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THE GO GREEN PROJECT: A NEW INITIATIVE TO SUPPORT SCHOOLS' MISSION ON ENVIRONMENTAL ISSUES

PROIECTUL GO GREEN: O INIȚIATIVĂ NOUĂ ÎN SPRIJINIREA MISIUNII ȘCOLILOR ÎN PROBLEME DE MEDIU

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Abstract.
The article is study of the Transdisciplinary Approaches to Teaching Environmental Sustainability (Go Green) project, funded by the Erasmus+ Programme, Cooperation partnerships in education, developed by educational institutions from Italy, Ireland, Spain, and Romania. Its goal is to foster collaboration among schools to create innovative theoretical and methodological frameworks and practical models to address environmental issues. The paper gives insights into the project's main output, the e-learning course, based on thorough research on teachers' specific needs. The research findings facilitated the development of materials meant to empower teachers to incorporate environmental and sustainable development-related subjects into the curriculum to motivate students to become active members of society and participate in local environmental issues. Additionally, the article analyzes teachers' comments on the e-learning course.
Key words: research findings, *e-learning course*, sustainable development education

Rezumat.
Articolul e un studiu al proiectului Transdisciplinary Approaches to Teaching Environmental Sustainability (Go Green), finanțat prin programul Erasmus+, Parteneriate de cooperare în educația școlară, dezvoltat de instituții de învățământ din Italia, Irlanda, Spania și România. Scopul său este de a încuraja colaborarea între școli pentru a crea cadre teoretice și metodologice și modele practice pentru abordarea problemelor de mediu. Lucrarea oferă o perspectivă asupra principalului rezultat al proiectului, cursul online de formare, bazat pe cercetări aprofundate privind nevoile specifice ale profesorilor. Rezultatele cercetării au facilitat elaborarea de materiale menite să le permită profesorilor să integreze în programa școlară subiecte legate de mediu și

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dezvoltare durabilă, care să motiveze elevii să devină membri activi ai societății și să participe la problemele locale de mediu. În plus, articolul analizează comentariile profesorilor referitoare la cursul online.

Cuvinte cheie: rezultatele cercetării, curs online, educația pentru dezvoltarea sustenabilă

INTRODUCTION

The concept of Education for Sustainable Development (ESD) emerged in Europe as part of a wider movement towards increasing environmental awareness and global efforts to address sustainability. In the 1980s and 1990s, Europe experienced a growing recognition of the pressing need to confront environmental degradation, social inequalities, and economic challenges. The term "sustainable development" was introduced in The Brundtland Report (1987), which highlighted the importance of education in promoting awareness and action towards these goals [United Nations, 1987].

Education for Sustainable Development (ESD) in Europe has since been driven by the recognition of the need to transform traditional education to reflect the interconnectedness of environmental, economic, and social issues. The term ESD was defined by the United Nations Economic Commission for Europe [UNECE, 1987] as follows: ”Education for sustainable development develops and strengthens the capacity of individuals, groups, communities, organisations, and countries to make judgements and choices in favour of sustainable development. It can promote a shift in people’s mindsets and enable them to make our world safer, healthier, and more prosperous, thereby improving the quality of life. Education for Sustainable Development (ESD) can provide critical reflection and greater awareness and empowerment so that new visions and concepts can be explored, and new methods and tools developed”. Several global environmental agreements and initiatives have emphasised the vital need for embedding ESD in educational policies (e.g., the United Nations, 1992, which established Agenda 21-a comprehensive plan for sustainable development; the UNECE Strategy for Education for Sustainable Development, 2005, which called for integrating sustainability into education systems at all levels; the EU’s Lisbon Strategy, 2000). Europe’s focus on environmentalism, global cooperation, and social responsibility has provided fertile ground for the development of ESD [UNECE, 2022]. The 2030 Agenda for Sustainable Development, built on the United Nations Declaration of Human Rights, was adopted by the United Nations General Assembly in 2015 [United Nations, 2015]. This is a comprehensive and worldwide framework aimed at promoting action for the betterment of humanity, the environment, economic well-being, and peace. It addresses the significant development and environmental issues that currently confront humanity and our planet. Incorporating seventeen Sustainable Development Goals with 169 goals, the Agenda aims to harmonise the five aspects of sustainable development: environmental, social, economic, and political. The crucial role of education is the aspiration that by 2030, educators

should have fulfilled their moral obligation to guarantee that all learners obtain the necessary information and skills to advance sustainable development.

The European Go Green project aligns with all European efforts advocating for a shift in the role of school systems in relation to environmental concerns and how schools therefore address environmental challenges. Schools should facilitate the education of new generations in an integrated and sustainable perspective of development, ensuring their comprehension of the environmental impact of their conduct and the future repercussions of their activities. The objective is to raise awareness among schools and communities about environmental concerns and sustainable development. It seeks to encourage a multidisciplinary approach and problem-based learning. It proposes the implementation, experimentation, and dissemination of training models specifically focused on the environment. The goal is to enhance the contribution of the education system to environmental sustainability. Developed within a partnership of educational institutions (universities, schools, NGOs) from Italy, Ireland, Portugal, Spain, and Romania, the initiative aims to provide innovative ecological resources to Romanian teachers and students in the first two grades of high schools [Go Green project, 2021].

The school curriculum can incorporate the three project results: an e-learning course for teachers to encourage a multidisciplinary approach to sustainable environmental development; a set of problem-based learning lesson plans and teaching materials about environmental and sustainable development issues; a transnational pilot syllabus for schools to teach environmental sustainability through a multidisciplinary and problem-based learning approach.

MATERIAL AND METHOD

The project's outcomes rely on thorough research into the context and the needs of teachers. The desk research and surveys administered to teachers enabled the project partners to establish the course objectives and choose a scientific methodology. The educational frameworks for environmental protection, adopted by the Ministry of Education in each country, have greatly benefitted the writers. Our study identified both the advantages and disadvantages of the current textbooks, as well as the absence of additional organised resources that provide pre-designed activities to cater to the varied requirements and interests of students.

The surveys filled out by 50 teachers indicated their comprehension of the fundamental principles, their awareness of the matter, requirements regarding materials, methodologies to be used, examples of activities to do with students, assessments, and so on. There was unanimous consensus that they require captivating and appealing resources that have the potential to raise students' awareness of the issue in question, facilitate their comprehension of the causes of environmental degradation, and motivate them to take responsible actions. Their optimism about fostering an environmentally conscious mindset and behavior was strong.

Overall, teachers demonstrated their enthusiasm for the matter and were willing to coordinate and participate in environmental conservation alongside their colleagues and community. Nevertheless, the surveys also unveiled the challenges associated with the level of awareness regarding ecological issues, the required knowledge and abilities, and the ecological behaviour centred around actions and remedies.

The research findings enabled project partners to compile a list outlining the objectives that materials meeting the needs of students and teachers should accomplish: they should stimulate students to acquire further knowledge about the environment, encourage them to explore, experiment, participate in activities, and cultivate the mindset that motivates them to take action for environmental preservation and develop a sense of responsibility and perspective essential for progressive actions towards nature.

RESULTS AND DISCUSSIONS

The e-learning course (Fig. 1) aims to inspire and empower secondary school teachers to include environmental and sustainable development-related topics in their lessons. This will enable students to achieve the essential knowledge, skills, and competencies required to become engaged citizens and adopt sustainable lifestyles. The first module of the course presents fundamental information on Education for Sustainable Development, outlines the four aspects of sustainable development - environmental, social, economic, and political - and illustrates some practical applications. The second module of the training course focuses on the importance of teachers having sustainability skills, which are seen as the fourth crucial aspect of integrating Education for Sustainable Development (ESD) into secondary schools. The module is based on the European sustainability competency framework (GreenComp) outlined in the European Green Deal [European Commission, 2022]. This framework is the agreed-upon framework for the Go Green project and is organised around four interrelated areas of learning in sustainability: values, complexity, futures, and action. This set of competencies is not a "minimum standard" that all educators must achieve but rather a target that all educators should strive for. The third module converts theoretical knowledge into action by presenting feasible applications for implementing ESD principles in real-life situations and practical tools for developing solutions. It allows instructors to create a specific framework for action-planning for Education for Sustainable Development (ESD) in their schools.

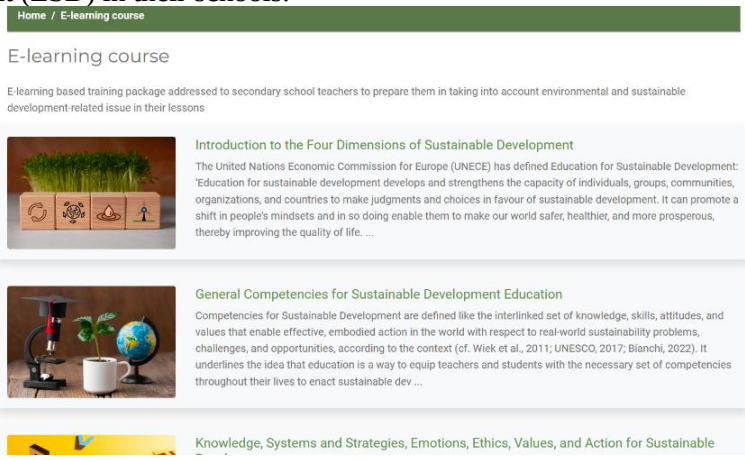

Fig. 1. The e-learning course

The fourth module covers active didactic approaches and techniques that teachers can employ to augment students' interest and motivation, cultivate their higher-level cognitive abilities, and foster a wide range of essential skills, including important competencies for sustainability. The implementation of participatory teaching and learning approaches, such as the flipped classroom combined with peer-review instruction, problem-based learning, or project-based learning, will help promote the cultivation of appropriate attitudes and values towards sustainability. Additionally, these methods will empower students to contribute actively to sustainable development.

The last module emphasizes interdisciplinary and transdisciplinary educational methods and interventions, which are crucial in the field of education for sustainability. These approaches and interventions are derived from the necessity to adopt a comprehensive, integrated, and interdisciplinary perspective to address present challenges from a sustainability perspective. The module enables teachers to recognise and introduce authentic environmental, social, and economic issues or scenarios to students, facilitating their ability to transcend subject boundaries and address these everyday life concerns in a connected manner. This module offers three learning units that showcase various examples of transdisciplinary educational interventions, covering the human, social, economic, and environmental aspects of sustainable development. Different academic disciplines typically tackle the content of these units, requiring a combination to fully understand them. The goal is to gain a global perspective on critical issues such as climate crisis, flood risk, and fast fashion by employing active teaching methods and developing sustainability competencies. This will enable the acquisition of knowledge as well as the development of skills, attitudes, and values that encourage effective, embodied action in the world to work on the multifaceted aspects and origins of socio-environmental phenomena.

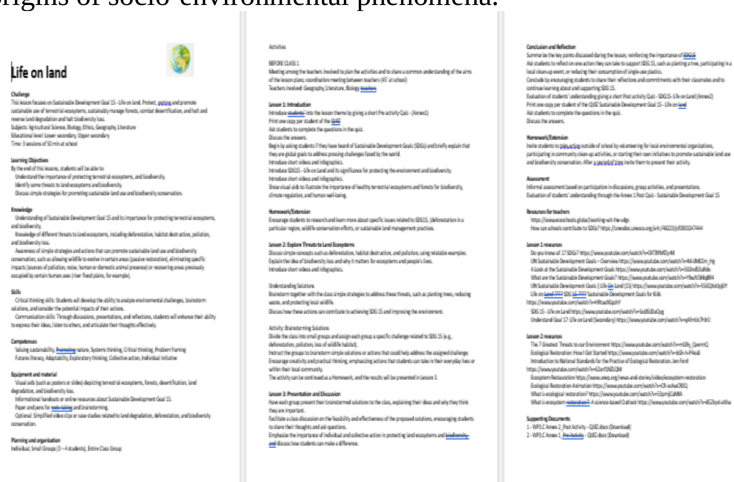
Life on land

Fig. 2. A lesson plan: Life on land

The e-learning course is complemented with lesson plans that demonstrate the practical application by teachers in their classrooms. Each session focuses on a major ecological subject and incorporates pertinent content and interactive activities that help students structure and organise their knowledge and, more particularly, shape their ecological behaviour. Students can engage in classroom investigations or field trips, research, and look for answers that endorse the principles of sustainable development (Fig. 2).

The e-learning course was initially tested with 21 teachers teaching various subjects such as biology, chemistry, physics, English, French, and educational classes. The teachers were invited to share their feedback on the relevance, consistency, and overall quality of the course as they studied and utilised it with their students. The average score of their evaluation was 9.2 out of 10 (Fig. 3). The most valued aspect of the e-learning course was its coherence, rated at 9.4%, followed by the relevance of the materials to the respondents' context. All teachers reported a positive experience, stating that their students engaged with the activities with increased interest.

The e-learning course was described as a valuable tool that provides individuals of all ages with the necessary understanding, competencies, principles, and autonomy to address interconnected global issues such as climate change, biodiversity depletion, unsustainable resource utilisation, and inequity. The video presentations at the beginning of each unit offer a concise and visually appealing overview of the content. The presentations are highly graphical, and both online and offline resources are comprehensive, providing support for a better understanding of key concepts.

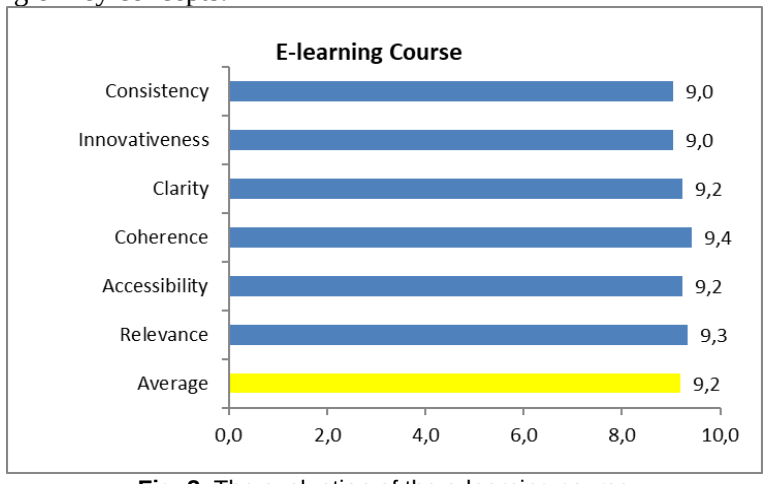

Fig. 3. The evaluation of the e-learning course

The teachers valued the e-learning course for its provision of pertinent information and models tailored to the students' context, as well as its ability to foster creativity, challenge, and stimulate students' passion for the environment and their intrinsic motivation to study, therefore potentially paving the way for future

careers in the subject. The interactive and intellectually stimulating activities and resources on ecological issues motivate students to take individual accountability and proactive measures to address climate change. Furthermore, they facilitate the formation of engaged student groups focused on environmental conservation.

Furthermore, teachers highly valued the e-learning course for its profound influence on students, emphasizing that it grounds students in their immediate reality, offers a wide range of topics appropriate for the age group, suggests engaging, inspiring, and appealing hands-on activities, proposes an interdisciplinary approach to knowledge, cultivates creative, analytical, and critical thinking abilities, encourages students to apply the acquired knowledge and skills in daily life, and promotes responsible behaviour towards the environment.

CONCLUSIONS

The Go Green project's primary goal is to raise awareness among both teachers and students about the importance of studying environmental concerns as a fundamental component of constructive civic conduct. To this end, it provides teachers with invaluable resources, materials, and interactive teaching-learning approaches to effect the necessary changes in reaction to the environmental issues posed by our lifestyles. It empowers teachers to incorporate ESD into classrooms and emerge as facilitators who lead students to become agents for change to achieve a sustainable future.

The project advocates for active teaching-learning approaches that prioritize students as the focal point of learning, viewing it as a constructive rather than a passive process. These teaching methods enhance students' skill development, empower them to take charge of their own learning, ensure that students acquire practical and concrete knowledge that they will encounter in their everyday and professional lives, and promote critical and reflective thinking about the world, the knowledge they are acquiring, how they assimilate it, and the cumulative outcomes they are achieving.

By integrating Go Green resources and suggestions into their teaching practices, teachers facilitate students' comprehension of the environment around them and enhance their ability to engage and intervene in it more constructively. Students can engage with the course materials in a variety of ways through cognitive processes including critical thinking and problem-solving, which provides students with several pathways for learning. These methods and engaging activities facilitate a more personal connection between students' interests and the course content, greatly enhancing their motivation and interest.

ACKNOWLEGMENTS

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DYNAMICS OF SOME PHYSIOLOGICAL PARAMETERS IN *Silphium perfoliatum* L. IN PEDO-CLIMATIC CONDITIONS FROM WESTERN ROMANIA

DINAMICA UNOR PARAMETRI FIZIOLOGICI LA *Silphium perfoliatum* L. ÎN CONDIȚIILE PEDO-CLIMATICE DIN VESTUL ROMÂNIEI

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Abstract.
Silphium perfoliatum L., or cup plant (Asterales: Asteraceae), is a native, herbaceous, prairie species cultivated to produce biomass, food, medicines, and animal feed in many countries. Its native range is the eastern United States (USA) from North Dakota to Arkansas and eastward, and Ontario and Quebec in Canada. Due to its high ecological plasticity, its ability to improve ecosystems (remediating degraded or polluted soils) and its multiple fields of use (energy biomass, industrial raw material, animal feed, etc.) the species has generated a special interest in cultivation in the last two decades. The research objectives consisted in the dynamic evaluation, for a period of five years of the bio productive capacity in correlation with the soil and climatic conditions specific for the western part of the country and to determine the impact of these conditions on the main physiological indices underlying the formation of biomass. The obtained results attest to the ability of S. perfoliatum plants to easily adapt to the conditions determined by drought and heat, managing to achieve high and stable biomass productions by forming a high leaf area and the biosynthesis of assimilating pigments in the foliar apparatus.
Key words: cup plant, biomass, leaf area, assimilating pigments

Rezumat.
Silphium perfoliatum L., sau planta cupă (Asterales: Asteraceae), este o specie nativă, erbacee, de preerie cultivată pentru producția de biomasă, alimente, medicamente & hrană pentru animale în multe țări. Arealul său nativ este estul Statelor Unite (SUA) din Dakota de Nord până în Arkansas & spre est, & Ontario & Quebec în Canada. Datorită plasticității ecologice ridicate, a capacității de ameliorare a ecosistemelor (remedierea solurilor degradate sau poluate) & a multiplelor domenii de utilizare (biomasă energetică, materie primă industrială, furajarea animalelor, etc) specia a generat un interes deosebit pentru cultivare în ultimele două decenii. Obiectivele cerectării au constat în evaluarea în dinamică, pentru o perioadă de cinci ani a

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capacității bioproductive în corelație cu condițiile pedologice & climatice din vestul țării & determinarea impactului acestor condiții asupra principalilor indici fiziologici ce stau la baza formării biomasei. Rezultatele obținute atestă capacitatea plantelor de S. perfoliatum de a se adapta cu ușurință condițiilor determinate de secetă & caniculă, reu&nd să realizeze producții mari & stabile de biomasă prin formarea unei suprafețe foliare ridicate & a biosintezei de pigmenți asimilatori în aparatul foliar.

Cuvinte cheie: planta cupă, biomasă, suprafață foliară, pigmenți asimilatori

INTRODUCTION

Silphium L. is a herbaceous flowering plant in the Asteraceae family. The name of the genus *Silphium* comes from the Greek *silphion* and means a resin secreted by plants, used since ancient times by Hippocrates [Kowalsky & Kedzia, 2007]. It is attested that the various species of *Silphium* were imported to Europe around the 18th century as ornamental plants from the North American continent. The best known species are *Silphium perfoliatum* L., *Silphium trifoliatum* L., *Silphium integrifolium* Michx and *Silphium laciniatum* L., although there are several subspecies and genotypes [Assefa *et al.*, 2015; Titei *et al.*, 2020].

Silphium perfoliatum L. (silphium) It is one of the most promising perennial herbaceous plants, mainly due to its high biomass yield and multiple uses. It is a C3 photosynthetic species, which has a wide range of valuable practical properties, and which has been and is also cultivated as a medicinal, melliferous, fodder, ornamental plant and for bioremediation of soils affected by pollution [Nescu *et al.*, 2022; Sumalan *et al.*, 2023; Jucsor *et al.*, 2018].

Biomass, a non-fossil organic material containing intrinsic chemical energy with the potential to offset fossil fuel emissions, could be a good alternative to fossil fuels [Rozzi *et al.*, 2020]. The potential of *S. perfoliatum* as an energy crop for biogas production started to be studied in Germany in 2009 [Gansberger *et al.*, 2015], and by 2014, the cultivated areas with this specie increased to 400 ha [Gansberger *et al.*, 2015]. Gansberger *et al.* [2015] concluded their literature review by describing *S. perfoliatum* as a "valuable, alternative crop for biogas production facilities, with reduced care requirements and production costs after the first year, promising high biomass and biomethane yields and numerous associated environmental benefits". The environmental benefits of the species have recently been recognized by the EU, which includes the different silphium species on the list of eligible species for EFAs [Cumplido-Marin, 2021].

The crop of *S. perfoliatum* is characterized by low production costs and low requirements for soil quality, being able to be located on less productive or polluted soils [Nescu *et al.*, 2021; Sumalan *et al.*, 2020 & 2023]. The crop is tolerant of winter frosts and summer droughts and is less dependent on atmospheric precipitation [Jasinskas *et al.*, 2014]. Moreover, in Central Europe, it is not very

sensitive to the attack of pests and diseases that affect the productivity or yield of biomass [Stolarski *et al.*, 2018].

Therefore, the main cultivation purpose for silphium is the production of green or dry biomass with different uses. The main objective of the research was to contribute to a better understanding of the physiological and biochemical mechanisms involved in achieving biomass dynamics in *S. perfoliatum*, in the pedo-climatic conditions specific to the Timisoara area by applying sustainable technology.

MATERIAL AND METHOD

The experimental conditions

The experiment was carried out in the didactic field of Experimental Didactic Station, of USV Timisoara, between 2016 and 2020 and consisted, to begin with, in the establishment in the first three years, respectively 2016, 2017 and 2018, of a culture of *S. perfoliatum* on an area of 200 sqm annually. These crops were then maintained and monitored in terms of the dynamics of some morphological and physiological parameters until 2020, so that it was possible to evaluate and analyze the dynamics of these processes in plants of year 1, 2, 3, 4 and 5 after planting, in correlation with the specific climate of each year.

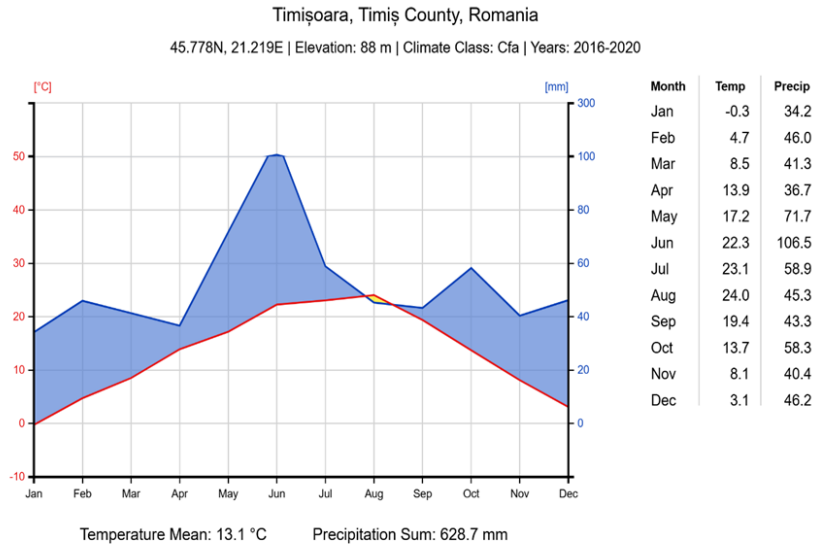
The soil analysis reveals that the land on which the experiment was located is of the clay-sandy type, predominantly colloidal clay and physical clay in association with fine sand, it is poorly structured, the particle size being reduced. The soil exhibits a weakly acidic reaction (6.22), with a medium humus content (2.66%) and a low total nitrogen content (0.22%). However, it has a good supply of phosphorus (69.54 ppm), potassium (140 ppm), calcium (20.06 mg/100g soil) and mobile magnesium (9.73 mg/100g soil).

Characterization of climatic conditions

The characterization of the climatic conditions for the five experimental years 2016-2020 (Figure 1), shows general conditions of good favorability, with an average rainfall of 628.7 mm/year and a multiannual average temperature of 13.1 ℃ well above the multiannual average determined since climate measurements have been made in Timisoara of 11.02

The analysis of climate data highlights high levels of average monthly temperatures throughout the years studied, but especially in the summer/autumn months, June (22.3 ℃), July (23.1 ℃), August (24.0 ℃) and September (19.4 ℃).

Regarding the amounts of precipitation that fell, the analysis of data from 2016-2020 shows that the rainiest months were June 106.5 mm/m^2, May 71.7 mm/m^2, July and October with 58.9 mm/m^2 and 58.3 mm/m^2 respectively. The annual average of rainfall over the five years analyzed was 628.7 mm, also above the multi-year average of the 595.37 mm/m^2. Of all the analyzed years, the climatic conditions specific to 2018 were characterized by a marked deficit of precipitation in the months of April 19.7 mm/m^2, October 22.5 mm/m^2, August 24.8 mm/m^2, September 30.3 mm/m^2 and November 32.4 mm/m^2. The sum of the rainfall of these months is 129.7 mm/m^2 represents about 22 % of the total annual rainfall, and the hot temperatures were especially manifested in the months of June, July and August.



Month	Temp	Precip
Jan	-0.3	34.2
Feb	4.7	46.0
Mar	8.5	41.3
Apr	13.9	36.7
May	17.2	71.7
Jun	22.3	106.5
Jul	23.1	58.9
Aug	24.0	45.3
Sep	19.4	43.3
Oct	13.7	58.3
Nov	8.1	40.4
Dec	3.1	46.2

Fig.1. Climate diagram 2016-2020 (processed by ClimateCharts)

The average daily temperatures also recorded high values, well above the multiannual monthly average in May 20.7 ℃, June 21.7 ℃, July 22.8 ℃ and August 24.9 ℃. The hot days of these months were numerous, and the overlap with the soil moisture deficit due to low amounts of rainfall acted as stressors for field crops. It should be noted that the average value of the air temperature in 2018 of 13.5 ℃ represented a record at that time.

Cultivation technology

The planting of the experimental field was carried out in 2016, 2017 and 2018, in April, by seedlings of *S. perfoliatum,* obtained in the greenhouse, on a flat land, prepared by scarification, fertilization, deep ploughing, leveling and shredding.

Planting in the field was done manually and started after 60 days from emergence, the planting distances being 50 x 50 cm between plants.

After planting, a watering norm of 5 liters of water per plant was applied. Fertilization was carried out with N:P:K – 20-20-0 at doses of 350 kg/ha at land preparation and NH_4NO_3, at doses of 150 kg/ha at mid-leaf rosette formation (June- 1.6. BBCH). The planting distances were 50 x 50 cm, ensuring a density of 40000 plants per hectare.

In years 2, 3, 4, and 5 after establishment, nitrogen fertilizers (NH_4NO_3) were applied in doses of 200 kg/ha, half of the dose at the beginning of March, and the rest at the beginning of the stem formation (April-3.5. BBCH).

Experimental variants

Plants of the 1st, 2nd, 3rd, 4th and 5th year

Determined physiological indices

Leaf area – determined according to a Jucsor *et al.* method [2018], based on the use of morphological parameters of the leaves and using a multiple regression equation.

Determination of chlorophyll pigments

For the extraction of the pigments, 80% acetone was used as a solvent, and the procedure consisted of using a quantity of 0.25 g sample of leaves from each plant that were mortified in 2 ml of 80% acetone in combination of 0.1% quartz sand and 0.1 $CaCO_3$ to avoid chlorophyllase activities, then the samples were filtered through Whattmann filter paper, and the final volume was completed to 25 mL and taken to the spectrophotometer to read the absorbance at 663 and 646 nm, and the calculations were made according to equations 1, 2, and 3 [Lichtenthaler, 1987; Lichtentaler & Buschmann, 2001].

Chlorophyll a = 12,25 (A663) – 2,79 (A646) (1),

Chlorophyll b = 21,5 (A646) – 5,1 (A663) (2),

Total chlorophyll = 5.24 (A663) + 22.24 (A664) / leaf area of the sample (3).

Determinations of green and dry biomass accumulations (5 plants from each experimental variant).

Whole plants were harvested from the field in phenophase 1.9. BBCH (at the end of foliage growth) for year 1 plants that form only the leaf rosette, in phenophases 5.1. BBCH (appearance of flower buds) and 6.9. BBCH (end of flowering and beginning of seed formation) for plants in years 2, 3, 4 and 5.

After cleaning, separating and weighing the plant organs separately, they were placed pre-dried in the greenhouse for 4-5 days, then shredded on a vegetable chopper to facilitate drying, and then placed in the oven at 70 °C for 72 hours, up to constant weight, thus obtaining the dry mass specific to each organ.

RESULTS AND DISCUSSIONS

The values *of the leaf area* are extremely varied, both intra and interspecific, but mainly due to environmental conditions. Numerous empirical studies have addressed the nature of variation in leaf traits and leaf surfaces, showing the existence of systematic relationships between leaf properties and surface and climatic conditions or soil properties [Ordoñez *et al.*, 2009; Maire *et al.*, 2015; Cornwell *et al.*, 2018, Dong *et al.*, 2020]. Figure 2 presents leaf area dynamics in the current study.

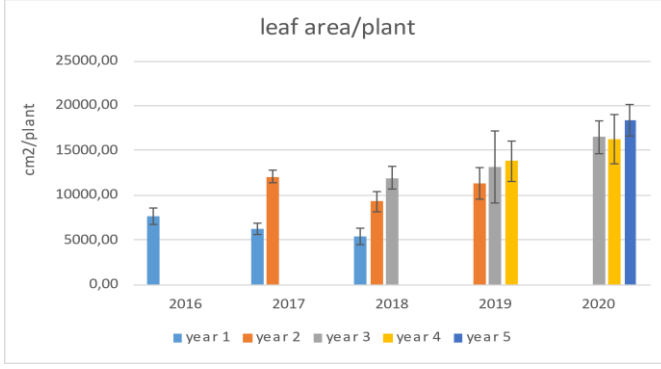


Fig. 2. Leaf area dynamics of S. perfoliatum plants in the experimental years 2016-2020

First year plants achieved the largest leaf area in the experimental year 2016 (7665,66 ± 909,89 cm^2/plant), and the lowest in 2018 (5411,15 ± 920,03 cm^2/plant). Given that the degree of soil fertility was identical by applying the same types and quantities of fertilizers, it is found that the differences that occurred are strictly related to the specific climatic conditions. As we have shown in the climatic characterization, the year 2018 had a major deficit of precipitation in the months of April, August, September, October and November, with a sum of the precipitation of these months of 129.7 mm/m^2 i.e. about 22 % of the total annual rainfall. Because the drought interval was intense and overlapped a good part of the vegetative growth period, this explains the low values of the leaf area.

Another important analysis is the dynamics of the leaf area of 2nd year plants in 2017, which became 3rd year plants in 2018. The data obtained show that in the 3rd year of vegetation the leaf area is reduced from 12802.65 cm^2/plant (2017) to 11930.95 cm^2/plant (2018).

In the experimental years 2019 and 2020, against the background of relatively favorable climatic conditions, generally devoid of periods of drought or extreme heat, the leaf area continues to grow in direct correlation with the age of the plants. Thus, in 2019, the highest value of the leaf area was recorded for plants in the 4th year with 13807.45 cm^2/plant, followed by those in the 3rd year of vegetation with 13183.31 cm^2/plant and respectively the plants of the 2nd year with 11317.95 cm^2/plant. The situation remains similar in the experimental year 2020, the plants in the 3rd and 4th years of vegetation presenting values significantly close to the leaf area, around 16300 cm^2/plant while the plants in the 5th year recorded values of the leaf area of 18320.09 cm^2/plant.

Chlorophyll (Chl), the most abundant pigment on earth and an essential component of photosynthesis necessary for the absorption of sunlight [Hörtensteiner & Kräutler, 2011].

Chlorophyll a and b (µg/cm^2) content determinations of the leaf apparatus of S. *perfoliatum* plants were carried out dynamically, in the months of May, June, July, August, September and October, in the experimental years 2018, 2019 and 2020 in plants from years 1, 2 and 3 (2018), years 1, 2, 3 and 4 (2019) respectively years 1, 2, 3, 4 and 5 (2020).

Although 2018 was the experimental year with the most stressful conditions, due to the water deficit in April and the summer months and the hot temperatures in July and August, the plants of year 1 reach the highest values of chlorophyll content in July (47.6 ± 8,4 µg/cm^2 foliar surface), and the lowest in October (40.8 ± 8.3 µg/cm^2) (Figure 3). In fact, it can be seen that July caused the highest accumulation of chlorophyll pigments for both year 1 and year 2 and 3 plants. In general, the values of chlorophyll pigments recorded were between 37.7 ± 4,9 µg/cm^2 to 3rd year plants in October and 47.6 ± 8,4 µg/cm^2 to 1st year plants in July.

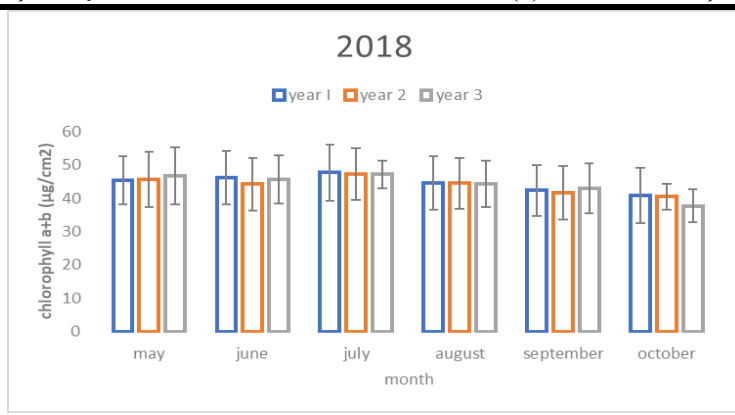


Fig. 3. Dynamics of chlorophyll pigment content in the foliar apparatus of *S. perfoliatum* plants in the experimental year 2018

Regarding the results obtained in the experimental year 2019, regarding the dynamics of chlorophyll pigment accumulations in the foliar apparatus of *S. perfoliatum* plants (Figure 4), the values of this physiological index are higher compared to 2018, due to the specific climatic conditions, more favorable to the crop. However, the same trend is maintained that the plants of year 1, in the leaf rosette phase, register higher values, especially in the months of July and August ($53.7 \pm 6{,}2$ µg/cm^2 and $54.7 \pm 7{,}4$ µg/cm^2).

The reduction in the content of chlorophyll pigments with the appearance of flowering and fruiting organs attests to the entry into senescence especially of the leaves located on the outside and middle of the rosette, in the plants of year 1 and respectively in the basal leaves and those located medially on the stems in the leaves of plants of years 2, 3 and 4.

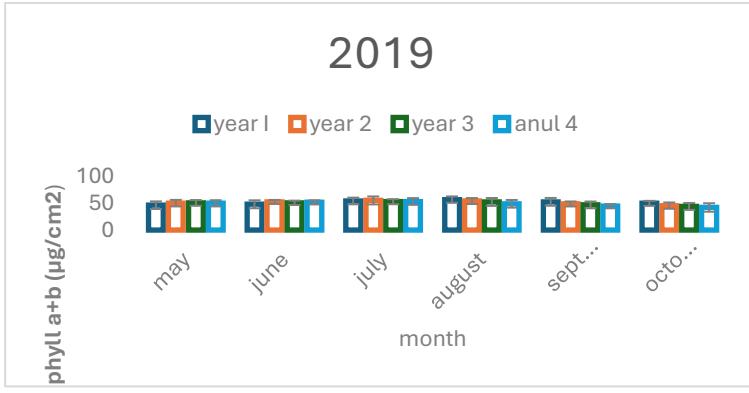


Fig. 4. Dynamics of chlorophyll pigment content in the foliar apparatus of *S. perfoliatum* plants in the experimental year 2019

In fact, the same trend was manifested in the case of the experimental year 2020 (Figure 5), the accumulation of chlorophyll pigments being specific to late spring and early summer, and then, starting with August, chlorophyll biosynthesis went into decline, moreover some of the pigments being biodegraded and probably transformed into molecules with a role in increasing tolerance to abiotic stress. From the analysis of the data presented below, the decline in the amount of chlorophyll pigments manifests itself faster in plants of 3, 4 and 5 years of vegetation and somewhat later in young plants in 1 and 2 years.

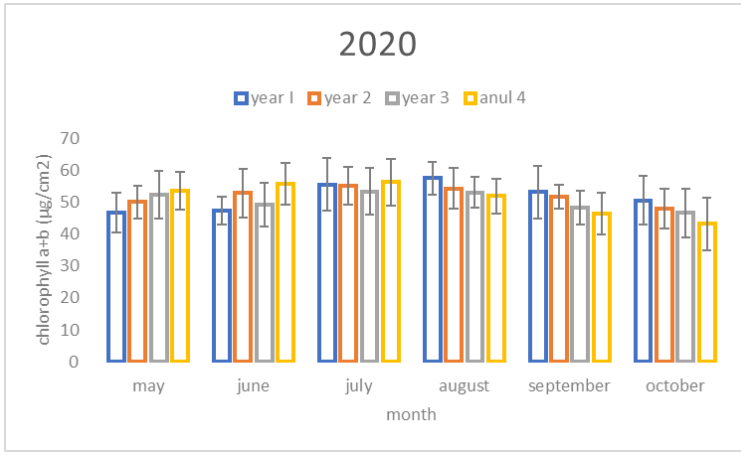


Fig. 5. Dynamics of chlorophyll pigment content in the foliar apparatus of *S. perfoliatum* plants in the experimental year 2020

Therefore, the reduction of chlorophyll content and implicitly of the flow of electrons through photosystems is a frequently reported reaction of the onset of senescence [Tanaka & Hisashi, 2024]. The maximum regional yield for a given crop can be achieved in the absence of biotic and abiotic stressors [Evans & Fischer, 1999], However, as radiation, water, nutrients, etc., become limiting or there is pressure from pests and/or pathogens, bio productive yields decrease, resulting in a yield gap [Lobell *et al.*, 2009].

