative techniques are needed to repurpose food waste into uses with a higher value in order to lessen the environmental load that is brought on by their production. This will improve the long-term

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sustainability of our food system and reduce the environmental impact that food waste causes (Chetrariu A. & Dabija A., 2020).

One of the guiding principles of the circular economy and one of the most significant challenges in food engineering, with implications for the strategic fields of bioeconomy, health, and environment, is the identification and establishment of new directions for utilizing the nutritional and functional potential of wine lees produced as a by-product from the wine industry.

Wine lees are described by European Regulation (EEC) number 337/79 as the residue that remains at the bottom of wine-containing containers following fermentation, storage, or treatment, as well as the residue that is acquired following filtering or centrifugation. Wine lees are made of phenolic chemicals, inorganic materials, tartaric acid, and microbes. The complex mixture of yeast cells, insoluble carbohydrates, organic acids, ethanol, phenolic compounds, proteins, inorganic salts, and lignin that makes up wine lees accounts for 15-20% of all waste produced in wineries and produces about 2–6% of all wine produced. Wine lees can account for up to 5% of the overall weight of the processed grapes (Athanasiou P.E. *et al*, 2024; Balmaseda A. *et al,* 2024; García Álvaro A. *et al,* 2024).

Wine lees represent a significant portion of by-products from winemaking, and while they include various high-value components that may be used in industrial sectors, like phenolic compounds, they are still one of the wastes that receives the least attention and utilisation. Traditionally, wine lees are essential raw materials for the synthesis of tartaric acid and ethanol. Anaerobic digestion uses wine lees to produce methane-rich biogas. Yeast cells and their cell walls are primarily home to proteins, lipids, and polysaccharides. Yeasts perish and a process known as cell lysis starts when the alcoholic fermentation process comes to a stop. Peptides, fatty acids, nucleotides, and amino acids found in the cytoplasm as well as components of the cell wall called mannoproteins can be released by this mechanism. Although autolysis is a very slow and drawn-out process, it can be triggered in industrial processes by a variety of physical, chemical, or biological stimuli, including a rise in temperature, alternating freezing and thawing, osmotic pressure, detergents and antibiotics (Di Nicolantonio L. *et al*, 2023; Timira V., *et al,* 2024).

In the context of the circular economy and the promotion of "green technologies," this paper offers a mini-review of the specialized literature on the valorization of wine lees in order to obtain food and feed with high nutritional value and antioxidant potential, as well as other biotechnological applications.

COMPOSITION OF WINE LEES

Wine lees consist of the solid component that decants to the bottom of wine tanks at the end of the alcoholic fermentation process. Depending on the environment, agronomic traits, grape variety, and winemaking techniques (such as racking or ageing for a period of time in wood barrels or tanks), wine lees are primarily made up of organic acids, carbohydrates, inorganic salts, proteins, fibres, phenolic compounds, and plant residues from grapes. Significant concentrations of proteins, lipids, polysaccharides, and other organic species with a high oxygen demand can be found in wine lees. The grape variety and provenance, the ageing period in the wine vessels, and the ambient factors all affect the makeup of wine lees. Low pH levels and high chemical oxygen demand (COD $>$ 30,000 mg/ L) levels are characteristics of wine lees, which are composed of phenolic compounds, organic acids, proteins, lignin, tartaric acid, ethanol, grape remnants, and yeast cells. According to estimates, wine lees make about 14% of all processing waste in winemaking, which results in the production of nearly 1.26 million tonnes of wine lees globally (Chiappero M. *et al,* 2023; Chioru A. *et al*, 2023, De Luca M. *et al.,* 2023; Melo, F.D.O. *et al*, 2024).

Yeast has been found to be present in considerable amounts in wine lees. The presence of yeast and other microorganisms in high concentration causes the secretion of enzymes (β-glucosidase, E.C. 3.2.1.21) that can accelerate the hydrolysis and transformation of phenolics. Furthermore, wine lees produce specific enzymes that facilitate the breakdown and conversion of polyphenolic substrates into extremely useful compounds such as ellagic acid or gallic acid. Wine lees are important because they can affect wine's colour and organoleptic characteristics by interacting with the polyphenol in the wine. The chemical composition of wine lees includes anthocyanins (6–11.7 mg/g DW) and phenolics (29.8 mg/g DW) (Constantin, O.E. *et al,* 2024). Varelas *et al.* (2016) have described the first environmentally friendly method of isolating β-glucan from wine lees.

Wine lees are therefore regarded as an environmental contaminant. Its composition, however, varies widely due to a multitude of factors, primarily connected to the varieties of yeast and grapes utilised as well as the vinification process, as evidenced by data published in the literature. Figure 1 provides an overview of the components of wine lees.

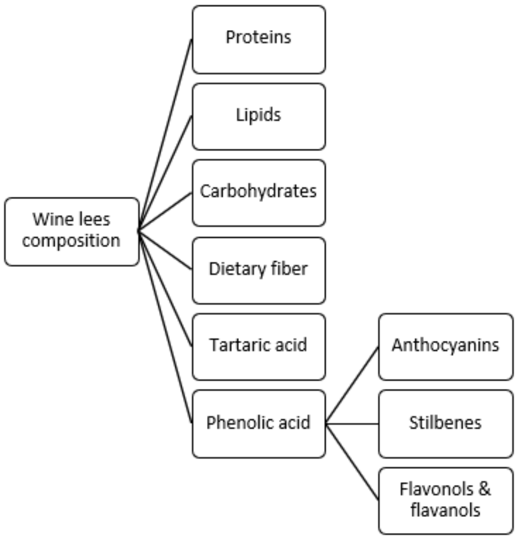

Figure 1. **Main components of wine lees**

Minerals (particularly K), organic debris, and water-soluble polyphenols are abundant in wine lees. These qualities, along with their low pH, render raw wine lees unsuitable for direct agricultural use. The suggestion to use wine lees as a source of protein for ruminants originated from the high concentrations of protein and total nitrogen as well as the good presence of essential amino acids (tyrosine, valine, and aminocaproic acid). However, a significant portion of that fraction is indigestible due to the high concentrations of polyphenols connected to the proteins. Wine lees can contain anywhere from 1.9 to 16.3 g of polyphenols/kg, depending on the type of wine and how it was processed, according to Bustamante et al. (2008). The characterisation of this fraction has been the subject of more recent research, which has identified a number of phenolic chemicals primarily from the subclasses of anthocyanins, flavonols, and phenolic acids. Because wine lees adsorb polyphenols onto the cell walls of the yeast during the winemaking process, the polyphenols are present in both the liquid fraction (basically wine) and the solid fraction. The kind and quantity of the various phenolic compounds, as well as a number of other factors like the grape variety, fruit maturity level, maceration technique, and fermentation temperature, all affect the mechanism of adsorption. However, because of the fragility of these interactions, polyphenols have the potential to be used because they are easily retrieved from yeast lees. In fact, food-grade organic solvents and membrane technologies have been used to recover polyphenols from wine lees. These methods might be used on a massive scale to produce food-grade phenolic extracts, which the food industry could use as natural antioxidant and antibacterial additives (De Iseppi A. *et al,* 2020).

Furthermore, it has been demonstrated that wine lees have an average anthocyanin content that ranges from 10 to 31 mg/g. Surprisingly, these chemicals' existence in wine lees has been linked to significant functions like antioxidant properties and the control of sheep peripheral blood mononuclear cell proliferation. Polyphenols from wine lees can be extracted using a variety of methods, including membrane technology, enzymatic hydrolysis, supercritical CO_2 extraction, solid-liquid extraction utilising organic solvents, and microwave-assisted extraction (García, R.M. *et al,* 2023).

Lipids from yeast cell walls and grape seeds are also present in wine lees. Gomez et al. (2004) state that high-value fatty acids such as stearic (C18:0, ≈10%), linoleic (C18:2, ≈21%), and palmitic (C16:0, ≈33% of the lipid fraction) can be found in wine lees. However, non-food grade solvents were used to extract these lipids. Further research is required to fully comprehend the nature and concentration of potentially beneficial compounds found in wine lees, as well as the ways in which winemaking techniques, grape varietal, and yeast strain might influence their variability.

APPLICATIONS OF WINE LEES

Recent studies have revealed the existence of considerable amounts of bioactive components in wine lees, including minerals, organic acids, phenolic acids, flavonols, flavanols, anthocyanins, and polysaccharides found in yeast cell walls, such as β-glucans and mannoproteins. Thanks to its valuable composition, wine yeast has numerous applications, some of which are outlined below (Figure 2).

Applications in food. Wine lees have been used in a large number of earlier investigations to assess their nutritional value and antioxidant activity in various food matrices, such as burgers, cereal bars, ice cream, microbial oil, yoghurt, biscuits, and even food packaging (Caponio, G.R. *et al,* 2024; Gümüş T. *et al,* 2024). Incorporating wine lees also altered the food's sensory qualities and had an antibacterial effect on aerobic psychrotrophic bacteria. Following sensory analysis, the hamburgers showed features of low-intensity wine and bakery notes, which were deemed to be agreeable. This resulted from the growth of acids, esters, and benzene compounds, all of which were previously present in wine lees (Constantin, O.E. *et al,* 2024).

To create enriched biscuits with dietary fibre and polyphenols, Caponio et al. (2024) were utilised wine lees flour (WLF). The amount of bioactive compounds such phenolic acids, flavonoids, and anthocyanins increased when 10% and 20% WLF was substituted for wheat flour in the biscuits, improving their nutritional composition and enabling the nutritional claims "source of fibre" and "high fibre". For vegetarian and vegan recipes, yeast mannoproteins can serve as a viable substitute for commercial emulsifiers (De Iseppi A. *et al,* 2020).

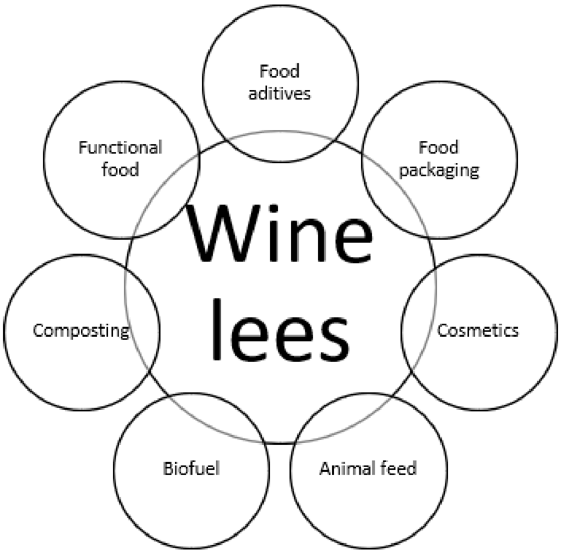

Figure 2. **Wine lees' potential for value generation**

In their 2023 study, Bianki et al. sought to assess the viability of wine lees as a sustainable fat alternative in baked items. To investigate wine lees' potential as a fat substitute in various cereal-based food formulations, more research is required. Studies have shown that fish gelatine supported by wine lees may be utilised in place of egg proteins to create affordable, sustainable spreadable emulsions (Kaynarca G.B., 2024).