The plant productivity level is quantified by most of the time in relation to the useful green biomass in relation to the unit area (t/ha). Thus, the highest amount of biomass was determined in plants from years 3, 4 and 5 in 2020, around 57-59 tons/ha (Figure 6). The lowest values were recorded in the climatic year 2018, both for the plants of the 2nd year (about 22 t/ha) and for that of the 3rd year (30 t/ha). It can be said that the stress factors generated by water scarcity and heat have determined important loss in the production of useful biomass of 32.25% for 2nd year plants and about 40% for 3rd year plants.

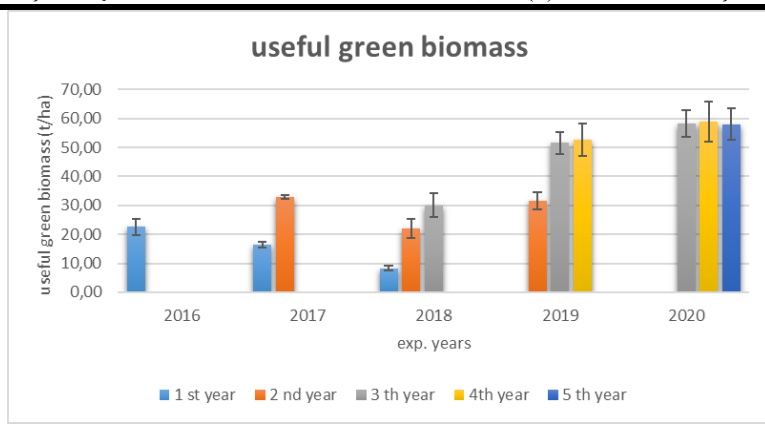


Fig. 6. Dynamics of accumulations of green biomass useful for *S. perfoliatum* cultivation in the experimental years 2016-2020

Therefore, temporal variation in rainfall and temperatures undoubtedly contributed to large variations between years for biomass production and plant morphological traits. The low biomass production in 2018 could be attributed, in part, to prolonged drought and high temperature in the middle of the growing season.

In contrast, in 2017 and 2020, higher biomass yields were in response to higher amounts of rainfall and a lower frequency of hot days. High biomass production again in 2019, when rainfall was close to normal, indicated a resilience that allowed plants to recover strongly from the stress of 2018, as demonstrated by 100% plant survival from October 2018 to October 2020.

Perennial industrial crops can play an important role as a source of lignocellulosic biomass in the form of wood, semi-wood biomass and straw [Amaducci *et al.*, 2017; Stolarski *et al.*, 2018].

Particular attention should also be paid to perennial herbaceous crops, which are a valuable source of semi-woody biomass and straw. Dicotyledonous perennials in this group, such as *Sida hermaphrodita* Rusby L, *Helianthus salicifolius* and *S. perfoliatum* are sources of semi-woody biomass [Jankowski *et al.*, 2019; Peni *et al.*, 2020], and the use of biomass of these species both as raw material for both bio-based products and energy production is important and brings many benefits for economic development, environmental protection, improved energy independence and various social and economic aspects [Lantz *et al.*, 2014; von Cossel *et al.*, 2019].

CONCLUSIONS

The climatic characterization of the five experimental years, specific to the Timisoara Meteorological Station (SMT), shows high values of average annual temperatures (12.6-13.8 °C) with an abundance of hot days in July and August

associated with moisture deficit (especially 2018). Although the level of total annual rainfall was within normal limits, its distribution over time was often chaotic with excess rainfall in June and July and deficit in April, August and September.

The determination of the leaf's surface was carried out according to a proprietary method, specific to the species *S. perfoliatum*, based on correlations between different morphological parameters of the leaves. The dynamics of this parameter are increasing from the plants in the 1st year of cultivation to the plants in the 4th and 5th year of cultivation, but strongly influenced by the climatic conditions specific to each vegetation cycle, in the context of constant technological measures.

Chlorophyll content determinations showed an ascending dynamic of this parameter starting from the spring months, until August for the plants of 1st year and until July for the plants of 2nd, 3rd, 4 th and 5th years. After the second half of the summer, the values decline, the biosynthesis of chlorophyll pigments ceases, and moreover part of the chlorophyll is biodegraded and converted into other types of compounds.

The reduction in the amount of chlorophyll pigments is due to the onset of plant senescence and involves an important part of the leaf apparatus, with repercussions on photosynthesis.

By harvesting the production only once a year, in October, the amount of total green biomass ranged from about 20 t/ha for plants in first of cultivation to about 100 t/ha for plants in the 5th year of cultivation. The useful green biomass (harvestable) was between 8 and 60 t/ha with the minimum values in the first year and the maximum values in the 5th year.

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USE OF MAGNETICALLY POLARIZED WATER IN HORTICULTURAL RESEARCH

UTILIZAREA APEI POLARIZATĂ MAGNETIC ÎN CERCETAREA HORTICOLĂ

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Abstract.
Irrigation water is a poly-phasic system, which consists of water in combination with dissolved and dispersed substances. Magnetically polarized water can be obtained by using installations that use an energy source. Several mobile water distribution devices equipped with ferrite permanent magnets have been made for trickle irrigation. When creating these devices, the aim was to exploit the magnetic field areas with maximum intensity, in order to obtain a maximum yield of water treatment. The mobile distribution devices can be located at any point of the hydraulic system and can diversify their functions. The research carried out revealed the affinity of plants to magnetically polarized water. A number of effective results have been obtained in the germination of seeds in some tree species such as cherry and sour cherry, as well as conifers.
Key words: distribution device, germination, irrigation, treatment.

Rezumat.
Apa pentru irigație este un sistem polifazic, care este format din apă în combinatie cu substanțe dizolvate și dispersate. Apa polarizată magnetic se poate obține prin utilizarea unor instalații care utilizează o sursă de energie. Pentru irigarea prin picurare s-au realizat dispozitive de distribuție a apei, de tip mobil, dotate cu magneți permanenți din ferită. La realizarea acestor dispozitive s-a urmărit valorificarea zonelor de câmp magnetic cu intensitate maximă, pentru obținerea unui randament maxim al tratării apei. Dispozitivele de distribuție mobile pot fi amplasate în orice punct al sistemului hidraulic și își pot diversifica funcțiile. Cercetările efectuate au evidențiat afinitatea plantelor către apa polarizată magnetic. O serie de rezultate eficiente au fost obținute la germinarea semințelor la unele specii pomicole cum ar fi cele de cireș și vișin, precum și de conifere.
Cuvinte cheie: dispozitiv de distribuție, germinație, irigație, tratament.

INTRODUCTION

The terrestrial environment is permanently under the influence of the natural magnetic field [Muraru, 1992, Butnaru *et al.*, 1989]. This field can be amplified due to natural or artificial factors. These factors determine an additional effect of

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the magnetic field, which acts on the living environment with intensities and frequencies different from the existing one. High values occurring naturally or artificially can be reversible or irreversible and can cause a stimulating or inhibitory action on the environment. Water is present in the structure of plants, a situation in which it will react to the increase of the magnetic field. Other fluids are also influenced by additional magnetic fields [Cotae *et al*., 1997].

Water is considered to be diamagnetic (it is easily repelled by a magnet). Irrigation water is a poly-phasic system, which consists of water in combination with dissolved and dispersed substances. The research carried out on the influence of an additional magnetic field on water showed changes in increasing the Ph and evaporation rate, in the easier dissolution of salts and gases and others [Butnaru, 1989, Nițescu *et al*., 1988]. A series of researches aimed at determining the technical characteristics of the process of watering plant and tree seeds with magnetically polarized water in order to influence the germination process [Nițescu et al., 1988, Luca și Maxim, 1995].

Internationally, there are a number of works on the production of magnetically treated water using an electric source. The water thus obtained is used for therapeutic purposes in humans and animals, for technical purposes and also in agriculture (most research was carried out in the U.S.S.R., U.S.A., Germany, Japan, Belgium and others) [Butnaru, 1989]. The first patent in this field was obtained in Belgium.

However, the documentary study carried out highlights a relative divergence of the conclusions regarding the mode of action of the magnetic field on the "poly-phasic water system", but convergent in presenting a series of positive qualitative aspects. The advent and development of permanent magnet water treatment devices has boosted the research and the results are visible at the current stage. The most eloquent result is the device for removing lime deposits from the pipes that transport hot water.

The purpose of the work is to open a series of new research directions in the production and application of magnetically polarized water in the field of horticultural crops, especially in the study in research laboratories, in nurseries, experimental platforms, irrigation systems and others.

ELEMENTS OF ANALYSIS REGARDING THE MAGNETIC POLARIZATION OF THE "POLY-PHASE WATER SYSTEM"

In a "poly-phasic water system" the magnetic field acts on the ions of salts dissolved in water, polarizing and deforming them, and determines new crystallization centres, but also new crystallization structures. In this case it is admitted that the Lorentz force has an important role by acting on the ions under the influence of the magnetic field; results in a change in the trajectories of moving particles and limiting their attraction to the pipe wall and their deposition in the form of a crust.

A number of researchers admit that there is a direct action of the magnetic field on the intermolecular, or molecular, structure of water and even at the level of the nucleus. Thus, one of the hypotheses refers to the possibility of the orientation of the hydrogen spins, a situation in which an "ortho-water system" and a "para-water system" would result, or combinations between the two systems.

The research has addressed various topics, among which can be listed:

- the way of structuring the installations and devices that magnetically polarize the "water poly-phase system" with a certain chemical composition;
- the correlation between the quality of the treated fluid and the parameters of the treatment magnetic field, as well as the duration of application, the purpose of treatment, types of treatment and others;
- the constructive structure of the installations and treatment devices, which effectively capitalize on the parameters of the magnetic field;
- the influence of some hydraulic parameters of the installation and magnetic polarization devices in increasing the yield of the treatment process; among the parameters studied were: the speed of circulation in the device, the degree of turbulence, the transit time of the magnetic field area and others.

Experiments have shown that the effect of the magnetic treatment of water does not disappear when the action of the magnetic field ceases; the effect gradually diminishes over time. This feature is well exploited by mobile magnetic polarization devices using permanent ferrite magnets. Devices of this type no longer depend on an electric current source and thus can be placed in various positions of the hydraulic installation that transports and distributes water.

The research issue is very complex and is currently being studied in depth in the form of various scientific studies. The research topic is interdisciplinary and requires the participation of a group of researchers with specializations in the fields of interference (hydrotechnics, horticulture, physics, chemistry and others). Research also requires more work time due to laboratory and field studies, as well as comparative analyzes between research options.

DEVICES FOR THE MAGNETIC POLARIZATION OF THE "POLYPHASE WATER SYSTEM"

A series of researches have confirmed that the changes introduced in the structure of the poly-phase water system by magnetic polarization favourably influence the development of some vegetative processes of plants [Nitescu *et al*., 1988, Grumezea and Kleps 1984, Butnaru G. *et al*., 1989]. This result led to the design and manufacture of magnetically polarized water distribution devices using ferrite permanent magnets. This result led to the design and manufacture of magnetically polarized water distribution devices using ferrite permanent magnets. The research carried out in the Department of Hydraulics and Hydroimprovements in the Faculty of Hydrotechnics of the Iasi Polytechnic Institute (later the Technical University of Iasi, Romania) contributed to the design and execution of some water distribution

devices for drip irrigation. Water distribution devices for micro-irrigation must perform two functions in this case:

1. The dripper function, i.e. taking water from the watering pipe and emitting it with a calibrated flow rate and at a service pressure adaptable to the watering requirements of the plant.

2. The function of magnetic polarization of water with a high efficiency, a situation in which the constructive structure of the dropper allows the optimal utilization of the characteristics of the permanent magnets in ferrite.

In order to increase the yield of the magnetic water treatment, a long water circulation path was analyzed, a situation that imposed a special constructive structure of the water distribution devices. Water circulation must be predominantly in the maximum field area of the ferrite permanent magnets. At the same time, the vortex-like circulation of the water amplifies the turbulence necessary to dissipate the excessive pressure in the emission section.

A distribution device was made with a constructive structure to realize a movement in the area of the maximum field of permanent ferrite magnets [Luca, 1993]. The device has the shape of a cylinder, and at one end it is closed with a threaded cap (fig. 1.a).

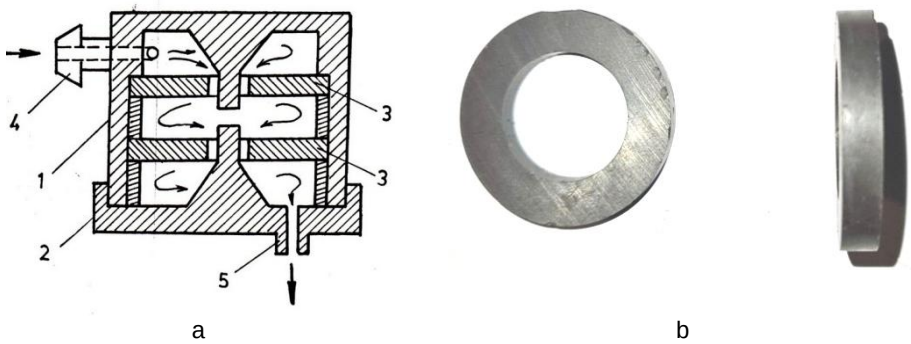
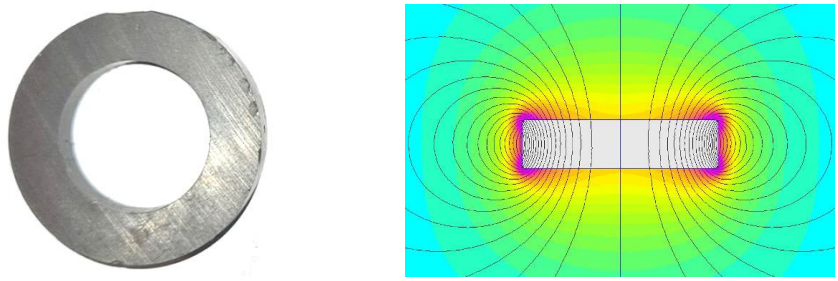


Fig. 1. Magnetically polarized water distribution device: a – longitudinal section; b – ferrite magnets from the equipment of the device (Luca, 1993).

The water distribution device has two chambers for the magnetic polarization of water and uses two circular magnets with a central hole (fig. 1.b). The water is introduced tangentially into the device and performs a rotational movement combined with a translational movement, a situation that causes a longer contact time with the magnets. The circulation zones between the two magnets are consistent in distance according to measurements on the magnetization curve in the case of parallel coupling.

For the type of magnet used in the research (fig. 2.a), the magnetic induction vector $\vec{B}$ was measured with a Hall probe Gaussmeter. The structure of the magneto static field for ring-shaped magnets is shown in fig. 2.b. The magnetic induction is

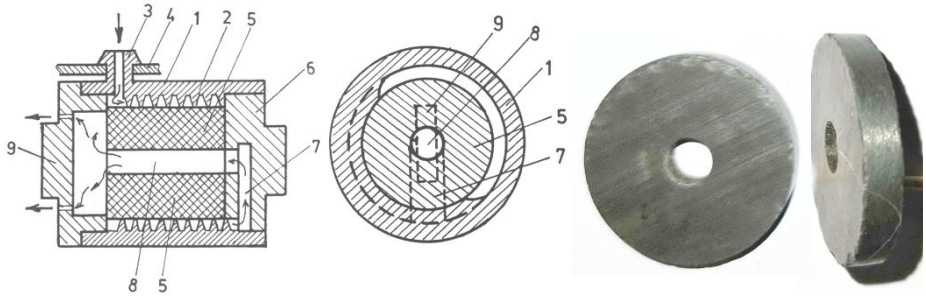
maximum along the vertical z-axis, in areas of greatest density of field lines (Purcel, 1982). For the considered magnet, a maximum induction of 25 mT resulted. The induction of the terrestrial magnetic field during the experiment was 55 μT. The dimensions of the ferrite permanent magnet were outer diameter, De = 39 mm, inner diameter, Di = 24 mm, and thickness t = 6.0 mm. The magnetic field is maximum towards the sides of the circular magnet and minimum in the area of the central hole.



a b

Fig. 2. Characteristics of permanent ferrite magnets used in mobile devices of magnetic polarization and water distribution: a – the structural characteristic of the magnet; b – the image of the magnetic field generated during the measurements.

A more efficient utilization of the magnetic field was achieved by designing a distribution device that achieves a greater contact time between the magnet and the water [Luca *et al*., 1990]. It is structured from a plastic cylinder (hard PVC) (fig. 3.a), a circular ferrite magnet (or a set of magnets) with a central hole reduced in diameter (fig. 3.b), two closing parts and the connection spigot to the supply pipe. The cylinder wall has an internal thread, and water flows through the thread in direct contact with the most active part of the magnet.



a b

Fig. 3. Magnetically polarized water distribution device: a – longitudinal section, 1 - body, 2 - flow area and magnetic polarization, 3 - connecting piece, 4 - pipe, 5 - magnet, 6 - cover, 7, 8 - exhaust channel, 9 - cover with holes; b – the ferrite magnets of the device (Luca *et al*., 1995).

The water circulation path inside the device also ensures the dissipation of excess pressure from the dripper supply line. The closing part with the role of emitting magnetically polarized water has 1-4 holes with calibrated diameters for the flow required for watering.

For the magnet considered in the equipment of the device, a maximum induction of 61 mT resulted. The dimensions of the permanent ferrite magnet were outer diameter, De = 30 mm, inner diameter, Di = 6.4 mm and thickness t = 5.0 mm. A circular magnet with a central hole with dimensions De = 30 mm, Di = 8.5 mm and t = 5.0 mm was also used in the experiment, where the maximum induction was 65 mT.

The presented distribution devices (fig. 2 and fig. 3) were made as a prototype and calibrated for flow rates with values of 4 – 16 l/h at supply pressures of 0.2 – 1.2 bar. Magnetically polarized water distribution devices using permanent ferrite magnets have been patented [Nițescu E et. al., 1989, Luca et al., 1995]. The scientific novelty and technical achievement of these devices was appreciated by the International Salons of Invention [Luca, 1994].

Several types of distribution devices with magnetic polarization have been made for the watering pipes used in drip irrigation systems [Nițescu E et. al., 1989, Luca et al., 1995]. These devices have a simpler construction structure, with reduced dimensions and are calibrated on a flow rate specific to the type of irrigated plant. Such a device (fig. 4) consists of a plastic cylinder in which are placed a permanent circular ferrite magnet (or a calibrated set of magnets), a filter and a closing cap.

Fig. 4. Magnetically polarized water distribution device for drip irrigation: a – body; b – magnet; c – filter; closure cap with calibrated orifice.

The water circulation is carried out along the length of the device, between the inner wall and the magnet, and the evacuation is done through the calibrated hole in the closing cover. The device is fed through a specialized spigot for connecting to plastic pipes. For the magnet considered in the dripper equipment with magnetic polarization of the water, a maximum magnetic induction of 65 mT resulted by measurement. The dimensions of the experimental ferrite permanent magnet were: outer diameter De = 24 mm and thickness t = 5.0 mm.

RESULTS AND DISCUSSIONS

The results regarding the realization of devices for magnetic polarization of irrigation water through the use of permanent ferrite magnets allowed the approach of a new direction of study in the joint research process carried out by the Department of Hydraulics and Hydroimprovements of the Faculty of Hydrotechnics of the Polytechnic Institute of Iasi and the Station of Iasi Orchard Research and Production (S.C.P.P. Iasi).

Through the scientific and technical collaboration of the two collectives, a series of concrete achievements in fruit growing were obtained. Thus, modern drip irrigation systems were created for orchards and fruit bushes in the hill area of Moldova, respectively in the research area of SCPP Iasi [Luca et al., 1988, Luca et al., 1992, Luca et al. et al., 1995]. Drip irrigation systems were developed for super-intensive apple orchards. For a super-intensive shrub plantation (red currant, blackberry, raspberry) a localized irrigation system (small infiltration furrows fed with water distribution devices) was realized [Luca et al., 1988].

The research directions analyzed for the study of the action of magnetically polarized water in fruit growing were divided into two areas:

A - Analysis of the mode of operation and applicability of magnetically polarized water distribution devices to the improvement of experimental activity in laboratories, nurseries and experimental fields with a horticultural profile. Also, the ways of technical verification and improvement of these devices through the prism of the results obtained.

B – The effect of magnetically polarized water on the vegetation phases of fruit trees and shrubs. Also, the influence of magnetically polarized water was researched for a series of therapeutic situations or for some negative environmental actions on plants.

The results of the research in the first field of study were obtained in a relatively shorter time. These were realized by obtaining magnetic water polarization devices that can be used to water horticultural crops (Luca and Romingher, 1995) located in research laboratories, experimental fields and nurseries. The determination of the hydraulic parameters of the devices and their calibration on fields of flows and pressures specific to horticultural plants was carried out in the Hydraulics Laboratory of the Department of Hydraulics and Hydroimprovements in the Faculty of Hydrotechnics.

For the devices for the magnetic polarization of water, research was continued on a series of parameters of the magnetic polarization of water, respectively the residual induction (B), the intensity of the coercive magnetic field (H), the magnetization curve in the case of connecting the magnets in series and parallel, intrinsic magnetization (M), the maximum energy density located in the body of the magnet, and others. A new phase of research has begun on the magnetic polarization of a "water poly-phase system" to include a range of substances from the category of fertilizers, herbicides and pesticides.

From the second field of study, two research directions were highlighted, which presented a priority for the development of the fruit-growing technologies studied in that period in the research stations, respectively:

- the first direction of research referred to the improvement of the seed germination process in a series of trees and shrubs, especially those that had seeds with a hard shell;

- the second direction of research referred to the seeds that had a low percentage of germination, and in this case conifers were considered.

Research in the first field was carried out in parallel in the laboratories of the two research collectives. In the first stage of research, cherry and cherry seed sets were considered to define the influence of magnetically polarized water on the germination process.

The research in the second field of study was carried out in the laboratory and experimental field of SCPP Iasi. The *Thuja orientalis* shrub (fig. 5) was selected for the research by considering the following aspects:

- the long-lived ornamental shrub with a special effect on the environment;

- the shrub presents a difficult reproduction through germination and maturation;

- presents great losses during development in the nursery;

- the shrub has a difficult adaptation in the field.

Fig. 5 Thuja Orientalis

In the first direction of research, the influence of magnetically polarized water on the germination process of *Thuja orientalis* seeds was followed. In the second direction of research, the influence of magnetically polarized water on the vegetation process in the first years of the shrubs *Thuja orientalis* Obovata variant and *Thuja orientalis* Monoax variant in the nursery was studied.

In the research, two variants of the shrub were considered: *Thuja orientalis* Obovata, respectively *Thuja orientalis* Monoax. Shrubs were placed in the SCPP Iasi nursery in consecutive rows. The distance between the rows was 2.0 m, and 18 shrubs were planted per row. Some of the shrubs were planted on the ground, and others were planted in pots [Luca and Maxim 1985].

The research program was carried out on both types of *Thuja* and included seven study variants V1 – V7, as follows: variants V1, V3, V4, V6 and V7 used magnetically polarized water, Variant V2 was the control variant with water taken from a lake; variant V5 was the non-irrigated control variant.

Study variants V1, V3, V4, V6 and V7 were divided into research sub variants with differentiated profiles, respectively:

A – Characteristics of the watering process: volumes of water distributed to the plant (the volume was 1.0 – 5.0 l/plant), distribution mode of the treated water, water quality and others.

B – Vegetative characteristics pursued in the research: vegetative growth (increases in diameter, shoot growth) broken down by years of planting in the nursery, phyto-sanitary influences, adaptation to soil type and others.

The results obtained on research variants and sub variants were compared between study samples and control samples. The values regarding the irrigation regime were also correlated with the rainfall collected in the research area. The research in this case was long-lasting, and the results were systematized over years of study. In the first years of research, influences on the rate of growth in plants watered with magnetically polarized water (higher in the first year of vegetation than in the second year) and a faster revival of shrubs affected by the disease were highlighted.

The political and economic problems that arose after 1990 internally disrupted partially and then totally the collaborative research programs between the two groups of researchers from different institutes. A factor in the interruption of the collaboration was also the disappearance of one of those who initiated this joint research. But the researches can be resumed today and through the help given by the development of research techniques and equipment in the field of magnetic polarization of "water polyphase system".

Part of the research results can be documented and studied in the works published from that period in the specialized literature [Luca and Maxim 1985, Luca and Romingher, 1995 and others].

CONCLUSIONS

The use of permanent ferrite magnets allows the creation of installations and devices for magnetic polarization of water, which through their mobility can be placed in any position of the hydraulic system serving a horticultural research sector.

The constructive and functional design of mobile magnetic water polarization devices using permanent ferrite magnets will harness the field areas of maximum intensity in order to achieve maximum efficiency of water treatment.

Devices with permanent ferrite magnets can fulfil a unique function, when magnetically polarizing the irrigation water, in which case their location is done in the inlet section of the hydraulic system; they can also have a double function, water treatment and the emission of a calibrated flow, situation when they are placed in the distribution sections of the irrigation pipes.

The use of magnetically polarized water in research on the germination of cherry and sour cherry seeds revealed an increase in the percentage of germination

depending on the volume of water used, the duration of water treatment and the intensity of the related magnetic field related to the installation.

The use of magnetically polarized water in research on the effect on seed germination and vegetative development in the nursery of conifers of the Thuja Orientalis type revealed an increase in the percentage of seed germination and a faster vegetative development in the nursery.

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CONSIDERATIONS REGARDING THE CROSS-BORDER POLLUTION PHENOMENON

CONSIDERAȚII PRIVIND FENOMENUL DE POLUARE TRANSFRONTALIERĂ

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Abstract.
The interference between natural and anthropogenic risk factors can trigger pollution phenomena, which can be transformed into local and regional ecological disasters. In the case of a fast transport vector (water and wind), pollution can also be cross-border. The ecological disaster produced in the area of sodium chloride extraction from Ocnele Mari, Valcea County caused such pollution. The implosion of some underground caverns with sodium chloride generated a wave of brine that was successively taken over by the Paraul Sarat River, the Olt River and the Danube River. The brine wave generated a local pollution phenomenon, later transformed into a regional and cross-border one. The initial flow of salt water was 3.0 – 4.0 m^3/s, and the brine concentration was 30.000 mg/l – 250.000 mg/l. The discharged brine flow decreased over time to 0.15 - 0.20 m^3/s, and the brine concentration to 225.0 - 250.0 g/l. The brine wave polluted the Olt River, the downstream reservoirs (mainly Govora) and finally the Danube River.

Key words: *brine surge, concentration, ecological disaster, river*

Rezumat.
Interferența dintre factorii de risc natural și antropici poate declanșa fenomene de poluare, care pot fi transformate în dezastre ecologice locale și regionale. În cazul unui vector rapid de transport (apa și vântul), poluarea poate fi și transfrontalieră. Dezastrul ecologic produs în zona de extragere a clorurii de sodiu de la Ocnele Mari, județul Vâlcea a determinat o astfel de poluare. Implozia unor caverne subterane cu clorură de sodiu a generat o undă de saramură care fost preluată succesiv de Paraul Sarat, Râul Olt și Râul Dunărea. Unda de saramură a generat un fenomen de poluare local, transformat ulterior în regional și transfrontalier. Debitul inițial de apă sărată au fost de 3,0 – 4,0 m^3/s, iar concentrația saramurii de 30.000 mg/l - 250.000 mg/l. Debitul de saramură evacuat s-au redus în timp la 0,15 - 0,20 m^3/s, iar concentrația saramurii la 225,0 - 250,0 g/l. Unda de saramură a poluat râul Olt, acumulările din aval (în principal Govora) și în final fluviul Dunărea.

Cuvinte cheie: *concentrație, dezastru ecologic, râu, undă de saramură*

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INTRODUCTION

The phenomenon of pollution can be initiated and developed in the three characteristic environments: air, water, soil and subsoil. The pollution phenomenon can be natural or anthropogenic. The pollutant can be transported from the source to the emissary by convection, diffusion, dispersion and reactive processes [Hancu S., 2008]. Monitoring the pollution phenomenon generally requires knowing the transport distance, the deposition area and the concentration of its pollutants in various significant points or areas. The main transport vector is the velocity of the medium in which the pollutant is incorporated. The pollution phenomenon can be local, on a small area, or regional in the case of affecting large areas of land. When state borders are crossed, the phenomenon of pollution becomes transboundary.

Cross-border type pollution phenomena are generally carried out by a fast transport vector such as air speed and water speed. A classic example of cross-border type natural pollution is that produced by volcanoes. Anthropogenic cross-border pollution is that produced by the noxes emitted by the thermo-energy industry in the atmosphere [Luca M. et al., 1996]. Also, the noxes emitted into the atmosphere by the steel industry can create cross-border pollution.

Watercourses can generate cross-border pollution phenomena through the transport vector represented by the speed of the liquid current. Water courses take in a wide range of pollutants which they process through diffusion and dispersion, a situation in which the concentration of pollutants decreases. The transport of pollutants in water courses in Romania created local and regional pollution with a particular impact on the natural and human environment [Stematiu D. et al., 2001, Manescu A. et al., 2014, Hobjila V. and Luca M., 2004].

The pollution phenomena produced in the underground environment due to the extraction of minerals have a local extension and in certain situations are of a regional type [Hobjila V and Luca M., 2004]. The pollution produced by industrial waste deposits has negatively modified the quality of groundwater at the local level [Luca M. and Balan R., 2008]. The geographical areas where mining operations are located permanently present natural and anthropogenic risk factors on the environment. The combination of natural and anthropogenic risk factors can generate and maintain a series of negative actions on the natural and social environment. Natural risk factors include earthquakes, landslides, collapses, floods and others. Among the anthropogenic risk factors, the absence of conservation works of mines and tailings deposits, the lack of annual repair and maintenance works, negligence in the operation process and others are highlighted [Hobjila V and Luca M., 2004]. In certain situations, pollution phenomena occurred, which turned into local or regional ecological disasters [Luca M. and Tigaret G., 2007].

In this situation is the mining of non-ferrous metals through waste dumps located in mountainous areas [Hobjila V and Luca M., 2004]. Oil exploitations, through the locations of extraction points and intermediate hydrocarbon deposits, present the danger of triggering ecological disasters [Avram M. et al., 2018]. The discharges from the settling and water treatment ponds located next to the ore

preparation plants are negative phenomena that can turn into ecological disasters under certain conditions [Stematiu D. et al., 2001].

Such a situation is exemplified by the phenomena produced in recent years at the Ocnele Mari salt mine [Luca M. and Tigaret G., 2007, Luca M. et al., 2021]. The accumulation of some deficiencies in exploitation, but also the cooperation of some negative factors initiated and triggered an ecological disaster. Due to the speed of transport of the pollutant, the ecological disaster has expanded its scope at the regional and cross-border level.

MATERIAL AND METHOD

The research was carried out on the propagation path of the salt water wave produced in the mining operation in the Ocnele Mari city area, Valcea county. In the mining of sodium chloride used in the chemical industry, a number of underground deposits (caverns) filled with brine were in the conservation phase.

The serial implosion of a number of caverns at different time intervals generated pollution phenomena on the surface of the land, underground and in water courses. The theoretical and experimental research was carried out in the following fields of study:

- Studies and research on the natural and anthropogenic risk factors that intervene in the evolution over time of brine caverns in the exploitation and conservation phases.
- Researching the phenomenon of cave implosion and the formation of brine waves.
- Research on the polluting impact of brine waves on the environment at local, regional and cross-border levels.

The research used data from various studies and research carried out on the phenomenon of pollution produced in the Ocnele Mari area (S. C. MINESA and I.C.P.M. S. A. Cluj-Napoca 2006, Serban P. *et al*., 2002, ANM, 2018). Also, an own experimental research was carried out on the site of the collapsed caverns in the Ocnele Mari area [Luca M. and Tigaret G., 2007]. The research carried out in the field analyzed the state of the caverns destroyed by implosion, the formation of brine waves and the routes followed on the ground and in the water courses (Sarat Stream, Olt River, reservoirs and others). Data collection from the field was carried out through measurements, taking material samples, photo surveys and filming of the phenomenon of the development of caverns, etc. The primary data collected were processed by using calculation programs specific to the transport of pollutants [Hâncu S., 2008, Drever J.I., 1997].

RESULTS AND DISCUSSIONS

The pollution phenomenon was generated by the degradation of the caverns that contain the waste resulting from the extraction of sodium chloride in the area of Ocnele Mari, Valcea County. The mining operation belonged to the National Salt Society and the Ramnicu Valcea Mining Company. Sodium chloride was extracted from the underground layers of salt in the form of a saturated aqueous solution. The concentrated solution in sodium chloride was transported through pipelines to beneficiaries in the chemical industry [Luca et al., 2008, Serban et al., 2002].

Extraction of sodium chloride is done with probes through a controlled dissolution with water. The dissolution starts from the base of the deposit towards

the surface, and a hole in the form of a cavern results in the rock. The cavern was filled with an aqueous salt solution, and the ceiling was sealed with an insulating fluid (diesel). Thus, over time, a three-dimensional cavern is formed in the massif of salt and rock, which evolves in size over time. Some caverns have increased in size by joining extraction wells. This situation requires monitoring during the conservation period and resupplying the caves with water.

The partial application or absence of maintenance and rehabilitation works of the installations serving the wells led to the implosion of some caverns at various time intervals. A series of failures occurred in September 2001 in the Ocnele Mari - Teica extraction area, a situation that caused the implosion of the cavern at well 317 [Luca and Tigaret 2007, Serban P. et al, 2002]. The rock ceiling of the cavern collapsed due to loss of stability. The amount of rock that entered the cavern expelled part of the brine volume in the form of a fluid wave with a time-varying flow rate. The cavern immediately turned into a brine-filled surprise cone. The collapse of the cavern banks under the effect of gravity (fig. 1.a), but also of the chemical action of the brine, continued the evacuation of some amounts of solution saturated in salt on the surrounding land [Luca and Tigaret 2007, Luca et al., 2008].

a b

Fig. 1. The evolution of the local pollution phenomenon in the Ocnele Mari extraction area: a – view of the cavern after the implosion (year 2001); b – local pollution of the land through the discharge of brine (year 2004) [Luca and Tigaret 2008].

The phenomenon of the degradation of the caverns was repeated in July 2004, being determined by the torrential rainfall that affected the stability of the slope with the location of the salt extraction wells. The action of the pollutant wave in the basement, on the land surface and in waters (rivers, lakes) highlighted the spatial distribution of the pollution phenomenon (local, regional and cross-border). The implosion of a cavern caused an initial local type of pollution, which was manifested by the expulsion of the brine solution in the area of the extraction wells. The land occupied by vegetation was chemically degraded, thus being excluded for agricultural use (fig. 1.b).

The movement of the brine wave in the well extraction area caused a "*local pollution*". This affected a limited area of land in the area where the caves are located (fig. 2.a). The location of the wells being on a slope allowed the quick evacuation of the brine wave and increased the polluted surface. The degradation of the spaces between the caves, the exploitation roads, the cave conservation facilities, as well as some constructions was accelerated in a very short time (fig. 2.a, fig. 3).

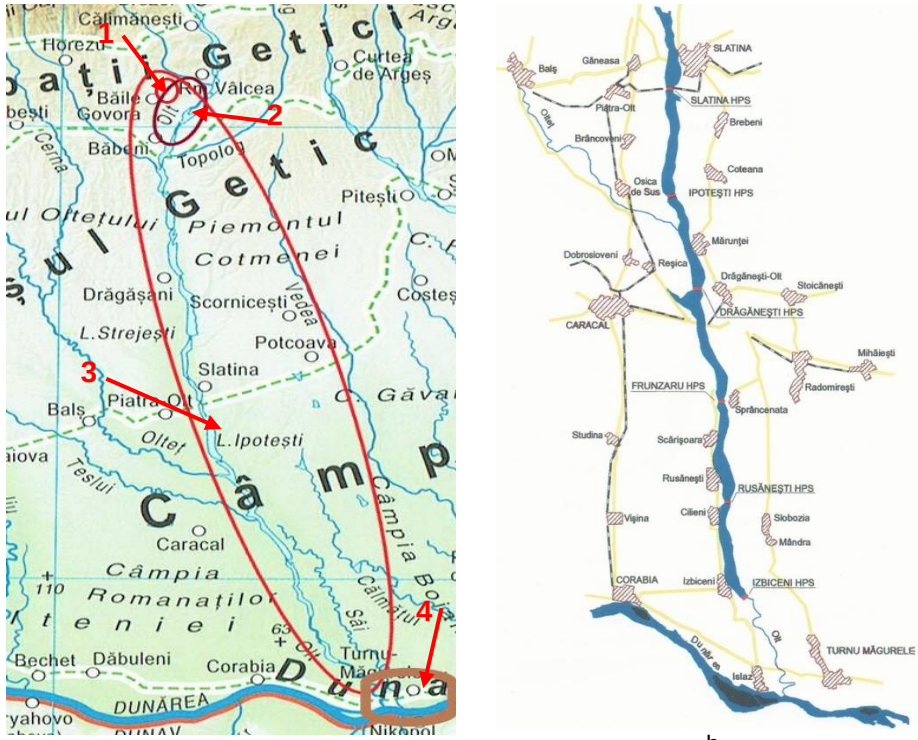

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Fig. 2. Pollution areas of the brine wave: a – types of pollution in the Olt River area, 1 – local pollution, 2 – extensive local pollution, 3 – regional pollution, 4 – cross-border pollution; b – regional pollution of reservoirs on the Olt River.

The brine wave produced by the implosion of the cave travelled a route formed by the slope of the extraction area, Sarat Stream and discharged into the Olt River, respectively into the lakes in the area of the city Rm. Valcea. Thus, local pollution became "*extensive local pollution*". The 2001 brine wave increased the flow on Sarat Stream from the monthly average value of 0.100 m^3/s to a maximum of 12.4 m^3/s in a few hours. The concentration of sodium chloride in Sarat Stream was about 205.61 g/l. The brine wave significantly influenced the quality of the water in the Govora reservoir on the Olt River. In September 2001, an initial amount of maximum brine of 12.642 t entered Govora Lake, which after eight days decreased to 376 t [Luca *et al*., 2008].

a b

Fig. 3. Transport routes of the brine wave: a – in the location of the caverns; b – wave on the Salt River [Luca and Tigaret 2008].