Recent research has explored the possible application of wine lees as a source of food additives like β-glucans and mannoproteins, as well as a nutritional supplement for the microbial synthesis of several industrially significant chemicals like lactic acid, citric acid, and xylitol. Because it can influence food's physicochemical and rheological qualities, such as viscosity, water holding capacity, oil binding, and emulsion stability, β-glucan from grains and yeast is especially interesting (De Iseppi A. *et al,* 2020).

Moreover, an initial investigation has demonstrated the possible advantages of adding lees to grape must fermentation (Onetto C. *et al*, 2024).

Tartaric acid is usually made from wine lees. Numerous biological and chemical procedures can be used to gather tartaric acid and supply it to the food and pharmaceutical industries. Cation exchange resin can be used to process wine lees waste from the wine industry, recovering industrially relevant tartaric acid while lowering the undesirable potassium concentration. Tartaric acid recovery was about 74.9%, and the resin concentration, pH of the process, and water content all had a big impact on this. Tartaric acid, ethanol, and antioxidants can all be obtained by using wine lees. The portion left over, which is plentiful in yeast cells, could be used as a feedstock for other types of fermentation (Constantin, O.E. *et al,* 2024).

Food packaging. Food's self-life is observed to be increased when phenolic extracts with antibacterial and antioxidant properties are added to biodegradable biopolymer films, including chitosan films. Therefore, the creation of chitosan films enhanced with phenolic compound-rich wine lees extracts has the potential to enhance current food packaging systems by offering new biodegradable and bioactive substitutes that support the circular economy (Athanasiou P.E. *et al*, 2024).

Among the most prevalent and significant by-products of the winemaking process, wine lees are a great source of phenolic compounds, which have strong antioxidant and other biological properties. To create phenolic polymers with adjustable properties, the wine lees phenolic polymerisation reaction was investigated over a range of time intervals. In order to track the polymerisation process and look into the properties of the newly produced products, like thermal stability, spectroscopic and analytical techniques were used to analyse the polymerisation reaction and the formed polymeric products. Finally, the addition of several polymeric goods to chitosan films enhanced their antioxidant activity, suggesting that these materials can serve as viable substitutes for additives in biodegradable food packaging films (Athanasiou P.E. *et al*, 2024).

Animal nutrition. Animals, especially those housed on farms, are regularly fed food scraps and other types of waste. This is a typical practice that dates back a long time. Along with international policies to lessen their detrimental effects on the environment, these by-products can also contribute to the physical wellbeing of animals. In order to maintain sustainability in the livestock industry, "waste into development potential" can be a useful method (Nath P.C. *et al*, 2023). Animals have the ability to convert indigestible by-products and forages into food that humans may consume. So, the best method to transform these wastes into useful products that also reduce environmental issues is to feed nutritious by-products to animals (Rashwan A.K. *et al*, 2023). Moreover, compared to spent brewer's yeast, wine lees do not contain bitter compounds that could cause negative effects to animals, especially to dairy cattle (Schlabitz C. *et al*, 2022).

Wine lees are primarily used in animal feed, but the use of various pretreatment processes transforms them into a product with a variety of uses intended for human consumption. For example, they can be used to improve or impart a meaty flavor to food products, as an alternative to protein production, or as a folate-rich yeast extract (Avrămia I. & Amariei S., 2021; Gokulakrishnan M. *et al,* 2022; Tao Z. *et al*, 2023).

Cosmetics. Certain research describes the extraction of bioactive compounds that are of interest to cosmetics, like squalene, polyphenols (flavonols and phenolic acids), and mannoproteins and beta-glucans. Pretreatments that permit the release of these chemicals typically facilitate their recovery. Although lees have been shown to offer skin-beneficial characteristics, few cosmetic firms have included this agro-industrial waste into their formulations; in many cases, wine lees have been used exactly as is, without modification (Di Nicolantonio L. *et al*, 2023; Souza, A. *et al,* 2024).

Biofuels. Wine lees must be sent to distilleries in accordance with European Council Regulation in order to produce ethanol. This alcohol's high concentration of fragrant wine components allows it to be used to manufacture spirit liquors. Among the high-value elements that can be extracted from the distilled lees, vinasses, or distillation by-product are tartrates, polyphenols, and yeast biomass. On the other hand, because of their high organic content and high oxygen consumption, vinasses provide a possible ecological risk when disposed of (Constantin, O.E. *et al,* 2024).

CONCLUSIONS

The massive amounts of solid-liquid waste that are thrown away each year without specific uses make wine lees, a significant by-product of the wine industry, a significant environmental concern. Wine lees are a by-product that has the potential to be used in a variety of industries, including the food, winemaking, biotech, and pharmaceutical sectors. Wine lees contain various high-value components. Despite this potential, wine lees are now one of the least researched and utilised by-products of winemaking, in contrast to grape skins and seeds. Subsequent uses ought to concentrate on creating a comprehensive strategy that targets the extraction of the greatest quantity and variety of chemicals from wine lees that may find applications in various industries.

Further research is therefore required to effectively recover important compounds. For instance, it would be appropriate to create an integrated process for extracting polyphenols, ethanol, and tartaric acid. The residual biomass may be utilised to acquire nutrients for the fermentation medium, hence aiming for full lees exploitation. The variation in the composition of wine lees is one problem with industrial scaling. In this regard, recovering the polysaccharides found in yeast cell walls could be a viable strategy for biomass valorisation.

ACKNOWLEGMENTS

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REFERENCES

Athanasiou, P.E., Gkountela, C.I., Patila, M., Fotiadou, R., Chatzikonstantinou, A.V., Vouyiouka, S.N., Stamatis, H., 2024 - *Laccase-Mediated Oxidation of Phenolic Compounds from Wine Lees Extract towards the Synthesis of Polymers with Potential Applications in Food Packaging.* Biomolecules, 14(3), 323.

Athanasiou, P.E., Patila, M., Fotiadou, R., Chatzikonstantinou, A.V., Stamatis, H., 2024 - *Valorization of Wine Lees: Assessment of Antioxidant, Antimicrobial and Enzyme Inhibitory Activity of Wine Lees Extract and Incorporation in Chitosan Films*. Waste and Biomass Valorization, 1-16.

Avrămia, I., Amariei, S., 2021 - *Spent Brewer's yeast as a source of insoluble β-glucans*. International Journal of Molecular Sciences, 22(2), 825.

Balmaseda, A., Miot-Sertier, C., Lytra, G., Poulain, B., Reguant, C., Lucas, P., Nioi, C., 2024 - *Application of white wine lees for promoting lactic acid bacteria growth and malolactic fermentation in wine*. International Journal Of Food Microbiology, 413, 110583.

Bianchi, F., Cervini, M., Giuberti, G., Simonato, B. 2023 - *The potential of wine lees as a fat substitute for muffin formulations*. Foods, 12(13), 2584.

Bustamante, M.A., Moral, R., Paredes, C., Pérez-Espinosa, A., Moreno-Caselles, J., Pérez-Murcia, M.D., 2008, - *Agrochemical characterisation of the solid by-products and residues from the winery and distillery industry.* Waste management, 28(2), 372-380.

Caponio, G.R., Miolla, R., Vacca, M., Difonzo, G., De Angelis, M., 2024 - *Wine lees as functional ingredient to produce biscuits fortified with polyphenols and dietary fibre.* LWT, 198, 115943.

Chetrariu, A., Dabija, A., 2020 - *Brewer's spent grains: Possibilities of valorization, a review.* Applied Sciences, 10(16), 5619.

Chiappero, M., Berruti, F., Fiore, S., 2023 - *Biomethane potential of wine lees from mesophilic anaerobic digestion*. Biochemical

Engineering Journal, 196, 108954.

Chioru, A., Chiselita, N., Suhodol, N., Boiştean, A., Paladi, D., Capcanari, T., Chirsanova, A.,2023 - *Physico-Chemical and Microbiological Profile of Wine Lees of Red Wines from Local Grapes Varieties.* Food and Nutrition Sciences, 14(11), 1133-1148.

Constantin, O.E., Stoica, F., Rațu, R.N., Stănciuc, N., Bahrim, G.E., Râpeanu, G., 2024 - *Bioactive Components, Applications, Extractions, and Health Benefits of Winery By-Products from a Circular Bioeconomy Perspective: A Review.* Antioxidants, 13(1), 100.

Dabija, D., Năstase, C., 2024 - *Exploring the Evolution of Sustainability Paradigms: From Linear to Circular Economy Models.* In Proceedings of the International Conference on Business Excellence (Vol. 18, No. 1, pp. 754-769).

de Andrade Bulos, R.B., da Gama Paz, F., Machado, C.G., Tavares, P.P.L.G., de Souza, C.O., Umsza-Guez, M.A., 2023 - *Scientific and technological research on the use of wine lees.* Food Production, Processing and Nutrition, 5(1), 1-14.

De Iseppi, A., Lomolino, G., Marangon, M., Curioni, A., 2020 - *Current and future strategies for wine yeast lees valorization.* Food Research International, 137, 109352.

De Luca, M., Restuccia, D., Spizzirri, U.G., Crupi, P., Ioele, G., Gorelli, B., Aiello, F., 2023 - *Wine Lees as Source of Antioxidant Molecules: Green Extraction Procedure and Biological Activity.* Antioxidants, 12(3), 622.

Di Nicolantonio, L., Ferrati, M., Cristino, M., Peregrina, D.V., Zannotti, M., Vitali, L. A., Di Martino, P., 2023 - *Evaluation of Physicochemical and Microbial Properties of Extracts from Wine Lees Waste of Matelica's Verdicchio and Their Applications in Novel Cosmetic Products.* Antioxidants, 12(4), 816.

García Álvaro, A., Ruiz Palomar, C., Hermosilla, D., Gascó, A., Muñoz, R., de Godos, I., 2024 - *Improving the Anaerobic Digestion Process of Wine Lees by the Addition of Microparticles.* Water, 16(1), 101.

García, R.M., Martínez-Lapuente, L., Guadalupe, Z., Ayestarán, B., Marchante, L., Díaz-Maroto, M. C., Pérez-Coello, M.S., 2023 - *Ultrasound and microwave techniques for assisting ageing on lees of red wines.* Food Chemistry, 426, 136660.