In July 2004, following the collapse of the cavern walls, a total volume of brine of about 400,000 m^3 was expelled. A large part of this volume was retained in an accumulation basin made at the base of the slope. In this situation, the initial flow on Sărat Stream had maximum values of 3.05...3.80 m^3/s (fig. 4), and the initial concentration of chlorides was a maximum of 225.0 - 250.0 g/ l (fig. 5).

The pollution caused by the brine is complemented by that induced by the diesel fuel used to stabilize and waterproof the walls and ceiling of the extraction caverns. Diesel fuel began to be driven and moved underground, as well as on the surface in the water course.

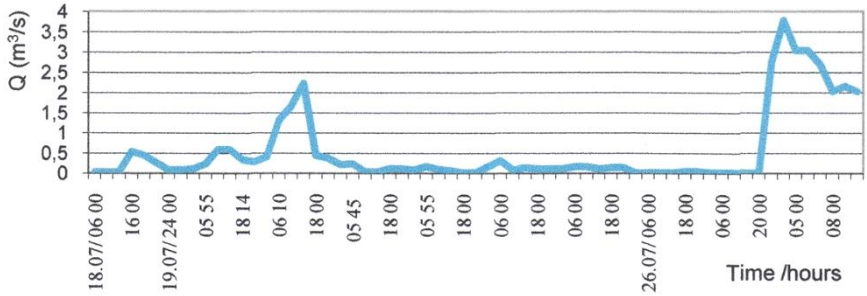

Fig. 4. The variation of brine flows on Sarat Stream in July 2004 [Luca *et al*., 2008].

The in situ research carried out by the authors in 2007 revealed a continuous degradation of the geotechnical structure of the caverns affected by the implosions. Their walls showed continuous collapses, which led to the expulsion of salt water (fig. 1.a). At the current stage, a salt water lake has formed in the extraction area, as a result of the union of the imploded caverns.

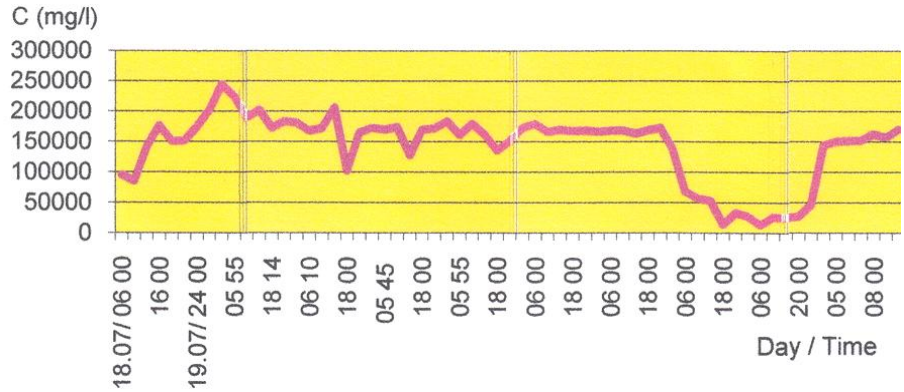

Fig. 5. Chloride concentration variation in Sarat Stream in July 2004 [Luca *et al*., 2008].

The wave of brine spilled into the Olt River affected the water quality from the existing downstream reservoirs (fig. 2.b), and especially the Govora Reservoir (a concentration of 2900 mg/l). The water from the Govora Reservoir was used in industrial technological processes. The movement of the brine wave on the Olt River turned "local pollution" into "regional pollution". The movement of the brine wave was favoured by its higher density, which placed it towards the bottom of the reservoirs. Ensuring the servitude flows from the lakes is achieved by emptying the bottom of the dams. This process of exploitation of the reservoirs allowed the transmission downstream of an important amount of salt water.

Downstream from the Rm. Valcea town and up to the town of Islaz, there are 15 reservoirs along an approximate length of 210 km, namely Râureni, Govora, Băbeni, Ionești, Zăvideni, Drăgășani, Strejești, Arcești, Slatina, Ipotești, Drăgănești, Frunzaru, Rusanesti, Izbiceni and Islaz. Their accumulation volume is between 142,167 million m^3 (Strejesti) and 14.10 million m^3. The brine wave moved with average speeds of 0.90 - 1.50 m/s along the Olt River to the Danube River, a situation in which the concentration of sodium chloride decreased through a dilution process in the volume of water existing in the lakes of accumulation.

Concentrated sodium chlorides were monitored along the path of the flood wave and mainly in the reservoirs. Water from the reservoirs on the Olt River downstream from the Rm. Valcea city is used to supply the population and industrial facilities, water for irrigation and fish farming, leisure and others. The monitored sodium chloride values in the reservoirs are shown for the brine flood of July and August 2004 are shown in (fig. 6, fig. 7). The maximum and minimum values highlight the evolution of the concentration along the path of the brine wave, respectively the intensity of the dilution phenomenon over time.

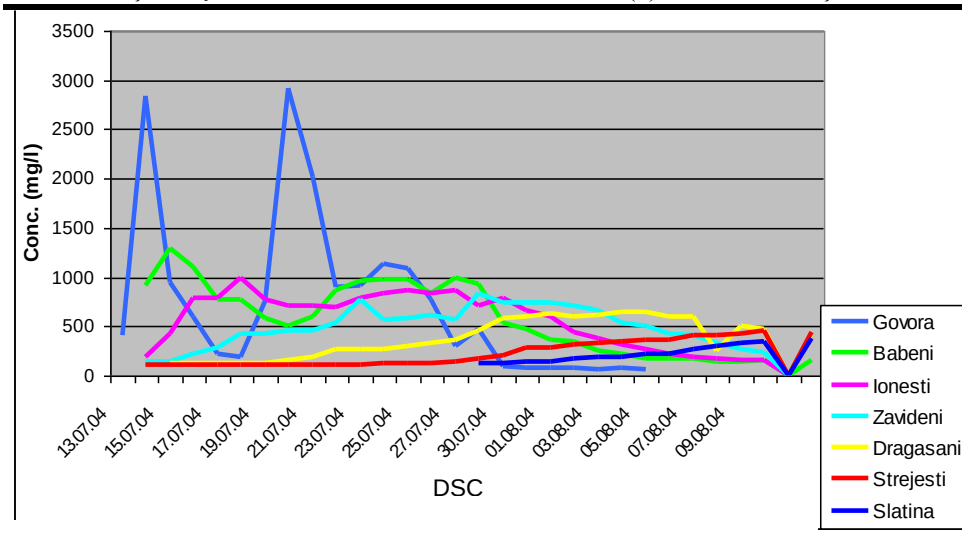

Fig. 6. The variation of the concentration of sodium chloride in the reservoirs between July and August 2004: Conc. – concentration of the solution; DSC – sample collection date.

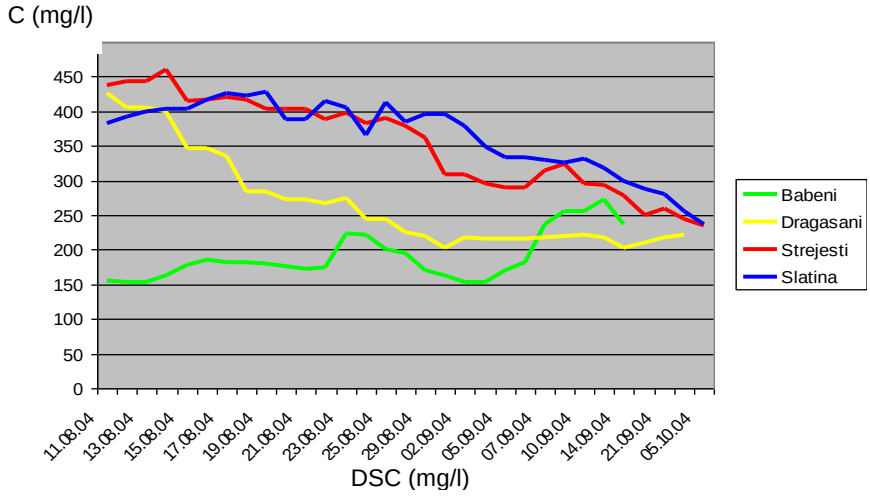

Fig. 7 The variation of the concentration of sodium chloride in the reservoirs on the Olt River in the period August - October 2004: C. – concentration of the solution; DSC – sample collection date.

The maximum concentrations at the confluence of the Sarat Stream in the Olt River, respectively in the Govora Lake, show the influence of the random expulsion of salty water during the cave degradation process. The maximum value of the brine concentration at the entrance to Lake Govora was 280-290 g/l. The value of the brine concentration varied in each lake depending on the distance from the source, the volume of accumulation, the operating conditions of the lake and others.

For example, Lake Babeni with an accumulation volume of 52 million m^3 presented high values of the initial brine concentration (C_{max} = 130 g/l). Lakes with accumulation volumes of 45 – 25 - 52 mil.m^3 (Ionești Zavideni, Drăgășani) presented much lower values of brine concentration (fig. 6). The Strejesti reservoir, which has the largest accumulated volume (142,167 mil.m^3), presented low brine concentration values at the initial moment. The low speed of pollutant movement in this lake allowed the concentration of sodium chloride to increase over time (fig. 6).

The polluting wave from the Olt River also reached the Danube River after a period of time. The phenomenon of sodium chloride pollution was highlighted by river residents in 2001 and 2004. In this context, the regional pollution process turned into a "cross-border pollution process". The Danube River being an international watercourse, or a border for Romania, requires compliance with water quality parameters. The presence of cascading accumulations on the Olt River allowed a satisfactory dilution of the brine, so transboundary pollution was reduced in value. The absence of accumulations would have determined an important pollution of the Olt and Danube rivers.

The natural process of surging of the cave walls and sliding of some areas of the slope, on which the mining operation is located, has a random character. These situations influenced the variation and parameter values of the pollutant wave formed by brine with a certain concentration of chlorides. The local pollution of the land in the extraction area was caused by a mixture of chlorides and hydrocarbons (diesel oil used to waterproof the cavern). In the dam lakes built along the Olt River, the presence of a clogging process was found as a result of the large amounts of alluvium transported from the catchment area and from the bed of the Sarat Stream. The prevention of this type of disaster necessarily requires a process of permanent monitoring of the pollution phenomenon. Following the 2001 disaster, a series of measures were taken by the Olt Water Basin Administration to limit the volume of the flood wave and monitor the water quality along the path of the brine wave (Univ. Buc. 2003, Luca M. and Tigaret G., 2007).

CONCLUSIONS

1. Pollution sources located underground or on the surface, in the case of caverns with residues from the exploitation of sodium chloride, can emit noxes at a local, regional and even cross-border level depending on the characteristics of the transport vector and the level of concentration existing in the initial stage.

2. The main pollutant transport vector is speed, represented by the speed of air, water and solid mass. The second vector is given by the concentration of the pollutant and its evolution along the transport length and in time.

3. Air speed manages to transport gaseous pollutants, mixtures of gases and liquids, and dusts to very large distances, of the order of thousands of kilometres, a situation in which classic cross-border pollution is achieved.

4. The speed of the water in the rivers makes it possible for the pollutants incorporated in the liquid stream in the form of dissolved gases, liquids and solid

particles to be transported to medium and long distances of the order of tens and hundreds of kilometres, a situation in which cross-border pollution can occur.

5. The absence of an effective monitoring of the parameters that characterize the evolution over time of the brine caves under conservation can trigger an ecological disaster at the local, regional and even cross-border level.

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QUALITY ASSURANCE OF DENSIFIED BIOFUELS FROM VINEYARD RESIDUES: CASE STUDY FOR "CABERNET" AND "MOLDOVA" VARIETIES CULTIVATED IN THE REPUBLIC OF MOLDOVA

ASIGURAREA CALITĂȚII BIOCOMBUSTIBILILOR DENSIFICAȚI DIN REZIDUURI DE VIȚĂ-DE-VIE: STUDIU DE CAZ PENTRU SOIURILE „CABERNET” ȘI „MOLDOVA” CULTIVATE ÎN REPUBLICA MOLDOVA

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Abstract.
In the context of efficiently utilizing available biomass resources, this study explores the possibility of ensuring the quality of pellets and briquettes produced from biomass obtained from vineyard residues, through a case study of the most widespread grape varieties in the Republic of Moldova – "Cabernet" and "Moldova." The aim of the study is to validate the proposed hypothesis, which focuses on the feasibility of producing densified solid biofuels made of biomass resulting from vineyard care, in all aspects covered by the ENplus certification system. The adopted methodology includes both statistical analyses based on data from the scientific literature and experimental investigations carried out in the Scientific Laboratory of Solid Biofuels at the Technical University of Moldova. The results indicated a promising potential of using vineyard residues for biofuel production, while adhering to ENplus quality standards. Additionally, the study highlights the need for implementing specific technological procedures to maximize yield and minimize losses throughout the entire production process. The conclusions emphasize the multiple benefits of utilizing vineyard residues, both from an economic and ecological perspective, contributing to the sustainable development of the viticulture industry and environmental protection.
Key words: Biomass, vine residues, densified solid biofuels, pellets, briquettes

Rezumat.
În contextul valorificării eficiente a resurselor disponibile de biomasă, studiul de față explorează posibilitatea asigurării calității peleților produși din biomasă provenită din reziduuri de viță-de-vie, printr-un

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[3] CC „Basadoro Agroteh” LLC

studiu de caz pentru cele mai răspândite soiuri de struguri din Republica Moldova – „Cabernet" și „Moldova". Scopul studiului este validarea ipotezei propuse, care se concentrează pe posibilitatea obținerii biocombustibililor solizi densificați din biomasă rezultată din îngrijirea viței-de-vie, în toate aspectele prevăzute de sistemul de certificare ENplus. Metodologia adoptată include atât analize statistice bazate pe date din literatura de specialitate, cât și investigații experimentale efectuate în cadrul Laboratorului Științific de Biocombustibili Solizi al Universității Tehnice din Moldova. Rezultatele indică posibilitatea utilizării reziduurilor de viță-de-vie pentru producția de biocombustibili, cu respectarea standardelor de calitate ENplus. În plus, studiul evidențiază necesitatea implementării unor proceduri tehnologice specifice pentru a maximiza randamentul și a minimiza pierderile pe parcursul întregului proces de producție. Concluziile subliniază beneficiile multiple ale valorificării reziduurilor de viță-de-vie, atât din perspectivă economică, cât și ecologică, contribuind la dezvoltarea durabilă a industriei vitivinicole și la protejarea mediului.

Cuvinte cheie: Biomasă, reziduuri de viță-de-vie, biocombustibili solizi densificați, peleți, brichete

INTRODUCTION

The use of densified solid biofuels (DSBFs), in the form of pellets and briquettes, is continuously increasing worldwide, including in the Republic of Moldova. This has become a popular solution due to its renewable nature and numerous advantages, such as energy efficiency, reduction of harmful gas emissions, economic feasibility, and wide availability [Marian *et al*., 2021; Rupasinghe *et al*., 2024; Ţenu *et al*., 2024].

In the context of using DSBFs as renewable energy in the Republic of Moldova, briquettes and pellets play an essential role in providing sustainable fuel alternatives [Marian, 2016]. Both forms of DSBFs are produced from lignocellulosic biomass, offering economic solutions to reduce energy imports [Marian *et al*., 2021].

Although briquettes and pellets have similar origin, they differ significantly in terms of size and shape, physical and mechanical characteristics, production processes, applications, and prices. For this reason, to make DSBFs competitive in the market and accessible to consumers, it is important to ensure an optimal balance between quality and price, which depends on several factors in the production value chain [Cesprini *et al*., 2021; Ene and Ranca, 2023].

DSBFs are considered high quality if they meet the requirements stipulated by ENplus standards, which indicate consistent quality for pellets and briquettes [Schön *et al*., 2019; Cesprini *et al*., 2021; Marian *et al*., 2022]. Producing DSBFs with properties compliant with ENplus standards not only provides renewable energy solutions that are environmentally friendly but also contributes to new income streams for agricultural producers [Pavlenco, 2018; Kpalo *et al*., 2020; Ţenu *et al*., 2021].

In the Republic of Moldova, the main sources of raw materials for DSBFs production are agroforestry residues. However, their use remains inefficient, partly due to limited information on the feasibility of raw material supply chains. Also, data regarding the energy potential of different types of biomass and methods for ensuring the quality of biomass-based final products are scarce. This situation, exacerbated by recent energy shortages in the Republic of Moldova, has served as a catalyst for seeking affordable methods to increase the available and sustainable biomass energy for producing DSBFs with properties satisfying the international quality standards [Marian *et al*., 2021, 2022; Ciolacu *et al.*, 2022].

At the same time, several studies on the use of biomass generated from agroforestry activities for DSBFs production in the Republic of Moldova have highlighted that, although there is a significant amount of biomass suitable for DSBFs production, only a portion can be directly used for producing pellets and briquettes with ENplus characteristics [Gudîma, 2017; Pavlenco *et al*., 2018].

An important source of agricultural residues that can be used as a feedstock for producing pellets and briquettes with properties close to ENplus standards is the residual biomass from vineyard pruning [Senila *et al*., 2020, 2022; Kovacs *et al.*, 2022].

Based on these findings, the study hypothesis focuses on the potential of producing DSBFs with ENplus characteristics from waste biomass from vineyard care. To confirm this hypothesis, it is of interest to conduct a detailed study of the major components of the quality assurance chain for pellets and briquettes produced from vineyard residues, throughout the entire life cycle of the final product.

This study aims to demonstrate the feasibility of using vineyard pruning residues by evaluating the biomass potential obtained per hectare of plantation and assessing the quality of this biomass, as well as the pellets and briquettes produced from it. Moreover, the study highlights the main methods for ensuring the quality of the final product, to be certified according to ENplus standards.

Thus, the goal of the study is to validate the hypothesis that utilizing biomass generated from vineyard pruning residues is feasible for DSBFs production in all aspects provided by the ENplus certification system.

To achieve this goal, the following specific objectives were set:

- Identify the particularities of the value chain for DSBFs production from vineyard residues, with a focus on ensuring the quality of the final product.
- Evaluate the biomass potential from vineyard residues, estimated per unit area for grape plantations of the "Cabernet" and "Moldova" varieties.
- Conduct a qualitative analysis of vineyard residues, as well as the final pellets and briquettes produced.

MATERIAL AND METHOD

Design of Experiments and Sample Collection. The research was carried out according to an algorithm consisting of four distinct stages, as presented in Figure 1.

Following a detailed analysis of the studies published in the scientific literature on the use of agricultural plant residues, with a special focus on vine residues, and critically evaluating the presented data, we formulated the working hypothesis. This hypothesis assumes the possibility of using the residues generated from vine pruning for the production of DSBFs with characteristics that comply with ENplus standards.

Considering that ensuring the quality of DSBFs is a continuous process integrated into all stages of the value chain, a comprehensive research methodology was defined. This involves a detailed analysis of the major factors influencing the quality of the final product throughout the entire life cycle of the pellets and briquettes. The investigations are based on a case study focusing on the use of vine residues as raw material.

The studied material of this research was the biomass resulting from the vineyard pruning, as well as DSBFs produced either only from this biomass or from mixtures based on it. The biomass was sampled from five vineyards located in the villages of Geamănă, Anenii-Noi district, FCP "ASCONI" SRL; the town of Căinari, Căușeni district, SRL PI – CAFT and the communes of Trușeni and Stăuceni in the municipality of Chișinău.

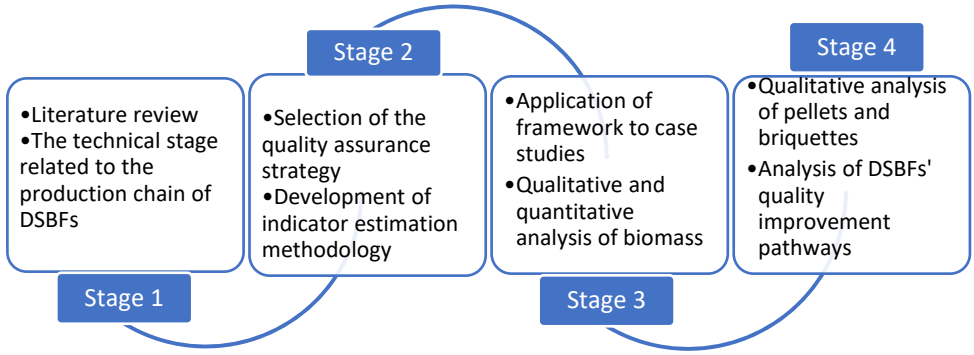

Fig. 1. Research algorithm

To determine the mass of residues generated from pruning the vines, 5 vineyard sectors were selected for each of the two grape varieties examined. The surface area of the sectors varies according to the actual conditions in the field (see Table 1).

The biomass was estimated for a predetermined number of vine stocks, selected from each field, using the quarter method for sampling. The biomass from the pruning of the selected vine stocks (approximately 2% of the total number of vine stocks in each field) was collected and shredded directly in the field by the mobile woodchipper Morena 1, available at the Scientific Laboratory of Solid Biofuels at the Technical University of Moldova (SLSBF TUM). It was then weighed using an ACEN scale of 50 kg, with a precision of 10 g.

Part of the biomass was hermetically packed in polyethylene bags to determine the moisture content at harvest, ash content, and calorific value. All selected biomass was transported on the same day to the SLSBF TUM, where it was prepared for further testing and the production of briquettes and pellets necessary for the qualitative assessment of the final product.

The average values obtained were used as a reference for calculating the mass of residues that can be harvested per hectare of vineyard for the respective grape variety.

Laboratory testing. The qualitative indicators of the biomass and the final products were estimated using the validated standard methods applied at the SLSBF. Each test was performed in five repetitions to ensure measurement accuracy. Finally, the standard deviation and confidence interval were calculated for the results obtained within each test series, corresponding to each grape variety. The methodology for tests' conduction has been described in our previous works [Ciolacu *et al.*, 2022; Marian *et al*., 2022].

Biomass densification into briquettes was carried out using two distinct methods. The first method involved multiple pressing using the Briklis hydraulic press, available at SLSBF. The second method consisted of single pressing on the specially designed device for studying the densification process of a plant biomass in the form of briquettes, protected by the patent MD 1734 Y from 2023.12.31 [Daraduda *et al.*, 2023]. Pellet manufacturing was done using the pellet production technological line Kovo Novák at SLSBF TUM.

RESULTS AND DISCUSSIONS

General aspects related to the value chain for the production of solid biofuels made of plant biomass, from the perspective of ensuring the quality of the final product

The major elements in the quality assurance chain throughout the life cycle of solid biofuels from biomass generated from the vineyard maintenance are presented in Figure 2.

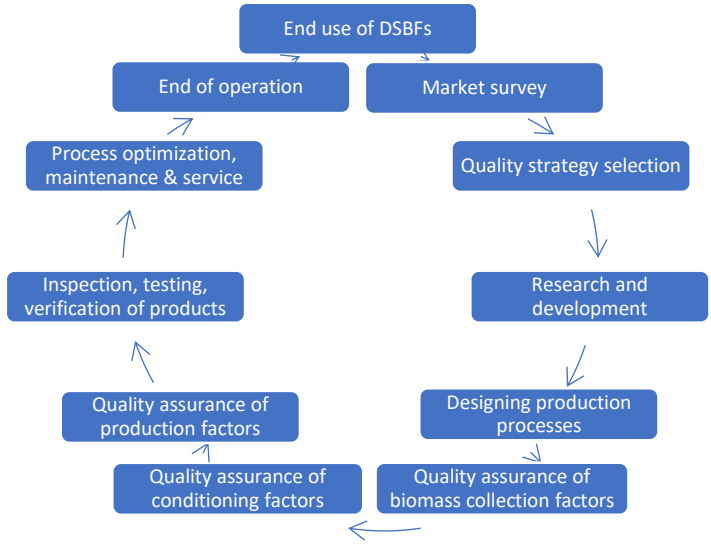

Fig. 2. Juran's quality spiral adapted for solid biofuels

The value chain for the production of solid biofuels from residues derived from agroforestry activities is characterized by the quantitative and qualitative specifics of the raw material collection process and the processing of biomass into final products with qualitative characteristics capable of meeting the requirements of beneficiaries [Cesprini *et al.*, 2021].

Quality management in the production of solid biofuels from plant biomass is a complex process that begins with a well-conducted market study and continues with the implementation of rigorous quality assurance strategies. Through continuous monitoring and optimization of production processes, companies can ensure high-quality products that comply with international standards and effectively meet market demand [Marian, 2016].

This holistic approach ensures not only the fulfillment of consumers' energy needs but also the long-term sustainability and success of businesses in this sector.

Market survey is the first important step in quality management, playing a crucial role in the value chain of quality assurance, influencing every stage from production to consumption. It is vital to understand the beneficiaries' requirements, whether they are residential or industrial consumers, and assess their consumption capacity.

The market study provides essential information about the demand and supply for biomass pellets and briquettes. It helps producers understand market trends, consumer preferences, competitive prices, and the quality standards needed to meet market demands. Through detailed analysis, companies can identify the most profitable market segments and adapt production processes to meet the specific requirements of their clients.

For example, in the case of producing solid biomass fuels from vine residues, production should be organized in vineyard areas, such as those in the Central and Southern regions of the Republic of Moldova. However, these regions are not uniform regarding the availability of biomass in different districts, which requires careful planning and knowledge of the existing potential of biomass suitable for using as a raw material in the production of solid biofuels.

Selecting a quality strategy is another essential aspect for any solid biofuel-producing enterprise. Entrepreneurs intending to bring a new product or service to the market must create viable strategies to advertise and introduce their product. Regarding DSBFs, strategies should aim to produce a final product that meets international standards like ENplus [Nunes *et al*., 2021]. To achieve this goal, the enterprise must establish, document, implement, and maintain a quality management system throughout all technological stages of the production [Pavlenco, 2018].

The effective implementation of quality assurance strategies requires accurate data based on studies conducted for each specific case. This includes the selection and preparation of raw materials, the use of appropriate production processes and equipment. Regular inspections, testing, and verification of the final

product are also essential to ensure compliance with relevant industry standards, such as ENplus or the standards from the SM EN ISO 17225 package.

An important part of the quality assurance strategy relates to process optimization. The use of sensors and control systems for real-time monitoring of the process allows for quick and efficient adjustments. Regular maintenance of equipment is also crucial to ensure the main parameters of technological equipment reliability, such as proper functioning, durability, and maintainability.

Potential and quality of biomass resulting from pruning the "Cabernet" and "Moldova" vines

The grape varieties "Cabernet" and "Moldova" cover significant areas in the Republic of Moldova. "Cabernet", a variety used for wine production, is known for its organoleptic qualities and international popularity, holding an important place in local viticulture. According to the National Office of Vine and Wine (ONVV) data, the "Cabernet" wine grape variety ranks second in terms of area covered by red grape varieties in Moldova and first in vineyards with Protected Geographical Indication [ONVV, 2024].

The "Moldova" grape variety is an indigenous table grape created in the Republic of Moldova, which is widespread and cultivated in the Central and Southern regions of the country. Since the "Moldova" vines are vigorous with good maturation of the canes, they result in a significant amount of biomass following seasonal pruning [Cuharschi *et al*., 2019], which can be utilized in the production of pellets and briquettes.

Table 1 provides a detailed estimate of the residue production resulting from pruning the "Cabernet" and "Moldova" vines, including various variables such as the average mass of residues per vine, moisture content, and calorific values of the biomass.

Table 1

The production of pruning residues from the "Cabernet" and "Moldova" grape varieties

Field	Plantation scheme, m / No of grapevines examined	S_i, ha	n_p, units/field	m_b, kg/grapevine	$m_{t.h.}$, kg	M_h,%	$m_{d.Si}$, kg	m_d, kg/ha	$m_{M=10\%}$, kg/ha	Q_{vd}, J/g	$Q_{Vnet\ d}$, J/g	$Q_{Pnet\ M=10\%}$, J/g	A, %
Cabernet													
1	1,2x2,5/24	0.41	1312	0.777	1019.42	59.41	413.8	1009.2	1121.4	18857.2	17475	15483	2.97
2	1,2x2,5/36	0.58	1856	0.711	1319.62	59.29	537.2	926.2	1029.1	18959.3	17589	15586	2.88
3	1,2x2,5/16	0.19	608	0.771	468.77	59.30	190.8	1004.2	1115.7	19157.4	17781	15759	3.07
4	1,2x2,5/8	0.14	448	0.846	379.01	59.39	153.9	1099.4	1221.5	18862.2	17480	15487	2.92
5	1,2x2,5/12	0.19	608	0.778	473.02	59.57	191.2	1006.5	1118.4	18857.0	17481	15488	3.02
Total		**1.51**	**4832**		**3659.8**		**1486.9**						
Mean				**0.777**		**59.4**		**1009.1**	**1121.2**	**18938.6**	**17561.3**	**15560.8**	**2.97**
Std. dev.		**0.19**	**599.26**		**415.0**		**169.0**	**61.3**	**68.2**	**129.8**	**132.1**	**118.9**	**0.1**
Confidence		**0.1641**	**525.27**		**363.75**		**148.2**	**53.77**	**59.74**	**113.8**	**115.8**	**104.212**	**0.067**
Moldova													
1	1,75x3/16	0.24	457	1.011	462.23	46.05	249.4	1039.1	1154.5	18827.2	17443	15454	2.77
2	1,75x3/23	0.36	686	1.038	711.86	45.85	385.5	1070.8	1189.7	18768.1	17398	15414	2.78
3	1,75x3/16	0.25	476	1.156	550.55	46.09	296.8	1187.2	1319.1	18741.1	17363	15382	2.81
4	1,75x3/8	0.12	229	1.125	257.18	46.16	138.5	1153.9	1282.1	19057.2	17653	15644	2.82
5	1,75x3/12	0.18	343	1.089	373.42	46.11	201.2	1118.0	1242.2	18827.0	17438	15450	2.72
Total		**1.2**	**2190.8**		**2355.2**		**1271.3**						
Mean				**1.1**		**46.1**		**1113.8**	**1237.5**	**18844.1**	**17459.0**	**15468.8**	**2.78**
Std. dev.		**0.09**	**170.39**		**172.96**		**93.90**	**60.10**	**66.78**	**124.87**	**113.46**	**102.12**	**0.04**
Confidence		**0.0784**	**149.35**		**151.6**		**82.31**	**52.68**	**58.53**	**109.46**	**99.46**	**89.51**	**0.035**

Note: S_i – the area of the field from which the samples were collected; n_p – the number of grapevines in the fields from which the samples were collected; m_b – the average mass of residues collected from one grapevine; $m_{t.h}$ – the total mass of residues collected from the field from which the samples were collected; M_h – moisture content at harvest; $m_{d.Si}$ – the total mass of residues collected from the field from which the samples were collected, calculated on a dry basis; m_d – the mass of residues collected per hectare of plantation, calculated on a dry basis; $m_{M=10\%}$ – the mass of residues collected per hectare of plantation, calculated for a moisture content of M=10%; Q_{Vd} – gross calorific value determined for constant volume; $Q_{Vnet\ d}$ – net calorific value calculated for constant volume; $Q_{Pnet,M=10\%}$ – net calorific value calculated for a moisture content of M=10%; A – ash content.

The analysis of the obtained results shows that the vine varieties "Cabernet" and "Moldova" generate a significant amount of residues from seasonal pruning, which can be used as a feedstock for the production of densified solid biofuels.

For the "Cabernet" variety, the average residue production, at a moisture content of 10%, was estimated at 1121±59.7 kg/ha across the five fields analyzed. In the case of the "Moldova" variety, this value is 1237.5±58.53 kg/ha, which represents an average 1.1 times higher than that of "Cabernet."

The moisture content at the time of collection was high for both varieties, which is explainable by the fact that the biomass was harvested in early spring, right after rainfall. For this reason, the biomass quantity was calculated for both 0% and 10% moisture content, with the latter being considered optimal for the production of pellets and briquettes, as well as for the estimation of densified solid biofuels upon delivery.

The high moisture content at harvest suggests that, in order to reduce drying costs, it is reasonable to leave the biomass in the field for a certain period. After natural drying, the biomass can be coarsely chopped directly in the field and then transported to the processing site.

Additionally, the biomass from the "Cabernet" variety as well as from the "Moldova" variety – both exhibit a high ash content. This indicates the need for further processing of the material or mixing it with other biomass sources with a lower ash content, especially for pellet production.

Table 2 provides an assessment of the characteristics of pellets and briquettes produced from the pruning residues of the "Cabernet" and "Moldova" vine varieties.

The results indicate that the net calorific value ($Q_{Pnet,M=10\%}$) of the pellets produced from the residues of both grapevine varieties is below 16.5 MJ/kg, meaning they do not meet ENplus quality classes. The same situation is observed with the ash content, which exceeds 2%, the required value for residential and commercial class B pellets, and 3% for industrial class I3 pellets.

The grapevine residues studied in this work can be more effectively used for producing briquettes, for which the requirements regarding calorific value and ash content are more lenient. For class B, the calorific value needs to be at least 14.4 MJ/kg, and the ash content should be no more than 5%.

Other parameters for both pellets and briquettes meet ENplus standards. This confirms that grapevine pruning biomass can be effectively used to produce briquettes with fairly high quality. The potential to produce ENplus-standard pellets is also of interest; however, this would require additional processing of the biomass or mixing with other biomass sources that have higher calorific value and lower ash content.

Table 2

Characteristics of pellets and briquettes produced from pruning residues of the "Cabernet" and "Moldova" grape varieties

No of repetitions	Q_{Vd}, J/g	$Q_{Vnet\ d}$, J/g	$Q_{Pnet\ M=10\%}$, J/g	A, %	BD kg/m³	F (<3,15), %	Vd, %	Q_{Vd}, J/g	$Q_{Vnet\ d}$, J/g	$Q_{Pnet\ M=10\%}$, J/g	A, %	DE, g/cm³
	Cabernet											
	Pellets							**Briquettes**				
1	19058.2	17676	15664	3.98	670.34	0.78	77.79	18581.8	17200	15236	3.97	1.05
2	19105.8	17736	15718	4.02	680.54	0.54	77.85	18045.8	16677	14765	4.18	1.11
3	18892.4	17516	15520	3.98	685.85	0.72	78.13	19157.4	17782	15760	3.97	1.09
4	19002.2	17620	15613	3.89	690.74	0.66	79.58	18902.2	17521	15524	4.04	1.07
5	19007.0	17631	15623	4.05	694.85	0.68	77.88	18857.0	17482	15489	4.07	1.15
Mean	**19013.1**	**17635.7**	**15627.9**	**3.98**	**684.46**	**0.68**	**78.25**	**18708.84**	**17332.35**	**15354.8**	**4.05**	**1.09**
Std. dev.	**79.6**	**80.9**	**72.8**	**0.1**	**9.5**	**0.1**	**0.8**	**423.2**	**420.4**	**378.3**	**0.1**	**0.0**
Confidence	**69.781**	**70.932**	**63.839**	**0.053**	**8.3629**	**0.078**	**0.6638**	**370.922**	**368.4788**	**331.631**	**0.076**	**0.0337**
	Moldova											
	Pellets							**Briquettes**				
1	19058.2	17674	15662	3.41	77.91	0.49	78.31	18827.2	18827	16700	3.47	77.91
2	18995.8	17626	15619	3.36	77.85	0.54	78.25	18758.1	18758	16638	3.48	77.85
3	18882.4	17504	15509	3.43	78.03	0.58	78.08	18741.1	18741	16623	3.41	78.03
4	19002.2	17598	15594	3.32	77.98	0.44	78.58	18957.2	18957	16817	3.54	77.98
5	19007.0	17618	15612	3.55	77.78	0.47	78.38	18827.0	18827	16700	3.78	77.78
Mean	**18989.12**	**17603.98**	**15599.29**	**3.41**	**77.91**	**0.50**	**78.32**	**18822.12**	**18822.12**	**16695.61**	**3.54**	**77.91**
Std. dev.	**64.61**	**62.32**	**56.09**	**0.09**	**0.10**	**0.06**	**0.18**	**85.09**	**85.09**	**76.58**	**0.14**	**0.10**
Confidence	**56.630**	**54.624**	**49.161**	**0.077**	**0.087**	**0.049**	**0.160**	**74.580**	**74.580**	**67.122**	**0.126**	**0.087**

Note: BD – bulk density; F – fine fraction content; Vd – volatile matter content; DE – particle density.

CONCLUSIONS

This study validates the feasibility of using grapevine residues from the "Cabernet" and "Moldova" varieties for the production of densified solid biofuels in the Republic of Moldova. The results indicate that one hectare of "Cabernet" grapevine plantations generates on average 1121±59.7 kg of residues, with a moisture content of 10%, suitable for use as raw material for densified solid biofuels' production. For the "Moldova" variety, the average yield is 1237.5±58.53 kg/ha.

Analysis of the final products obtained from grapevine residues showed that they can be efficiently converted into briquettes and pellets. However, for pellets, additional processing or mixing with other types of biomass is required to meet ENplus standards, due to the high ash content and lower calorific value.

The results of this study, along with the fact that utilizing vineyard residues supports the economic sustainability of vineyards and environmental protection, provide solid reasons for future research directions. Specifically, future research should focus on improving the quality of pellets produced from blends of grapevine residues with other types of biomass available in the Republic of Moldova to reduce ash content and increase calorific value, so that the final product meets ENplus standards.

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CRITERIAL ANALYSIS OF BIOCHAR PRODUCTION EQUIPMENT AND DETERMINATION OF THE OPTIMUM SOLUTION FOR A NEW TYPE OF INSTALLATION

ANALIZA CRITERIALĂ A UNOR ECHIPAMENTE PENTRU PRODUCȚIA DE BIOCHAR ȘI CONCEPEREA UNOR INSTALAȚII INOVATIVE

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Abstract.
The main objective of this study is the analysis of representative technical solutions described in invention patents, as well as the study of existing equipment in this field, for the development of an eco-innovative system for biochar production from plant waste under laboratory conditions (The Generalized Object Method of Technical Creation, Vitalie Belousov). Biochar is produced from biomass by burning it in the absence of oxygen or at low oxygen levels. Once in the soil, it activates its properties, such as carbon sequestration and water retention in the ground. The study utilized a technical creativity method through the criterial analysis of existing technical solutions and the development of a cylindrical matrix, which will determine the discovery of a new constructive-functional version that will be further developed through design and research activities. The research carried out has led to an original, patentable solution, which will be developed by designing and executing a prototype based on a research contract
Key words: biochar, reactor, biomass, plant waste, technical creation.

Rezumat.
Obiectivul principal al acestui studiu este analiza soluțiilor tehnice reprezentative descrise în brevetele de invenție, precum și studiul echipamentelor existente în acest domeniu, pentru dezvoltarea unui sistem eco-inovator de producere a biocharului din deșeuri vegetale în condiții de laborator (The Metoda obiectului generalizat de creație tehnică, Vitalie Belousov). [1] Biocharul este produs din biomasă prin piroliza cesteia în absența oxigenului sau la niveluri scăzute de oxigen. Odată ajuns în sol, își activează proprietățile, cum ar fi captarea

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carbonului și reținerea apei în sol. Studiul a utilizat o metodă de creativitate tehnică prin analiza criterială a soluțiilor tehnice existente și dezvoltarea unei matrice cilindrice, care va determina descoperirea unei noi versiuni constructiv-funcționale care va fi dezvoltată în continuare prin activități de proiectare și cercetare. Cercetările efectuate au condus la o soluție originală, brevetabilă, care va fi dezvoltată prin proiectarea și executarea unui prototip pe baza unui contract de cercetare.
Cuvinte cheie: biochar, reactor, biomasă, deșeuri vegetale, creație tehnică.

INTRODUCTION

Biochar is produced from biomass by burning it in the absence of oxygen or at low oxygen levels. Once in the soil, it activates its properties, such as carbon sequestration and water retention in the soil. This transformation process is known as pyrolysis, and the resulting "biochar" is a solid, coal-like substance. This proposed carbon dioxide removal (CDR) approach can utilize very large amounts of biomass, such as forest or agricultural products and waste, and high pyrolysis temperatures, e.g., up to 900 °C, to produce a carbon-rich residue that can be mixed into the soil, where the carbon is – theoretically – stored and absorbed by plants. Compared to other products, biochar has a value ten times higher in terms of increasing soil fertility. Once in the soil, it activates its properties, such as carbon sequestration and water retention in the soil. Under normal conditions, nitrogen in biomass is lost through decomposition, which is why the subsequent administration of nitrogen is necessary for agricultural crops. This issue is resolved by biochar, which retains nitrogen from biomass like a sponge. Biochar retains nitrogen, nutrients, and even *E. coli* bacteria in the soil, giving it extraordinary qualities [Ion *et al.*, 2021].

At the local or regional level, pyrolysis and gasification units can be operated by larger companies and can process up to 4.000 kg of biomass per hour qualities [Ion *et al.*, 2021]. Small-scale gasification and pyrolysis systems, which can be used on farms or in small industries, are commercially available with biomass inputs ranging from 50 kg/h to 1.000 kg/h. Biochar kilns are low-tech biochar production units with a primary design function of producing biochar, fig.2 [Ushakumary, 2022]. Dr. Brown highlights several specific goals for advanced biochar manufacturing: continuously-fed pyrolyzers to improve energy efficiency and reduce pollution emissions associated with batch kilns, exothermic operation without air infiltration to improve energy efficiency and biochar yields, recovery of by-products to reduce pollution emissions and improve process economics, control of operating conditions to enhance biochar properties and allow modifications to by-product yields, and feedstock flexibility, allowing both woody and grassy biomass (such as crop residues or grasses) to be converted into biochar [Menya, 2019].

The German demonstration model GO-GRASS converts lower-nutrient grass from wetland areas into biochar. By installing a complete processing line, the grass is converted into biochar through pyrolysis or hydrothermal carbonization

Globally, various biochar production equipment exists, which will be presented and analyzed in the following chapter.

Nationally, Professor Erol Murad from the University Politehnica of Bucharest has conducted numerous studies on biochar production equipment. ECOHORNET has designed and developed biochar and heat production equipment from agricultural waste for large production capacities (1-4 tons/hour) [Ion *et al.*, 2021].

MATERIAL AND METHOD

Research on technical creativity methods for biochar production equipment

For the analysis of known equipment, as well as for finding the optimal design solution for a laboratory biochar production device from plant waste, the "Generalized object method of technical creation" will be used (Belous and Boris, 2005).

The following classification criteria are used:

B - by type of equipment:

B1 - fixed equipment for biochar production:

B2 - mobile equipment for biochar production:

?- other solutions unknown at the time of the research.

Elaboration of the generalized object of technical creation (Belous and Boris, 2005).

The generalized object of creation is presented in the form of a cylindrical morphological matrix, visualized in Fig. 5, with each sector representing a solution (each sector represented by a tri-assembly BiCjDk, the total number of solutions being: N=2x3x4=24 solutions, some of which are known, while others are unknown).

Among these, incompatible solutions must be eliminated, while others must be analyzed, as their complete resolution may lead to highly efficient designs.

After eliminating clearly incompatible solutions and highlighting the apparently incompatible ones, the existing solutions need to be identified (Belous and Boris, 2005).

C - by the constructive solution of the equipment:

C1- retort equipment;

C2- horizontal screw conveyor equipment;

C3- inclined screw conveyor equipment;

?- other solutions unknown at the time of the research.

D- by the thermal agent used:

D1- with solid fuel;

D2- with gaseous fuel;

D3- with ignition resistance-electric current;

D4- with liquid fuel

?- other solutions unknown at the time of the research.

The following possible combinations are presented:

- B1C1D1 - Fixed equipment, with retort, using solid fuel;- B1C2D1 - Fixed equipment, with horizontal screw conveyor, using solid fuel; - B1C1D2 - Fixed

equipment, with retort, using gaseous fuel; - B1C1D3 - Fixed equipment, with retort, using electric ignition resistance; - B2C1D1 - Mobile equipment, with retort, using solid fuel; - B2C1D2 - Mobile equipment, with retort, using gaseous fuel; - B2C1D3 - Mobile equipment, with retort, using electric ignition resistance;

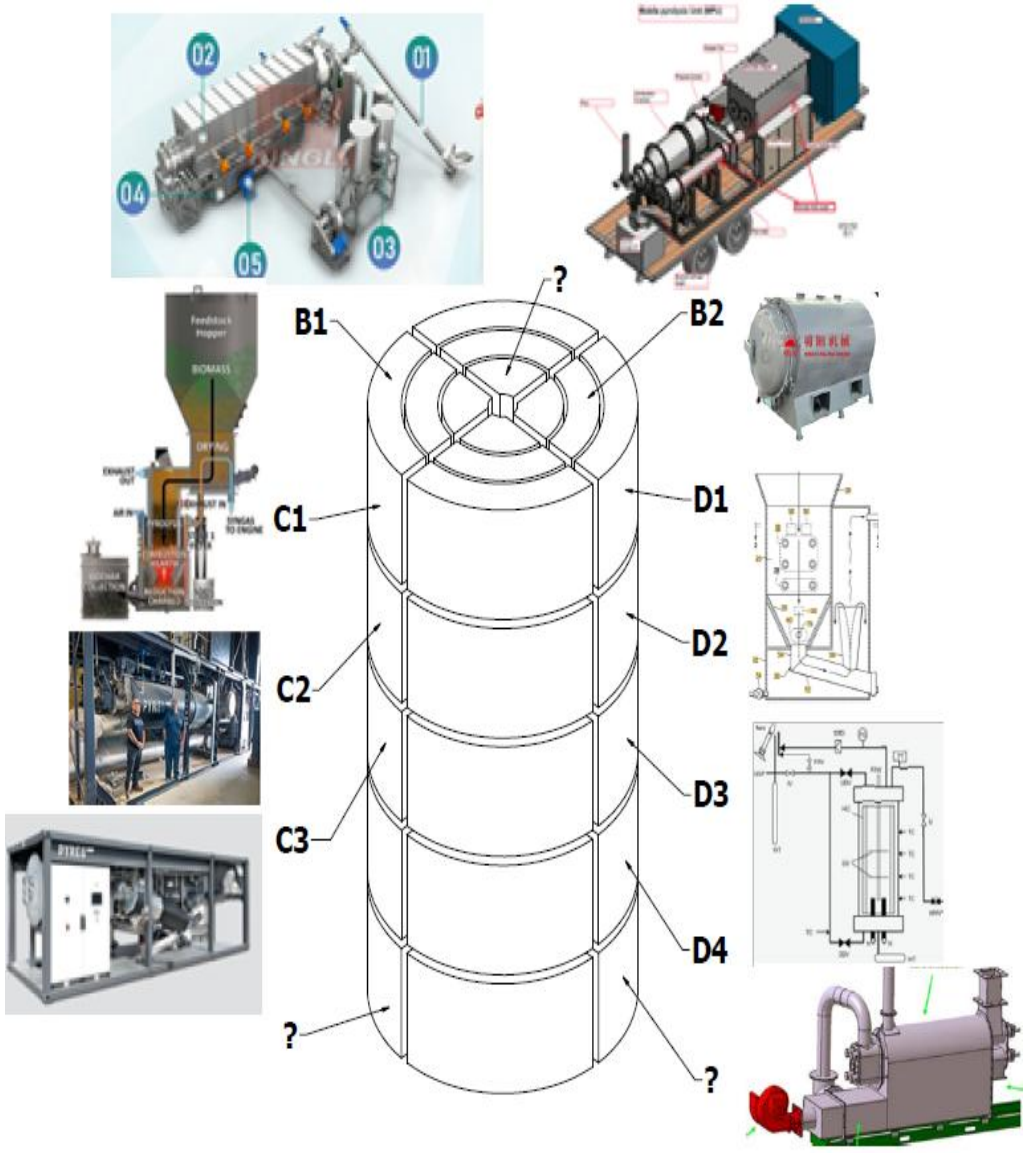

Fig. 5. The generalized object of technical creation in the field of biochar production equipment (Belous and Boris, 2005).

- B2C2D1 - Mobile equipment,with horizontal screw conveyor, using solid fuel; - B2C2D2 - Mobile equipment, with horizontal screw conveyor, using gaseous fuel; - B2C2D3 - Mobile equipment, with horizontal screw conveyor, using solid fuel; - B2C3D1 - Mobile equipment, with inclined screw conveyor, using solid fuel; - B2C1D1 - Mobile equipment, with retort, using solid fuel; - B2C1D2 - Mobile equipment, with retort, using gaseous fuel; - B2C1D3 - Mobile equipment, with retort, using electric ignition resistance; - B2C2D1 - Mobile equipment, with horizontal screw conveyor, using solid fuel; - B2C2D2 - Mobile equipment, with horizontal screw conveyor, using gaseous fuel; - B2C2D3 - Mobile equipment, with horizontal screw conveyor, using solid fuel; - B2C3D1 - Mobile equipment, with inclined screw conveyor, using solid fuel; - B2C3D2 - Mobile equipment, with inclined screw conveyor, using gaseous fuel; - B2C3D3 - Mobile equipment, with inclined screw conveyor, using electric ignition resistance; - B1C2D4 - Fixed equipment, with horizontal screw conveyor, using liquid fuel-tar; - B2C3D2 - Mobile equipment, with inclined screw conveyor, using gaseous fuel; - B2C3D3 - Mobile equipment, with inclined screw conveyor, using electric ignition resistance; - B1C2D4 - Fixed equipment, with horizontal screw conveyor, using liquid fuel-tar.

From the 15 possible combinations, 6 reliable solutions will be selected for analysis: B1C1D1; B1C2D1; B1C1D2; B1C1D3; B2C1D3; B1C2D4.

After eliminating the clearly incompatible solutions and highlighting the apparently incompatible ones, the existing solutions need to be identified (Belous and Boris, 2005).

Level	Ranking coefficient
B1C1D1	3
B1C1D2 BIC2D1 B2C1D1	4
B1C2D2 B2C2D1 B2C1D2 B1C3D1 B1C1D3	5
B2C2D2 B1C3D2 B1C2D3 B1C1D4 B2C1D3	6
B1C3D3 B2C2D3 B1C2D4 B2C1D4	7
B1C3D4 B2C2D4 B2C3D3	8
B2C3D4	9

- Highlighting, evaluating, and critiquing existing variants

Eight known solutions were identified at the time of drafting the generalized object from Fig. 5, and certain tri-assemblies remain unknown, potentially serving as the foundation for new inventions in the field (Belous and Boris, 2005).

For evaluating the existing variants, the "imposed decision" technique from value analysis is used, considering the following key evaluation criteria:

- maneuverability degree, noted as MD;
- automation degree, noted as AD;
- investment cost, noted as IC.
- moisture content of raw material, noted as M,
- duration of the technological process, noted as T.

The criteria marked as MD, AD, and IC are compared in pairs, resulting in D decisions in the form of 1-0; 0.5-0.5; 0.3-0.7; 0.6-0.4, etc., or 0-1 (see Tables 1, 2, 3). The number of decisions is given by the known formula:

D = C2e = 5 (5-1)/2 =10 decisions.

To determine the importance coefficient and reorder the five criteria, the imposed decision method is used (Belous and Boris, 2005) (Table 1).

Table 1

Reorder the five criteria

No.	Criterion	Decisions										No. of positive decisions	Importance coefficient
		1	2	3	4	5	6	7	8	9	10	N	N/D
1	MD	0.6	0.7	0.6	0.5							2.4	0.24
2	AD	0.4				0.5	0.6	0.3				1.8	0.18
3	IC		0.3			0.5			1	0.5		2.3	0.23
4	M			0.4			0.4		0		0.6	1.4	0.14
5	T				0.5			0.7		0.5	0.4	2.2	0.22

The number of positive decisions N is divided by the total number of decisions D, obtaining the importance coefficient for each criterion, which leads to reordering these criteria according to Table 2.

Table 2

Reordering these criteria

No.	Criterion	Importance coefficient
1	Maneuverability degree - MD	0.24
2	Investment cost - IC	0.23
3	Duration of the technological process - T	0.22
4	Automation degree - AD	0.18
5	Moisture content of raw material - M	0.14

From the 15 possible combinations, the following constructive variants are representative:

B - Based on the degree of mobility:

- B1 - fixed equipment for biochar production:Fig.6.

- B2 - mobile equipment for biochar production:Fig.7.

C - Based on the constructive solution of the equipment:

- C1- Equipment with retort (US2013264831A1**;** US2014250784A1**;** *[2;3]***.**

-C2- Equipment with horizontal screw conveyor:

D- Based on the thermal agent used:

-D1 - using solid fuel (CN215103026U-2021; **CN218002214U-2022**).

-D2 - Using using gaseous fuel (US2008014132A1-2008), fig.11.

-D3 -Using electric ignition resistance (US2013264831A1-2013; **US 6790317B2**).

For the comparison of the seven solutions, determining their numerical value, and reordering them to identify the optimal solution, Table 3; 4; 5; 6 and 7 is used, specific to value engineering [Ion *et. al.,* 2021]**.**

Table 3

Decisions based on maneuverability degree

No	Solution	Decisions based on the criterio																				D_{MD}	0,24 DT/21
		Maneuverability degree - MD																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
1	B1	0.5	0.3	0.4	0.5	0	0																1.9	0.01028
2	B2	0.5						1	0.5	0.6	0.3	0.5											3.4	**0.03886**
3	C1		0.7					0					0.6	0.5	1	0.5							3.3	0.03771
4	C2			0.6					0.5				0.4				0.5	0.3	1				3.3	0.03771

5 6 7	D1 D2 D3				0.5	1	1			0.4	0.7	0.5		0.5	0	0.5	0.5	0.7	0	0.5 0.5	0.3 1	0.4 0.6	2.2 3.3 3.6	0.02514 0.03771 **0.04114**

Table 4

Decisions based on criterion investement cost

No.	Solu-tion	Decisions based on the criterion																				D_{IC}	0,24 D_T/21
		Investment cost - IC																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
1 2 3 4 5 6 7	B1 B2 C1 C2 D1 D2 D3	0.3 0.7	0.5 0.5	0.7 0.3	0.4 0.6	0 1	0 1	1 0	0.7 0.3	0.6 0.4	0.7 0.3	0.5 0.5	0.6 0.4	0.5 0.5	1 0	0.5 0.5	0.5 0.5	0.3 0.7	1 0	0.5 0.5	0.3 1	0.4 0.6	1.9 4.2 3.1 2.8 2.8 2.9 3.6	0.02171 **0.048** 0.03542 0.032 0.032 0.03314 **0.04114**

Table 5

Decisions based on duration of the tehnological process

No.	Solu-tion	Decisions based on the criterion																				D_T	0,24 D_T/21
		Duration of the technological process - T																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
1 2 3 4 5 6 7	B1 B2 C1 C2 D1 D2 D3	0.4 0.6	0.3 0.7	0.4 0.6	0.5 0.5	0 1	0 1	1 0	0.7 0.3	0.6 0.4	0.6 0.4	0.5 0.5	0.6 0.4	0.5 0.5	1 0	0.3 0.7	0.5 0.5	0.3 0.7	0.4 0.6	0.5 0.5	0.3 0.7	0.4 0.6	1.6 4 3.8 2.5 2.7 3 4.1	0.01828 **0.04571** 0.04342 0.02857 0.03085 0.03428 **0.04686**

Table 6

Decisions based on automation degree

No.	Solu-tion	Decisions based on the criterion																				D_{AD}	0,24 D_T/21
		Automation degree - AD																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
1 2 3 4 5 6	B1 B2 C1 C2 D1 D2	0.5 0.5	0.3 0.7	0.4 0.6	0.5	0 1	0	1 0	0.7 0.3	0.7	0.7	0.5	0.6 0.4	0.5	1 0	0.4	0.5	0.3 0.5	0	0.5	0.3	0.4	2 4.1 3.1 2.1 2.7 2.9	0.02286 **0.04686** 0.03543

7	D3				0.5		1			0.3	0.3	0.5		0.5		0.5	0.5	0.7	1	0.5	1	0.6	4.6	0.024 0.03086 0.03314 **0.05257**

Table 7

Decisions based on moisture content of raw material

No.	Solu-tion	Decisions based on the criterion																					
		Moisture content of raw material – M																				D_M	0,24 D_T/21
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
1	B1	0.5	0.4	0.5	0.4	1	0																2.8	0.032
2	B2	0.5						1	0.5	0.6	0.3	0.5											3.4	**0.03886**
3	C1		0.6					0					0.6	0.7	0.5	0.5							2.9	0.03314
4	C2			0.5					0.5				0.4				0.4	0.3	0				2.1	0.024
5	D1				0.6					0.4				0.3			0.6			0.5	0.3		2.7	0.0308
6	D2					0					0.7				0.5			0.7		0.5		0.4	2.8	0.033
7	D3						1					0.5				0.5			1		1	0.6	4.6	**0.05257**

To calculate the numerical value of each technical solution, we use the following equation:

Nv=(0.24 x DMD + 0.23 x DIC + 0.22 x DT +0.22 x DAD +0.18 x DM) /10.

In accordance with the table, the numerical values of the seven representative solutions are:

NVB1=(0.24x1.9+0.23x1.9+0.22x1.6+0.18x2+0.14x2.8)/10=0.1997

NVB2=(0.24 x 3.4 + 0.23 x 4.2 + 0.22 x 4 +0.22 x 4.1 +0.18 x 3.4) /10=0.4129

NVB3=(0.24 x 3.3 + 0.23 x 3.1 + 0.22 x 3.8 +0.22 x 3.1 +0.18 x 2.9) /10=0.3545

NVB4=(0.24 x 3.3+ 0.23 x 2.8 + 0.22 x 2.5 +0.22 x 2.1 +0.18 x 2.1) /10=0.2826

NVB5=(0.24 x 2.2 + 0.23 x 2.8 + 0.22 x 2.7 +0.22 x 2.7 +0.18 x 2.7) /10=0.2846

NVB6=(0.24 x 3.3 + 0.23 x 2.9 + 0.22 x 3 +0.22 x 2.9 +0.18 x 2.8) /10=0.3261

NVB7=(0.24 x 3.6 + 0.23 x 3.6 + 0.22 x 4.1 +0.22 x 4.6 +0.18 x 4.6) /10=0.3656

The technical solutions with the highest numerical values are selected:

NVB2=0.4129 which corresponds to mobile equipment with a retort for biochar production,

NVB7=0.3656 which corresponds to equipment using electric resistance ignition with electric current.

Thus, the optimal variant results for the design of the Laboratory equipment for biochar production from plant residues - a mobile device, with a retort, and electric burner ignition of the raw material [Olan *et. al*., 2023].

RESULTS AND DISCUSSIONS

The final proposed variant for the design and patenting of laboratory equipment for biochar production from various plant residues, combining B2C1D3 — Mobile equipment, with a retort, and electric burner ignition of the material, will be developped.

The laboratory equipment for biochar production from plant residues [Olan *et. al.*, 2023], consists of a mobile support (1) that includes a platform (2) fitted with four self-locking wheels (3) and two side walls (4) where two weighing cells (5) and two rotating bearings (6) are mounted, fastened to the top plate of the weighing cells (5) with hexagonal head screws (7). The weighing cells measure the weight of the raw material introduced into the retort and the amount of biochar produced, fig.6

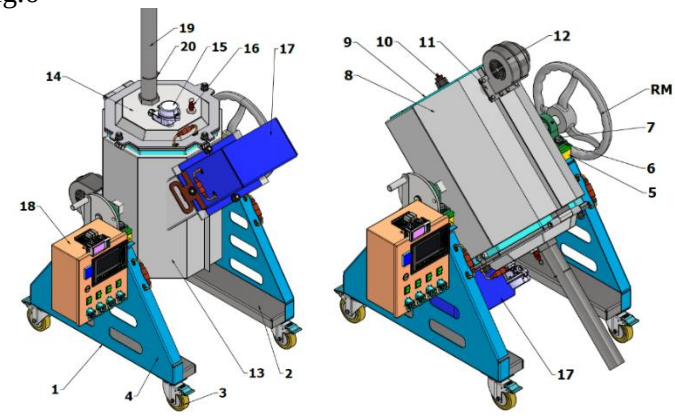

Fig.13. Biochar production equipment – Working position Biochar discharge

On the mobile support (1) is mounted a casing (8) with spindles that penetrate the rotating bearings (5). The casing (8) consists of two concentrically mounted octagonal chambers insulated between them with a layer of ceramic fiber and supports a lower cover (9) with an electric resistance (10) for igniting solid fuel and an air diffuser with holes (11) that supplies the necessary air for igniting the combustible material which is received from a fan (12). The rotation of the casing (8), which contains the retort (13) for burning the raw material to produce biochar, is done with a handwheel (RM). On the casing (8) is mounted an upper cover (14) that supports a thermocouple (15) for measuring temperature and a sensor (16) for pressure control inside the chamber. The casing (8) has a discharge outlet for the biochar, which is emptied into a sealed tray (17).

For programming the working parameters: temperature, pressure, electric ignition control, draft fan adjustment, vacuum pump, the equipment is equipped with a programmable logic controller (PLC) (18). Monitoring these parameters helps establish optimal values for obtaining high-quality biochar from various types of plant residues under laboratory conditions.

The exhaust gases at the start of raw material ignition are vented through a chimney (19), which is then closed off with the drawer (20).

CONCLUSIONS

The equipment for biochar production from plant residues has the following advantages:

-It does not require a biochar unloading system (conveyor screw, trays, etc.), as the produced material can be discharged by rotating the equipment with the help of a handwheel and emptied into a sealed tray;
-The equipment has a single chamber, eliminating the need for a separate retort for heating and drying material. The raw material is introduced into the reactor tray where the entire technological process takes place;
-Low energy consumption for starting and running the production cycle;
-Automated production cycle with a process computer;
-Short working time;
-Thermal insulation with ceramic fiber and a double jacket ensures low energy consumption;
-The equipment is mobile, compact, and recommended for laboratory tests, with automatic adjustment of working parameters;
-It can utilize plant residues with moisture content between 30-40%, compared to known solutions which can only handle residues with a maximum of 15% moisture.

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CHANGES IN NUTRIENT STATUS OF SOYBEAN IN RELATION TO *BRADYRHIZOBIUM JAPONICUM* AND SALYCILIC ACID APPLICATION UNDER LOW PHOSPHORUS AND WATER SUPPLY

MODIFICĂRI ÎN STATUSUL NUTRITIV LA SOIA ÎN DEPENDENȚĂ DE APLICAREA *BRADYRHIZOBIUM JAPONICUM* ȘI ACIDUL SALICYLIC ÎN CONDIȚII INSUFICIENTE DE FOSFOR ȘI UMIDITATE

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Abstract.

Phosphorus (P) deficiency of soil and drought are major environmental constraints, which alter key physiological constituents and functions in plants. The study was carried out to determine the influence of rhizobacteria Bradyrhizobium japonicum and salicylic acid (SA) on particularities of soybean mineral nutrition under low P supply and drought conditions. Plants were treated with two regimes of irrigation water: normal soil moisture, 70% of water holding soil capacity (WHC) and 35% of WHC as drought. The bacterial suspension of Bradyrhizobium japonicum was applied as seeds treatment and SA by foliage treatment (0,5mM). Plants cultivated under P insufficiency and drought exhibited lower physiological parameters. Experimental data demonstrated that integrated application of nitrogen-fixer bacteria and SA better improved phosphorus and potassium contents in leaves.

Key words: *rhizobacteria, acid salicylic, soybean, phosphorus, nutrients*

Rezumat.

Deficitul de fosfor din sol și seceta sunt impedimente majore ce au repercursiuni negative asupra starii fiziologice a plantelor. S-a organizat un studiu pentru a determina influența aplicării rizobacteriilor Bradyrhizobium japonicum și acidului salicilic (AS) asupra particularității nutriției minerale a plantelor de soia cultivate în condiții de deficit de fosfor și secetă. Plantele au fost supuse la două regimuri de umiditate a solului: umiditate optimă, 70% din capacitatea totală de apă a solului (CTAS) și deficit de umiditate, 35% CTAS. Tulpinile de B. japonicum au fost administrate la tratarea semințelor, iar AS în concentrație de 0,5mM prin tratarea plantelor în perioada de vegetație. Indicii fiziologici la plantele cultivate la insuficiența de fosfor și secetă au înregistrat valorile cele mai mici. Rezultatele experimentale au demonstrat că aplicarea integrată a tulpinilor fixatoare de azot și AS au îmbunătățit nutriția plantelor cu fosfor și potasiu.

Cuvinte cheie: *acid salicilic, rizobacterii, soia, fosfor, nutrienti*

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INTRODUCTION

Soybean is the main leguminous crop and is cultivated for high yields of protein and vegetable oils needed for human food and animal feed. In the Republic of Moldova soybean yields are low in particular in drought conditions. The major impediment to fully realizing productivity is poor soil fertilization, particularly in carbonate chernozem with low phosphate levels and insufficient soil moisture [Andrieș, 2011]. An insufficient supply of mineral elements and water to agricultural plants impairs the physiological functioning of the photosynthetic apparatus, including photosynthetic pigment synthesis, and reduces the efficiency of nutrient and moisture utilization from the soil. Improving the microbiome has been adopted as an option to stimulate plant physiological functions under adverse conditions [Singh et. al., 2023]. It is known that the B. japonicum plays an important role in enhancing plant growth and enhancing plant resistance under unfavorable conditions [Egamberdieva *et al.*, 2017]. There are many reports demonstrating that *Bradyrhizobium japonicum* strains interact with soybean plants setting a symbiotic system that benefits plant growth and nutrition [Kothari *et al.*, 1990]. Another strategy to mitigate the effects of abiotic stress factors on plants is the use of phenolic growth regulators [Vurukonda *et. al.*, 2016]. Among them, acid salicylic (AS) is a phytohormone with regulatory action in physiological processes and plays an important role in triggering protective mechanisms against biotic and abiotic stresses [Kabiri *et al.*, 2014; Urban *et al.*, 2022; Szalai *et al.*, 2000]. Under water deficit, the ameliorating effect of salicylic acid is determined by the trigger activities of antioxidant enzymes [Ștefarța *et al.*, 2014] as well as by the accumulation of osmolytes that provide a more effective protective system for plants. Although it has been documented that both rhizobacteria and AS show a stimulatory effect on plants, the effect of their combined application on some physiological characteristics of plants grown under unfavorable environmental conditions is not fully elucidated. To date, however, little research has been conducted on the effects of *B. japonicum* inoculation in combination with foliar AS application on changes in nitrogen, phosphorus, and potassium content in soybean plants subjected to drought and low phosphorus availability in the soil. We speculated that the rhizobia and AS may display synergism for plant growth and improvement of nutrient status of plants. The aim of the research was to evaluate the effect of *Bradyrhizobium japonicum* and salicylic acid application on the nutrient status of soybean grown under conditions of low supply of phosphorus and soil moisture.

MATERIAL AND METHOD

To accomplish the purpose of the study a pot experiment was conducted in the vegetation complex of Institute of Genetics, Physiology and Plant Protection, MSU, Republic of Moldova. Plants were grown on carbonate chernozem with low mobile phosphate content. All pots were well watered at 70% water holding capacity (WHC) until drought stress was imposed. The application of rhizobacteria was carried out by

treating soybean seeds (cv Horboveanca) with *Bradyrhizobium japonicum* (Rh) before sowing. Insufficient soil moisture (35% WHC) was installed at the flowering stage for a period of 12 days. A set of plants were twice treated with 0,5mM salicylic acid (SA) solution in the branching and early flowering phases. All variants were set up in eight replicates. The changes in nitrogen, phosphorus, potassium and water contents in leaves were examined as a function of rhizobacteria and AS application. At the end of the drought, the leaves were sampled. The total nitrogen content was determined by Kjeldahl method. The phosphorus content was determined using a spectrophotometer as described by Murphy and Riley (1962). Potassium in leaves was determined by flame photometer [Mineev, 1989]. Plant water status was estimated by determining the relative water content in leaves [Turner, 1981]. Data were statistically analyzed using analysis of variance (ANOVA) by Statistic program 7 and presented as treatment mean ± SE of three replicates.

RESULTS AND DISCUSSIONS

Abiotic factors have a negative impact on plant physiology of soybean. Low soil fertility and insufficiency of soil moisture causes nutritional imbalance in plants. However, little is known about the impact of rhizobacteria *Bradyrhizobium japonicum* and AS application on particularities of plant mineral nutrition under low P and low moisture of soil. Literature data have shown that rhizobacteria have the ability to beneficially influence the nutrient uptake and utilization by crops. Therefore, it was important to examine the impact of the treatments on the nitrogen, phosphorus and potassium contents in leaves of soybean plants. The changes of N concentrations in leaves in relation to rhizobacteria and salicylic acid application are shown in *Figure 1*.

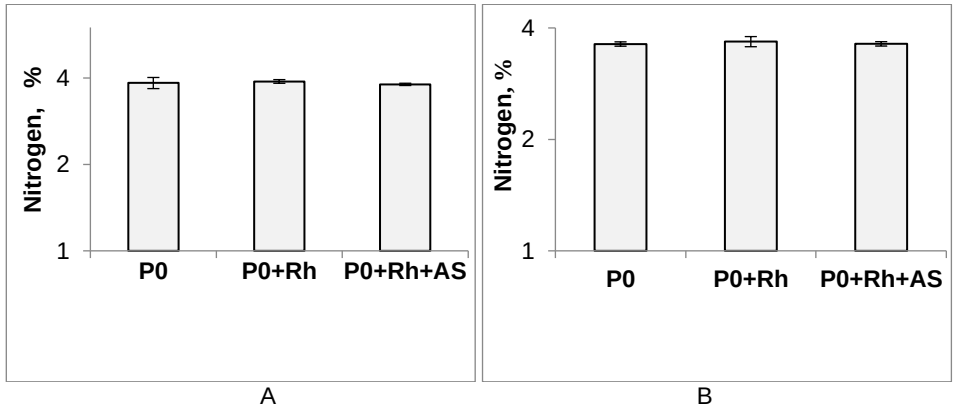

Fig. 1. The influence of *B. japonicum* inoculation alone or in combination with AS treatments on nitrogen content in leaves of soybean grown under normal moisture (A) and low soil moisture (B). Values represent the mean value of 3 replicates ± SE**.**
Note: P0 – low phosphorus; Rh - *Bradyrhizobium japonicum*; AS - acid salicylic.

Nitrogen content in leaves showed that the use of rhizobacteria both separately or in combination with foliar treatment of plants with salicylic acid did not

significantly alter this physiological parameter. Thus, it has been revealed that the application of rhizobacteria to soybean plants did not produce significant differences in the nitrogen content in the leaves of plants grown under optimal moisture of soil compared to control plants (without inoculation). The same effect was found when rhizobacteria were used separately or in combination with AS treatments on leaf nitrogen content under suboptimal (35% WHC) soil moisture conditions (*Fig. 1B*). Adequate phosphorus nutrition has an important function in maintaining the physiological activity of plants at the higher level. According to data of the literature, sufficient phosphorus supply ensures better drought tolerance of crops. Analysis of the data obtained in this experiment from plants grown under optimal moisture conditions (*Fig. 2A*) showed that the use of bacteria in combination with AS treatments contributed to the improvement of phosphorus nutrition compared to the control variant (without rhizobacteria application). In this case, the phosphorus content in leaves increased up to 6.22 mg/g while in the control variant this parameter was 5.57 mg/g. The highest phosphorus content was registered in plants of the variant with integrated use of rhizobacteria and AS. Under water deficit conditions, the lowest percentage of P registered in control plants, which were not inoculated and received an insufficient phosphorus supply (*Fig. 2B*). Also, in soybean plants subjected to temporary drought it was observed that the integrated use of *Bradyrhizobium japonicum* and AS provided better phosphorus nutrition than the application of *B. japonicum* bacteria alone. These results suggest that the improvement in phosphorus nutrition due to the treatments had a beneficial impact on plant growth under conditions of low phosphorus and limited water supply (data not sown).

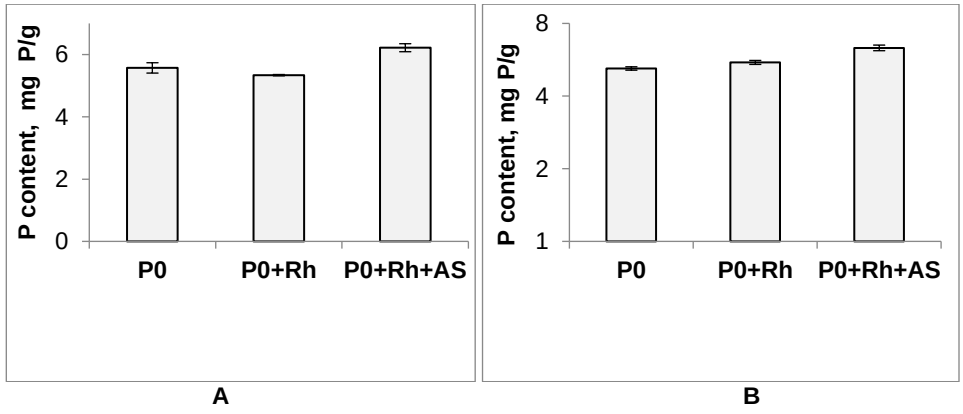

Fig. 2. The influence of *B. japonicum* alone or in combination with AS on phosphorus content in leaves of soybean grown under normal soil moisture (A) and low soil moisture (B). Values represent the mean value of 3 replicates ± SE.

Thus, it was revealed that the integrated application of bacterial strains and salicylic acid increased the phosphorus content in leaves to 6.34 mg/g versus 5.21 mg/g

recorded in the control plants. We believe the higher phosphorus content in leaves, resulting from the combined application of bacterial strains and the growth regulator AS, is due to the development of a more vigorous root system, which ensures more efficient uptake and translocation of phosphorus from the nutrient medium to the aerial parts of the soybean. Other researchers have also demonstrated the stimulatory effect of bacterial strains and salicylic acid on nutrient accumulation in plants. For instance, Ghazijahani and co-workers (2014) reported that foliar treatments with this phytohormone or citric acid altered the dynamics of nutrient acquisition in plants of *Ocimum basilicum* L. After nitrogen and phosphorus, potassium plays an important physiological function both in the growth process and in the osmotic adjustment of plant cells under abiotic stress. A number of external environmental factors control the accumulation of this nutrient in plants. This study investigated whether the application of rhizobacteria *B. japonicum* and AS has the potential to modify the potassium content in leaves of plants. The data presented in *Table 1* show that the application of rhizobacteria separately or in combination with AS weakly affected this leaf parameter in plants grown at optimal humidity of soil (70% WHC).

Table 1

The influence of *Bradyrhizobium japonicum* (Rh) and acid salicylic (AS) on potassium contents in leaves of soybean cultivated under insufficiency of phosphorus and low soil moisture, % average ± standard error

Variant	70% WHC	35% WHC
P0	1.79±0.01	1.91±0.02
P0+Rh	1.67±0.03	2.06±0.02
P0+Rh+AS	1.64±0.01	2.05±0.04

Examination of the data obtained from plants subjected to water deficit of soil revealed that the combined application of *B. japonicum* and AS increased potassium content by 7.3% compared to the control variant where this index was 1.91%. One of the reasons for the positive impact of treatments can be explained by the fact that rhizobacteria producers phytohormones, in particular AIA (3-acid indolyl acetic), gibberellins that stimulate the development of the root system, thus increasing root surface area which consequently increases the rate of nutrient uptake from the soil [Naseem *et. al.*, 2018]. It has been stipulated that improving potassium nutrition have a beneficial impact on water status as well as on the assimilation of nitrate, phosphate and other nutrients, which also contributes to strengthening the physiological functions of plants and increases plant tolerance under adverse environmental conditions [Khan *et. al*., 2015].

Relative water content (RWC) in leaves is an important physiological marker in the assessment of water balance in plants. According to literature data, the use of both rhizobacteria species and phenolic growth regulators [Naseem *et. al.*, 2018; Urban *et. al.*, 2022] modifies to some extent the drought tolerance of plants,

providing better conditions for water uptake and nutrients utilization efficiency. Experimental results of the study revealed changes of relative water content of soybean plants in relation to application of rhizobacteria and salicylic acid treatments (*Fig. 3 and 4*).