Gokulakrishnan, M., Kumar, R., Pillai, B.R., Nanda, S., Bhuyan, S.K., Kumari, R., Sundaray, J.K., 2022 - *Dietary brewer's spent yeast enhances growth, hematological parameters, and innate immune responses at reducing fishmeal concentration in the diet of climbing perch, Anabas testudineus fingerlings.* Frontiers in Nutrition, 9, 982572.

Gómez, M.E., Igartuburu, J. M., Pando, E., Luis, F.R., Mourente, G., 2004 - *Lipid composition of lees from sherry wine.* Journal of Agricultural and Food Chemistry, 52(15), 4791-4794.

Gümüş, T., Altan Kamer, D.D., Kaynarca, G.B., 2024 - *Investigating the potential of wine lees as a natural colorant and functional ingredient in jelly production.* Journal of the Science of Food and Agriculture, 104(3), 1357-1366.

Kaynarca, G.B., 2024 - *Characterization and molecular docking of sustainable wine lees and gelatine-based emulsions: innovative fat substitution.* Journal of the Science of Food and Agriculture.

Medana, C., Spizzirri, U.G., Schiavo, V., Fusi, F., Panti, A., Saponara, S., Restuccia, D., 2024 - *Screening of the antioxidant and vasorelaxant activity of wine waste ultrasonic extracts, and HRMS targeted and semi-targeted profiling of glycosylated polyphenols vs free polyphenols.* LWT, 208, 116666.

Melo, F.D.O., Ferreira, V.C., Barbero, G.F., Carrera, C., Ferreira, E.D.S., Umsza-Guez, M.A., 2024 - *Extraction of bioactive compounds from wine lees: A systematic and bibliometric review.* Foods, 13(13), 2060.

Nath, P.C., Ojha, A., Debnath, S., Sharma, M., Nayak, P.K., Sridhar, K., Inbaraj, B.S., 2023 - *Valorization of Food Waste as Animal Feed: A Step towards Sustainable Food Waste Management and Circular Bioeconomy.* Animals, 13(8), 1366.

Onetto, C., McCarthy, J., Solomon, M., Borneman, A.R., Schmidt, S.A., 2024 - *Enhancing fermentation performance through the reutilisation of wine yeast lees.* OENO One, 58(1).

Rashwan, A.K., Bai, H., Osman, A.I., Eltohamy, K.M., Chen, Z., Younis, H.A., Yap, P.S., 2023 - *Recycling food and agriculture by-products to mitigate climate change: a review.* Environmental Chemistry Letters, 1-25.

Schlabitz, C., Lehn, D. N., & de Souza, C. F. V., 2022. *A review of Saccharomyces cerevisiae and the applications of its byproducts in dairy cattle feed: Trends in the use of residual brewer's yeast.* Journal of Cleaner Production, *332*, 130059.

Souza, A.L.A.D., Gomes, A.K.C., Morgado, C., Monteiro, M.S., 2024 - *Nanoemulsion with wine lees: a green approach.* Anais da Academia Brasileira de Ciências, 96(2), e20230373.

Tao, Z., Yuan, H., Liu, M., Liu, Q., Zhang, S., Liu, H., Wang, T., 2023 - *Yeast Extract: Characteristics, Production, Applications and Future Perspectives.* Journal of Microbiology and Biotechnology, 33(2), 151.

Timira, V., Chen, X., Zhou, P., Wu, J., Wang, T., 2024 - *Potential use of yeast protein in terms of biorefinery, functionality, and sustainability in food industry.* Comprehensive Reviews in Food Science and Food Safety, 23(3), e13326.

Turcu, R.P., Panaite, T.D., Untea, A.E., Șoica, C., Iuga, M., Mironeasa, S., 2020 - *Effects of supplementing grape pomace to broilers fed polyunsaturated fatty acids enriched diets on meat quality.* Animals, 10(6), 947.

Van Raamsdonk, L.W.D., Meijer, N., Gerrits, E.W.J., Appel, M.J., 2023 - *New approaches for safe use of food by-products and biowaste in the feed production chain.* Journal of Cleaner Production, 135954.

Varelas, V., Tataridis, P., Liouni, M., Nerantzis, E.T., 2016 - *Valorization of winery spent yeast waste biomass as a new source for the production of β-glucan.* Waste and Biomass Valorization, 7, 807-817

MICROBIOLOGICAL INDICATORS AS IMPORTANT TOOL FOR SOIL QUALITY ASSESSMENT

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Abstract

The most significant and appropriate soil indicators are microbiological indicators because they provide a comprehensive picture of the viability of the entire soil ecosystem as well as the quality of the crop. In the Romanian Plain, two Chernozems (P1-irrigated and P2-non-irrigated) were used for the study. The researches presented in this paper belong to a complex study, part of the results (based on the hydrostability indicators) being also published. Thus, the initial premises of the researches were that the results obtained perfectly matched: the microbiological activity should be higher in an ecosystem with a high structural stability and, consequently, with a porous system stable and interconnected. The obtained results emphasized that, according to the microbiological indicators (the number of bacteria; the number of fungi; and the soil respiration), the higher activity of microbiota were in the less stable structural profile, but with higher humidity due to irrigation. In P2, bacteria and fungi, as well as the soil respiration reached higher values. In what concerning the taxonomic identification, in P2, a richness of species, both bacteria and fungi, had been identified, comparing to P1. The microbiological diversity and their distribution in the two soil profiles had been different as a result of the anthropic influence through irrigation. The microbiological indicators use in the paper to emphasize soil quality, proved to be important tools for soil quality assessment and marching with the others important physical indicators, showing also a great accuracy.

Key words: soil quality indicators; microbiology; micromorphology

The most used definition for soil quality (according to the Natural Resources Conservation Service) is the ability of a certain soil to function within a natural or human-used ecosystem, to support the productivity of plants and animals, to preserve or increase the quality of water and air and to ensure the health of living things and the habitat.

Obviously, any change in the ability of the soil to function (respectively in the quality of the soil) will be reflected in the properties of the soil, with corresponding consequences in fertility, economic efficiency, the state of the environment and its biotope.

What is worth pointing out is that soil quality cannot be measured directly, due to its complex characteristics.

Therefore, soil quality can be assessed indirectly, through a series of qualitative and quantitative indicators that describe and quantify both the composition and the structure of the soil, as well as the physical, chemical and biological properties that emphasized the complex processes which shaped the soil in a continuous dynamic and the quality of its life.

The soil quality indicators (SQI), used frequently into the scientific papers are: physical SQI, chemical SQI and biological SQI.

There are several biological soil properties that soil quality can be assessed on the basis of biological properties considered as such or together with physical and chemical properties (Zerihun et al., 2021). Unfortunately, these quality indicators are not universal, but must be considered in relation to the concrete situation in which the assessment is made (Martinez-Salgado M.M., 2010).

When developing sustainable development strategies, it is recommended to consider the soil quality (SQ) indicators that hold degradation factors in various land use and soil management systems (LUSMS) (Bünemanna et al., 2018; Tesfahunegn et al., 2016).

The purpose of this study is to highlight the microbiological indicators (bacteria and fungi number as well as soil respiration) that can be used to evaluate the quality of the soil under irrigated and non-irrigated conditions.

MATERIAL AND METHOD

[1] National Research and Development Institute for Soil Science, Agrochemistry and Environment - ICPA Bucharest, Romania.

The researched had been performed in two sites (P1 – non-irrigated; and P2 – irrigated) located in the Eastern part of the Romanian Plain. The soils are Typic Chernozems (according to SRTS-2012; and Calcic Chernozems according to WRB-SR-2014) formed in loess like deposits.

The climate in the area is temperate continental with an average annual temperature of 10.8 degrees, rainfall of 480 mm. evapotranspiration of 470 mm. The area is characterized by prolonged periods of drought during the summer and early autumn.

The researched area belongs to the steppe bioclimatic zone, where the vegetation (dominated by the associations of *Festuca valesiaca*) had been replaced by the crops with mezo-xerophyle weeds.

Soil samples were taken from each pedogenetic horizon for the microbiological and micromorphological analysis, according to the Research Institute for Pedology and Agrochemistry from Bucharest – Romania Methodology (1987).

Micromorphological investigations were carried out on samples in natural setting, air-dried and impregnated with epoxy resins, on thin sections (25 - 30 μm), studied with the optical microscope in PPL (polarized light) and XPL (cross-polarized light), using the Bullock's terminology (Bullock et al., 1985).

The number of bacteria, fungi and the soil respiration were analized as microbiological indicators.

The number of heterotrophic bacteria (x 10^6 viable cells x g^{-1} dry soil) was determined using the method of dilutions - soil suspensions by dispersion on Topping nutrient medium. The total number of fungi, expressed in x 10^3 cfus x g^{-1} dry soil, was determined by dispersing soil dilutions-suspensions on the Czapek-Dox nutrient medium.

Taxonomic identifications were made according to the manual of determinative bacteriology (Bergey D. H., 1994) and fungi in agricultural soils (Domsch K. H., Gams W., 1972).

Soil respiration (mg CO_2 x g^{-1} dry soil) was determined by the Ştefanic method.

RESULTS AND DISCUSSIONS

The researches presented in this paper belongs to a complex study, part of the results being also published (Răducu D., et al., 2022).

The most significant and appropriate soil indicators are microbiological indicators because they provide a comprehensive picture of the viability of the entire soil ecosystem as well as the quality of the crop. In this respect, the microbiological indicators analyzed had been the number of bacteria and fungi and soil respiration.

The quantitative results of the microbiological analysis showed, in **P1 – non-irrigated** (*figure 1*), a medium (14.68 x 10^6 viable cells x g^{-1} d.s.) total counts of ***bacteria*** in the top Ap horizon, which highly increased to 34.21 x 10^6 viable cells x g^{-1} d.s. in the lower Apt horizon of the tilled layer.

The quantitative findings of the microbiological analysis revealed that the top Ap horizon of the **non-irrigated P1** layer had a medium total bacterial count (14.68 x 106 viable cells x g^{-1} d.s.), which significantly increased to 34.21 x 106 viable cells x g^{-1} d.s. in the lower Apt horizon of the tilled layer (*figure 1*).

The total amount of fungi in the tilled layer was medium, with 69.83 x 103 CFU g^{-1} d.s. in the Ap horizon and 63.38 x 103 CFU g^{-1} d.s. in the Apt horizon, respectively.

These values, which ranged from 21.22 x 103 CFU g^{-1} d.s. to 29.91 x 103 CFU g^{-1} d.s., sharply reduced in the underlying horizons.