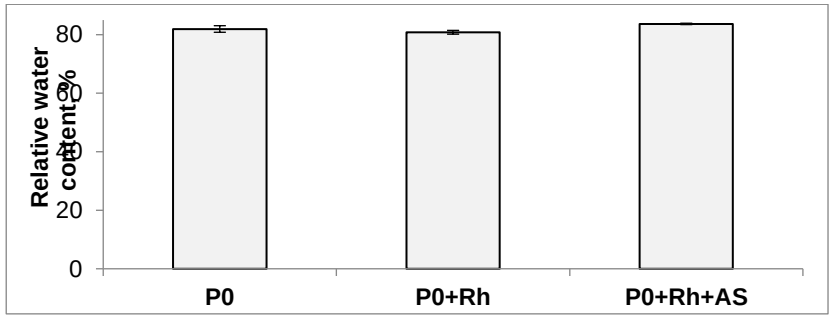

Fig. 3. The influence of *B. japonicum* and AS on relative water content in leaves in soybean grown under low P and normal soil moisture (70% WHC)

The combined use of rhizobacteria *Bradyrhizobium japonicum* and salicylic acid improved leaf water status in plants grown under phosphorus deficiency, especially of soybean grown under normal moisture conditions. Likewise, their beneficial effect was also observed in plants subjected to temporary drought conditions (*Fig. 4*). However, the relative water content in leaves changed more significantly under the combined action of rhizobacteria and AS in the plants subjected to low moisture supply (35% WHC) compared to the variant with the use of *B. japonicum* alone. The positive effect obtained due to the application of the bacterial strains could be conditioned by the hydraulic nature of the root system, which was better developed, with more fasciculate roots, improving radial water transport, as demonstrated in the research of Kothari and authors (1990). Likewise, it should be mentioned that the improvement of water status in plants could be explained by the fact that the application of rhizobacteria obviously enhanced the development of the root system, because in the literature was reported that bacterial strains have the ability to produce phytohormones, especially AIA (3-acid indolyl acetic). Therefore, it can be assumed that the application of rhizosphere microorganisms has created additional opportunities for the exploration of a larger soil volume and more efficient utilization of soil moisture reserves. In general, water deficit associated with insufficient phosphorus in soil contributes to a decrease in plant water content and this had negative effects on soybean productivity (data not shown). Therefore, the results of this study contribute, to some extent, to understand profoundly the necessity of the integrated use of rhizobacteria and salicylic acid for enhancing plant cross-tolerance to phosphorus deficiency and moisture deficit of soil.

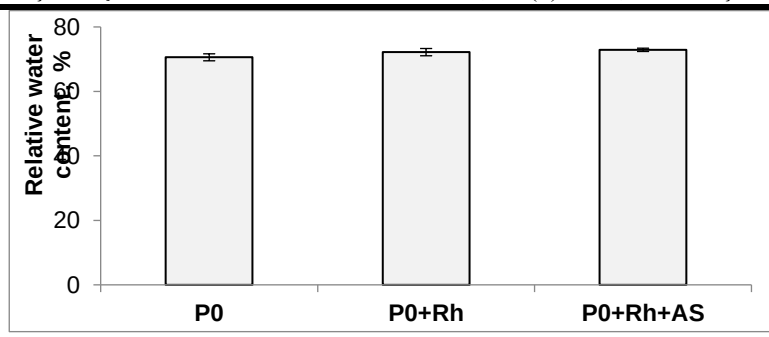

Fig. 4. The influence of *B. japonicum* and AS on relative water content in leaves in soybean grown under low P and low soil moisture (35% WHC)

The integrated application of beneficial microorganisms and acid salicylic could offer an alternative to improve plant nutrition and growth under abiotic stresses. However, further studies are required to investigate the effect of rhizobacteria and AS on physiological changes of plants for long period of abiotic stresses.

CONCLUSIONS

1. The present study indicated that phosphorus insufficiency and low soil humidity caused changes in nutrient status of soybean leaves.
2. The integrated use of the rhizobacteria *B. japonicum* and salicylic acid improves phosphorus and potassium nutrition of plants under both optimal moisture and temporary low soil moisture.
3. The combined application of rhizobacteria B. japonicum and salicylic acid maintains higher leaf water content in soybean plants subjected to both phosphorus deficiency and moderate drought. Therefore, using rhizobia and salicylic acid together could enhance phosphorus and potassium nutrition in soybean under conditions of low P and water deficit.

ACKNOWLEDGEMENTS:

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THE EFFECTS OF HEAVY METAL POLLUTION ON THE METABOLISM OF PLANTS

EFECTELE POLUĂRII CU METALE GRELE ASUPRA METABOLISMULUI PLANTELOR

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Abstract.
The present study aims to show the influence of phytohormones on the defense mechanism of plants to the stress caused by heavy metal pollution. This type of pollution influences both biochemical and physiological reactions. The study also highlights the importance of new technologies used and international collaboration to protect the therapeutic potential of plants by reducing environmental contamination in the first place. The most effective strategy to reduce the impact on the defense capacity of plants is the application of effective strategies to mitigate the causes that lead to environmental pollution with heavy metals.
Key words: plants, heavy metals, therapeutic potential

Rezumat.
Studiul de față are rolul de a arăta influența fitohormonilor asupra mecanismului de apărare al plantelor la stresul produs de poluarea cu metale grele. Acest tip de poluare influențează deopotrivă reacțiile biochimice și cele fiziologice. Studiul evidențiază și importanța noilor tehnologi utilizate și colaborarea internațională pentru a proteja potențialul terapeutic al plantelor prin reducerea în primul rind a contaminării factorilor de mediu. Cea mai eficientă strategie de reducere a impactului asupra capacității de apărare a plantelor o reprezintă aplicarea unor syrategii eficiente de atenuare a cauzelor care conduc la poluarea mediului cu metale grele.
Key words: plante , metale grele, potential therapeutic

INTRODUCTION

Over time, medicinal plants have proven their role as constant partners of man to maintain health and heal. In addition to therapeutic properties, medicinal plants symbolize the continuity of ancestral practices that shaped the relationship between man and nature over time. In modern days, these botanical resources with varied bioactive compounds are of great importance in identifying and creating new effective therapeutic solutions. Alkaloids, flavonoids, terpenoids and polyphenols are chemicals with therapeutic effects [Asiminicesei *et al.*, 2024].

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Investigating how heavy metals influence the therapeutic efficacy of active compounds in medicinal plants contributes to a better understanding of the impact that pollutants have on plants, and therefore, human health.

Oxidative stress and free radicals are factors responsible for the appearance of various diseases and are directly involved in the aging process. Science can provide us with information about the connection between the antioxidant capacity of medicinal plants and the influence that pollutants have on the well-being of the organisms on which they act.

MATERIAL AND METHOD

Comprehensive database research was conducted to identify sources of relevant information for this study. The following sources of information were used:

Databases: Major databases such as ScienceDirect, Springer, Wiley, PubMed, Scopus and Web of Science were searched to retrieve relevant studies. These databases cover the period 2010-2024.

The search strategy was carefully designed to be both broad and specific, aiming to capture all relevant studies addressing heavy metal toxicity and antioxidant levels in medicinal plants. Great attention to detail has been paid to ensure that no significant research is omitted. Also, the strategy was documented in detail and transparently so that it could be easily replicated by other researchers, guaranteeing the consistency and rigor of the documentation process.

The study selection process was carried out in several steps to ensure the inclusion of relevant studies of high scientific quality.

The search strategy was carefully designed, involving the systematic exploration of major scientific databases, including ScienceDirect, Scopus and Web of Science. These resources were selected for their breadth and diversity, covering a wide range of scientific literature in the field of heavy metal toxicity and herbal antioxidants. The choice of databases was made with the aim of ensuring the inclusion of studies of the highest quality and relevance in the present work.

The search terms were carefully selected to optimally capture all relevant aspects of the topic under study. They included specific keywords related to heavy metal toxicity, antioxidants, and medicinal plants, thus ensuring complete coverage of the literature. In order to refine and increase the precision of the results, Boolean operators (such as AND, OR and NOT) were used, which allowed the variable combination of terms, thus reducing the information and creating the relevance of the identified articles.

The search strategy was also optimized by applying additional filters, such as public data, to focus on the most recent research, thus ensuring that the studies considered reflect the most current findings in the field. The language of the articles was restricted to English to facilitate access to widely accepted and internationally accessible reference works.

Date of last search: Databases limited to studies published after the year 2015 to ensure that the most recent studies were included in the review.

The study included both theoretical and experimental research that explored the link between heavy metal toxicity and antioxidant levels in plants.

RESULTS AND DISCUSSIONS

Antioxidants can be classified according to several parameters, including their origin, biochemical activity, and suitability for efficient nanoparticle synthesis. The main classes of antioxidant compounds are: polyphenols, flavonoids, alkaloids, carotenoids, terpenes, phenolic acids and saponins.

They can be found in various natural extracts prepared from different available species such as plants, fungi, bacteria, algae, lichens and actinomycetes.

Understanding and harnessing plant antioxidant defense mechanisms is essential for improving crop yield, promoting sustainable agriculture and conserving biodiversity [Cao *et al*., 2023; Chan, 2012].

Antioxidants help plants combat oxidative stress, which occurs due to an imbalance between the production of reactive oxygen species (ROS) and the plant's ability to detoxify them.

ROS are generated during normal metabolic processes and are exacerbated by environmental stressors such as UV radiation, pollutants and pathogen attacks [Kumar *et al.*, 2021]. Therefore, antioxidants are essential for plant defense mechanisms against pathogens. When a plant encounters pathogenic microorganisms, it initiates a defense reaction of the oxidative exposure type.

Antioxidant activity is crucial for maintaining human health, it helps combat the negative effects of oxidative stress, which arises from the imbalance between reactive oxygen species (ROS) and the body's ability to neutralize them. Antioxidants play an important role in the prevention and management of various diseases such as cardiovascular disease, diabetes and neurodegenerative disorders. They act as preventive agents and, in certain cases, can support treatment against certain conditions.

The antioxidant activity of plants can be positively or negatively influenced by a number of factors such as: climatic conditions, exposure to light, soil quality, phytosanitary treatments.

The most important factor that negatively affects the antioxidant capacity is pollution, Heavy metals, pesticides, industrial residues can be absorbed by plants changing their chemical structure and implicitly reducing the health benefits or can cause health problems such as cancer or neurological diseases and can seriously affect the reproductive capacity of human and animal organisms. The interaction between heavy metals and plants is a complex one.

Pesticides, in particular, can disrupt the plant's antioxidant defense system [Fan *et al.*, 2023; Aye *et al.*, 2019].

Atmospheric emissions can be absorbed by plants increasing their oxidative stress. Ozone affects photosynthesis and nitrogen oxides influence the amount of flavonoids and phenolic acids in plants.

Inadequate quality control measures for herbal products may lead to the unintended inclusion of contaminated plant material on the market [Hlihor *et al.*, 2022; Asiminicesei *et al.*, 2020].

Molecular biology and genomic investigations are making essential contributions to the detailed understanding of the structure and function of genetic variation for stress-related traits in plants. These domains allow not only the identification and characterization of genetic traits related to stress tolerance, but also the integration of this information into gene-assisted selection programs. By identifying molecular markers and using high-throughput genotyping technologies, researchers are able to expand the gene pool available for plant breeding, opening the way for exploiting new sources of stress resistance.

These discoveries are directly applied to plant breeding, which translates them into practice by developing crop varieties more resistant to abiotic and biotic stress conditions.

CONCLUSIONS

The work highlights the risks of toxic accumulation in plants that lead to changes in the balance between antioxidant capacity and oxidative stress. Genetic modification of plants in order to increase resistance to polluting agents can be considered a promising solution for the purpose of protecting bioactive compounds in plants. Further research and the finding of new innovative solutions to prevent the contamination of environmental factors with pollutants are important. Investigating the change in plant bioactive compounds following exposure to heavy metals can provide valuable information about the risks of consuming plants from polluted areas.

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PROTECTION OF BIOLOGICAL DIVERSITY OF MEDICINAL PLANTS

PROTECȚIA DIVERSITĂȚII BIOLOGICE A PLANTELOR MEDICINALE

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Abstract.
Protecting the biological diversity of medicinal plants is essential for preserving ecosystem health and human well-being. This paper explores the significance of medicinal plants in traditional and modern medicine, highlighting their contribution to the provision of therapeutic resources. The study identifies the main threats to the biodiversity of these species, including unsustainable harvesting, habitat development, and the impact of climate change. Conservation proposals discussed include in situ protection through the creation of natural protected areas and ex-situ conservation through the establishment of seed banks and botanical gardens. It also emphasizes the importance of community education and the involvement of local people in conservation efforts. Collaboration between researchers, policymakers, and communities is essential to save medicinal plant biodiversity and ensure sustainability.
Keyword: biodiversity, medicinal plants, sustainability

Rezumat.
Protejarea diversității biologice a plantelor medicinale este esențială pentru păstrarea sănătății ecosistemelor și a bunăstării umane. Această lucrare explorează semnificația plantelor medicinale în medicina tradițională și modernă, subliniind contribuția lor la furnizarea de resurse terapeutice. Studiul identifică principalele amenințări la adresa biodiversității acestor specii, inclusiv recoltarea nesustenabilă, dezvoltarea habitatelor și impactul schimbărilor climatice. Propunerile de conservare discutate includ protecția in situ prin crearea de arii naturale protejate și conservarea ex situ prin înființarea băncilor de semințe și grădini botanice. De asemenea, se pune accent pe importanța educației comunității și implicarea localnicilor în eforturile de conservare. Colaborarea între cercetători, factori de decizie și comunități este esențială pentru salvarea diversității biologice a plantelor medicinale și asigurarea sustenabilului.
Cuvinte cheie: biodiversitate, plante medicinale, sustenabilitate

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INTRODUCTION

The protection of biological diversity of medicinal plants has become a priority of global interest, which requires integrative and collaborative strategies. This paper examines the importance of conserving medicinal plant biodiversity to identify the threats they face and effectively address them for conservation.

About 40% of plant species face extinction in the coming decades [Anmol *et al.*, 2024]. Various traditional medicinal systems around the world have documented a wide range of plants, highlighting the profound therapeutic significance of medicinal plants [Atanasov *et al.*, 2015]

Deepening the link between human health, biodiversity, and sustainability leads to a deeper understanding of botanical resources and the need to protect them.

To avoid wasting resources on ineffective interventions, there is an urgent need to understand which conservation actions will have positive outcomes for endangered species [Binley *et al.*, 2025]

Medicinal plant diversity is one of the key components of plant diversity, and medicinal plants are one of the material bases of our current medical and food supplies [Davis and Choisy, 2024].

The biological diversity of medicinal plants is a valuable fundamental resource for human health and ecosystem balance. Over time, these plants have been used in various therapeutic traditions and continue to have a significant impact on contemporary medicine. Thanks to their bioactive compounds, medicinal plants offer solutions for a variety of conditions, from chronic diseases to acute disorders, being indispensable resources in the search for natural and effective treatments.

MATERIAL AND METHOD

For this study, scientific databases were searched to identify sources of relevant information. Databases were used as sources of information: ScienceDirect, Springer, Wiley, PubMed, Scopus, and Web of Science databases were searched.

These databases cover the period 2010-2024 because we have studied the most recent studies to carry out an objective and up-to-date review of the topic addressed.

The search strategy was designed to be comprehensive and specific, aiming to capture all relevant studies related to the biological diversity of medicinal plants.

The study selection process was carried out in several stages to include only high-quality studies.

Initially, all identified studies were screened based on their titles and abstracts to determine their relevance to the chosen research topic. In the next step, the remaining studies underwent a comprehensive review to assess their eligibility for inclusion in the systematic review. Studies that met predefined inclusion criteria were selected for further analysis.

The selected studies were then included in the systematic review, where their findings and methodologies were critically appraised and synthesized.

The careful research carried out in this study aimed to identify all relevant studies on the protection of medicinal plant biodiversity and the complex relationship between factors that positively or negatively influence this aspect.

RESULTS AND DISCUSSIONS

Medicinal plants have been used for centuries across cultures for treatment. Over 50,000 plant species are considered medicinal, with around 4,000 used in pharmaceutical products. Studies show that 80% of the global population relies on medicinal plants, especially in rural and developing areas with limited access to modern medicine. However, these plants face constant threats, including over-exploitation, unsustainable harvesting, pollution, climate change, and reduced interest in their cultivation and conservation.

Increasing numbers of different concurrent multifactorial stressors cause a severe decrease in plant growth and survival, as well as the biodiversity of the microbiome on which plants depend [De Chandra, 2016].

Various factors such as environment (rainfall, lack of pollinators, clogging of water bodies), development activities (deforestation, infrastructure, submergence), agriculture and forestry methods (monoculture, overexploitation, invasions) have led to the disappearance of these traditionally important medicinal plants [Huang et al, 2019]. Overharvesting is one of the biggest threats to species' survival [Hossain, 2016]. The conservation and protection of medicinal plants is particularly important as at least two-thirds of medicinal plants continue to be harvested from the wild [Liu et al., 2019]. Excessive collection based on medicinal and economic value has the potential to damage regional ecosystem stability [Davis and Choisy, 2024]. Ensuring the controlled collection of medicinal plants through sustainable policy instruments plays an important role in areas where traditional medicine is predominantly used [McNeil et al, 2023].

Many medicinal plants are intensively harvested from their natural habitat for industrial, medicinal, or commercial use. This leads to the decline of populations and, in some cases, the complete disappearance of the specific. For example, ginseng (*Panax ginseng*) and echinacea root (*Echinacea purpurea*) are often under pressure to survive due to high market demand.

Panax ginseng is highly valued in traditional Asian medicine and is often used for its adaptogenic properties, which help increase the body's resistance to stress [Nazari, 2023]. Its popularity has grown not only in Asia but also in international markets, leading to intensive harvesting. This, along with the plant's long growth time, which can take 6-10 years for an optimal harvestable size, means that natural resources are quickly depleted.

Echinacea purpurea often faces significant pressures on survival due to high market demand. This plant is particularly valued for its properties as an immunostimulant, being widely used in traditional medicine and the food supplement industry [Posadzki et al, 2013].

This herb has been used for centuries by Indigenous communities in North America and is recognized as a natural remedy for a variety of ailments, including respiratory infections, colds, and inflammation [Sun et al, 2022]

Unfortunately, the high demand has led to the intensive harvesting of echinacea from its natural habitat. Currently, *Echinacea* is popular in the world and

is found in different forms. The United States has implemented regulations to limit the harvesting of echinacea during certain growing seasons to allow the plants to regenerate. A case study conducted in North Carolina analyzed the effects of implementing *Echinacea* harvest restrictions in the context of increasing market demands and pressures on wild populations. This study, conducted by Huang et al., 2020, revealed essential aspects of medicinal plant conservation and natural resource management strategies [Tan et al., 2018]

Hossain, 2016, conducted a study to assess the impact of overharvesting *Panax ginseng* in North Carolina forests. This research included a detailed analysis of plant density in different areas, comparing regions with intensive harvesting activity to those benefiting from protection or harvesting restrictions, and found that uncontrolled harvesting causes significant declines in plant numbers, affecting their long-term viability [Zandalinas et al, 2021]

In addition to the abusive harvesting of plants with therapeutic potential, an important factor influencing their biodiversity is the threats related to the irrational use of all polluting substances. The intensive use of pesticides and fertilizers in agriculture, along with industrial emissions, generates chemical pollution. These substances can enter the soil and water, affecting medicinal plant plantations.

Some pesticides can inhibit root growth or reduce the plant's ability to absorb nutrients, which can lead to poor growth or even plant death. Plants have to cope with the attacks of various pests and pathogens of the environmental conditions increase the vulnerability of plants to the attack or different ways of attack by insects [De Chandra, 2016], [McNeil et al., 2023]. Declines in the density of crucial pollinator species such as bees, butterflies, beetles, and other insects have also resulted in drastic negative effects on medicinal plant biodiversity.

Pollinators, especially bees, feed on the nectar of medicinal plants, while other animals consume their leaves or seeds. Thus, medicinal plants play a dual role – they support both local biodiversity and ecosystem health.

Lavandula officinalis, Mentha piperita, or *Hypericum perforatum* are just some of the plants used for medicinal purposes, whose reproduction and development are directly influenced by pollination [Zhang et al, 2017].

The decline of pollinators, especially in polluted areas, directly affects the survivability of these medicinal plants, threatening both ecological balance and access to medicinally important resources. Many medicinal plants are not only therapeutic resources for humans, but also food for insects, birds, and small mammals.

Drought and salinity stress pose significant threats to sustainability and biodiversity, jeopardizing essential medicinal resources for both traditional healing and the pharmaceutical sector [Zhang et al., 2020].

Another factor influencing the biodiversity of medicinal plants is genetic diversity. This is essential for the adaptation and survival of medicinal plants to environmental changes, diseases, and other stressors.

Studies on medicinal plants have also focused on breeding high-yielding cultivars with adaptability to environmental stress conditions [Zhang et al. 2020].

The decrease in genetic diversity of medicinal plants caused by climate change, pollution, habitat reduction, or pollinator decline has ecosystem consequences.

It is important that genomic sequencing be used to select new improved medicinal plant varieties or to help transform this knowledge into "living factories" of bioactive compounds [Anmol et al. 2024].

A plant population with low genetic diversity loses its ability to adapt effectively to environmental factors in the absence of robust genetic diversity, medicinal plants become more susceptible to these changes, which may threaten their survival.

CONCLUSIONS

Recent studies on the overharvest of medicinal plants highlight its negative impact on biodiversity and the need for effective conservation. Genetic variability is crucial for the survival of these plants, allowing them to adapt to climate change, pests, and other stressors. High genetic diversity ensures stronger plants and a wider range of chemical compounds, vital for discovering new treatments. Loss of this diversity weakens reproductive capacities and threatens species survival. Ongoing research, sustainable management strategies, and community education are essential for preserving medicinal plants, with collaboration between researchers, authorities, and locals being key to their protection.

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SUPERMARKET VS. FARMERS MARKET: A COMPARATIVE ANALYSIS

SUPERMARKET VS. PIAȚĂ AGROALIMENTARĂ: O ANALIZĂ COMPARATIVĂ

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Abstract.
Vegetable products are part of a balanced diet regardless of the consumer's age. Their diversity and the options offered for marketing multiply the factors considered when purchasing them. Through the present study we analyzed three vegetable products widely distributed and consumed by all population groups (potatoes, tomatoes and spinach). Supermarket products and similar products from a farmers market were selected, and the indicators analyzed were pH, acidity and the content of nitrite, phosphate, iron and copper ions. Differences were observed between the two categories of products, in the sense that those purchased from the farmers market had a higher content of dry matter, but also high values for the analyzed ions, which denotes the application of fertilization and foliar treatments to increase production. The highest values, compared to data from the literature, of the phosphate content were recorded in farmers market potatoes (20.62 mg P/100 g), for nitrite, in farmers market spinach (7.23 mg/100 g), and as for iron and copper ions, all products exceeded the values provided in the literature.
Key words: potatoes, tomatoes, spinach, quality indices

Rezumat.
Produsele vegetale fac parte dintr-o dietă echilibrată indiferent de vârsta consumatorului. Diversitatea acestora și opțiunile oferite pentru comercializare multiplică factorii luați în considerare la achiziția lor. Prin intermediul prezentului studiu am analizat trei produse vegetale distribuite pe scară largă și consumate de către toate grupele de populație (cartofi, tomate și spanac). Au fost selectate produse din supermarket și produse similare dintr-o piață agroalimentară, iar indicatorii analizați au vizat pH-ul, aciditatea și conținutul în ionii azotit, fosfat, fier și cupru. Au fost observate diferențe între cele două categorii de produse, în sensul că cele achiziționate din piață au avut un conținut mai mare de substanță uscată, dar și valori ridicate pentru ionii analizați, ceea ce denotă aplicarea fertilizării și a tratamentelor foliare pentru creșterea producției. Cele mai mari valori, comparativ cu datele din literatură, ale conținutului de fosfați s-au înregistrat la cartofii din piață (20.62 mg P/100 g), pentru azotiți, la spanacul din piață (7.23 mg/100 g), iar în ceea ce privește ionii de fier și cupru, toate produsele au depășit valorile prevăzute în literatură.

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Cuvinte cheie: cartofi, tomate, spanac, indici de calitate

INTRODUCTION

In modern society, the consumption of vegetables has become more and more important in a healthy and balanced diet. When thinking about shopping for vegetables, two of the most popular options are supermarkets and traditional markets. Both places offer a wide range of fresh and delicious vegetables, but there are significant differences between them.

One of the important aspects to consider is the quality of the products. In general, vegetables found in markets are considered to be of better quality, as they are often fresh and sourced directly from local producers [Rahman *et al*., 2021]. They are picked at optimal maturity and may be less subject to chemical treatments or preservatives. Many producers practice organic farming methods, which means that the vegetables are grown without the use of pesticides or chemical fertilizers [Parris, 2011].

On the other hand, supermarkets offer a wider range of vegetables available throughout the season, regardless of the season. This is because supermarkets can import vegetables from other countries or use preservation techniques to keep them fresh for longer. However, this can come at a cost, as imported vegetables may be of lower quality or may be treated with preservatives to extend shelf life.

Similarly, market vegetables are often grown traditionally, without using intensive farming techniques or genetically modified organisms (GMOs). Instead, many supermarkets sell vegetables that come from large factory farms, where these practices are used to achieve higher yields. The applied treatments may involve the use of chemical fertilizers and pesticides that may have a negative impact on the environment [Havugimana *et al*., 2017].

However, it is important to note that there are exceptions to both cases. Some markets may be located near industrial areas or have access to polluted water and soil [Bell *et al*., 2011; Kumar *et al*., 2021]. There are also supermarkets that offer organic or locally sourced products that meet ecological standards and reduce the use of toxic substances.

Therefore, when comparing vegetables from the market to those from the supermarket, it is important to consider the main factors determining the quality of the products so that we can make the right choice.

MATERIAL AND METHOD

In this study, the following vegetable products from an agro-food market and a supermarket, both very frequented, were subjected to laboratory analysis: white potatoes (*Solanum tuberosum*) – P 1 supermarket, P 2 farmers market, tomatoes (*Solanum lycopersicum*) - P 3 supermarket, P 4 farmers market and spinach (*Spinacia oleracea*) - P 5 supermarket, P 6 farmers market. Characteristic methods were used to determine some quality physico-chemical parameters: the content of dry matter and moisture by oven drying at 105^0C, the pH by the potentiometric method, with a Hanna Instruments device, the acidity by titration with NaOH solution of factor known and expressed in mg citric acid/100 g, the content of nitrites was determined with a Spekol

1100 spectrophotometer, by the Griess method, the content of phosphates by the colorimetric method using sulfomolybdenic solution, the content of Fe^{3+} ions (by colorimetric method, with the help of sulfosalicylic acid) and Cu^{2+} (by colorimetric method, based on the formation of the ammonia complex).

RESULTS AND DISCUSSIONS

The plant product purchased from the farmers market refers to the products obtained from plant raw materials that have not been treated with pesticides or chemical fertilizers, that do not come from genetically modified organisms, and in the process of processing these products, the use of radiation or food additives is avoided [https://health.clevelandclinic.org/diet-food-fitness/nutrition].

For these reasons, consumers are inclined to pay a higher price for products from the farmers market to the detriment of those from large stores.

At the same time, in order to obtain profitable productions, in addition to irrigation, fertilization with different doses of N, P and K is applied, according to the requirements of the culture, as well as treatments against diseases and pests, or the application of preservatives to maintain the fresh appearance of the harvested fruits or vegetables.

The analyzed products show different stages of development until they reach consumption maturity, as follows:

- potatoes - dormancy, sprouting, vegetative growth, tubering, maturation;
- tomato - seedling, spacing, transplanting, green, mature green, color breaker, half ripe, ripe, red ripe, full ripe;
- spinach - germination, spacing, thinning.

In the different development phases presented above, there is the possibility of applying some chemical substances, that is why comparative determinations were made for the three types of products, the results being detailed below.

The moisture and dry matter of the analyzed samples were determined using a Biobase hot air oven at 105ºC, their values being presented by comparison with the data from literature in Figure 1.

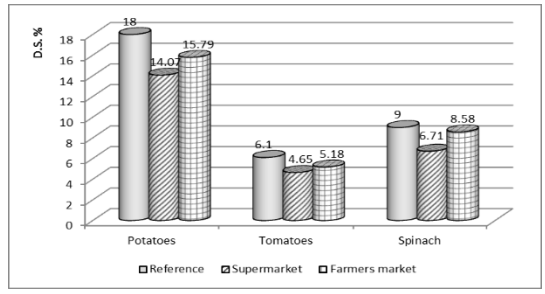

Fig. 1. Dry matter values for the analyzed samples

The products in the farmers market have a higher dry matter content compared to those in the supermarket. This can be explained by the agricultural

system applied, the use of synthetic chemicals that can affect the accumulation of nutrients and the early harvesting of plant products, before maturity is achieved, either for consumption in natural form or for industrial processing.The pH values were determined in the samples' extracts, at room temperature, as seen in Figure 2. Acidity was expressed in g citric acid/100 g of fresh product and the obtained values are presented in Figure 3. After analyzing the results graphically represented above, we can see that there are no big differences in pH within the three groups of products. We can mention that the products in the market tend to be slightly more acidic than those in the supermarket.

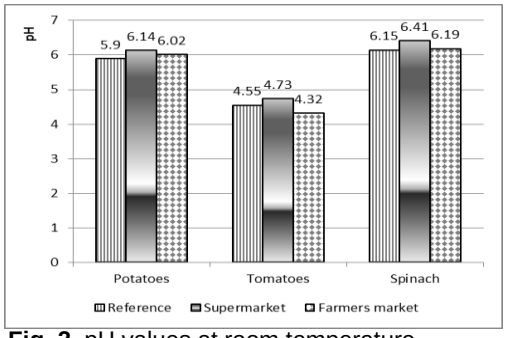

Fig. 2. pH values at room temperature

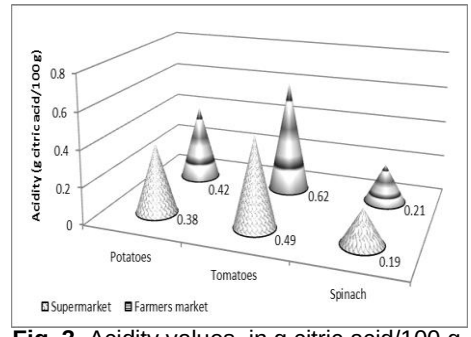

Fig. 3. Acidity values, in g citric acid/100 g

According to Griess method, we prepared a series of standard solutions and drew a calibration curve, based on which we determined the nitrite content of the samples, as presented in Figure 4.

Regarding the nitrites content for the tomatoes subjected to the determinations, there are no significant differences for this parameter. On the other hand, for potatoes and spinach, the samples from the farmers market show a higher nitrite concentration than those from the supermarket, almost double for potatoes and about five times higher in the case of spinach.

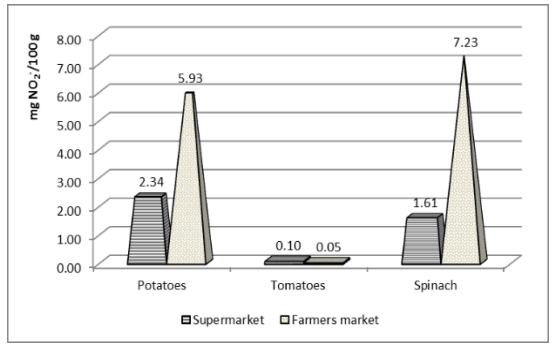

Fig. 4. Nitrite contents of samples in mg NO_2^-/ L

Among the factors affecting the nitrate and nitrite contents in vegetables, food processing (washing and boiling, peeling the skin) is found to lower the nitrate

content. Chopping or mashing of vegetables releases enzymes in the plant cells that convert nitrates into nitrites, therefore, it is advisable to cook vegetables soon after these processing, especially when preparing baby food. If necessary, storage below 4°C is appropriate if they are not cooked immediately, to inhibit the activities of enzymes and bacteria [Salehzadeh *et al*., 2020].

Following the results obtained when analysing the phosphate content (Figure 5), it was found that vegetable products purchased from the farmers market have higher values compared to similar products from the supermarket, but no product reaches the level provided by the literature. The content of phosphate ions is higher in vegetable products from the farmers market because the probability of applying phosphorus-based chemical fertilizers during the vegetative and ripening period is higher.

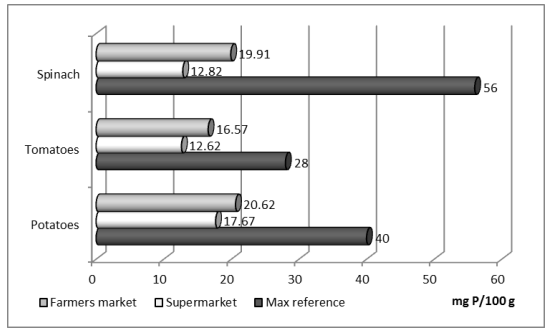

Fig. 5. Phosphate contents for the analyzed samples

Iron-rich vegetables include broccoli, string beans, dark leafy greens (dandelion, collard, kale, spinach), potatoes, cabbage, Brussels sprouts, and tomato paste [Welk et al., 2023]. Iron content in the analyzed species was similar to literature values, with slight variations, but notably higher in potatoes and tomatoes. Iron-based fertilizers are used to address soil deficiencies and improve plant weight, chlorophyll, protein, and enzyme activity [Reda et al., 2019]. Copper levels in potatoes and tomatoes should be low, and 0.174 mg per 100 g in spinach. However, the analyzed samples showed higher copper concentrations, particularly in potatoes, with spinach from the market having over twice the concentration compared to supermarket samples and literature values (Figure 7).

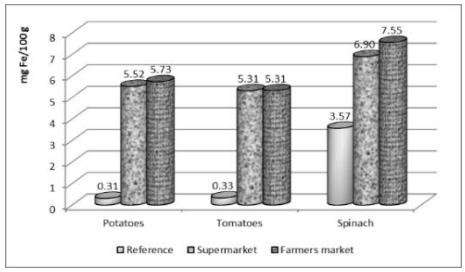

Fig. 6. Iron (Fe^{+3}) content

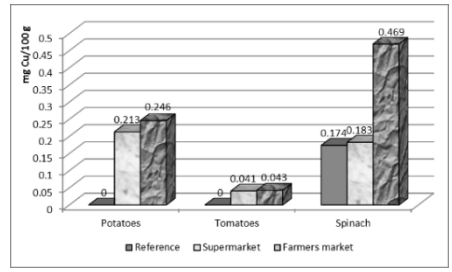

Fig. 7. Copper (Cu^{+2}) content

The treatments applied with copper-based products can cause an increased concentration in the commercialized products, especially in spinach or other species where the leaves are consumed, considering the foliar application of the treatments and the more intense absorption from this level.

CONCLUSIONS

The farmers' market products had a higher content of dry matter, which shows that the harvest was carried out at the ripeness for consumption. Also, the products purchased from the market had a more appetizing appearance.

The content of iron, nitrites and phosphate ions was higher in these products, indicating the application of fertilization in different phases of vegetation.

The presence of an increased level of copper ions in the vegetables purchased from the farmers market also shows that treatments were applied to the crops from which the analyzed samples came.

It is up to each consumer to choose the place of purchase for vegetable products, and the factors include, in addition to the quality of the products, the appearance, the price, proximity and personal experience.

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BIOISOSTERS' IMPACT ON WINE CONDITIONING

IMPACTUL BIOIZOSTERILOR ÎN CONDIȚIONAREA VINURILOR

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Abstract. *Bioisosters are compounds with different substituents and with similar biological, physical or chemical properties. Pyridazine derivatives bioisosters are compounds with an intense biological activity, being used as anticancer, antituberculosis, antihypertensive, antifungal or antimicrobial agents. Several studies have tested the effect of some cyclic compounds with nitrogen in wine conditioning because stabilisation treatments against metal case are frequent operations used in winemaking production. The present paper aims to improuve the oenological products array used in wine conditioning, using pyridazine derivatives bioisosters, capable to expel the excess of metals, by complexing reactions. The impact of the tested compounds was studied on wines obtained from Fetească regală grape variety. The analysis method used was atomic absorption spectrometry.*
Key words: *wine conditioning, bioisosters, demethalytion.*

Rezumat. *Bioizosterii sunt compuși cu substituenți diferiți, dar cu proprietăți biologice, fizice și chimice asemănătoare. Derivații de piridazină sunt compuși cu o intensă activitate biologică, cu acțiune anticanceroasă, antituberculoasă, antihipertensivă, antifungică și antimicrobiană. Diferite studii au demonstrat efectul ciclurilor cu azot, în condiționarea vinurilor, împotriva casărilor metalice. Lucrarea propune lărgirea gamei de produse oenologine, prin utilizarea derivaților de piridazină bioisosterici, capabili să extragă excesul de metale din compoziția vinurilor, prin reacții de complexare. Impactul compușilor studiați a fost testat pe un vin alb, din soiul Fetească Regală. Analiza s-a realizat prin spectrometrie de absorbție atomică.*
Cuvinte cheie: *condiționarea vinului, bioizosteri, demetalizarea vinului.*

INTRODUCTION

Wine is a natural product and is one of the most widely consumed beverages [Zoecklein *et al*., 1994]. Due to its complex chemical structure, wine is regarded as a complex beverage [Han *et al*., 2022]. Wine develops complexity through the

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presence of chemicals derived from the grapes [Thorngate *et al*, 1997]. Trace elements in wine are important: organoleptic (Fe, Cu, Mn and Zn concentrations are directly related to the destabilization and oxidative evolution of wines) and toxicological (wine contamination with heavy metals may pose long-term human health risks and environmental damages, so toxic elements content should be under the allowable limit in wine identification) [Stafilov *et al.*, 2009; Sebecic *et al.*, 1998].

The content of metals in wine depends on various factors such as: natural sources (vineyard soil structure, climate, and geography), v*iticulture management practices (*fertilizers, pesticides, chemical sprays, grape-growing approaches) [Fiket *et al.*, 2011; Pohl, 2007; Stoleru *et al.*, 2015]; or c*ontamination during the winemaking process*, caused by prolonged contact with different materials: pipes, casks, steel tanks, fining and clarifying substances, equipment and other operations [Fiket *et al*., 2011].

The presence of excessive metal amounts induces wine denaturation with negative consequences regarding the smell, taste, and color, but also the appearance of the unavoidable wine turbidity [Moreno-Arribas *et al.*, 2009]. Today is a special interest for the content reduction of metals by using various treatments allowed by the legislation [Aceto *et al*., 2002; Conde *et al.*, 2002; De Lima *et al.*, 2004].

In this sense, the study offers information concerning synthesis and activity of three bioisosters (pyridazine derivatives, substituted with methyl group, fluorine atom and chlorine atom) in wine treatment. Bioisosterism is used to enhance the desired biological or physical properties of a compound without making significant changes in chemical structure. Also, bioisosterism is used to reduce toxicity, change bioavailability, or modify the activity of the lead compound and may alter the metabolism of the lead.

In literature, cyclic compounds with nitrogen, as imidazole and pyrrolidone ring are chelating agents and are a good choice in preventing denaturation of wine, by the insoluble salts that precipitate out [Moreno-Arribas *et al.*, 2009].