As a general indicator of soil microbiological activity, the data for **soil respiration** showed a medium level of activity, the data values ranging from 51.315 mg CO_2 x g^{-1} d.s. to 54.436 mg CO_2 x g^{-1} d.s.

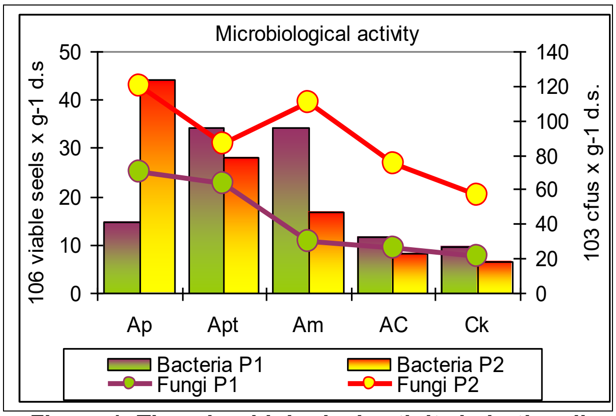

Figure 1. The microbiological activity in both soil (P1 – non-irrigated and P2 – irrigated).

Regarding the **investigations of P2 – irrigated**, the values of the total count of ***bacteria*** were high (44.29 x 10^6 viable cells x g^{-1} d.s.) in the top Ap horizon, and further drastically decreased to low values (6.58 x 10^6 viable cells x g^{-1} d.s.) in the deeper horizons.

The total number of ***fungi*** decreased from the surface, from the high values (120.03 x 10^3 CFU g-1 d.s.), throughout the deeper horizons, where their value was medium (56.68 x 10^3 CFU g-1 d.s.).

The ***soil respiration*** attended high value (67.007 mg CO_2 x g^{-1} d.s.) in the top Ap horizon and slowly decreased (to 45.802 mg CO_2 x g^{-1} d.s.) towards the bottom profile.

The obtained data (*figure 1*) showed that in the irrigated profile (P2), both bacteria and fungi reached higher values (comparing to P1 – non-irrigated). The more compacted Apt horizon is an exception, due to the lower total number of bacteria (comparing to P1).

Into the more compacted Apt horizon, the fungi also decreased, but the total count number still remains higher than in P1.

In both profiles, the values of the total count of both microorganisms showed a general trend of decreasing from the surface toward the deeper horizons.

The fungi in P2 make exception: in the top Ap horizon the higher value (120.03 x 10^3 cfus x g^{-1} d.s.) is attended, but drastically decreased in the more compacted Apt horizon (to 86.61 x 10^3 CFU g-1 d.s.), and increased again into the Am horizon (110.42 x 10^3 CFU g-1 d.s.), where the ecological conditions are best. In the deeper horizons, the fungi decreased again.

The ***taxonomic identification of bacteria*** in relation to the qualitative results (according to the manual of determinative bacteriology of Bergey, 1994) from P1 (*figure 2*) had been showed the dominance of the bacilli group, as well as of the *Pseudomonas*. Moreover, the main genus of *Bacillus* identified in P1 was: *B. megaterium, B. cereus, B. circulans*, and *Bacillus cereus* var. *mycoides*. With respect to the tilled layer (corresponding to Ap and Apt horizons) the same genus had been identified (such as: *B. megaterium, B. cereus,* and *B. circulans*).

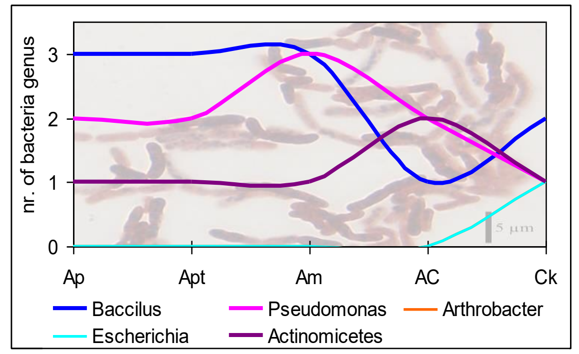

Figure 2. The bacteria taxonomic identification in P1 – non-irrigated.

Concerning the *Pseudomonas* presence in the tilled layer, the identified genus has been: *P. fluorescens* and *P. spp*.

Furthermore, in Am horizon *Pseudomonas pseudogleyi* also appear, enriching the number of genus.

The Actinomycetes, were also identified both in the tilled layer and in the deeper horizons, with the series: *Albus Ruber*, *Fuscus*, and *Flavus*.

In the bottom profile (Ck horizon respectively), the bacilli group, *Pseudomonas*, and Actinomycetes, together with *Arthrobacter citreus* and *Escherichia freundii* were also detected.

In P2, the ***taxonomic identification of bacteria*** highlighted both the presence of more species and their different distribution into the soil profile (*figure 3*), compared to P1.

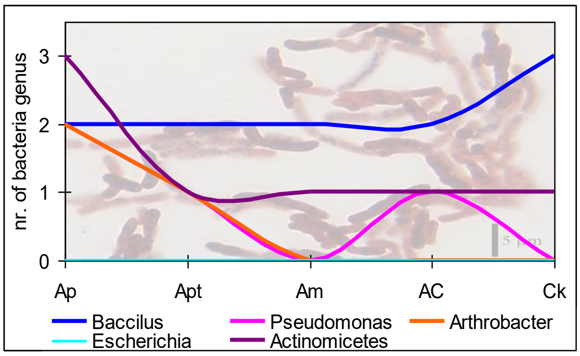

Figure 3. The bacteria taxonomic identification in P2 – irrigated.

Thus, into the Ap horizon of the tilled layer, the identified bacteria had been: *Micrococcus* spp., *Pseudomonas fluorescens, Arthrobacter globiformis, Xanthomonas pseudogleyi, Bacillus megaterium, Bacillus circulans, Pseudomonas lemonnieri, Arthrobacter citreus,* and Actinomycetes (Series *Albus*, *Luteus*, and *Fuscus*).

In this respect, the more abundant bacteria in the top horizon of the P2 – irrigated, showed better living conditions. Even better than into the Am horizon, where the bacteria identified had been: *Bacillus mesentericus,* and *Bacillus circulans,* together with the Actinomycetes S. *Albus*.

In Apt horizon, even if more compacted and implicitly less porous, the bacteria identified were, in decreased order: *Bacillus circulans, Pseudomonas* spp., *Bacillus megaterium, Arthrobacter globiformis*, and Actinomycetes S. *Albus*.

In the deeper horizon of P2 (Ck horizon), the number of bacteria genus is also high: *Bacillus megaterium, Bacillus cereus, Bacillus circulans, Pseudomonas* spp., *Micrococcus* spp., and Actinomycetes with *Fuscus*, and *Albus* Series).

Into the studied profiles, either non-irrigated, or irrigated, *Pseudomonas* is among the most dominant bacteria.

Rhizobacterium *Pseudomonas fluorescens* has a variety of traits that allow it to function as a biocontrol agent and to encourage plant growth. *Pseudomonas fluorescens* competes aggressively with other microorganisms, adapts to environmental stresses, and also produces a wide range of bioactive metabolites (antibiotics, siderophores, volatiles, and growth-promoting substances) in the plant rhizosphere. In addition, they are in charge of the natural suppressiveness of some soil-borne pathogens (David B.V., et al., 2018).

Although *Bacillus* is, by far, the dominant bacteria in P1 non-irrigated, in P2 irrigated it was no identified, the humidity conditions being higher.

The effects of members of the *Bacillus* genus on plant growth and development have long been recognized. They increase agricultural output by strengthening plant stress tolerance, disease defense, and mineral and water uptake (Zerihun T., et al., 2021). Another crucial factor is connected to *Bacillus* species' ability to build biofilms on plant surfaces, which helped plants tolerate drought better (Zerihun et al., 2021).

Alia S., et al. (2020) pointed out that both *Pseudomonas* and *Bacillus* strains demonstrated the potential to create a biofilm on an artificial surface, allowing them to colonize and benefit the host plant to the fullest extent possible.

By increasing the amount of lateral roots and root hairs, bacterial phytohormone secretion can alter root architecture, which in turn boosts nutrient and water uptake and fosters development (Persello-Cartieaux F., et al., 2003). Plants utilise microbial compounds such exopolysaccharides (EPS), phytohormones, and 1-aminocyclopropane-1-carboxylate (ACC) for drought tolerance. Plants partially rely on soil microorganisms to reduce stress produced by drought (Zerihun T., et al., 2021).

Arthrobacter had been identified into the deeper horizon of P1 non-irrigated, as well as into the surface horizons (both Ap and Apt) of the P2 – irrigated.

One of the most often isolated, native, aerobic bacterial genera found in soils is *Arthrobacter* sp. Members of the genus have a variety of metabolic and ecological traits and can endure severe environments for long periods of time (Mongodin E.F., et al., 2006).

Regarding **the *fungi* *taxonomic identification*** (according to Domsch et Gams, 1972) in both studied profiles (P1 and P2 - *figure 4* and *5*), the number and the distribution of the species and genus, had been different from one profile to another (as in case of bacteria).

In P1 the identified genus of fungi into the tilled layer were (*figure 4*): *Trichoderma harzianum, Fusarium oxysporum, Penicillium verrucosum, Aspergillus ochraceus,* and *Acremonium strictum (*in the top Ap horizon*)*; and *Trichoderma harzianum, Trichoderma viride, Fusarium pallidoroseum,* and *Aspergillus terreus (*into the Apt horizon*)*.

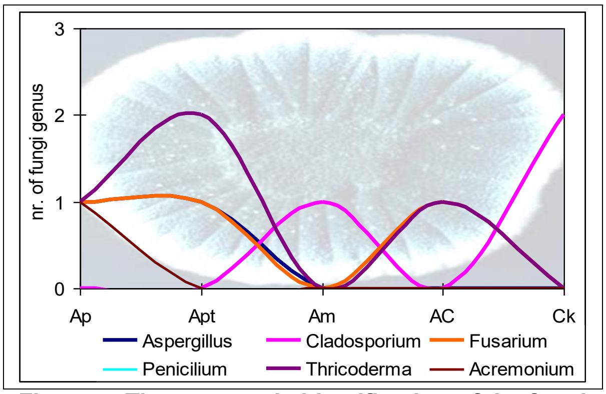

Figure 4. The taxonomic identification of the fungi from P1 – non-irrigated.

In the deeper horizon of P1 – non-irrigated, the number of the fungi species drastically decreased.

Thus, into the mollic (Am) horizon, with the best ecological conditions, only *Cladosporium sphaerospermum* had been identified, while into the AC horizon *Trichoderma harzianum* and *Fusarium solani* were detected. In the deeper Ck horizon, only *Cladosporium herbarum,* and *Cladosporium sphaerospermum* had been observed.

In **P2 – irrigated, the *fungi taxonomic identification*** showed a richness of species, in all the pedogenetic horizons (*figure 5*). Thus, in the top horizon of the soil and in the tilled layer, the identified species of fungi were: *Trichoderma viride, Trichoderma harzianum, Penicillium verrucosum, Chaetomium globosum, Penicillium commune, Penicillium frequentans, Aspergillus ustus, Mucor hiemalis,* and *Eurotium herbariorum*.

Into the Apt horizon, the species number slightly decreases: *Fusarium culmorum, Cladosporium herbarum, Aspergillus terreus, Aspergillus flavus, Penicillium* sp., and *Penicillium frequentans*.

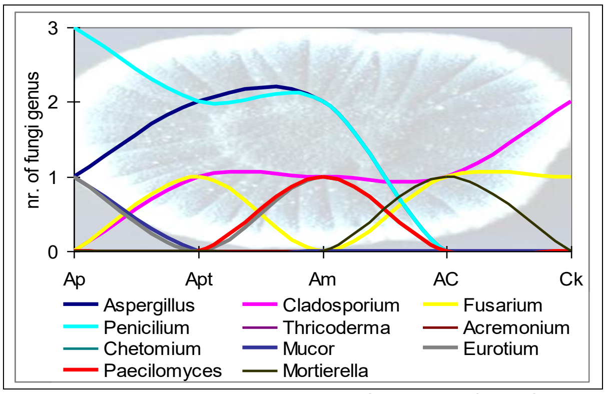

Figure 5. The taxonomic identification of the fungi from P2 – irrigated.

Mollic horizon, rich in organic matter, had been favored the development of: *Aspergillus tamarii, Penicillium* sp., *Cladosporium herbarum, Paecilomyces variotii, Eurotium herbariorum, Aspergillus terreus,* and *Penicillium* sp.

Into the deeper horizons, the fungi were still abundant: into the AC horizon *Fusarium oxysporum, Cladosporium cladosporioides, and Mortierella isabellina* also developed.

In the bottom profile, the number of fungi genus maintained to a relatively high level, thus, *Cladosporium sphaerospermum, Fusarium verticillioides, Cladosporium macrocarpum,* and *Mortierella isabellina*, *Paecilomyces elegans, and Cladosporium herbarum* were identified.

According to studies, "biofilm" is crucial to both the development of plant diseases and beneficial interactions (Lugtenberg B., Kamilova F., 2009).

By ensuring a strong root system, maintaining rhizosphere moisture, and adjusting soil pH, it can give organisms a way to establish and maintain themselves in a favorable environment, benefit from nutrients secreted by the plants, and influence them directly or indirectly, resulting in improved nutrient cycling (Davey M.E., O'Toole G.A., 2000).

Răducu D., et al. (2022), studying the structural vulnerability (using the structural hydrostability indicators' objective) of the Chernozems approached in this paper, showed that in P2-irrigated, due to their friability, the aggregates disintegrated when subjected to physico-mechanical operations. Consequently, an instable pore system formed.

The initial premises of this paper researches were that the microbiological indicators results should perfectly matched with the hydrostability indicators values (Răducu D., et al., 2022): the microbiological activity should be higher in an ecosystem with a high structural stability and, consequently, with a porous system stable and interconnected. But the obtained results pointed out that, according to microbiological indicators, the higher activity of microbiota were in the less stable structural profile, but with the higher humidity (in the P2-irrigated respectively). It was obvious that for the microorganisms, the soil humidity represented the crucial factor for their development (for their number as well as for their species and genus richness).

The microbiological diversity and their distribution in the two soil profiles (non-irrigated and irrigated) had been different as a result of the anthropic influence through irrigation.

The microbiological indicators use in the paper to emphasize soil quality, proved to be important tools for soil quality assessment and marching with the others important physical indicators, showing also a great accuracy.

CONCLUSIONS

The obtained results based on the study of microbiological indicators in different conditions (non-irrigated and irrigated), were different of the initial premises of the researches: best higher activity in best structured soil (with high and stable porosity).

The obtained data showed that in P2 – irrigated, higher values were attained for the soil respiration, bacteria, and fungi, comparing to P1 – non-irrigated, except the Apt horizon where the total number of bacteria is lower (than in P1), and the fungi also decrease, but the total count number still remains higher than in P1.

On the other hand, the taxonomic identification highlighted in P2 – irrigated a richness of species, both for bacteria and fungi, in all the pedogenetic horizons, comparing to P1 – non-irrigated.

The number of bacteria, the number of fungi and the soil respiration proved to be important and accurate indicators for soil quality assessment in both ecological different conditions of non-irrigated and irrigated.

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REFERENCES

Alia S., Hameeda S., Shahida M., Iqbala M., Lazarovitse G., Imran A., 2020 - *Functional characterization of potential PGPR exhibiting broad-spectrum antifungal activity*. Microbiological Research, 232: 2-17.

Bergey D. H., Holt J. G., 2000 - *Bergey's manual of determinative bacteriology.* 9th ed. Philadelphia, Lippincott Williams & Wilkins: 787 pp.

Bouma J. 2002 - *Land quality indicators of sustainable land management across scales*. Agriculture Ecosystems and Environment, 88: 129-36.

Bullock P., Fedoroff N., Jongerius A., Stoops G., Tursina, T., Babel, U. 1985 - *Handbook for soil thin sections description*. Wine Research Publication: 150 pp.

Bünemanna E.K., Bongiornoa G., Bai Z., Creamer R.E., De Deyn G., de Goede R., Fleskens L., Geissen V., Kuyper T.W., Mäder P., Pulleman M., Sukkel W., van Groenigen J.W., Brussaard L. 2018 - *Soil quality – A critical review*. Soil Biology and Biochemistry, ELSEVIER, The Netherlands, 120: 105–125.

David B.V., Chandrasehar G., Selvam P.N., 2018 - *Pseudomonas fluorescens*: *A plant-growth-promoting rhizobacterium (PGPR) with potential role in biocontrol of pests of crops – Chapter 10. Crop Improvement Through Microbial Biotechnology*. New and Future Development in Microbial Biotechnology and Bioengineering, ELSEVIER: 221–243.

Davey M.E., O'Toole G.A., 2000 - *Microbial biofilm: from ecology to molecular genetics*. Microbiology Molecular Biology Reviews, 64: 847–867.

Domsch K.H., Gams W., 1972 - *Fungi in agricultural soils*. Germany: 290 pp.

Dumitru M., Manea A. (coordonatori), 2011 - *Metode de analiză chimică și mcrobiologică (Utilizate în Sistemul de Monitorizare a Solurilor).* Editura Sitech, Craiova: pp. 298.

Florea N., Munteanu I., 2012 - *Sistemul român de taxonomia solurilor – SRTS–2012 (Romanian Soil Taxonomy System)* Editura Estfalia, Bucharest, Romania: 182 pp.

ICPA Methodology–1987. *Methodology for elaborating pedological studies*. Redacția de Propagandă Tehnică Agricolă, Bucharest, Romania, Vol. I – III.

Levi N., Hillel N., Zaady E., Rotem G., Ziv Y., Karnieli A., Paz-Kagan T., 2021 - *Soil quality index for assessing phosphate mining restoration in a hyper-arid environment*. Ecological Indicators: 1–13.

Lugtenberg B., Kamilova F., 2009 - *Plant-growth-promoting rhizobacteria*. Annual Review of Microbiology, 63: 541–556.

Martinez-Salgado M.M., Gutiérrez-Romero V., Jannsens, M., Ortega-Blu R., 2010 - *Biological soil quality indicators: a review*. In A. Mendez-Vilas (Ed.) Current Research, technology and Education Topics in Applied Microbiology and Microbial Biotechnology: 319-328.

Mongodin E.F., Shapir N., Daucherty S.C., DeBoy R.T., Emerson J.B., Shvartzbeyn A., Radune D., Vamathevan J., Riggs F., Grinberg V., Khouri H., Wackett L.P., nelson K.E., Sadowsky, M.J. 2006 - Secrets of soil survival revealed by the genome sequence of *Arthrobacter aurescens* TC1. *PLOS Genetics*, 2(12): 2094–2106.

Persello-Cartieaux F, Nussaume L, Robaglia C. 2003 - *Tales from the underground: Molecular plant-rhizobacteria interact-tions*. Plant Cell Environ, 26, 189–199.

Răducu D., Calciu I., Lăcătușu A.-R., Gherghina A., Manea A., Vizitiu O., Voicu P., 2022 - *The structural vulnerability of Chernozems from Bărăgan under the climate changes stress*. Lucrări Ştiinţifice, seria Agronomie, Vol. 65(1):

Ştefanic Gh., 1991 – *Assay of the potential level of soil respiration with an oxygen – generating respirometer*. Bull. Sci. Agric. Forest, vol. 21: 87-91.

Tesfahunegn G.B., 2016 - *Soil quality indicators response to land use and soil management systems in Northern Ethiopia's Catchment*. Land degradation & Development, Land Degradation Development, 27: 438–448.

Zerihun T. Dame M., Tofazzal I., 2021 - *Bacilli as sources of agrobiotechnology: recent advances and future directions*. Green Chemistry Letters and Reviews, 14 (2): 246–271.

WRB-SR-2014. *World reference base for soil resources.* World Soil Resources Reports 106, FAO of the United Nations, Rome: 181 pp.

THE STRUCTURAL VULNERABILITY OF CHERNOZEMS FROM BARAGAN UNDER THE CLIMATE CHANGES STRESS

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Abstract

The paper emphasized the structural vulnerability of two Chernozems from Baragan Plain (P1 – non-irrigated and P2 – irrigated) by the aim of the structural hydrostability indicators: structural instability index (IS); soil dispersion (D - % g/g); structural macro-hydrostability (AH - % g/g). The analytical results showed, in P1, that the values of the structural instability index (IS), in the tilled layer, is high (0.74 in Ap) to very high (1.01 in Apt) and decreased to medium (0.48 – 0.66) in the lower horizons.
In P2, the IS values ranging from extremely high (3.77) in the top Ap horizon to very high (1.04 – 1.58) in the deeper horizons; except the Am horizon, where the IS reached the minimum value (0.38) in the profile. The extremely high – very high values of IS showed a high risk to soil destructuration. The values of D are medium and low for AH (in THE tilled layer); while in P2: D values are high–medium, while AH values are very low–low, increasing with depth. At the microscopic level, the analytical data are clearly reflected by the micromorphological images for both soil profiles: in P1 the structural aggregates (as well as macrofauna coprolites) are partially (and/or totally) consumed by the terrophagous (and coprophagous) mesofauna – showed by their rounded shape; while in P2, the structural aggregates collapsed under physico-mechanical processes, due to their friability – showed by their angular shapes. The results showed medium–low (P1) – high (P2) vulnerability to structural degradation (in the tilled layers).