Pyridazine is a cyclic organic compound. The derivatives have demonstrated interesting potential applications in different fields of science, being highly valuable materials in medicinal chemistry, opto-electronics, agriculture etc. [Amariucai-Mantu *et al.*, 2021; Butnariu *et al.*, 2008]. So, these compounds have been extensively investigated being valuable compounds. Dates about synthesis and spectral analysis for pyridazine derivatives are in literature [Tucaliuc *et al*., 2013; Butnariu *et al*., 2018].

The purpose of this study is to decrease the metal content of wines obtained from *Fetească regală* grape variety by using the bioistosters that maintain and improve the quality of final product.

MATERIAL AND METHOD

Wine chemistry explains the flavour, balance, colour, stability that was once only possible through subjective description. Understanding the principles of wine chemistry

is very important for wine stability [Cotea *et al.,* 2009]. Undesirable, wine cases affect the clarification and/or stabilization and makes necessary the removal of insoluble and suspended products that may cause wine to become cloudy, gassy, form unwanted sediment deposit or tartric crystals [Robinson, 2006].

Cases of wines can be caused by protein aggregation, phenolic compounds or by several insoluble metal salts (only at concentrations higher than those usually found in wine). Also, the metal ions content from wine should not be over a specific quantity for not having a negative effect on the organism.

In literature, the methyl group (-CH_3), the fluorine atom (-F) and chlorine atom (-Cl) are presented as classical bioisosters and the pyridazine derivatives bioisosters have structures capable of extracting the metal ions from the wine, forming organic complexes, insoluble in wine. More than this, by filtering the treated wine, the used materials could be easily recovered – compared with the potassium ferrocyanide, where the cyanides remain as toxic residues.

To obtain the pyridazine derivatives bioisosters, pyridazine ring was treated with ω-bromacetophenone substituted in para position with classical bioisosters (the methyl group, the fluorine atom and chlorine atom) (Figure 1). The reactions take place mole by mole, in benzene anhydrous, in 3 hours at room temperature, by stirring. After filtered off and dried in vacuum, were obtained compounds (**5-7**) as crystals with good yield (η > 92 %). No purification required. They are stable in air and light and can be stored at room temperature for indefinite period of time. Structurally the compounds are similar. Only in para position from acetophenone group are different classical bioisosters: R = the methyl group (compound **5**), R = the fluorine atom or chlorine atom (compounds **6** and **7**).

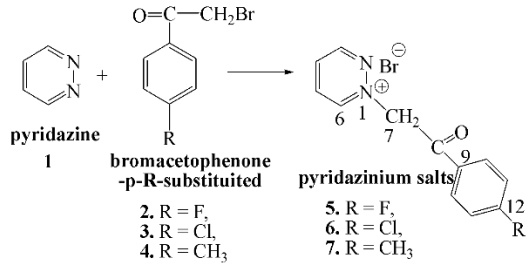

Figure 1. The synthesis of pyridazine bioisosters **(5-7)**

The structure of the compounds **(5-7)** was proved by spectral analysis: IR spectra, the 1H and 13C NMR spectra. These compounds have structures capable to extract the iron and copper ions from the wine, forming organic complexes, insoluble in wine. The main advantage is the possibility to recover used materials by filtering.

The study was performed on wine samples obtained from *Fetească regală* grape variety, according to the rules and regulations of the International Organization of Vine and Wine.

The wine samples (0.5 L) have been treated with 0,1 g from each tested product (**5**-**7**) and matrix solutions for the atomic absorption analysis were prepared at the same time, according to the Compendium of International Methods of Analysis – OIV, 2018. After 12 hours, the used compounds were recovered by filtering and their impact during the treatment was determined by atomic absorption spectrometry in flame, directly in wine. The addition of a spectral buffer (CsCl) to avoid ionisation of metals was necessary. The results were compared to the values of the control-sample.

RESULTS AND DISCUSSIONS

For both ions metal analyzed (iron and copper), standard solutions at different concentrations were prepared (Figure 2), according to the Compendium of International Methods of Analysis – OIV, 2018.

A known wavelength was selected, and the detector measured only the energy emitted at that wavelength. The concentration of the target atom in the sample increased and the absorption increased proportionally.

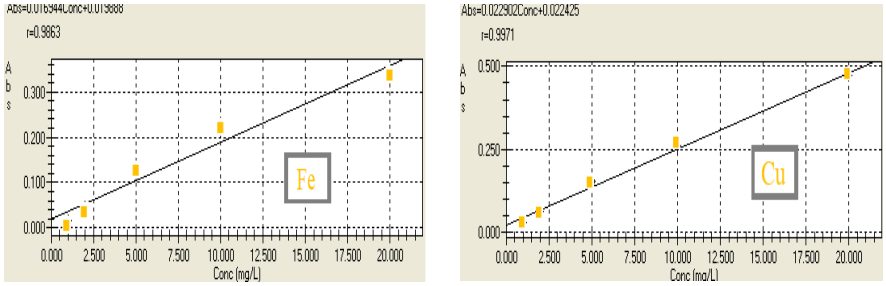

Figure 2: Calibration and standard curves for Fe and Cu

The comparative analysis of the obtained dates (**C_1 – C_3**) for wine samples treated with compounds (**5** and **7**) leads to the conclusion that the tested pyridazinic derivatives are not inert in wine, because the concentration in analyzed sample is less than in the control-sample. The results are presented in table 1.

Table 1

Atomic absorption results for Fe and Cu

Comp.	CS	C1	C2	C3
Conc. Fe (ppm)	12,9121	10,1012	9,8454	9,9085
Conc. Cu (ppm)	11,8142	9.784	9,8131	9,8001

C.S. = concentration for control sample

The compounds (**5 - 7)** extract easily iron and copper ions from the wine, by blocking metals in structures like *a cage*.

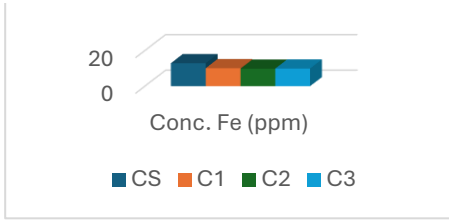

Figure 3: Iron ion concentration value

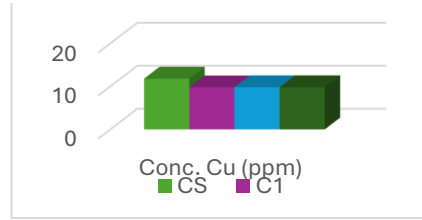

Figure 4: Copper ion concentration value

Figures 3 and 4 illustrate the decrease of trace metals (iron and copper) from wine composition, as a result of applied treatment with bioisosters (**5** – **7**).

The dates for the values obtained before treatment did not exceed normal limits allowed and were typical for the white wine obtained from *Fetească regală* grape variety.

CONCLUSIONS

For the first time, in this study have been used in wine conditioning pyridazinic bioisosters capable to absorb the metals by complexing reactions.

Atomic absorption spectrometry in flame is particularly suitable for direct identification and determination of trace metals in wine.

The comparative analysis of the obtained data leads to the conclusion that the tested pyridazinic bioisosters are not inert in wine: iron and copper ions were captured from the wine and the quality of wines was not affected.

The results shown that the bioisosters cand be used in winemaking for preserving, being a modern alternative to reduce or eliminate the trace metals.

The research will continue using compounds with similar structures.

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QUALITY ATTRIBUTES OF EGGPLANT VARIETIES GROWN UNDER DIFFERENT FERTILIZATION REGIMES

ATRIBUTELE DE CALITATE ALE VARIETĂȚILOR DE PĂTLĂGELE VINETE CULTIVATE SUNB INFLUENȚA UNOR REGIMURI DIFERITE DE FERTILIZARE

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Abstract.
Eggplants is an excellent nutritionally vegetable in all parts of the world, and it is extensively consumed, thus it has a considerable impact on the horticultural industry. The purpose of this study was to assess the qualitative of Two hybrid varieties (Mirval and Black Pearl) cultivated under various fertilization and farming regimes, with a focus on nutritional and antioxidant capabilities. The experiment was carried out on the farm of the Iasi University of Life Sciences in Romania, utilizing different agronomic techniques. A total of 8 version were cultivated using four different fertilization treatments: organic, chemical, control, and biological. Following harvesting, analyses were performed at the Andalusian Institute in Cordoba, Spain, using advanced laboratory modern. Quality and safety markers such as chlorophyll a, chlorophyll b, lycopene, beta-carotene, tannins, total polyphenols, and antioxidant activity (ABTS, DPPH assays) were assessed. The results showed significant variations between fertilization procedures. For example, the biofertilisation treatment produced the highest total polyphenol content, but the control group demonstrated modest antioxidant activity. Chlorophyll levels and carotenoid content also varied with cropping methods, demonstrating that fertilisation types had a significant impact on eggplant quality. This study examines the effects of planting schemes and irrigation regimes on the nutritional and phytochemical properties of eggplant, promoting sustainable agricultural methods that improve crop quality.

Keywords: eggplant, quality attributes, irrigation systems, fertilization types

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Rezumat.
Vinetele sunt o legumă excelentă din punct de vedere nutrițional în toate părțile lumii și sunt consumate pe scară largă, având astfel un impact considerabil asupra industriei horticole. Scopul acestui studiu a fost de a evalua calitatea a două soiuri hibride (Mirval și Black Pearl) cultivate în diferite regimuri de fertilizare și agricultură, cu accent pe capacitățile nutriționale și antioxidante. Experimentul a fost realizat la ferma Universităţii de Ştiinţe ale Vieţii din Iaşi din România, utilizând diferite tehnici agronomice. Un total de 8 versiuni au fost cultivate folosind patru tratamente diferite de fertilizare: organice, chimice, de control și biologice. În urma recoltării, au fost efectuate analize la Institutul Andaluz din Cordoba, Spania, folosind un laborator modern avansat. Au fost evaluați markerii de calitate și siguranță, cum ar fi clorofila a, clorofila b, licopenul, beta-carotenul, taninurile, polifenolii totali și activitatea antioxidantă (ABTS, testele DPPH). Rezultatele au arătat variații semnificative între procedurile de fertilizare. De exemplu, tratamentul de biofertilizare a produs cel mai mare conținut total de polifenoli, dar grupul de control a demonstrat o activitate antioxidantă modestă. Nivelurile de clorofilă și conținutul de carotenoide au variat, de asemenea, cu metodele de recoltare, demonstrând că tipurile de fertilizare au avut un impact semnificativ asupra calității vinetelor. Acest studiu examinează efectele schemelor de plantare și ale regimurilor de irigare asupra proprietăților nutriționale și fitochimice ale vinetelor, promovând metode agricole durabile care îmbunătățesc calitatea culturilor.
Cuvinte cheie: vinete, atribute de calitate, sisteme de irigare, tipuri de fertilizare

INTRODUCTION

Eggplants are grown mainly in the subtropics, where they account for 94% of world production. It is nicknamed ‘the king of vegetables’ because of its great popularity. So, it is an important part of the economy. According to the Food and Agriculture Organization of the United Nations [Caruso et al., 2017], China and India are the world's leading producers of auberges (28 and 13 Mt per year, respectively). In Europe, auberge cultivation is mainly concentrated in Turkey (827.000 t), Italy (220.000 t), Spain (206.000 t) and Romania (123.000 t/year) [Caruso *et al*., 2017]. According to FAO figures, eggplant rank sixth in total world production, behind tomatoes, watermelons, onions, cucumbers and cabbages, with 52.3 million tonnes produced in 2017 (Plazas et al., 2019]. Eggplants are also one of the 35 food crops considered to be the most important for global food security, and as such are included in Annex 1 of the International Treaty on Plant Genetic Resources for Food and Agriculture [Plazas *et al*., 2019]. Eggplants have a unique gastronomic and economic impact because of their great ecological plasticity, their appeal to consumers and their adaptability to different growing systems [Ciubotarita *et al*., 2022]. The fruit is rich in sugar, carbohydrates, protein and vitamin C, making it both tasty and nutritious. Canneries account for around 65-

70% of total production. Eggplant can be prepared in a variety of ways, including cooking, canning, stuffing, marinating, and frying [Kostadinov *et al*., 2019]. Eggplant is not expensive so it is in the diet of low-income consumers [Gürbüz *et al*., 2018]. This plant is gaining in popularity because of its high concentration of antioxidants (phenolic acids), which are beneficial to human health [Gajewski *et al*., 2009]. Eggplant is used in traditional medicine to treat a variety of ailments. For example, in certain regions of Asia, the vegetative aerial parts of S. Americanum/nigrum were traditionally used to treat skin ailments, as a purgative, to facilitate urination and to stimulate the libido [Meyer *et al*., 2014]. Nutrients affect the growth and development of Eggplant. Over the last 30 years, new varieties and hybrids have appeared on the Romanian market, but they have often failed to adapt to changing environmental conditions and consumer tastes. A recent study showed that the main elements influencing the quantity and quality of the harvest in organic and conventional systems are the cultivar, fertilizer and irrigation [Ciubotarita *et al*., 2022]. The area of farmland managed organically, the number of organic farms and the global market for organic products have all increased progressively. The most recent data suggests that this trend has been amplified by a sharp increase in consumer demand for organic food during the COVID-19 epidemic [Fernández *et al*., 2022]. The development of organic production has made it possible to produce food crops of superior nutritional quality while using fewer external inputs and reducing the impact on the environment [Plazas *et al*., 2019] the fertilizer applied has a direct impact on the quantity of nutrients available to plants. The use of inorganic or organic fertilizers has long been the subject of debate as to which promotes and preserves soil health in the long term [Canatoy & Daquiado, 2021]. Fertilization falls into three categories: chemical, biological and organic. It is an essential component of agricultural production. Although frequently used in agriculture, chemical fertilizers are highly controversial. Sustainable and environmentally-friendly alternatives for agriculture, such as organic and biological fertilizers, are becoming increasingly popular with farmers and consumers alike [Guilherme *et al*., 2020]. Consumers are increasingly interested in how, where and when food is produced. As a result, they are increasingly interested in organic vegetables, particularly those grown in greenhouses [Stoleru *et al*., 2019]. Greenhouses are suitable for crops that are affected by climate change, particularly in Romania due to the cold weather. So the experiment was in greenhouses in Romania. found that choosing the right cultivar and fertilizations method can result in better bioactive components in plant grown in the field under variable climatic conditions [Rusu *et al*., 2023]. The use of modern agricultural practices in crop production makes it possible to improve yield and fruit size while reducing labor costs in the fields. Therefore, in this study, we examined the effects of different fertilizations regimes and varieties on the quality and nutrient content of Two hybrid varieties (Mirval and Black Pearl) cultivars known for their adaptability to Romanian environmental conditions, pest resistance, high productivity and fruit quality. Using a different fertilization type

(chemical, biological, organic and control) the experiment was carried out in a greenhouse -eggplant in a field of "V. Adamachi" Farm of Iasi University of Life Sciences (47019'25" N, 27054'99" E, 150 m altitude), during 2021-2022. We have done the analyses at the Andalusian Institute of Agriculture, Food and Animal Production (IFAPA) - Cordoba – Spain. The antioxidant activity levels (ABTS, DPPH, total polyphenols, chlorophyll A and B, lycopene of conventional and organic eggplants. This study aims to provide insights into how farming practices influence the nutritional profile of eggplant by examining antioxidant activity, polyphenol content, chlorophyll levels, lycopene and B-carotene concentrations, ratios under different systems od fertilization. Finally, the results should contribute to the development of better farming techniques and the cultivation of eggplant with a higher nutritional content.

MATERIALS AND METHODS

Plant Material and Growth Conditions

The soil is characterized as a loam-clay chernozem, with pH 7.20; electrical conductivity (EC) 482 µS·cm-2, CaCO3 0.42%, organic matter (OM) 28.32 mg·kg-1, C/N 5.87, N 2.8 g·kg-1, P 34 mg·kg-1, was used for the experiment. The biological material used was represented by two cultivars (Mirval and Black Pearl) which can react differently in climatic conditions, regarding the nutritive content in organic compounds, mineral elements, and also the yield obtained. Factor A was represented by the cultivars Mirval F1 and Black Pearl F1, Factor B – was represented by nutrition regime: B1 – Control (Ct), B2 – Micoseed® (Mo); B3 – Orgevit® (O), B4 – Nutrispore® (Ch) (Table 1).

Table 1

Sample codes and classification according to variety, fertilization system

ID	Variety F1	Fertilization
1	Mirval F1	Control
2	Black Pearl F1	Control
3	Mirval F1	Biological
4	Black Pearl F1	Biological
5	Mirval F1	Organic
6	Black Pearl F1	Organic
7	Mirval F1	Chemical
8	Black Pearl F1	Chemical

The NPK chemical fertilization (Ch) was performed with 200 kg·ha^{-1} of Nutrispore® NPK 20-20-20, applied before transplant, and two supplies of 300 kg·ha-1 of Nutrispore® NPK 9-18-27+2 MgO. Organic fertilization (O) represented by chicken manure was applied by 2000 kg·ha^{-1} of commercial Orgevit® in two phases: 1250 kg·ha^{-1} before transplant and the remainder 30 days after planting. The same amount of active substance from the two fertilizers was used, taking into account that the plants use approximately 70% of the organic fertilizer in the first year.

The biological fertilization (Mo) consisted of the application of Micoseed® at 30 kg·ha^{-1} split in two equal doses supplied before transplant and 30 days after planting, integrated with 5 L·ha^{-1} Nutryaction®, according to the company recommendations. The biological product is based on microorganisms that predominantly contain arbuscular mycorrhizal fungi spores of *Claroideoglomus etunicatum*, *Funneliformis mosseae*,

Glomus aggregatum, *Rhizophagus intraradices*. In addition, the product is complexed with fungi and bacteria species belonging to the genera *Trichoderma* sp., *Streptomyces* sp., *Bacillus* sp., *Pseudomonas* sp. Fifty-five days old seedlings were used in the experiment. Grown in multicell trays in compliance with the organic regulation were transplanted in a greenhouse during mid-April at a density of 2.5 plants·m^{-1}. During the experiment, growing practices (training, pruning, and treatments for pests and diseases) were applied to all the plants [Stoleru *et al*., 2014]. The eggplant crop experiment ended on 31st October.

Material and sample preparation

A total of 40 eggplants were harvested from each group at the ripening stage. The samples were cut into small pieces and homogenized, then freeze-dried in an ECO EVO freeze-dryer (Tred Technology S.R.L., Ripalimosani, Italy). The dry samples were then ground and stored at -80°C until analysis.

Hydrophilic extraction

Hydrophilic extraction was carried out using a mixed solution of deionized water and methanol (20:80, v/v) with 1% formic acid. 0.2 g of freeze-dried sample was extracted with 1 mL of the extraction solvent, sonicated for 10 min in an ultrasonic bath and centrifuged at 15,000 rpm for 15 min. The supernatant was collected and the pellet re-extracted using the same protocol. The samples were transferred to vials and stored at -80°C until analysis. This extraction was used to analyze antioxidant activity, total phenolic compounds and total condensed tannins.

Antioxidant activity

The antioxidant activity of the eggplant samples was analyzed using two different tests: ABTS and DPPH using a Synergy HTX multimode microplate reader (Biotek Instruments, Winooski, VT, USA).

ABTS free radical scavenging activity was assessed in the phenolic extract according to the methods previously described by[Tuárez-García et al., 2023]. Antioxidant activity results were expressed as mmol Trolox equivalents per 100 g dry weight (mmol TE 100 g-1 DW).

The DPPH method adapted to the microplate reader [Gulcin & Alwasel, 2023]. Antioxidant activity results were expressed in mmol Trolox equivalents per 100 g dry weight (mmol TE 100 g-1 DW).

Total phenolic content

Total phenolic content was assessed using the Folin-Ciocalteau reagent according to the method of Slinkard and Singleton. The results were represented in milligrams of gallic acid equivalents per 100 grams of fresh weight (mg GAE 100 g-1 FW) [Cuevas *et al*., 2017].

Total condensed tannin content

Condensed tannins were assessed using the vanillin test described by Broadhurst and Jones [1978]. Results were represented in milligrams of catechin equivalents per 100 grams of dry weight (mg TE 100 g-1 d.w).

Pigment extraction

Lipophilic pigments were extracted using the method described by Nagata and Yamashita [1992]. Briefly, 0.2 g of freeze-dried sample was extracted in the dark with 1 ml of solvent mixed with hexane and acetone (4:6, v:v), then centrifuged at 15,000 rpm for 15 min. The supernatant was collected and the pellet re-extracted using the same protocol. Samples were transferred to vials and stored at -80°C until analysis.

Pigment analysis

The absorbance of the pigment extract was measured at 453, 505, 645 and 663 nm using a Synergy HTX multimode microplate reader (Biotek Instruments, Winooski,

VT, USA). The calculation of chlorophyll a, chlorophyll b, β-carotene and lycopene content were estimated using the equations described by Nagata and Yamashita (1992).

Statistical analysis

Univariate statistical analyses were performed to identify differences between samples using Statistix v. 9.0 software. The data were subjected to an analysis of variance (ANOVA), followed by a comparison of means using Tukey's post hoc tests. The level of significance was set at $p \leq 0.05$.

RESULTS AND DISCUSSION

The nutritional and antioxidant characteristics of the two eggplant cultivars, Mirval and Black Pearl, under different fertilization regimes (organic, chemical, biological and control) proved significantly different in the study (Table 2).

Table 2

Total polyphenol content, antioxidant activity, lycopene in eggpplants

Variety	Total polyphenols	ABTS	DPPH	Lycopene
Mirval F1 x Control	2.03±0.03c	1.04±0.05ab	1.28±0.10a	2.43±0.20ab
Black Pearl F1 x Control	2.01± 0.13c	1.002±0.10ab	1.13±0.06ab	2.05±0.23b
Mirval F1 x Biological	2.60±0.06bc	0.82±0.07ab	0.91±0.06b	1.09±0.30b
Black Pearl F1 x Biological	2.05±0.18c	1.07±0.08a	1.09±0.10ab	0.43±0.07c
Mirval F1 x Organic	3.61±0.36ac	1.02±0.01ab	1.37±0.02a	3.04±0.12a
Black Pearl F1 x Organic	2.32±0.25c	0.90±0.03ab	1.30±0.08a	0.65±0.11c
Mirval F1 x Chemical	3.51±0.30ab	0.85±0.07ab	1.13±0.06ab	2.38±0.25ab
Black Pearl F1 x Chemical	2.01±0.15C	0.80±0.06b	1.12±0.07ab	0.73±0.10c
Signification for $p \leq 0.05$	*	*	*	*

Total polyphenol content: Both chemically treated (3.51 ± 0.30 mg GAE/100g) and organically fertilized (3.61 ± 0.36 mg GAE/100g) samples showed significantly lower polyphenol levels than the control (2.03 ± 0.03 mg GAE/100g). Black Pearl showed consistently lower polyphenol levels; with organic fertilization, its highest value (2.32 ± 0.25 mg GAE/100g) was reached.

Antioxidant activity: Mirval achieved maximum ABTS activity in the control group (1.04 ± 0.05 mmol TE/100g) and showed the highest DPPH antioxidant activity in the organic treatment group (1.37 ± 0.02 mmol TE/100g). Organic fertilization led to lower antioxidant levels for both types, and Black Pearl showed lower antioxidant activity in all treatments.

Under organic fertilization, Mirval showed the highest levels of chlorophyll A (5.80 ± 0.63 mg/g) and chlorophyll B (8.68 ± 1.18 mg/g). Black Pearl had much lower levels of chlorophyll, particularly under chemical and organic fertilization.

Lycopene and β-Carotene: Black Pearl had the lowest lycopene concentration in the organic treatment (0.43 ± 0.07 mg/g), while organically fertilized Mirval had the highest lycopene content (3.04 ± 0.12 mg/g). A similar trend was observed for β-Carotene levels, where Mirval outperformed Black Pearl in the majority of treatments.

Tannins: Black Pearl showed reduced tannin levels in all treatments (Table 3), particularly in the organic and control groups, while organically fertilized Mirval had the highest tannin concentration (0.14 ± 0.01 mg/g).

Table 3

Chlorophyll A, B and tannin contents in eggplants

Variety	Chlorophyll A	Chlorophyll B	Tannins
Mirval F1 x Control	5.47±0.29ab	7.40±0.53a	0.09±0.00 def
Black Pearl F1 x Control	4.17±0.42b	6.24±0.90a	0.13±0.00 abc
Mirval F1 x Biological	2.36±0.36c	3.26±0.90b	0.08±0.00 ef
Black Pearl F1 x Biological	1.09±0.16c	1.29±0.23b	0.10±0.00 cde
Mirval F1 x Organic	5.80±0.63 a	8.68±1.18a	0.14±0.01 a
Black Pearl F1 x Organic	1.56±0.23c	1.84±0.23b	0.11±0.00 bcd
Mirval F1 x Chemical	5.19±0.39ab	7.25±0.75a	0.13±0.01 ab
Black Pearl F1 x Chemical	1.80±0.20c	2.20±0.30b	0.07±0.00 f
Signification for p ≤ 0.05	*	*	*

DISCUSSION

The results demonstrate the importance of fertilization practices in defining eggplant quality characteristics. The nutritional and antioxidant qualities of the Mirval variety were systematically improved by organic fertilization, while the Black Pearl variety responded less favorably to treatments.

Antioxidant activity and nutritional quality

The observation of increased antioxidant activity and polyphenol content in the organically fertilized Mirval variety raises the possibility that organic farming methods facilitate greater production of bioactive substances. These results are consistent with previous research showing that organic systems improve the nutritional profiles of crops by reducing synthetic inputs and responding to stress. The reduction in antioxidant activity and polyphenol concentration in Black Pearl may be due to variety-specific characteristics, such as genetic composition or nutrient absorption efficiency.

Pigment concentration

The increase in chlorophyll content in Mirval as a result of organic fertilization implies that this regime improves plant health and photosynthetic potential. This increase in chlorophyll content, combined with higher levels of lycopene and β-carotene, demonstrates that Mirval benefits greatly from organic and chemical fertilization in terms of yield and nutritional quality. Black pearl, on the other hand, may not respond as well to conventional fertilization techniques due to its comparatively lower pigment contents, necessitating the use of different techniques to maximize its quality.

Tannin levels

The high level of tannin concentration was found in organically fertilized Mirval eggplant, which may explain its astringency and possible health benefits. This finding implies that tannin synthesis can be influenced by organic farming methods, enhancing the nutritional value and flavor of eggplants. Black Pearl's

consistently lower tannin content suggests that it may be a better choice for consumers looking for less bitter eggplants, but it may also mean fewer overall health benefits.

CONCLUSION

This study highlights the importance of type and fertilization variation in the nutritional and antioxidant qualities of eggplant. The Mirval type, particularly when grown organically, showed superior polyphenol content, antioxidant activity and pigment levels, making it a good candidate for high-quality eggplant production. In contrast, the Black Pearl variety showed lower nutritional benefits in most treatments, implying that additional fertilization procedures may be required to improve its performance.

These results support the use of organic fertilizers to promote sustainable farming practices while improving eggplant nutrition. Further research is needed to investigate other aspects such as irrigation systems and soil health, which may influence eggplant quality and production in different growing situations.

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TOMATOES NUTRITIONAL CHARACTERISTICS UNDER FARMING TECHNOLOGY

CARACTERISTICILE NUTRIȚIONALE ALE TOMATELOR SUB INFLUENȚA UNOR FACTORI TEHNOLOGICI

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Abstract.
Tomatoes fruits are much nutritionally vegetable around the world. The quality of tomatoes is determined by fibre, vitamins, and minerals, all of which contribute to a healthy diet. Its adaptability and widespread cultivation make it an essential component of global food security and a variety of industries. This study looks at the qualitative characteristics of different tomato varieties grown under organic and conventional systems. The experiment was carried out on the farm of the Iasi University of Life Sciences from Romania. For this study used three tomato varieties: Caprese F_1, Cristal F_1 and Manistella F_1. These varieties are popular and of good production and quality in Romania. The goal was to determine the effect of both factors (cultivars and growing systems) on the quality of tomato fruits. The biochemical compounds were analysed at the Andalusian Institute in Cordoba, Spain. For tomato samples were determined: antioxidant capacity, chlorophyll a, chlorophyll b, lycopene, beta-carotene, tannins, total polyphenols. The findings revealed considerable differences across cultivars and farming practices to improve fruit quality while adhering to food safety norms.
Keywords: tomato varieties, quality attributes, farming systems

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Cuvinte cheie: tomate, calitate, factori tehnologici

INTRODUCTION

The tomato is one of the most important species in the world due to its antioxidant properties and economic importance [Stoleru *et al*., 2020]. Sustainable production should therefore be the main objective, particularly in terms of fertilization and growing systems. The tomato (*Solanum lycopersicum* L.) is the second most important vegetable crop after the potato [Stoleru et al., 2020]. particularly those studying the quality and ripening of fleshy fruits [Bertin & Génard, 2018]. Tomatoes are one of the most crop in the world, with production estimated at 186.82 million tons in 2020. In 2018, the FAO reported that Romania produced 742,899 tons of tomatoes [Bădulescu *et al*., 2020]. Interest in consuming high-quality fresh or processed tomatoes continues to grow. In Romania, the average annual tomatoes consumption per capita was recorded in 2015 of 38.6 kg/person [Soare *et al*., 2017].

Tomatoes are a valuable vegetable because of their high nutritional value (150 calories/100g) and their chemical composition, which includes minerals (P, N, Ca, Mg, and traces of Fe, Cu, Zn, Mn), vitamins (C, E), lycopene (a natural antioxidant that protects against cancer, heart and lung disease), beta-carotene, fiber and water [Periago *et al*., 2002].Tomatoes are an important source of antioxidants for the human diet, include phenolic compounds [Bertin & Génard, 2018]. Recent data shows that organic tomatoes are much healthier and more useful for the body than vegetables treated with synthetic pesticides. Tomatoes are considered functional products [Fernanda & Fonseca, 2005; Willcox *et al*., 2003]. Lycopene and β-carotene are powerful antioxidants in humans. Many health professionals recommend increasing lycopene levels in the diet by eating fresh tomatoes and tomato derivatives [Tonucci *et al*., 1995]. The antioxidant activity of tomato fruit is determined not only by the genotype, but also by the stage of ripening, production practices [De Sio *et al*., 2019]. Consumers are increasingly interested in how, where and when food is produced.as a result, they are increasingly interested in organic vegetables, particularly those grown in greenhouses [Stoleru *et al*., 2019]. The quality of tomato fruit depends on the variety, the growing strategy, the type of fertilizer and the harvesting period [Rusu *et al*., 2023]. Fertilizers are the most

important tools for improving plant nutrition. Chemical fertilization is a popular strategy for increasing agricultural yields, but it has been shown to have serious adverse effects on the environment and human health. For example, chemical fertilizers contribute significantly to the greenhouse effect and soil salinization. Organic fertilization is an alternative that mitigates the harmful effects of chemical fertilization [Singh *et al*., 2020]. In addition to the environmental benefits, organic fertilizers have a significant impact on the quality of plant products and the quantity of harvests. In the case of tomatoes, for example, it has been shown that organic farming has a positive impact on increasing the polyphenolic chemical substances and antioxidant capacity of fresh fruit and processed vegetables [De Sio *et al*., 2021]. found that choosing the right cultivar and fertilizations method can result in better bioactive components in tomatoes grown in the field under variable climatic conditions [Rusu *et al*., 2023]. This study aimed to examine the effects of different fertilizations regimes on the quality and nutrient content of three varieties crossing of farming system (conventional and organic).

MATERIALS AND METHODS

Plant Material and Growth Conditions

The experiment was carried out in a greenhouse of "V. Adamachi" Farm of Iasi University of Life Sciences (47019'25" N, 27054'99" E, 150 m a.s.l), during 2021-2022. The soil is characterized as a loam-clay chernozem, with pH 7.20; electrical conductivity (EC) 482 $\mu S \cdot cm^{-2}$, $CaCO_3$ 0.42%, organic matter (OM) 28.32 $mg \cdot kg^{-1}$, C/N 5.87, N 2.8 $g \cdot kg^{-1}$, P 34 $mg \cdot kg^{-1}$, was used for the experiment 3 hibrid cultivars were use in experiment Caprese, Cristal, respectively Manistella. Organic fertilization represented by chicken manure was applied by 2500 $kg \cdot ha^{-1}$ of commercial Orgevit® in three phases: 50% of the total amount in coincidence with the final soil preparation prior to planting; 25% when the first fruit reached a 1 cm diameter; the last dose (25%) when the first fruit of the third cluster reached a 1 cm diameter. Chemical fertilization used a complex fertilizer N:P:K -20:20:20, 400 $kg \cdot ha^{-1}$, applied to the soil at land preparation and Nutrispore®, N:P:K -8:24:24, $kg \cdot ha^{-1}$, applied in three applications during the growing season. Growing practices (training, pruning and treatments for pests and diseases) were applied for all the plants, according to the techniques described by [Zhang et al., 2023] During the experiment, when fruits were fully ripened (BBCH 805–808), a minimum of three fruits from each cluster/level (3–5) were collected for further analyses. Table 1 displays Sample codes and classification according to variety, fertilization system.

Table 1

Sample codes

ID CODE	*Variety*	*Treatment*
1	Caprese F1	Conventional
2	Caprese F1	Organic
3	Cristal F1	Conventional
4	Cristal F1	Organic
5	Manistella F1	Conventional
6	Manistella F1	Organic

Material and sample preparation

A total of 5 tomato fruits from each version were collected from group at phenotypic and physiological maturity (809 BBCH scale). The material was divided into small pieces and homogenised before being freeze-dried in an ECO EVO freeze-dryer (Tred Technology S.R.L., Ripalimosani, Italy). The dried samples were powdered and stored at -80°C for analysis.

Hydrophilic extraction

A mixed solution of deionised water and methanol (20:80, v/v) containing 1% formic acid was used for hydrophilic extraction. 0.2 g of freeze-dried sample was extracted with 1 ml of extraction solvent, sonicated for 10 minutes in an ultrasonic bath and then centrifuged at 15,000 rpm for 15 minutes. The supernatant was collected and the pellet re-extracted using the same procedure. Samples were stored in vials at -80°C until analysis. This extraction was tested for antioxidant activity, total phenolic compounds and total condensed tannins.

Antioxidant activity

The antioxidant activity of tomatoe samples was determined using two separate tests: ABTS and DPPH, both performed on a Synergy HTX multimode microplate reader (Biotek Instruments, Winooski, VT, USA). The phenolic extract was tested for ABTS free radical scavenging activity using procedures previously published by [Ordóñez-Díaz *et al*., 2020]. Antioxidant activity was calculated in mmol Trolox equivalents per 100 g dry weight (mmol TE 100 g-1 DW). The DPPH method was developed for microplate readers [Ordóñez-Díaz *et al*., 2020]. Antioxidant activity was calculated in mmol Trolox equivalents per 100 g dry weight (mmol TE 100 g-1 DW).

Total phenolic content

Total phenolic content was determined using the Folin-Ciocalteau reagent according to the procedure of Slinkard and Singleton. Results were expressed as milligrams of gallic acid equivalents per 100 grams of fresh weight (mg GAE 100 g-1 FW) [Cuevas *et al*., 2017].

Total condensed tannin content

Condensed tannins were assessed using the vanillin test described by Broadhurst and Jones [1978]. Data were provided in milligrams of catechin equivalents per 100 grams of dry weight (mg TE 100 g-1 DW).

Pigment extraction

Lipophilic pigments were extracted using the technique described by Nagata and Yamashita [Nagata & Yamashita, 1992]. In brief, 0.2 g of lyophilized sample was extracted in the dark with 1 ml of a mixture of hexane and acetone (4:6, v:v) and centrifuged at 15,000 rpm for 15 minutes. The supernatant was collected, and the pellet was extracted again using the same technique. The samples were transferred to vials and kept at -80°C until analysis.

Pigment Analysis

The absorbance of pigment extracts was measured at 453, 505, 645, and 663 nm using a Synergy HTX multimode microplate reader (Biotek Instruments, Winooski, VT, USA). The content of chlorophyll a, b, β-carotene, and lycopene was determined using Nagata and Yamashita's [1992] formulae.

Statistical analysis

Univariate statistical analyses were used to discover differences between samples using Statistix v. 9.0 software. Data were subjected to analysis of variance (ANOVA), followed by comparison of means using Tukey post hoc tests. The significance criterion was set at $p \leq 0.05$.

RESULTS AND DISCUSSION

Pigment content (chlorophyll A and B)

Figure 1 shows the impact of the interaction between tomato cultivars and farming practices on pigment content. Chlorophyll A concentration varies from 0.55 in the cultivar Caprese to 2.09 in the cultivar Cristal using the same Conventional technique. These results indicate that chlorophyll A content varies greatly according to cultivar and fertilization strategy.

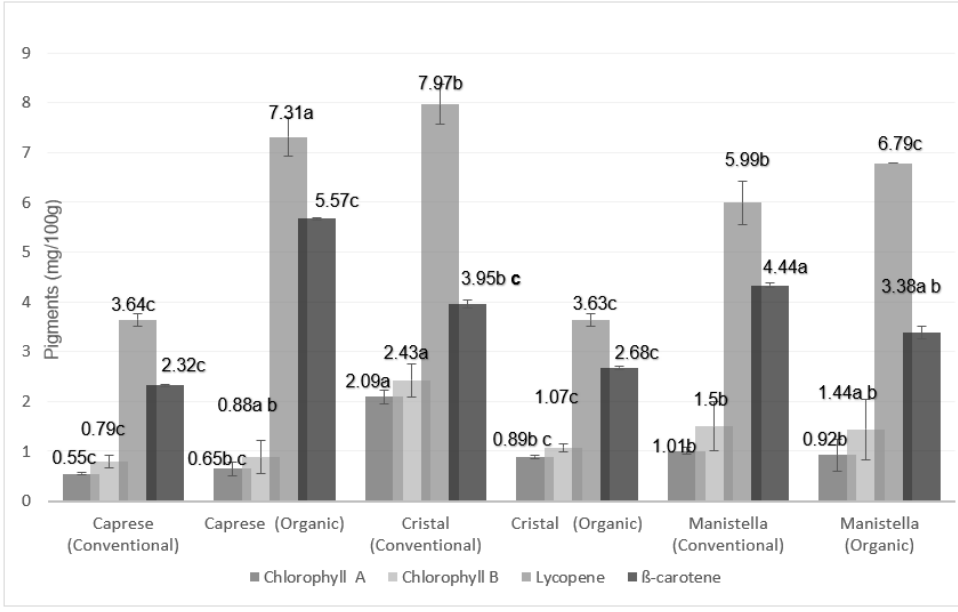

Fig. 1. Pigment contents from tomato fruits

Notably, the Cristal cultivar shows the greatest difference in chlorophyll A concentration between the Conventional and organic systems, with the Conventional system producing 134% more chlorophyll A than the organic system. The other two hybrids (Caprese and Manistella) show smaller differences. Interestingly, the Caprese cultivar responded better to organic fertilization, showing increased chlorophyll content under organic conditions, while the overall difference was less striking than for Cristal.