Key words: structural instability index; micromorphology; vulnerability.

INTRODUCTION

Chernozems are considered soils with low vulnerability to destructuration due to their high biological activity and organic matter content, but in the actual drastically change of the climate, all the terms of the „ecological equation" could also drastically altered.

Specialists warn that climate change will have a significant impact on soil resources and ecosystems as a result of the increase in temperature and changes in the rainfall regime. For the Carpathian Basin, for example, severe drought events are predicted during this century. (Gelybo G., et al, 2018).

The water stable aggregates is significantly influenced by the soil physical and chemical properties as: clay and humus contents, Ca^{2+}, base saturation degree, sum of the exchangeable bases, soil reaction, cation exchange capacity (Manea A. *et al.*, 2011).

Soil is the main supplier of macro and micronutrients for cultivated plants and therefore the study of the changes induced by climate changes on fertility properties is necessary and timely (Karmakar R. Et al., 2016).

Calcium ions promote the formation of a stable soil structure by saturating the humus and forming calcium humats, which increased the structural aggregates cohesion; a proportion of 50 – 80 % of Ca^{2+} ions from the total exchange capacity ensure the soil fertility, as well as the soil structure stability and the favorable regime for the water and air (Lixandru Gh. et al., 1990; Manea A. et al., 2011).

The higher stability of water-stable aggregates means the more C protected within the aggregates and therefore the water-stable aggregates could be consider a key factor in the stabilization of soil organic matter in the Chernozems (Simansky V. and Jonczak J., 2016).

The size and structural stability of the aggregates allow the appreciation of the effects

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produced by soil wtillageorks, organic matter inputs and soil erosion (Nimmo J.R. and Perkins K.D., 2022).

Kolodov V.A. et al. (2019) studying the changes in the distribution of structural units as a response of humus horizons in Typical Chernozems to anthropogenic loads of different intensity reported that during „Chernozem tillage, unstable soil particles < 0.25 mm ∅ formed due to comminution and may stick together to larger (>10 mm) water-unstable aggregates (clods). While the removal of tillage loads, large aggregates interact with fresh organic matter, and the water stability of aggregates increases; at the same time, the largest aggregates (mainly >10 mm) tend to transform into aggregates of smaller sizes‟.

„The content of agronomical valuable fractions (10.00 - 0.25 mm) is one of the main soil quality indicators and is particularly important because valuable fractions provide optimal porosity and water and air capacity of soil‟ (Medvedev V.V. and Cybulko W.G., 1995; Shein Y.V. et al., 2001; Ciric V. et al., 2012).

Manea A. et al. (2022) showed that the sutied „Chernozems (from Dolj County) were medium-high compacted according to the packing density (g/cm3) values, which required loosening works. They also showed a high correlation (R^2=0.955) between the compaction degree and the packing density (g/cm3). Also half of the studied Chernozems had extremely high – very high values of the structural stability index. While the mean (5.6%) value of the structural stability index indicated high risk of soil to degradation‟.

Dumitru M. et al. (2011) underlined that „one of the most important physical properties for soil fertility status is structural stability and shape of aggregates, which reflect micromorphological, agro-physical and agronomic aspects. The main factors influencing the structural stability are: clay and calcium carbonate content, quantity and quality of organic matter, soil management technologies. The structural degradation processes occur due to the humus content decrease, increase of acidity or alkalinity, irrational soil management, etc.‟

„The fundamental physical properties (such as the particle-size distribution, the specific surface, and the water sorption–desorption characteristics) of the typical Chernozems did not change significantly under the impact of the organic and mineral fertilizers during the long-term stationary experiment; at the same time, the physicomechanical properties of the soils, including the aggregate strength and the dependence of the penetration resistance on the water content, displayed significant changes under the impact of the long-term application of organic and mineral fertilizers‟ (Shein E.V. et al., 2011).

„Pseudo-compaction of the lower part of the treated layer can occur when loosening only the surface layers, which leads to hydrolysis degradation of Chernozem‟ (Parkhomenko G. et al., 2019). Furthermore, „according to the standards for changing the physical properties of Chernozems depending on the nature of the anthropogenic impact, the optimal density range of the tilth soil in the Rostov Region is 1.10 - 1.25 g/cm3, critical – more than 1.35 g/cm3 with a humus content of 3.5 - 4.5%; therefore, it is necessary to soften the soil by mechanical treatment‟ (Parkhomenko G. et al., 2019).

„Aggregation processes are very dynamic and complex as a result of the interaction of many factors such as soil management, plant growth, soil properties (soil texture, mineral composition, SOC concentration), microbial activities, nutrients reserve, exchangeable ions and quantity of available water" (Stătescu F. et al., 2013).

Shein E. and Milanovskiy E. (2014), studying the mechanism of structure formation with participation of hydrophilic and hydrophobic components showed „that organo-mineral water-stable aggregate has the following organo-mineral composition: «mineral particle surface − (hydrophilic-hydrophobic components) = (hydrophobic-hydrophilic components) − mineral surface»; where the symbol () denotes a molecule of soil organic matter, and the symbol «=» represents hydrophobic interactions. The combined action of the hydrophobic components of soil organic matter, which hydrophobize the surface of the mineral matrix and nonpolar molecules, isolated in microzones, stochastically distributed in the aggregate, cause its water-stable properties‟.

The objective of the paper is to emphasize the structural vulnerability of the Chernozems from Bărăgan Plain under the influence of the present increasingly stressful climate changes.

MATERIAL AND METHOD

The studied area is located in Bărăgan Plain, in the Eastern part of the Romanian Plain, where the soil is Typic Chernozem (according to SRTS-2012; and Calcic Chernozem according to WRB-SR-2014) formed in loess like deposits.

The climate is temperate continental, with an average annual temperature of 10.8°C and an average annual precipitation of 480 mm. The evapotranspiration reaches 700 mm, while De Martonne aridity index is 23. The summers are warm and long, with droughty periods in late summer and early fall.

The researched area belongs to the steppe bioclimatic zone, where the natural vegetation has been replaced by crops with meso-xerophyle weeds: *Echinocloa crus-gali, Cynodon dactylon, Agropyron cristatum, Agropyron repens, Bromus arvensis, Cirsium arvense, Solanum nigrum, Matricaria chamomilla,* and *Convolvulus arvensis.*

Two soil profiles (P1 – non-irrigated and P2 – irrigated) had been studied in the field and described (at macro-scale) according to ICPA Methodology-1987 and Soil Survey Field Handbook (Hodgson J.M. (ed.), 1997). The P1 – non-irrigated description showed:

Ap 0-28 cm: medium loam; vey dark brown (10YR 2/2) when wet and vey dark grayish brown (10YR 3/2) when dry; slightly moist; structure disturbed by tillage, breaking to coarse – medium subangular blocky structure; medium packing density; moderately sticky; moderately plastic; moderately adherent; moderately porous with very fine and fine pores; many lumbric coprolites and burrows; many thick roots; sharp wavy boundary;

Apt 28-42 cm: medium loam; vey dark brown - vey dark grayish brown (10YR 2.5/2) when wet and vey dark grayish brown (10YR 3/2) when dry; slightly moist; structure disturbed by tillage, breaking to fine – medium subangular blocky structure; medium packing density; moderately sticky; moderately plastic; moderately adherent; moderately porous with very fine and fine fissures and pores; many lumbric coprolites and burrows; many thick roots; sharp wavy boundary;

Am 42-60 cm: medium loam; vey dark brown (10YR 2/2) when wet and vey dark grayish brown (10YR 3/2) when dry; slightly moist; medium subangular blocky structure and medium – fine granular structure; low packing density; moderately sticky; moderately plastic; moderately adherent; very porous with very fine and fine pores; many lumbric coprolites and burrows; slightly thick roots; sharp wavy boundary;

AC 52-76 cm: medium loam; vey dark grayish brown (10YR 3/2) when wet and dark grayish brown (10YR 4/2) when dry; slightly moist; high – medium subangular blocky structure and medium – fine granular structure; low packing density; moderately sticky; moderately plastic; moderately adherent; very porous with very fine and fine pores; many lumbric coprolites and burrows; many thick roots; sharp wavy boundary.

The profile description of the P2 – irrigated:

Ap 0-17 cm: medium loam; vey dark brown (10YR 2/2) when wet and dark grayish brown - vey dark grayish brown (10YR 3.5/2) when dry; dry; structure disturbed by tillage, breaking to fine – medium subangular blocky structure; high packing density; moderately sticky; moderately plastic; moderately adherent; slightly porous with very fine and fine pores; rare lumbric coprolites; slightly thick roots; sharp wavy boundary;

Apt 17-31 cm: medium loam; vey dark brown (10YR 2/2) when wet and dark grayish brown - vey dark grayish brown (10YR 3.5/2) when dry; dry; structure disturbed by tillage, breaking to high – medium subangular blocky structure; high packing density; moderately sticky; moderately plastic; moderately adherent; slightly porous with very fine to coarse fissures and pores; rare lumbric coprolite; slightly thick roots; sharp abrupt boundary;

Am 31-52 cm: medium loam; vey dark brown (10YR 2/2) when wet and dark grayish brown - vey dark grayish brown (10YR 3.5/2) when dry; dry; fine and medium subangular blocky structure; high packing density; moderately sticky; moderately plastic; moderately adherent; medium porous with very fine and fine pores; rare lumbric coprolites and burrows; slightly thick roots; sharp wavy boundary;

AC 52-76 cm: medium loam; vey dark grayish brown (10YR 3/2) when wet and dark grayish brown (10YR 4/2) when dry; dry; high – medium subangular blocky structure; high packing density; moderately sticky; moderately plastic; moderately adherent; very porous with very fine and fine pores; many lumbric coprolites and burrows; slightly thick roots; sharp wavy boundary.

The two soil profiles (P1 – non-irrigated and P2 – irrigated) had also been sampled (from each pedogenetic horizon) for the structural hydrostability indicators and further analyzed according to ICPA Methodology-1987. The structural hydrostability indicators analyzed in the paper had been: soil dispersion (D – % w/w); structural macro-hydrostability (AH – % w/w); and structural instability index (IS).

Both D (% w/w) and AH (% w/w) indicators had been analyzed in the laboratory by the determination, throughout wet sieving, sedimentation, pipette and mechanical dispersion of: the content of the micro-aggregates unstable to water impact (< 0.01 mm∅); and the content of the macro-aggregates water-stable (> 0.2 mm∅).

The structural instability index (IS) had been calculated as the ratio between D and AH (according to the formula: $IS = D / AH - 0.9 \cdot ng$; where: 0.9 = is a correction factor; and ng = is the coarse sand content).

For the micromorphological study, undisturbed soil had been sampled (also from each pedogenetic horizon), air drayed and impregnated with epoxidic resins. After hardening, ten oriented thin sections (25 – 30 μm) had been made from the soil samples, that the investigation results be statistically covered. The thin sections had been studied with Documator (20 X) and optical microscope (50 – 100 X) in plain polarized light (PPL) and cross-polarized light (XPL). The terminology used for micromorphological description was according to Bullock P. et al. (1985).

RESULTS AND DISCUSSIONS

Among the most important physical properties of the soil that showed and influenced the status of soil fertility is the quality of the structural aggregates. This characteristic could be quantified by the aim of the structural hydrostability indicators as: soil dispersion (D – % w/w); the structural macro-hydrostability (AH – % w/w); and the structural instability index (IS).

The analytical data of the dispersion (D – % w/w) showed, in P1, medium values (4 – 5 % w/w – *figure 1*) in the upper layer (Ap and Apt) and high (8 % w/w) in the deeper horizons, and consequently, indicated a medium-high content of structural micro-aggregates (< 0.01 mm ∅) unstable to the water impact, giving also an image about the adjacent micro-pores.

In what concerning the structural macro-hydrostability (AH – % w/w), the values had been ranging between 5 and 17 % w/w, being low (5 – 6 % w/w) in the upper tilled layer and medium (11 – 17 % w/w) in the underlined horizons (*figure 1*).

The low content of macro-structural aggregates stable to water impact (as well as to other natural and anthropogenic factors) in the top horizon pointed out a high risk of crusting, very harmful to crop emergences.

Additionally, the structural instability index (IS) which represent the ratio between the two indicators D and AH respectively, give information about both micro-aggregates (< 0.01 mm ∅) unstable to the water impact, and the content of the structural macro-aggregates (> 0.2 mm ∅) stable to the water impact.

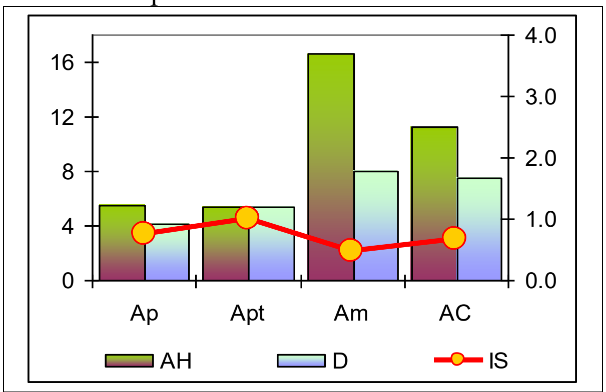

Figure 1. The structural hydrostability indicators: soil dispersion (D – % w/w); structural macro-hydrostability (AH – % w/w); and structural instability index (IS) in P1.

Consequently, the results of the analytical data showed that IS values of the tilled layer of P1 is high (0.74 in Ap) to very high (1.01 in Apt respectively) and decreased to medium (0.48 – 0.66) in the lower horizons of the soil profile (*figure 1*).

Regarding P2, the D reached high values (6 – 7 % w/w – *figure 2*), except Am horizon where the value drops to medium (3 % w/w).

The AH values (*figure 2*) are very low (2 % w/w) in the top horizon, and although they increase with depth, still remain within the class limits with low values (4 – 7 % w/w).

The low content of the structural macro-aggregates stable to the water impact give also information about the adjacent macro-pores stability.

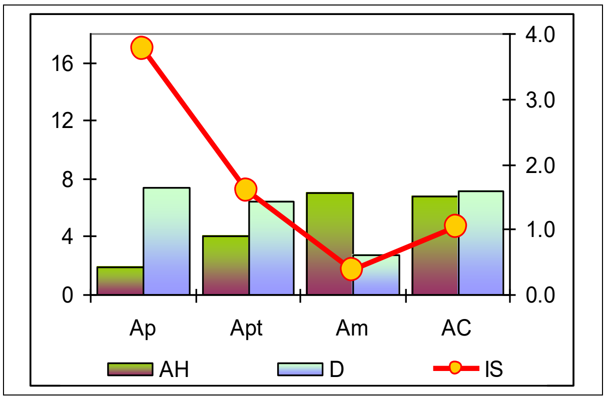

Figure 2. The structural hydrostability indicators: soil dispersion (D – % w/w); structural macro-hydrostability (AH – % w/w); and structural instability index (IS) in P2.

The IS values ranging from extremely high (3.77) in the top Ap horizon to very high (1.04 – 1.58) in the deeper horizons of the soil profile (*figure 2*), except the Am horizon, where the IS reached the minimum value (0.38) in the profile.

With regards to the structural instability index (IS), it can be concluded that higher values reflect greater instability of the soil structure and, conversely, showing high risk of soil degradation. Thus, the lower the IS index value, the more stable the soil structure is.

Corroborating the obtained data (*figure 3*), a clear picture had been resulted with the influence of the agricultural tools in the tilled layer (suggested by the graphs in *figure 1* and 2), which showed the vulnerability (*figure 3* and *4*) of the upper layer of the two profiles to disruption and its susceptibility to unwanted agro-pedological phenomena such as dusting followed by crusting, clogging of pores followed by waterlogging, etc.

P1 (non-irrigated)	**macro-aggregates**	**<**	**micro-aggregates**	**Harmful processes**	**Vulnerability**
Ap	low content		medium content	Dusting, crusting, etc.	mediu–low
Apt				Destructuration, compaction	
P2 (irrigated)	**macro-aggregates**	**>**	**micro-aggregates**		
Ap	very low content		high content	Dusting, crusting, etc.	very high – high
Apt	low content			Destructuration, compaction	

Figure 3. The vulnerability according to the macro- and micro-aggregate contents.

The hydrostability of the soil structural aggregates is a significant physical characteristic which emphasized the structuring capacity of the soil, and consequently its vulnerability to structural degradation, under the impact of natural and anthropic processes.

Structural instability			**Vulnerability**		
(non-irrigated) **P1**	<	**P2** (irrigated)	(non-irrigated) **P1**	<	**P2** (irrigated)
high – very high		extremely high	medium–low		high

Figure 4. The vulnerability according to the structural instability values.

Even if the Chernozem is the best agricultural soil, the results (*figure 4*) showed a warring level of vulnerability (medium–low in P1 non-irrigated to high in P2 irrigated, to structural degradation (in the tilled layers).

Consequently, in P2, the soil vulnerability of the tilled layer is higher, comparing to P1, as a result of the added impact of irrigation water.

At the microscopic level, the analytical data are clearly reflected by the micromorphological images for both soil profiles (*figure 5* and *6*).

The big structural elements are fragmented in both profiles, but it is a big difference between the processes that influenced this fragmentation: in P1 the processes are mainly biologic, while in P2 the processes are mainly physico-mechanical.

In P1, the structural aggregates (as well as macrofauna coprolites) are fragmented (*figure 5*), being consumed partially (and/or total) by terrophagous (and coprophagous) mesofauna – showed by their rounded shape.

This highlighted that the mesofauna influence on soil structuring is dominant, the small structural elements are rounded (mezofauna coprolites), prevailing to the physico-mechanical processes.

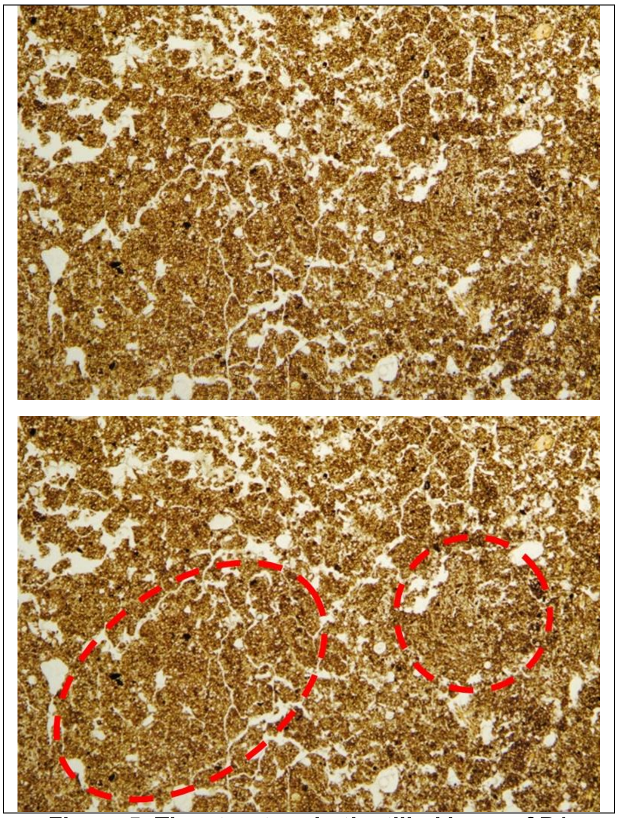

Figure 5. The structure in the tilled layer of P1 (non-irrigated): the macrofauna coprolites (– –) partially consumed by the coprophagous mesofauna. PPL.

The activity of the coprophagous and terrophagous mesofauna prevailed, being much more resistant to the conditions generated by the advanced drying of the profile and the reduced aeration due to the relatively dense packing of the interconnected pores.

In P2, many structural elements (both aggregates and macrofauna coprolites) collapsed due to their friability (*figure 6*) – showed by their shapes. The small structural elements are predominantly angular – subangular, their collapsed being the result of the physico-mechanical processes prevalence (and less to their consumption by coprophagous mezofauna).

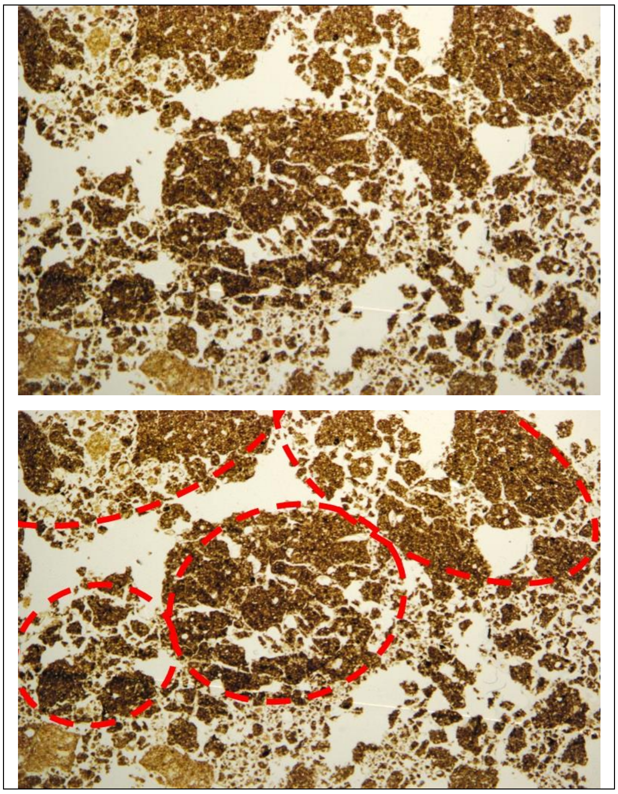

Figure 6. The structure in the tilled layer of P2 (irrigated): the macrofauna coprolites (– –) collapsed. PPL.