Antioxidant activity (ABTS and DPPH)

ABTS antioxidant activity (Figure 2) ranged from 0.94 mmol TE/100 g DW in cultivar Cristal under organic fertilization to 1.18 mmol TE/100 g DW in cultivar Caprese under the same conditions. Most cultivars showed no significant differences between fertilization methods, with the exception of cultivar Caprese, which showed a modest increase in antioxidant activity with organic fertilization.

DPPH antioxidant activity showed a similar trend, with values ranging from 1.07 mmol TE/100 g DW in Manistella under organic fertilization to 1.40 mmol TE/100 g DW in the same cultivar under Conventional fertilization.

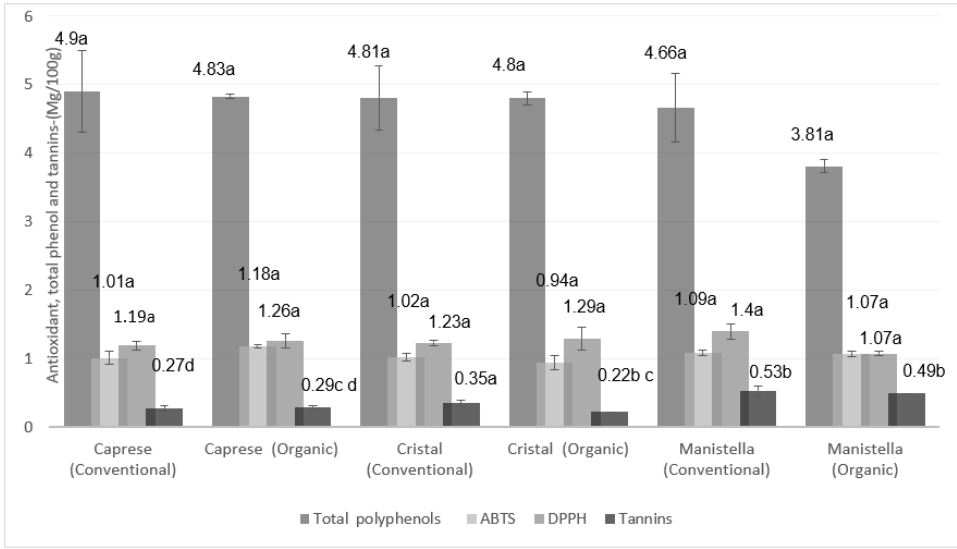

Fig. .2 Antioxidants, total phenol and tannins from tomato fruits

Total polyphenols

Total polyphenol content differs little between cultivars and fertilization techniques. Caprese has the highest value under Conventional fertilization (4.90 mg GAE/100 g FW), while Manistella has the lowest value under organic fertilization (3.81 mg GAE/100 g FW). Overall, polyphenol content varies slightly according to fertilization method, but the changes are not statistically significant.

Lycopene and ß-carotene

Lycopene content was significantly higher in organically fertilized tomatoes, with the highest values observed in Cristal under Conventional fertilization (7.97 mg/100 g). ß-carotene content followed, with Caprese having the highest value (5.67 mg/100 g FW) under organic fertilization. These results indicate that organic fertilization increases carotenoid concentrations, particularly lycopene, which is important for its antioxidant capacities.

Tannins

Tannin content was generally higher in tomatoes grown with chemical fertilizers, with the Manistella variety showing the highest content (0.53 mg TE/100 g). However, changes in tannin content between organic and chemical systems were less pronounced than those observed for the other components.

DISCUSSIONS

This study's findings revealed that fertilization methods have a substantial impact on the nutritional and antioxidant qualities of tomatoes. Organic and chemical fertilization treatments were compared across three tomato varieties, revealing differences in total polyphenols, antioxidant activity (ABTS and DPPH), chlorophyll content, lycopene, beta-carotene, and tannins.

Antioxidant properties and polyphenol content

Organic fertilizers often produced higher levels of antioxidant activity, as evidenced by DPPH and ABTS assays. *Caprese x Daymsa* and *Manistella x Daymsa* types had greater DPPH values after organic fertilization, with *Caprese x Daymsa* having the highest value. These findings are consistent with prior research, which found that organic farming promotes better antioxidant capacity due to stress produced by limited nutrient availability when compared to chemical fertilizers. This can be attributed to the higher phenolic chemicals found in organically cultivated tomatoes. The organically fertilized *Caprese* and *Cristal* types have somewhat greater total polyphenols. These findings are consistent with those of De Sio *et al*. [2019], who found that organic fertilization increases antioxidant activity in some tomato types but not all.

The polyphenol and tannin content

Organic fertilization encourages the synthesis of secondary metabolites like as polyphenols, which are linked to antioxidant qualities. Organically fertilized tomatoes, particularly the Manistella x Daymsa variety, have a greater total polyphenol content, supporting prior studies [Rosa-Martínez *et al*., 2021]. These findings underscore the potential health benefits of organic farming, as tomatoes with higher polyphenolic content and antioxidant capacity are more appealing to consumers because they are associated with a lower risk of chronic disease. The difference in tannin concentration across treatments was likewise minor, indicating that organic and chemical approaches are successful at maintaining tannin levels, which are an essential flavour and astringency element.

Chlorophyll and carotenoid content

The form of fertilization had a substantial effect on chlorophyll levels (both A and B), with Conventional fertilization providing increased chlorophyll content, particularly in the hybrids Cristal x Conv and Manistella x Conv. This is most likely owing to the easily available nutrients in Conventional fertilizers, which may encourage photosynthesis and pigment production more effectively than organic fertilizers. Interestingly, organically fertilized tomatoes, particularly the Caprese x Daymsa type, contained higher levels of lycopene and beta-carotene, both of which have documented health advantages. Organic tomatoes include higher quantities of lycopene and beta-carotene, which have been linked to antioxidant activity and potential protection against diseases including cancer. These results suggest that while chemical fertilization may enhance chlorophyll content, organic fertilization has a deeper effect on carotenoid synthesis.

Implications for agricultural practices

These findings highlight the necessity of selecting fertilization strategies depending on nutritional goals. Organic fertilizers, despite increasing antioxidant activity and carotenoid content, may reduce chlorophyll accumulation. In contrast, Conventional fertilizers increase chlorophyll concentration while decreasing beneficial molecules like lycopene and beta-carotene. Given the growing consumer demand for nutrient-dense meals, organic agricultural procedures appear to provide considerable benefits in improving the health-promoting characteristics of tomatoes.

CONCLUSION

The findings of this study show that organic fertilization improves the nutritional quality of tomatoes, particularly their antioxidant capacity, lycopene, and beta-carotene levels. These findings have substantial implications for agricultural operations, implying that organic methods may be better suited to growing tomatoes with more health advantages. However, fertilization should be adapted to the specific goals of the growing operation, as Conventional fertilization may bring benefits in terms of growth and chlorophyll concentration. More research is needed to look into the long-term effects of these approaches on tomato productivity and environmental sustainability.

Future directions (Recommendations)

More research is needed to compare the long-term impacts of organic versus Conventional fertilization on tomato yield, particularly in varied environmental conditions. Furthermore, studying the microbial content and influence of these fertilizers on soil health may provide more thorough insights into sustainable farming practices. Finally, customer preferences for flavor and texture, which are influenced by fertilization methods, should be evaluated to better align agricultural practices with market expectations.

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WEED INFESTATION DYNAMICS INFLUENCED BY SOME ALLELOPATHIC SPECIES IN CLIMBING BEAN (*PHASEOLUS VULGARIS*) CROP

DINAMICA ÎMBURUIENĂRII SUB INFLUENȚA UNOR SPECII ALELOPATICE ÎN CULTURA DE FASOLE URCĂTOARE (*PHASEOLUS VULGARIS*)

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Abstract.
The aim of this study was to evaluate the effect of eight allelopathic plant species on weed infestation in "Auria Bacăului" climbing bean (Phaseolus vulgaris) crop. The biological material included plant species with allelopathic potential: yellow mustard (Sinapis alba), sainfoin (Onobrychis viciifolia), oil radish (Raphanus sativus var. oleiformis), barley (Hordeum vulgare), two-row barley (Hordeum distichon), oats (Avena sativa), red clover (Trifolium pratense) and white clover (Trifolium repens). The experimental design involved a single factor represented by mixtures of these allelopathic species, which were sown simultaneously with climbing bean in an intercropping system. The weed species identified in the field included red-root amaranth (Amaranthus retroflexus), guasca (Galinsoga parviflora), flower-of-an-hour (Hibiscus trionum), pale knotweed (Persicaria lapatifolia), groundsel (Senecio vulgaris), purslane (Portulaca oleracea), field bindweed (Convolvulus arvensis), Canada thistle (Cirsium arvense), hairy crabgrass (Digitaria sanguinalis), and cockspur (Echinochloa crus-galli). The results showed that weed infestation was significantly reduced by intercropping of climbing bean with allelopathic species, highlighting the potential of this practice in sustainable weed management.
Key words: intercropping system, weed management, secondary metabolites

Rezumat.
Scopul acestui studiu a fost de a evalua efectul a opt specii de plante cu potențial alelopatic asupra nivelului de îmburuienare în cultura de fasole urcătoare „Auria Bacăului" (Phaseolus vulgaris). Materialul biologic a inclus specii de plante cu potențial alelopatic: muștar alb (Sinapis alba),

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sparceta (Onobrychis viciifolia), ridiche furajeră (Raphanus sativus var. oleiformis), orz (Hordeum vulgare), orzoaică (Hordeum distichon), ovăz (Avena sativa), trifoi roşu (Trifolium pratense) şi trifoi alb (Trifolium repens). A fost studiat un singur factor experimental. Acesta a fost reprezentat de mixurile de specii cu propietăţii alelopatice semănate simultan, în sistem intercropping, cu fasolea urcătoare. Speciile de buruieni identificate în cultura de fasole au fost: ştirul (Amaranthus retroflexus), busuiocul dracului (Galinsoga parviflora), zămoşiţa (Hibiscus trionum), iarba roşie (Persicaria lapatifolia), cruciuliţa (Senecio vulgaris), iarba grasă (Portulaca oleracea), volbura (Convolvulus arvensis), pălămida (Cirsium arvense), meişorul roşu (Digitaria sanguinalis) şi mohorul lat (Echinochloa crus-galli). Rezultatele au arătat că nivelul de îmburuienare a fost redus semnificativ de intercropping-ul dintre fasolea urcătoare şi speciile alelopatice, subliniind potenţialul acestei practici în controlul buruienilor.

Cuvinte cheie: culturi intercalate, controlul buruienilor, metaboliți secundari

INTRODUCTION

The term "allelopathy," introduced by Molisch in 1937, refers to the direct and indirect effects of biochemical substances released by one plant that impact another. Molisch's concept of "reciprocal perception" suggests plants interact both positively and negatively. In 1996, the International Allelopathy Society expanded the definition to include secondary metabolites from plants, viruses, microorganisms, and fungi that influence growth and development in biological and agricultural systems [Cheng and Cheng, 2015]. Allelochemicals, non-nutritive compounds produced by plants or microbial decomposition, usually act in mixtures under field conditions [Scavo and Mauromicale, 2021].

Reigosa et al. [1999] noted that environmental fluctuations, especially under abiotic and biotic stress, significantly impact plants' allelopathic potential. Stressors like drought, light intensity, temperature, nutrients, salinity, weeds, plant density, and pathogens can increase allelochemical production [Xuan et al., 2016; Scavo and Mauromicale, 2021]. Allelopathic crops are increasingly used for weed management in practices like intercropping, crop rotation, cover crops, green manure, and allelopathic extracts [Silva et al., 2014; Haider et al., 2015; Jabran et al., 2015]. These methods can be used alone or integrated into a broader weed management strategy [Scavo and Mauromicale, 2020].

The utilization of allelopathy for weed management is highly adaptable, differing from location to location, based on the unique attributes of each context, such as weed species present, soil and climate conditions, economic limitations, agricultural practices employed, and the goals of the farmer (Scavo and Mauromicale, 2020). Numerous allelopathic crops have been utilized in agricultural production [Calara *et al*., 2021]; however, their use has largely been restricted to small-scale and localized regions [Cheng and Cheng, 2015].

For many years, in agroecosystems, weed management has relied almost exclusively on mechanical methods and chemical herbicides. However, modern agriculture is now encountering several adverse effects stemming from the excessive use of tillage and synthetic herbicides, including accelerated soil erosion, degradation of soil structure, shifts in weed species composition, the proliferation of herbicide-resistant weeds, and herbicide residues persisting in crops [Scavo and Mauromicale, 2021]. Many of these issues can be mitigated by diversifying weed control strategies through the incorporation of allelopathic approaches. Employing a combination of multiple weed management techniques has been shown to effectively reduce the likelihood of weeds, developing resistance to herbicides [Cheng and Cheng, 2015].

Sustainable weed management is essential to securing food availability for future generations [Farooq *et al*., 2020]. Among the low-input, eco-friendly approaches available for weed control, the strategic use of allelopathic mechanisms is particularly significant [Scavo and Mauromicale, 2021]. Allelopathy can be utilized across various cropping systems, but it is especially advantageous in organic farming and in conservation, minimum, and no-tillage agricultural practices, where managing weeds frequently presents challenges [Munteanu and Stoleru, 2012; Scavo and Mauromicale, 2021].

The aim of this study was to evaluate the effects of various allelopathic species on weed management in climbing bean cultivation under organic farming conditions: yellow mustard (*Sinapis alba*), sainfoin (*Onobrychis viciifolia*), oil radish (*Raphanus sativus* var. *oleiformis*), barley (*Hordeum vulgare*), two-row barley (*Hordeum distichon*) oats (*Avena sativa*), red clover (*Trifolium pratense*) and white clover (*Trifolium repens).*

MATERIAL AND METHOD

The study took place at the Vegetable Research and Development Station Bacău in Moldavia during the 2024 growing season, focusing on climbing bean (Phaseolus vulgaris) cultivation under organic farming conditions. The "Auria Bacăului" climbing bean cultivar was used, and seeds were sown alongside allelopathic species at a 30 cm spacing. Allelopathic species included yellow mustard, sainfoin, oil radish, oats, two-rowed barley, barley, white clover, and red clover. A randomized block design with three replications was used, with five experimental variants, including a Control.

Table 1

Variants used in the study

Variants	Species with allelopathic properties
V1	- red clover*;*
V2	- white clover, red clover, sainfoin;
V3	- red clover, oil radish, yellow mustard;
V4	- red clover, oats, sainfoin, two-rowed barley, barley;
VM	- soil tillage (the control).

Mowing was carried out twice using a garden strimmer. The control variant was tillaged once mechanically and two times manually.

Weed presence was assessed using a metric frame to measure fresh biomass and density per square meter, with species identified based on a weed descriptor [Gurău, 2007]. Infestation was evaluated at two points: A - before the first tillage/mowing, B - before the second. Competitive and allelopathic effects were quantified using the formula: Overall weed biomass reduction (%) = 1 - (Weed biomass with allelopathic species / Weed biomass without allelopathic species) * 100. The constancy (K%) of each species was calculated as the percentage of repetitions/variants in which the species was present. [Magurran, 2004].

K = (pi / P) * 100

Where:pi = the number of repetitions/variants in which the species was present,

P = the total number of repetitions/variants

Chlorophyll and anthocyanin levels were measured using the OPTI-SCIENCES Chlorophyll and Anthocyanin Content Meters. Leaf samples were randomly collected from three plants per replicate. Total soluble solids concentration was measured with a handheld refractometer on juice from fresh pods, with results expressed in °Brix, following the 932.12 methodology [AOAC, 2005; Brezeanu *et al*., 2022].

At harvest, the total seed yield (kg/ha) and seed yield per plant (g), root length (mm), and root weight (g) and stem diameter (mm) were measured.

Statistical analysis were conducted using ANOVA. Mean comparisons were performed using Tukey's HSD test at a significance level of $P < 0.05$, utilizing IBM SPSS Statistics 20.

RESULTS AND DISCUSSIONS

The weeds encountered in the experiment belong to the following botanical families: *Asteraceae, Amaranthaceae, Convolvulaceae, Poaceae, Malvaceae, Portulacaceae,* and *Polygonaceae* (Table 2).

Table 2

Constancy of weed appearance (%): A- before the first tillage/mowing, B- before the second tillage/mowing

Classification	Species	Constancy of weed appearance (%)	
		A	B
Annual dicotyledons	red-root amaranth (*Amaranthus retroflexus*)	80	80
	gallant soldier (*Galinsoga parviflora*)	0	80
	flower-of-an-hour (*Hibiscus trionum*)	0	20
	pale knotweed (*Persicaria lapatifolia*)	40	0

	groundsel (*Senecio vulgaris*)	100	0
	purslane (*Portulaca oleracea*),	0	20
Perennial dicotyledons	creeping thistle (*Cirsium arvense*)	80	0
	field bindweed (*Convolvulus arvensis*)	60	40
Annual monocotyledons	cockspur (*Echinochloa crus – galli*)	100	100
	hairy crabgrass (*Digitaria sanguinalis*),	0	100

Observations showed cockspur and red-root amaranth had the highest constancy, while purslane and lower-of-an-hour had the lowest. Table 3 presents the weed species density in climbing bean crops, with cockspur, hairy crabgrass, red-root amaranth, and gallant soldier having the highest plant counts. The control variant had more weeds, like cockspur with 223.3 weeds per m², indicating higher infestation without allelopathic species.

Table 3

Number of weeds per m²: A- before the first tillage/mowing, B- before the second tillage/mowing

Species	Number of weeds per m²									
	V1		V2		V3		V4		VM	
	A	B	A	B	A	B	A	B	A	B
Red-root amaranth	16.7 ± 15.1	4.3 ± 0.5	3 ± 1	1.7 ± 0.6			1 ± 0	1 ± 0	4 ± 1	1.3 ± 0.6
Creeping thistle	1 ± 0		1.3 ± 0.6		1 ± 0				3 ± 1	
Field bindweed			2 ± 1.7			1 ± 0	1.3 ± 0.6		4.3 ± 1.5	1.7± 0.6
Hairy crabgrass		7.3 ± 2.3		5.7 ± 1.5		1.3 ± 0.6		11.7 ± 5.5		5.7 ± 1.5
Cockspur	54 ± 9.6	13 ± 3	22 ± 12.1	14.7 ± 1.5	3.3 ± 1.5	2 ± 1	5.7 ± 1.2	4 ± 1	223.3 ± 20.8	9 ± 1
Gallant soldier		3.33 ± 2.1		5.7 ± 1.5				4.3 ± 3.1		2 ± 1
Flower-of-an-hour										1 ± 0
Pale knotweed	10.3 ± 13.7		1.7 ± 0.6							
Purslane										2.3 ± 0.6

Groundsel	5 ± 3.6		1.7 ± 0.6		1 ± 0		1.7 ± 0.6		1±0	

Red-root amaranth initially shows high numbers with allelopathic species but decreases over time, eventually being better controlled than the control. Hairy crabgrass and field bindweed are less affected, with their numbers remaining the same or increasing. This indicates that intercropping with allelopathic species is effective for controlling some weeds, like cockspur and red-root amaranth, but varies by species.

Table 4 presents the statistical interpretation of weed biomass within the bean crop. The species with the highest biomass are also represented by: cockspur, hairy crabgrass, red-root amaranth and gallant soldier.

Table 4

Fresh weed biomass g/m^2: A- before the first tillage/mowing, B- before the second tillage/mowing

Species	Fresh weed biomass g/m^2									
	V1		V2		V3		V4		VM	
	A	B	A	B	A	B	A	B	A	B
Red-root amaranth	16.3 ± 12.1	83.3 ± 15.3	6 ± 1	32.7 ± 11.0			2.0 ± 0.0	23.3 ± 5.8	6.7 ± 2.1	52.7 ± 14.2
Creeping thistle	3 ± 1.7		4 ± 1.7		3.3 ± 2.3				8.0 ± 2.0	
Field bindweed			4.3 ± 3.2			25.0 ± 0.0	3.0 ± 1.7		25.0 ± 5.0	80.0 ± 36.1
Hairy crabgrass		69.7 ± 21.2		37.3 ± 11.2		26.7 ± 2.9		257.0 ± 262.5		180.3 ± 17.9
Cockspur	50 ± 13.2	923.3 ± 92.9	11 ± 3.6	900.3 ± 44.5	6.3 ± 0.6	9.0 ± 3.6	7.3 ± 2.3	95.0 ± 18.0	103.3 ± 15.3	1263.3 ± 25.2
Gallant soldier		31 ± 18.5		71.7 ± 10.4				33.3 ± 25.7		23.3 ± 12.6
Flower-of-an-hour										5.3 ± 0.6
Pale knotweed	4 ± 2.6		2.3 ± 0.6							
Purslane										72.3 ± 19.7
Groundsel	4.3± 2.1		3 ± 1		1.7 ± 0.6		4.3 ± 2.5		2.0 ± 0.0	

Table 5 presents the statistical interpretation of the height of weeds in the climbing bean crop. In this case as well, cockspur is the species that recorded the highest values. Red-root amaranth and cockspur show noticeable reductions in height in the variants with allelopathic species compared to the control, suggesting effective growth suppression. Field bindweed also shows a significant reduction in height, almost half the size in variants with allelopathic species, compared to the control.

Table 5

Height of weeds (cm): A- before the first tillage/mowing, B- before the second tillage/mowing

Species	Height of weeds (cm)									
	V1		V2		V3		V4		VM	
	A	B	A	B	A	B	A	B	A	B
Red-root amaranth	6.0 ± 0.0	42.3± 4.0	5.7 ± 0.6	31.0 ± 1.7			5.0± 0.0	25.0 ± 5.0	7.3 ± 0.6	50.0 ± 0.0
Creeping thistle	5.3 ± 1.2		6.7 ± 2.9		5.3± 2.3				6.0± 0.0	
Field bindweed			9.3 ± 1.2			32.7 ± 4.6	5.3± 0.6		17.7 ± 2.5	51.7 ± 7.6
Hairy crabgrass		33.7± 4.0		41.7 ± 2.9		36.3 ± 15.5		43.7 ± 3.2		55.0 ± 5.0
Cockspur	11.3 ± 1.2	55.0± 5.0	11.7 ± 1.5	57.3 ± 2.5	7.3± 0.6	26.7 ± 2.9	7.3± 0.6	44.7 ±13.6	15.3 ± 0.6	66.7 ± 2.9
Gallant soldier		25.7± 1.2		33.7 ± 1.5				31.0 ±1.7		41.7 ± 2.9
Flower-of-an-hour										21.7 ± 2.9
Pale knotweed	4.3 ± 0.6		4.7± 0.6							
Purslane										25.0 ± 0.0
Groundsel	5.0 ±0.0		4.3 ±0.6		4.3± 0.6		6.3± 3.2		4.3 ± 0.6	

For hairy crabgrass and creeping thistle, the allelopathic species has little to no effect on reducing height, as their measurements remain similar between the variants and control. Gallant soldier experiences a moderate reduction in height in the variant with allelopathic species.

In Table 6, the phenophases of weeds in climbing bean crop are presented. The encountered weeds exhibited various developmental stages, ranging from plants with only a leaf rosette to those bearing fruits or seeds. Gallant soldier experiences a moderate reduction in height with the allelopathic treatment.

Table 6

The phenophases of weeds in climbing bean crop

Species	Phenophases									
	V1		V2		V3		V4		VM	
	A	B	A	B	A	B	A	B	A	B
Red-root amaranth	1	4	1	4			1	4	1	4
Creeping thistle	1		1		1				1	
Field bindweed			1			1	1		1	1
Hairy crabgrass		4		4		4		4		4
Cockspur	1	4	1	4	1	3	1	4	1	4
Gallant soldier		3		3				3		3
Flower-of-an-hour										3
Pale knotweed	1		1							
Purslane										1
Groundsel	1		1		1		1		1	

Phenophases: 1 – plants with only a leaf rosette or those that exhibit stems and leaves; 2 – plants with floral buds or grasses in the booting stage; 3 – flowering plants; 4 – plants with fruits; 5 – plants that have undergone seed dispersal.

It was observed that the weed biomass was reduced across all treatments. The average value for the percentage reduction in weed biomass fluctuated between 33.9% and 96.4%, with the highest value recorded for treatment V3, prior to the second tillage/mowing (Figue 1)

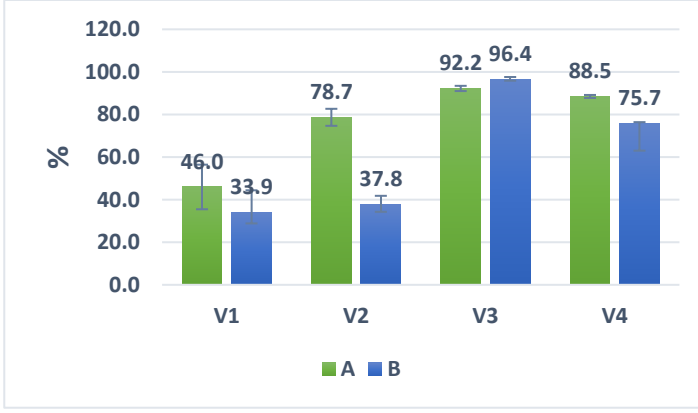

Fig. 1. Overall weed biomass reduction (%): A- before the first tillage/mowing, B- before the second tillage/mowing

Variant 3 demonstrated the most prolonged weed suppression, maintaining the field free of weeds for an extended duration, compared to the other variants.

The results of the ANOVA did not reveal any significant differences between the experimental variants concerning total seed production (Figure 2). The seed yields across the different variants ranged between 592.8 kg/ha and 664.8 kg/ha, with the lowest value recorded in the control variant. Despite these numerical variations, the differences were not statistically significant.

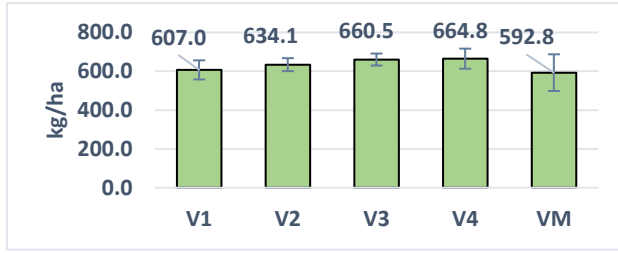

Fig. 2. Seed yield (kg/ha) at climbing bean

It is important to note that the observed seed production was considerably lower than the average yield of the cultivar, a result likely attributed to the specific climatic conditions experienced during the growing season.

Similar to the results observed for seed production (Figure 3), no significant differences were found between the experimental variants regarding the number of pods per hill. The number of pods per hill ranged from 16.8 in the control variant to 18.6 in the V3 variant.

Fig. 3. Number of pods per hill

No significant differences were observed between the treatments in terms of the Chlorophyll Content Index (CCI), Anthocyanin Content Index (ACI), Total Soluble Solids (TSS), or root weight (g) in the bean crop. However, significant differences were observed in stem diameter (mm) and root length (mm).

Table 6

Results of Biometric Measurements and Quality Indicators within the bean crop

Variant	Chlorophyll content index (CCI)	Anthocyanin content index (ACI)	Total soluble solids (TSS) (Brix)	Stem diameter (mm)	Root length (mm)	Root weight (g)
V1	13.3 ± 1.1	5.7 ± 0.7	6.3 ± 0.7	8.9 ± 1.1 bc	143.7 ± 22.3 a	8.1 ± 1.4

V2	11.7 ± 1.7	5.6 ± 0.3	6.8 ± 0.3	11.6 ± 1.5 ab	102.1 ± 6.5 ab	12.9 ± 6.2
V3	14.2 ± 1.8	5.3 ± 0.3	6.2 ± 0.8	8.6 ± 2.0 bc	104.2 ± 4.3 ab	7.7 ± 1.8
V4	14.5 ± 1.3	5.8 ± 0.6	6.5 ± 0.6	13.7 ± 2.1 a	95.6 ± 15.5 b	14.6 ± 2.4
VM	13.6 ± 0.5	5.4 ± 0.3	6.3 ± 0.2	6.4 ± 0.9 c	81.8 ± 30.6 b	6.2 ± 2.9
	ns	ns	ns	*	*	ns

The results are presented as means ± SD. Distinct letters indicate significant differences between the groups, as determined by the Tukey post-hoc test ($P < 0.05$): a–the highest value for the test performed, *–significant differences; ns- non-significant.

Specifically, the treatments with allelopathic species resulted in significantly increased stem diameter and root length compared to the control.

The lack of significant differences in biochemical markers like CCI, ACI, and TSS suggests that the allelopathic species did not cause any measurable stress or alterations in the metabolic functions associated with these quality indicators. This could imply that the allelopathic species did not interfere with the beans' photosynthetic activity, but instead acted primarily on the physical aspects of growth, such as root and stem development.

CONCLUSIONS

The level of weed infestation was significantly reduced by intercropping climbing beans with yellow mustard, oil radish, red clover, and climbing beans with barley, oat, two-row barley and red clover. It was noted that the weed biomass was reduced in all variants.

These findings suggest that the allelopathic species may have had a positive influence on the overall growth environment of the beans, particularly by improving root architecture.

The present study did not observe significant differences in the total climbing bean seed production between the variants.

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TRENDS IN TOTAL LIPID CONTENT OF PEA SEEDS UNDER STORAGE CONDITIONS

EVOLUȚIA CONȚINUTULUI TOTAL DE LIPIDE DIN SEMINȚELE DE MAZĂRE ÎN CONDIȚII DE DEPOZITARE

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Abstract.
Crop plant seeds deteriorate when stored improperly and for long periods. Thus, there is a loss of growth and vigor of aged seeds, which eventually leads to a decrease in total germ count. The decrease in vigor of young plants depends on the storage conditions, the crop species and the cultivar play a major role. Relative humidity and storage temperature are the major factors. that influence seed quality during storage. Seed deterioration is caused by loss of carbohydrate, protein, lipid, etc. Content in order to reveal the losses in lipid content, during 2017-2019, four garden pea cultivars stored under different temperature and humidity conditions were analyzed in triplicate. The obtained results highlight that lipids are influenced by both storage conditions and seed age. The data show a higher propensity to depreciation of the cultivar Gloriosa compared to Zsuzsi or Kelvedon Wonder, which denotes a better genetic capacity of both cultivars to adapt to storage conditions. The best results were obtained when seeds of these cultivars were stored at 4 °C and 8% humidity compared to 22 °C and 65% humidity.
Key words: pea seed, cultivars, storage conditions, seed deterioration

Rezumat.
Semințele plantelor de cultură se deteriorează atunci când sunt depozitate necorespunzător și pentru perioade lungi. Astfel, se produce o pierdere a creșterii și a vigorii semințelor îmbătrânite, ceea ce duce în cele din urmă la o scădere a numărului total de germeni. Scăderea vigorii plantelor tinere depinde de condițiile de depozitare, specia de cultură și soiul. Umiditatea relativă și temperatura de depozitare sunt principalii factori care influențează calitatea semințelor în timpul depozitării. Deteriorarea semințelor este cauzată de pierderea de carbohidrați, proteine, lipide etc. Pentru a evidenția pierderile în conținutul de lipide, în perioada 2017-2019, au fost analizate în triplicat patru cultivare de mazăre de grădină depozitate în condiții diferite de temperatură și umiditate. Rezultatele obținute evidențiază faptul că lipidele sunt influențate atât de condițiile de depozitare, cât și de vârsta semințelor. Datele arată o propensiune mai mare la depreciere a cultivarului Gloriosa comparativ cu Zsuzsi sau Kelvedon Wonder, ceea ce denotă o capacitate genetică mai bună a celor

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două cultivaruri de a se adapta condițiilor de depozitare. Cele mai bune rezultate au fost obținute atunci când semințele acestor cultivare au fost depozitate la 4 °C și 8% umiditate, comparativ cu 22 °C și 65% umiditate.

Cuvinte cheie: semințe de mazăre, cultivare, condiții de depozitare, deteriorarea semințelor

INTRODUCTION

Pea (*Pisum sativum* L.) is an annual vegetable plant of the *Fabaceae* family, native to southwest Asia. The plant is valued for the benefits it brings to the soil through its ability to fix atmospheric nitrogen, while the seeds are valued for their nutritional value, being an important source of plant protein, fiber, vitamins and minerals [Cojocaru *et al.*, 2024].

On average, pea seeds contain 55% starch and 23% protein [Sosulski and McCurdy, 1987]. As for the number of researches carried out in our country on lipid content of pea seeds, they are in very small number. Studies from other countries reported that lipid content in pea seeds ranged from 9% to 35% [Bastianelli *et al.*, 1998; Ryan *et al.*, 2007].

Saving vegetable seeds is an essential practice for farmers as it guarantees crop success. Depending on the vegetable species and storage conditions, seeds can be stored for long periods without losing germination or germination energy [Stefan *et al.*, 2013; Stoleru *et al.*, 2016].

The physiological ageing of seeds involves a series of degenerative changes leading to loss of viability. Ageing usually starts after physiological maturity, when the seed is qualitatively optimal. The major factors influencing the degree of aging are increased humidity and temperature during storage, both of which accelerate the rate of aging [Priestley *et al.*, 1986]. Physiological changes during aging include decreased enzyme activity, respiration, protein synthesis, lipid peroxidation and membrane damage [Coolbear, 1995]. The accelerated aging technique is commonly used as a method to determine the storage potential of seed lots and to assess their vigor [Delouche and Baskin, 1973]. Accelerated aging involves exposure of the seed to high humidity and temperature. Environmental conditions and exposure times that are effective for increasing the physiological age of seed can range from mild (25 to 30 °C, 75 to 94% RH for 6 to 24 weeks) to severe (45 °C, 100% RH for 1 to 8 days) [Delouche and Baskin 1973; Janusauskaite, 2023]. It is hypothesized that accelerated aging amplifies the deterioration processes that normally occur during prolonged storage [Delouche and Baskin, 1973] as the changes that occur during accelerated aging appear to be the same as those of natural aging [Chen *et al.*, 2023]. In addition, if a significant level of anaerobic respiration occurs during accelerated aging, for which by-products (ethanol) could be responsible. However, high levels of ethanol should accumulate in the seed before a significant decline in seedling vigor [Paulitz *et al.*, 1992].

The aim of the experiment was to evaluate the lipid content under storage conditions, age and cultivar influence.

MATERIALS AND METHOD

The experiment was carried out in the Laboratory of Vegetable Growing at the University for Life Sciences in Iasi, Romania. During the three years of experiments, four pea cultivars of Hungarian, Bulgarian, Italian and Dutch origin were used as biological material, which can react differently under specific growing conditions. The four pea cultivars (*Pissum sativum* L.) used in the experiment were: Zsuzsi, Gloriosa, Meraviglia and Kelvedon Wonder. Seed chemical analysis was performed at the biochemistry laboratory of the University for Life Sciences in Timisoara, Romania. The experimental protocol was based on the combination of three factors, three replicates were used for each combination of factors: Factor A - *the cultivar* had four graduations: a_1 - 'Zsuzsi'; a_2 - 'Gloriosa'; a_3 - 'Meraviglia'; a_4 - 'Kelvedon Wonder'; Factor B - the *crop year* had three graduations: b_1-'2017'; b_2-'2018'; b_3-'2019'; Factor C - *storage conditions* had five graduations: c_1-'SC_1-t=4^0C x U=8%'; c_2-'SC_2-t=4^0C x U=12%'; c_3-'SC_3-t=8^0C x U=8%'; c_4-'SC_4-t=8^0C x U=12%'; c_5-'SC_5-t=22^0C x U=65%'.

Results were reported as means ± standard error of the experiment for the three years (2017-2019), after processing the raw data by ANOVA and mean separation by Tukey's multiple range ($p \leq 0.05$) test ($p \leq 0.05$) using SPSS v21 software (IBM Corp, Armonk, NY, USA).

RESULTS AND DISCUSSIONS

Under storage conditions, seed metabolism is restricted, therefore it is likely that the aging reactions are randomly influenced. Studies on the effects of oxygen on seed deterioration and oxygen uptake by dry seeds [Fatokun *et al.*, 2020] suggest that the reactions may be oxidative. One of the most commonly cited hypotheses explaining seed deterioration points to lipid peroxidation as the mechanism by which cell membranes are subject to damage. There are many types of peroxidative reactions in which lipids serve as substrates, but the most commonly cited involve the breaking of the ester bond between the acyl and glycerol chain or the attack of the unsaturated bonds of the fatty acid chain. Results on lipid dynamics in pea seeds for the three years of storage are presented in Table 1.

The data in Table 1 highlight that lipids are influenced by storage conditions and age. The lipid content ranged within quite wide limits, from 23.37 g·100 g^{-1} d.w. in the case of cultivar Gloriosa harvested in 2017 and stored under normal atmospheric conditions to 31.86 g·100 g^{-1} d.w. in the case of cultivar Zsuzsi harvested in 2019 and stored under optimal temperature and humidity conditions, the difference of 36.33% being highly statistically significant ensured.

Significantly superior results are observed especially in the case of low-aged seeds, which means that they will have a favorable effect on the vigor of future plants with favorable repercussions on the yield capacity. Seed age is an important biological factor on which seed vigor depends. In general, old seeds lose their vigor rapidly, mostly due to primary metabolites.

Figure 1 shows the results on the influence of 4 °C temperature and 8% moisture on lipid content of pea seeds in the three years of experiments (2017, 2018 and 2019). The lipid content ranged from 27.62 g·100 g^{-1} d.w. in the seeds of cultivar Gloriosa in 2017 to 31.86 g·100 g^{-1} d.w. in the seeds of cultivar Zsuzsi in 2019.

Table 1

Influence of storage conditions of garden pea seeds on lipid content (g·100 g^{-1} d.w.)