In P1 the compaction process is more active than in P2, and the structure fragmentation is not so obvious. In this respect, in P1 the biological structural elements, generated by both maco- and mezofauna, are more packed (comparing to P2) as a result of a more active process of compaction.

Together with the analytical data of the structure vulnerability, the micromorphological images also emphasized a high biological activity of the macrofauna which created a higher porosity comparing to the more packed P1 (non-irrigated), where the mesofauna activity is dominant.

The micromorphological images (*figure 5* and *6*) supported the analytical data, together emphasizing the high fragmentation of macro-aggregates (therefore the dominance of micro-aggregates) and consequently the vulnerability of the two studied soils.

The destructuration processes represent the reduction or loss of the structural aggregates stability under the water and/or agricultural machinery impact, being the most dangerous physical processes for the soil architecture.

According to the agricultural technology that belong to the current tillage, specific to the different crops (in the rotation), different quantities of the organic residues remains on the field, food for soil life, the builders of the soil structure and porosity, and consequently of the resistant aggregates (to different impacts).

This is due to the specific characteristics of the pedogenetic structural stability of the macro-aggregates (mull calcic humus and balanced texture), but also due to the biological activity that permanently restores the structure (generating stable aggregates) and the adjacent pore space (borrowing channels and chambers).

Analytical data also reflected a relatively low-medium susceptibility of the soil to unwanted agro-pedological phenomena such as crusting, very harmful for many plants emergence, and further for crop yield.

Although it is well known that Chernozems are exceptional soils for most agricultural crops, due to its natural characteristics that contribute to the structure restoration, the agro-technologies with lowest traffic are recommended for both profiles (P1 and P2) to minimize the negative impact of the agricultural tools and water (from rainfall and/or irrigation) on the soil structure, but also on soil biodiversity.

The 3D soil aggregates arrangements (packing or loose), their sizes and shapes, generated the adjacent pores (size and shape), while their surface roughness give the type of the aggregate's accommodation, which further influenced the circulation and retention of water (from soil solution) and air circulation and exchange (between soil and atmosphere).

This architecture strongly influences the crop root architecture, and also the rooting depth of the crops (very important for non-irrigated soils as P1).

Even if medium compacted, the soil life was very active and „buffered“ the anthropic compaction by tillage.

The structural aggregate had been formed in P1 mainly by biological activity, while in P2 the breaking down processes under physico-mechanical forces was very active. The first type of structural aggregates showed stability and high quality, the second type showed low cohesion of peds and/or primary constituent particles.

The obtained data showed that studied Chernozems from Bărăgan Plain had a medium–low (P1) – high (P2) vulnerability to structural degradation, in the tilled layers (corresponding to the Ap and Aph horizons), and, in present, being stressed under the more and more obvious climate changes, is highly helped by the „buffering“ action of a positive characteristic, as soil life (that generated stable aggregated), and a negative one as the compacted tilled layer (which retained longer the water from precipitations in the active root layer).

Climate changes and land degradation are closely linked issues and conservation farming has showen promise in minimizing land degradation; hence, the potential of conservation agriculture in minimizing the impact of climate change needs thorough investigation (Karmakar R. Et al., 2016).

CONCLUSIONS

The indicators used to characterize structural hydrostability of two Chernozems (P1 – non-irrigated and P2 – irrigated) showed the following characteristics: the structural instability (IS) and the dispersion (D - % w/w) had a general tendency to increase from the surface horizon towards the bottom profiles, while structural macro-hydrostability (AH % w/w) decreases from the top to the bottom of the soil profiles.

In P1, on the general background of a low content of structural macro-aggregates (> 0.2 mm Ø) stable to water impact and a medium amount of structural micro-aggregates (< 0.01 mm) unstable to water impact the soil had medium – low vulnerability.

In P2, the agro-pedological conditions of the roots active layer is characterized by a low – very low stability of the soil structure, reflected by the extremely high – very high values of IS index, the soil had very high – high vulnerability.

Further results of micromorphological research had been provided information about the structural characteristics of the two Chernozems, the analytical data are clearly reflected by the micromorphological images for both soil profiles: in P1 the structural aggregates (as well as macrofauna coprolites) are consumed partially (and/or totally) by the terrophagous (and coprophagous) mesofauna – showed by their rounded shape; while in P2, the structural aggregates collapsed under physico-mechanical processes, due to their friability – showed by their angular shapes. Consequently, in P2 (irrigated), the soil vulnerability (to structural degradation) of the tilled layer is higher, comparing to the P1 (non-irrigated).

The results of the researches raise an alarm signal concerning the structural vulnerability of the Chernozems from Baragan Plain: even if they are the most favorable soils for agriculture, their structural vulnerability is high, characteristic that is negatively accentuated under the influence of current climate changes.

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REFERENCES

Bullock P., Fedoroff N., Jongerius A., Stoops G., Tursina, T., Babel, U., 1985 - *Handbook for soil thin sections description*. Wine Research Publication, pp. 150.

Ciric V., Manojlovic M., Nesic Lj., Belic M. 2012 - *Soil dry aggregate size distribution: effects of soil type and land use*. Journal of Soil Science and Plant Nutrition, Vol.12, no. 4: 689-703.

Dumitru M., Manea A., Ciobanu C., Dumitru S., Vrinceanu N., Calciu I., Tanase V., Preda M., Risnoveanu I., Mocanu V., Efene M., 2011 - *Agricultural soil quality monitoring in Romania (Monitoringulstării de calitate a solurilor din România*), Editura Sitech, Craiova: pp. 137.

Florea N., Munteanu I., 2012 - *Sistemul român de taxonomia solurilor – SRTS–2012 (Romanian Soil Taxonomy System)* Editura Estfalia, Bucharest, Romania: pp. 182.

Gelybo G., Toth E., Farkas C., Horel Á., Kasa I., Bakacsi Z., 2018 - *Potential impacts of climate change on soil properties*. Agrochemistry and Soil Science, Vol. 67, no. 1: 121-141.

ICPA Methodology–1987. *Methodology for elaborating pedological studies*. Redacția de Propagandă Tehnică Agricolă, Bucharest, Romania, Vol. I – III.

Karmakar R., Das I., Dutta D., Rakshit A., 2016 - *Potential effects of climate change on soil properties: A review*. Science International, nr.4: 51-73.

Kolodov V.A., Yaroslavtseva N.V., Farkhodov Yu.R., Belobrov V.P., Yudin S.A., Aydiev A.Ya., Lazarev V.I., Frid A.S., 2019 - *Changes in the ratio of aggregate fractions in humus horizons of Chernozems in response to the type of their use*. Eurasian Soil Science, Vol. 52: 162-170.

Lixandru Gh., Calancea L., Caramete C., Marin N., Goian M., Hera Cr., Borlan Z., Răuță C., 1990 - *Agrochimie*, Editura Didactică și Pedagogică, Bucharest, Romania: pp. 390.

Manea A., Dumitru M., Calciu Irina, Rizea N., 2011 - *Influence of soil acidification on some soil physical properties (water stable aggregates and dispersion)*. Lucrări ştiinţifice, Seria Agronomie, 54 (1): 83–86.

Manea A., Dumitru M., Gherghina A., Calciu I., Raducu D., Anghel A.., 2022 - *Physical quality evaluation of some soils from Dolj County*. Analele Universităţii din Craiova, seria Agricultură – Montanologie – Cadastru (Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series)Vol. 52/1/: 406-415.

Medvedev V.V., Cybulko W.G., 1995 - *Soil criteria for assessing the maximum permissible ground pressure of agricultural vehicles on Chernozem soils*. Soil and Tillage Research, vol. 36: 153-164.

Nimmo J.R., Perkins K.D., 2022 - *Aggregate stability and size distribution*. In Methods of soil analysis, Part 4 – Physical methods, Madisol, Wisconsin, Soil Science Society of America: 317–328.

Parkhomenko G., Kambulov S., Olshevskaya A., Babadzhanyan A., Gucheva N., Mekhantseva I., 2019 - *The tillage effect on the change of soil structure*. IOP Publishing of IOP Conf. of the XII International Scientific Conference on Agricultural Machinery Industry. Series: Earth and Environmental Science 403 012144: 1-5.

Shein Y.V., Arhangel'skaya T.A., Goncharov V.M., Guber A.K.,Pochatkova T.N., Sidorova M.A., Smagin A.V., Umarova A.B., 2001 - Field and laboratory methods of physical properties and soil status investigations. The University of Moscow, Russia: pp 199.

Shein E., Milanovskiy E., 2014 - *Soil Structure Formation: Role of the Soil Amphiphilic Organic Matter*. Biogeosystem Technique, Vol. 2, no 2: 182-190.

Shein E.V., Lazarev V.I., Aidiev Y.Y., Sakunkonchak T., Kuznetsov Y.Y., Milanovskii Y.Y., Khaidapova D.D., 2011 - Changes in the physical properties of typical chernozems of Kursk oblast under the conditions of a long-term stationary experiment," Eurasian Soil Science, Vol. 44, no. 10: 1097–1103.

Simansky V., Jonczak, J., 2016 - *Water-stable aggregates as a key element in the stabilization of soil organic matter in the Chernozems*. Carpathian Journal of Earth and Environmental Science, 11 (2): 511–517.

Hodgson J.M. (ed.) 1997 - *Soil Survey Field Handbook*. Soil Survey Technical Monography, No. 5, Solsoe: pp 116.

Stătescu F., Zaucă D.C., Pavel L.V., 2013 - *Soil structure and water-stable aggregates*. Environmental Engineering and Management Journal, "Gheorghe Asachi" Technical University of Iasi, 12 (4): 741–746.

WRB-SR-2014. *World reference base for soil resources. International soil classification system for namig soils and creating legends for soil maps*. World Soil Resources Reports 106, FAO of the United Nations, Rome: 181 pp.

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