Experimental factor		Storage conditions				
		SC$_1$	**SC$_2$**	**SC$_3$**	**SC$_4$**	**SC$_5$**
Zsuzsi	2017	28.19±2.07	27.26±2,00	27.71±2.03	25.74±1.89	23.85±1.75
	2018	31.11±2.28	30.08±2.2	30.58±2.24	28.4±2.08	26.32±1.93
	2019	**31.86±2.34**	30.81±2.26	31.32±2.3	29.09±2.13	26.95±1.98
Gloriosa	2017	27.62±2.02	26.71±1.96	27.15±1.99	25.22±1.85	**23.37±1.71**
	2018	30.47±2.23	29.46±2.16	29.95±2.2	27.82±2.04	25.78±1.89
	2019	31.21±2.29	30.18±2.21	30.68±2.25	28.49±2.09	26.4±1.94
Meraviglia	2017	27.67±2.03	26.76±1.96	27.2±1.99	25.26±1.85	23.41±1.72
	2018	30.53±2.24	29.52±2.16	30.01±2.2	27.87±2.04	25.83±1.89
	2019	31.27±2.29	30.24±2.22	30.74±2.25	28.55±2.09	26.45±1.94
Kelvedon Wonder	2017	27.76±2.03	26.84±1.97	27.29±2	25.34±1.86	23.48±1.72
	2018	30.63±2.25	29.62±2.17	30.11±2.21	27.97±2.05	25.91±1.9
	2019	31.37±2.3	30.33±2.22	30.84±2.26	28.64±2.1	26.54±1.95

SC$_1$- (t=4^{0}C x U=8%); SC$_2$- (t=4^{0}C x U=12%); SC$_3$- (t=8^{0}C x U=8%); SC$_4$- (t=8^{0}C x U=12%); SC$_5$- (t=22^{0}C x U=65%)

Figure 2 shows the results on the influence of 4 °C temperature and 12% humidity on lipid content of pea seeds in the three years of experiments (2017, 2018 and 2019). The lipid content ranged from 26.71 g·100 g^{-1} d.w. in seeds of the cultivar Gloriosa in 2017 to 30.81 g·100 g^{-1} d.w. in seeds of the cultivar Zsuski in 2019.

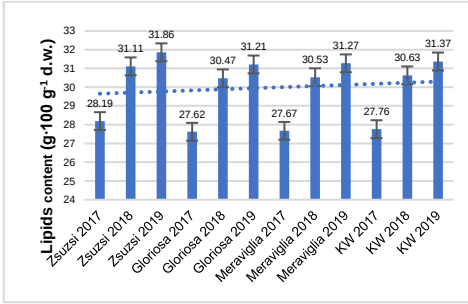

Fig. 1. Results on the influence of pea seed storage conditions (t=4^{0}C x U=8%) on lipid content

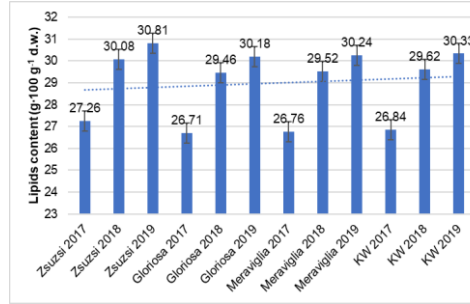

Fig. 2. Results on the influence of pea seed storage conditions (t=4^{0}C x U=12%) on lipid content

Figure 3 shows the results on the influence of 8^{0}C temperature and 8% moisture on lipid content of pea seeds in the three years of experiments (2017, 2018

and 2019). The lipid content ranged from 27.15 g·100 g^{-1} d.w. in the seeds of cultivar Gloriosa in 2017 to 31.32 g·100 g^{-1} d.w. in the seeds of cultivar Zsuski in 2019.

Figure 4 shows the results on the influence of 8 °C temperature and 12% moisture on lipid content of pea seeds in the three years of experiments (2017, 2018 and 2019). The lipid content ranged from 25.22 g·100 g^{-1} d.w. in seeds of the cultivar Gloriosa in 2017 to 29.09 g·100 g^{-1} d.w. in seeds of the cultivar Zsuski in 2019.

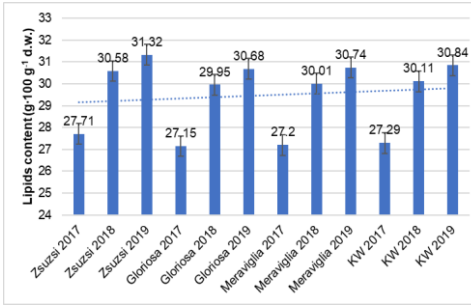

Fig. 3. Results on the influence of pea seed storage conditions (t=8^{0}C x U=8%) on lipid content

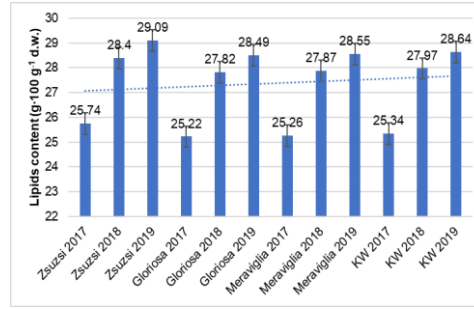

Fig. 4. Results on the influence of pea seed storage conditions (t=8^{0}C x U=12%) on lipid content

Figure 5 shows the results on the influence of 22^{0}C temperature and 65% humidity on the lipid content of pea seeds in the three years of experiments (2017, 2018 and 2019). The lipid content ranged from 23.37 g·100 g^{-1} d.w. in seeds of the cultivar Gloriosa in 2017 to 26.95 g·100 g^{-1} d.w. in seeds of the cultivar Zsuski in 2019.

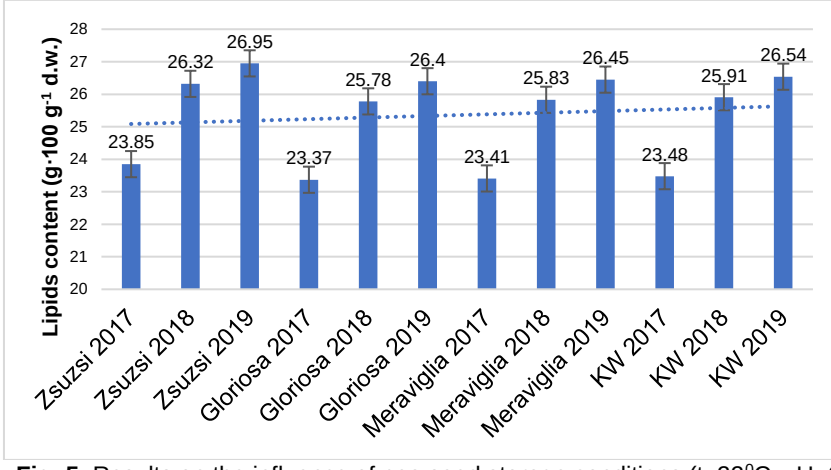

Fig. 5. Results on the influence of pea seed storage conditions (t=22^{0}C x U=65%) on lipid content.

CONCLUSIONS

The present study confirms that seed storage management as a function of temperature and humidity can significantly influence seed lipid content.

The finding that there were variations in lipid content indicates that the method of seed storage has statistical significance.

Seed age and storage temperature are the main factors in pea seed storage with regard to lipid content.

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RESPONSE OF TOMATO VARIETIES AND F_2 RECIPROCAL HYBRIDS TO STRESS TEMPERATURES

REACȚIA SOIURILOR ȘI HIBRIZILOR RECIPROCI F_2 DE TOMATE LA TEMPERATURI DE STRES

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Abstract.
The paper presents the results of assessing the resistance of some cultivars and 2 reciprocal F_2 hybrid combinations: Desteptarea x Flacara/Flacara x Desteptarea and Flacara x Vrojainii/Vrojainii x Flacara of tomato to stressful temperatures (41º, 43ºC). Seedlings grown at 25ºC served as a control variant. The analysis of the variability of the resistance character was carried out based on the length of the embryonic radicle, the stem, the whole seedling. In most cases, stress temperatures produced significant inhibition of growth organs. Through cluster analysis (k-means method) in the variant 41ºC, the reciprocal combinations F_2 Desteptarea x Flacara / F_2 Flacara x Desteptarea were identified, and in the case of the 43ºC temperature – Exclusiv, Prestij, Desteptarea, Flacara and F_2 Desteptarea x Flacara that formed separate clusters, with the highest values of the evaluated characters, which provides opportunities for their use in breeding programs as reliable sources of resistance. The research of the influence of stressful temperatures on the distribution of plants in phenotypic classes demonstrated that obtaining a greater number of segregates with reduced sensitivity to high temperatures is more likely in the case of the combinations F_2 Desteptarea x Flacara and F_2 Vrojainii x Flacara.
Key words: tomato, resistance, temperature, variability.

Rezumat.
În lucrare sunt prezentate rezultatele aprecierii rezistenței unor soiuri și 2 combinații hibride reciproce F_2: Deșteptarea x Flacăra/Flacăra x Deșteptarea și Flacara x Vrojainîi/Vrojainîi x Flacara de tomate la temperaturi de stres (41º, 43ºC). În calitate de martor au servit plantulele cultivate la 25ºC. Analiza variabilității caracterului de rezistență a fost efectuată în baza lungimii radiculei embrionare, tulpiniței, plantulei integrale. În majoritatea cazurilor, temperaturile de stres au produs inhibarea semnificativă a organelor de creștere. Prin analiză clusteriană (k-medii) în varianta 41ºC au fost identificate combinațiile reciproce F_2 Deșteptarea x Flacăra/F_2 Flacăra x Deșteptarea, iar în cazul temperaturii 43ºC – Exclusiv, Prestij, Deșteptarea, Flacăra și F_2 Deșteptarea x Flacăra care au format clustere separate, cu cele mai înalte valori ale caracterelor evaluate, ceea ce oferă oportunități de utilizare a acestora în programele de

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ameliorare în calitate de surse sigure de rezistență. Cercetarea influenței temperaturilor de stres asupra repartiției plantelor în clase fenotipice a demonstrat că obținerea unui număr mai mare de segreganți cu sensibilitate diminuată la temperaturi înalte este mai probabilă în cazul combinațiilor F_2 Deșteptarea x Flacăra și F_2 Vrojainîi x Flacăra.
Cuvinte-cheie: tomate, rezistență, temperatură, variabilitate.

INTRODUCTION

The challenges generated by climate change will require the implementation of new strategies to adapt the newly created varieties in a timely manner to local conditions to effectively reduce the risks of stressful temperatures [Porter *et al*., 2014; Bisbis *et al*., 2018].

The optimum temperature for growing tomatoes falls within the limits of 25-30ºC/20ºC – day/night. Although tomatoes show high adaptability to environmental conditions, stress temperatures can become a major limiting factor for plant growth, reproduction and production level [Camejo *et al*., 2005].
Increasing the temperature even by 2-4ºC above the optimal level can greatly affect reproductive organs, especially pollen viability, gamete development, pollination capacity, produce the fall of flowers and reduced fruit firmness [Firon *et al*., 2006; Ozores-Hampton *et al*., 2012]. Resistant tomato genotypes have the ability to form a much larger number of fruits than sensitive ones under stress conditions [Comlekcioglu *et al*., 2010]. So, high temperatures can cause significant productivity losses and damage to fruit quality [Ozores-Hampton *et al*., 2012; Ibukun *et al*., 2020].

The creation of resistant tomato varieties is one of the most effective strategies to control heat stress [Mihnea, 2016]. In relation to the need to create sources with sustainable resistance, special attention is paid to the interactions of tomato plants with temperature.

The aim of our research was to evaluate the influence of thermal stress on the growth and development characteristics of plants and to identify promising ones for exploitation in the breeding programs.

MATERIAL AND METHODS

As initial material for the intended research, 9 varieties were used (Pontina, Florina, Chihlimbar, Exclusiv, Prestij, Deșteptarea, Flacara, Vrojainîi, Mary Gratefully) and 2 reciprocal F_2 hybrid combinations: Desteptarea x Flacara / Flacara x Desteptarea and Flacara x Vrojainii/Vrojainii x Flacara.

Varieties and hybrid combinations were tested at 3 temperature levels: optimal – 25°C and stressful: 41°C and 43°C. The assessment of tomato samples resistance to high temperatures was carried out on the basis of the growth capacity of the embryonic radicle, stem and intact seedling for 7 days after maintaining them on day 4 at temperatures of 42° and 43°C for 6 hours [Mihnea, 2016]. Seedlings grown at 25°C served as a control.

The cluster analysis of the degree of similarity / difference of tomato genotypes based on growth and development characters at different temperatures was carried out

according to the centroid method of *k*-means, successfully used in the genetics and improvement research [Kanavi *et al*., 2020; Lupaşcu *et al*., 2019]. The obtained data were statistically processed in the STATISTICA 7 software package.

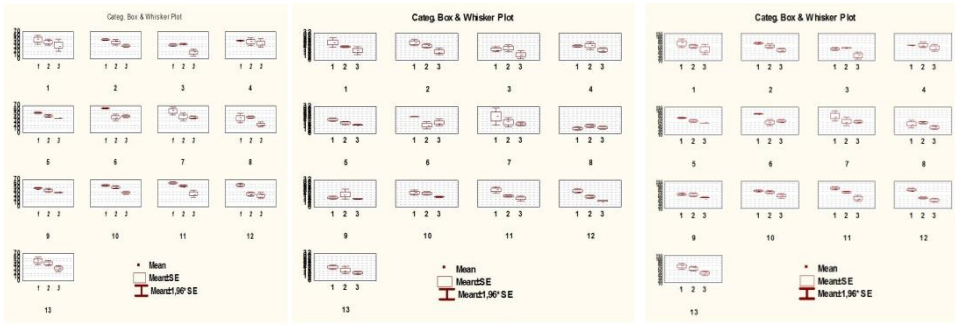
RESULTS AND DISCUSSIONS

Testing the reaction of some cultivars, reciprocal F_2 tomato hybrids at different temperature levels on the growth characteristics of tomatoes in early ontogenesis, demonstrated that the response of the plants to the 3 temperatures (25°C – optimal, 41°C and 43°C – stress) was differentiated – specific to the genotype, the hybrid, the analyzed character.

In the case of the radicle length, it was found that under optimal conditions, the root length varied within the limits of 35.6 … 61.7 mm (Fig. 1 A), and at the temperature of 41°C – 33.2 … 50.6 mm (Fig. 1 B).

The degree of growth inhibition for the studied forms varied in the range -5.1 … -41.6 (compared to optimal conditions). A strong inhibition was found in the Desteptarea variety (-36.6%) and the F_2 Flacara x Vrojainii hybrid (-41.6).

Stimulation was attested to the varieties Chihlimbar (+7.6%) and Vrojainii (+6.6%). A relatively low inhibition was found in the varieties Prestij (-5.1%), Mary Gratefully (-10.5%) and the hybrid combination F_2 Desteptarea x Flacara (-8.2%). Under the influence of temperature 43°C, a significant inhibition of radicle growth was observed in most of the F_2 cultivars/hybrids studied: -13.3 … -52.5%. Weak sensitivity was found in Exclusiv and Mary Gratefully cultivars (Fig. 1 C).



A B C

Fig. 1. The influence of temperature on the length of radicle (A), stem (B) and seedling (C) of tomato
***Horizontally*: 1 – Control (25°C), 2 – 41°C, 3 – 43°C**

1 – Pontina, 2 – Florina, 3 – Chihlimbar, 4 – Exclusiv, 5 – Prestij, 6 – Desteptarea, 7 – Flacara 8 – Vrojainîi, 9 – Mary Gratefully, 10 – F_2 Desteptarea x Flacara, 11 – F_2 Flacara x Deșteptarea,12 – F_2 Flacara x Vrojainii, 13 – F_2 Vrojainîi, x Flacara

The length of the stem in the control variant varied between 11.0 … 23.0 mm (Fig. 1 A). Under the influence of stress temperatures, the genotypes showed a

rather differentiated reaction and a high character variability: in 21 cases there was inhibition (-3.0 … -44.5%), and in 4 cases – growth stimulation stems at a temperature of 41°C in the Chihlimbar, Exclusiv, Vrojainii, Mary Gratefully varieties: + 6.7, +1.0, +22.7 +23.5%, respectively. At the temperature of 43°C, there was a 5.4% stimulation in the Vrojainii variety.

Regarding the seedling length, its reduction compared to the control varied between 0.02 … 37.2% at 41°C, and 15.0 … 47.4% – at 43°C. At the same time, the temperature of 41°C most strongly influenced the genotypes Chihlimbar (-36.4%), F_2 Flacăra x Deșteptarea (-37.2). At the temperature of 43°C, the inhibition was greater than 40.0% at varieties Chihlimbar, F_2 Flacara x Deșteptarea, F_2 Flacara x Vrojainii (Fig. 1 C).

The evaluation of tomato genotypes based on three test parameters demonstrated that the Exclusiv variety showed complex resistance to stress, the resistance falling within the limits of 80.6 … 101.0. Florina, Prestij, Flacara, Mary Gratefully, F_2 Desteptarea x Flacara, F_2 Vrojainii x Flacara proved to be resistant. They are of interest as sources of heat resistance and can be included in prospective breeding activity.

Classification of the genotypes by the centroid method of *k*-means based on the 3 characters, revealed that in the control variant cluster 1 met 4 genotypes – 6, 7, 11, 12, with the highest values of the analyzed characters: radicle length – 59.50 mm, stem length – 22.25 mm, plant length 81.75 mm; cluster 2: 7 genotypes – 1, 2, 4, 5, 9, 10, 13, with average values of the analyzed characters: radicle length – 37.4% mm, stem length – 22.7 mm and seedling length 70.3, respectively; cluster 3: 2 genotypes – 3, 8, with the lowest values.

In the 41ºC variant, hybrids 10, 11 (cluster 2), and the 43ºC variant, genotypes/hybrid – 4, 5, 6, 7, 10 (cluster 3) they recorded the highest values of the evaluated characters. It should be noted that the stem length slightly differs between the clusters in both variants (Table 1), which denotes that this character showed a weaker discriminating capacity compared to the other two characters.

Table 1

Descriptive cluster analysis

Cluster	Caracter	*Control (25°C)*		*Temperature 41°C*		*Temperature 43°C*	
		Average	**Genotype**	**Average**	**Genotype**	**Average**	**Genotype**
1	Legth of the radicle, mm	59.50	6, 7, 11, 12	43.51	1, 2, 4, 5, 7, 9, 13	19.15	3, 8
	Legth of the stem, mm	22.25		18.00		11.45	
	The seedling length, mm	81.75		61.83		32.00	
2	Legth of the radicle, mm	50.46	1, 2, 4, 5, 9, 10, 13	52.40	10, 11	33.58	1, 2, 9, 11, 12, 13
	Legth of the stem, mm	19.83		18.10		13.92	
	The seedling length, mm	70.30		70.45		47.47	
3	Legth of the radicle, mm	36.75	3, 8	38.025	3, 6, 8, 12	39.56	4, 5, 6, 7, 10
	Legth of the stem, mm	13.70		15.30		15.60	
	The seedling length, mm	50.40		53.30		56.34	

The influence of the temperature factor on the distribution of plants in phenotypic classes in the segregating populations was analyzed based on the reciprocal hybrids F_2 Desteptarea x Flacara, F_2 Flacara x Vrojainii (Fig. 2-4).

In optimal conditions, in the combination Desteptarea x Flacara the maximum distribution frequencies were located in the phenotypic class 50-60 mm (26%), then at F_2 Flacara x Desteptarea – in the class 60-70 mm class (23%).

Regarding the reciprocal combination F_2 Flacara x Vrojainii/ F_2 Vrojainii x Flacara, the maximum of the distribution of frequencies in both combinations was represented by the phenotypic class 50-60 mm, being 27 and 24%, respectively (Fig. 2).

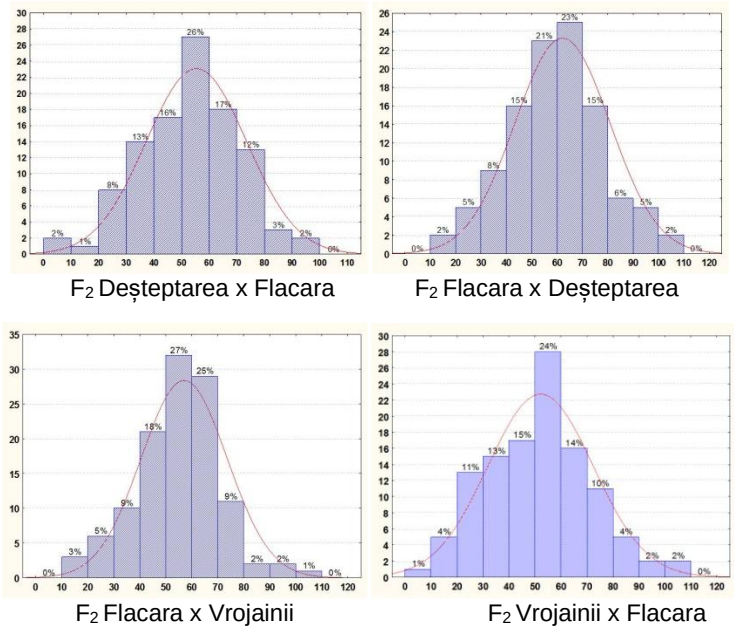


Fig. 2. Distribution histograms of tomato plants based on radicle length in reciprocal segregating populations F_2 under optimal conditions (25 ºC)
Vertically: the number of seedlings, horizontally: phenotypic classes (mm)

By researching the influence of the 41ºC temperature on the distribution of plants in phenotypic classes in the segregating populations F_2 Desteptarea x Flacara / F_2 Flacara x Desteptarea and F_2 Vrojainii x Flacara / Flacara x Vrojainii, it was found that the peak of the distribution of values differed greatly between both pairs of reciprocal hybrids (Fig. 3).

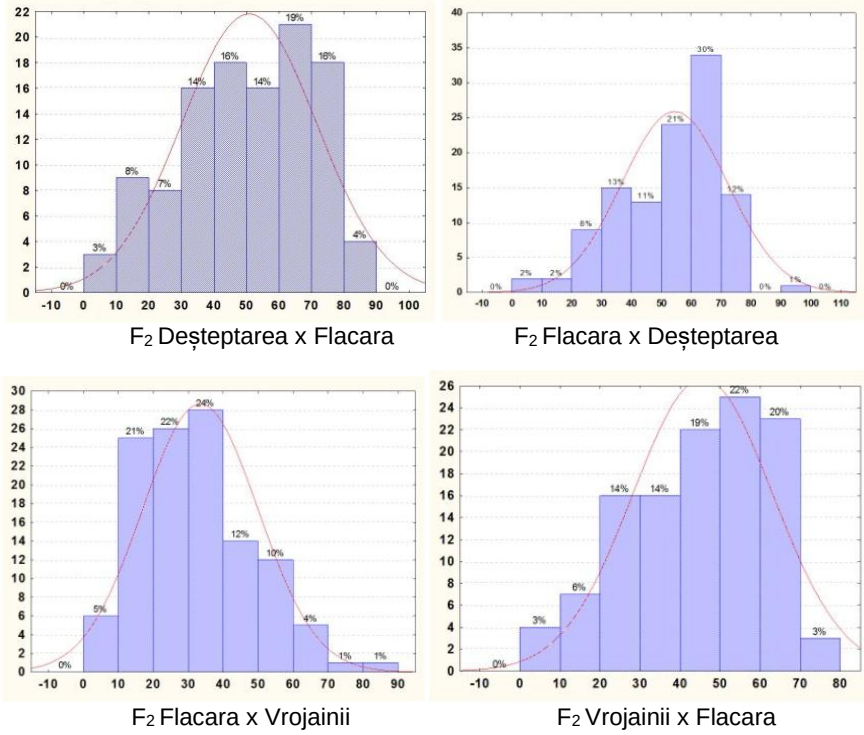


Fig. 3. Distribution histograms of tomato plants based on radicle length in reciprocal segregating populations F_2 under stressful temperature (41°C)
Vertically: the number of seedlings, horizontally: phenotypic classes (mm)

Regarding the temperature of 43°C, it can be seen that in the combinations F_2 Flacara x Desteptarea and F_2 Flacara x Vrojainii the maximum of the frequency distribution compared to the optimal conditions was shifted to the left, while in the combinations in which the variety was used as the paternal form Flacara, the rate of plants that developed relatively long embryonic radicle (40-80 mm) was much higher than in their counterparts (Fig. 4).

So, obtaining a larger number of segregants with reduced sensitivity to high temperatures is more likely when using the F_2 Flacara x Deșteptarea and F_2 Flacara x Vrojainii combinations.

As can be seen from the distribution histograms, the phenotypic classes based on the radicle length in early ontogeny in the reciprocal F_2 populations were influenced by the temperature level and the parental factor selected as the hybridization component.

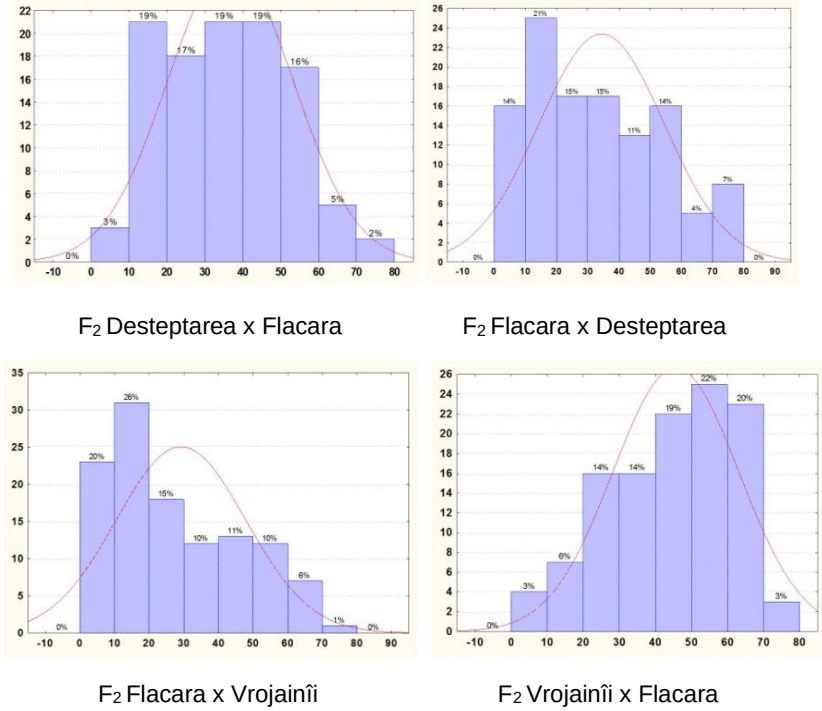


Fig. 4. Distribution histograms of tomato plants based on radicle length in reciprocal segregating populations F_2 under stressful conditions (43°C)
Vertically: the number of seedlings, horizontally: phenotypic classes (mm)

CONCLUSIONS

The analysis of the growth characteristics – of the radicle, the stem, the seedling in the varieties and reciprocal combinations, at different temperature levels highlighted the differentiated character of their reaction to limiting temperatures. In the most cases, stressful temperatures produced a significant inhibition of growth organs in tomato.

Through cluster analysis (*k*-means method), the most resistant genotypes/hybrids were identified at 41°C – F_2 Deșteptarea x Flacara / F_2 Flacara x Deșteptarea and at temperature 43 °C – Exclusiv, Prestij, Deșteptarea, Flacara and F_2 Deșteptarea x Flacara with the highest values of the evaluated characters, which provides opportunities for their use in breeding programs as reliable sources of resistance.

The research of the influence of stressful temperatures on the distribution of plants in phenotypic classes demonstrated that obtaining a greater number of segregates with reduced sensitivity to high temperatures is more likely in the case of the combinations F_2 Deșteptarea x Flacara and F_2 Vrojainii x Flacara.

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PRELIMINARY STUDIES ON THE ALLELOPATHIC EFFECT OF SOME ENDEMIC SPECIES OF AROMATIC PLANTS AND THEIR POSSIBLE USE AS BIO-HERBICIDES

STUDII PRELIMINARE PRIVIND EFECTUL ALELOPATIC AL UNOR SPECII ENDEMICE DE PLANTE AROMATICE ŞI POSIBILA UTILIZARE A ACESTORA CA BIO-ERBICIDE

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Abstract. *Allelopathy as a process defines the process of inhibition or influence of some plants on other associated plants, by means of biochemical compounds or by the production of chemical substances that eliminated in nature by various means inhibit the germination of weed seeds. Studies in the scientific literature indicate that the main plants with allelopathic effect are aromatic and medicinal species containing essential acids or essential oils such as basil, rosemary, fennel, mint, lavender, thyme, or mustard. The potential for using these plants to produce natural herbicides can be significant, and the percentage reduction in the amount and germination rate of weed seeds in crops is high. Further study of this phenomenon is necessary for the development of biologically active substances for the treatment of weed infestation of crops. Allelopathy and its beneficial effects help to control weeds without harming the health of people, wildlife and the environment. Our preliminary studies include a review of research to date and a proposal for the use of allelopathic plants in urban and peri-urban gardens.*

Key words: domestic garden, medicinal and vegetable plants, allelopathy, bio-herbicide

Rezumat. *Alelopatia ca proces definește procedeul de inhibare sau influența unor plante asupra altor plante asociate, prin intermediul unor compuși biochimici sau prin producerea unor substanțe chimice care eliminate în natură prin diferite moduri inhibă germinația semințelor de buruieni. Studiile din literatura științifica menționează ca principalele plante cu efect alelopatic sunt reprezentate de speciile aromatice și medicinale care conțin acizi sau uleiuri eterice cum ar fi: busuiocul, rozmarinul, feniculul, menta, lavanda, cimbru, sau mușcatele. Potențialul de utilizare a acestor plante cu scopul de a produce erbicide naturale, poate fi semnificativ, iar procentul de reducere a cantității și procentul de germinație a semințelor de buruieni din culturi este ridicat. Efectuarea unui studiu mai amănunțit al acestui fenomen este necesar, pentru dezvoltarea de substanțe biologic active pentru tratarea infestării culturilor cu buruieni. Alelopatia și efectele benefice ale acesteia*

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contribuie la combaterea buruienilor fără a afecta sănătatea populație, a faunei și mediul înconjurător. Studiile preliminarii efectuate de noi cuprind o analiză a cercetărilor efectuate până în prezent și o propunere de folosire a plantelor cu efecte alelopatice în grădinile urbane și peri-urbane.

Cuvinte cheie: grădini private, plante medicinale și legumicole, alelopatie, bio-erbicide

INTRODUCTION

All elements and organisms in nature are connected by food chains which are represented by the subsistence links between humans, plants and animals. Since ancient times man has sought to experience and discover these connections and the mechanisms that underlie them. Thus, just as there is a hierarchy among humans to distinguish themselves, and the strongest are on the surface, so also plants struggle for hierarchy. This is influenced by symbiotic ties, competence and environmental factors that have certain negative or positive effects on them [Hangan *et. al.*, 2020].

Due to the different cultivation technologies of different vegetable species, their different association is allowed for a more intensive exploitation of the vegetable potential by practicing a rotation on cultivated land, whether it is a household garden or a farm specializing in vegetables [Istrate *et. al.*, 2023].

Allelopathy is a biological phenomenon, through which biochemical substances are produced, which occurs between plants through the inhibitory influence or mutual interaction of plants with those near them by means of allelochemical substances with a negative or positive effect (aromatic oils). Plants that have the ability to influence the growth and development of other plants by releasing chemical compounds into the growing medium are called allelopathic plants [Stoleru *et. al.*, 2016].

Elroy Leon Rice, in his monograph on allelopathy, describes a more complex definition, including all direct and indirect effects of plants on each other and on other plants. It also mentions researchers who closely observed the phenomenon of allelopathy and ruled out the idea of competition between plants, the allelopathic effect being a cause of the appearance of certain changes in the process of plant development. In disagreement with this, many biologists believe that allelopathy is part of the competition between plants or in some works its effect is not admitted, some studies even eliminate allelopathy as a possible cause of the observed results, [Rice, 2012].

The presence of the allelopathic effect in the soil depends on the addition of certain chemical compounds in the environment or an allelopathic agent, thus allelopathy is separated from competition, not being part of them, because it can be induced, less often it can occur involuntarily between plants [Calara *et. al.*, 2021].

Most of the experiments and studies carried out so far are based on adding plant extracts to the soil to observe their effect on the evolution and development of plants, but allelopathy can also be present by planting different plants together

and living together. whether or not they have a beneficial effect on their cultivation [Stoleru *et. al*., 2015].

After documenting and carrying out some reviews on the research carried out, we have extracted some conclusive studies with positive results in the field of allelopathy and its use in agriculture and horticulture.

Allelopathy processes can also be influenced by environmental conditions including UV radiation, temperature, water and nutrient availability, as well as competitive stress between plants. This we can say that the environment can affect the production of allelochemicals in three ways: the production of the compounds, their bioavailability and their effect on the target species [Cheng F. and Cheng Z., 2015].

Environmental stress is a very good precursor to the formation and stimulation of the production of allelochemicals, hormones and the triggering of plant gene expression. Similarly, the stress produced by the interaction between plants is very important in the production of allelochemicals. For example, rice seedlings grown together with *Echinochloa crus-galli*, a grass species, showed stimulation of momilactone B production than that of rice seedlings grown alone. [Cheng F. and Cheng Z., 2015]

The presence of allelochemicals in soil also depends on transfer (absorption and leaching) and degradation (abiotic and biotic) processes. The production of allelochemicals is a complex problem that is affected by the environment and the donor and target plant species, stress and environmental factors involved in the process.

This paper will include a review of allelopathy and allelopathic effect research done so far along with the experimental design of the research.

MATERIAL AND METHOD

The study and work material is represented by a rich specialized literature comprising over 6.000 works on allelopathy and 88 works on urban and peri-urban gardens, works published so far by different authors. Also, the most detailed studies were chosen that best included the necessary details on allelopathic plants and the allelopathic effect, which helps to inhibit the growth and germination of weeds.

Following the results gathered from the research, we chose to use the following aromatic and seasoning plants: basil, thyme, oregano, rosemary, sage and pelargonium sp. along with several other vegetable species.

The working method is represented by deepening and understanding the results obtained so far by researchers in the field and choosing the plants with the greatest potential and using them in one's own experience to understand exactly the mechanisms of allelopathy and the potential for use for beneficial purposes.

DISCUSSIONS ON THE INFLUENCE OF PLANTS WITH AN ALLELOPATHIC EFFECT

Following further studies on allelopathy and the effect of allelopathic plants, we found that extracts obtained from aromatic and medicinal herbs as well as some

legume species can have positive allelopathic effects against weeds in crops, inhibiting seed germination and even plant growth.

Basil extracts inhibited germination of broadleaf weeds by up to 80% in laboratory experiments and reduced plant biomass by up to 97% in field experiments.

If we talk about herbs, their effect has been tested on several weeds in crops, with lavender, mint, oregano, rosemary and thyme being the most important, giving the best results.

Also, the results of the effects of the treatments for each concentration on each individual plant were analyzed separately, the inhibitory effects of the essential oils had an effect on the germination after 14 days of its production, the germination in the control group being 88%.

However, the essential oils of *Coriandrum sativum*, *Foeniculum vulgare*, *Lavandula Stoechas*, *Pimpinella anisum*, *Rosmarinus oficinalis* and *Salvia officinalis* had a lower inhibition coefficient, especially at low concentrations of 3.6 ml, except for *Raphanus* seeds, which did not show outstanding results, the other seeds showed significant results. Although they did not show a statistically significant result, increasing the concentration to 10-20 ml decreased the germination percentage in the case of *Raphanus* seeds.

Table 1.

Germination rate of weed seeds

Germination rate of weed seeds (%)							
Name of plants	**Hollyhock (*Alcea pallida*)**	**Amaranth (*Amaranthus retroflexus*)**	**Yellow starthisle (*Centaurea solstitialis*)**	**Wild mustard (*Sinapis arvensis*)**	**Field thistle (*Sonchus oleraceus*)**	**Wild radish (*Raphanus raphanistrum*)**	**Patience dock (*Rumex nepalensis*)**
Caraway (*Carum carvi*)	46.7	7.4	7.6	0.5	0.0	0.1	13.6
Coriander (*Coriandrum sativum*)	64.7	37.9	15.8	9.4	10.5	13.2	27.4
Fennel (*Foeniculum vulgare*)	86.7	36.7	16.3	23.0	97.3	5.6	84.2

Lavander (*Lavandula stoechas)*	58.3	36.6	12.7	1.0	30.4	1.3	56.1
Mint (*Mentha spicata)*	46.7	2..9	10.6	1.0	5.6	0.1	6.7
Oregano (*Origanum onites)*	71.7	16.5	15.4	1.1	3.2	0.2	20.2
Anise (*Pimpinella anisum)*	84.7	53.7	61.3	66.2	97.8	10.9	92.0
Rosema ry (*Rosmar*	73.3	59.5	5.4	3.0	87.1	2.8	40.1
Sage (*Salvia officinalis)*	83.4	63.7	44.4	17.0	95.1	22.7	80.6
Thyma (*Thymbra spicata)*	74.5	1.1	41.5	0.3	1.3	0.6	35.8
X^2	23.9	31.0	25.9	30.5	32.4	29.8	33.0
p-value	**	***	**	***	***	***	***
Control (water)	100	100	96	100	100	88	100
****p<0.001*, ***<0.01*							

A study of the allelopathic potential of pelargonic acid in *Pelargonium* plants has been studied in a laboratory experiment and its results may be promising for its

use as a bio-herbicide against weeds in large crops as well as in small vegetable crops or private gardens.

The study aimed to compare the effectiveness of four solutions of pelargonic acid, three essential oils (*lemon, pine and manuka*) and two mixtures of the two against species of *Lolium rigidum, Avena sterilis and Gallium aparine*.

Table 2.

Results obtained in Lolium rigidum plants

Treatment	Dry weight (%)			Height of plants (%)		
	Day 1	Day 3	Day 7	Day 1	Day 3	Day 7
PA1	46	42	41	44	43	40
PA2	34	29	30	38	27	28
PA3	59	52	53	63	54	51
PA4	41	37	37	42	33	35
EO1	41	27	10	45	28	8
EO2	42	39	40	40	36	38
EO3	38	34	33	37	35	36
MI	37	22	6	36	24	7
M2	36	29	23	40	26	21
LSD (0.05)	8	10	11	7	8	11
***p* value**	**	**	***	***	***	**

***(Legend:** PA1 – Pelargonic acid 18.67%; PA2 – Pelargonic acid 50%; PA3 – Pelargonic acid 3.102% + maleic hydrazide 0.459%; PA4 – Pelargonic acid 18.67% + maleic hydrazide 3%; EO1 – Manuka oil 5%, EO2 – Lemongrass 5%; EO3 – Pine oil 5%; MI – Pelargonic acid + manuka oil; M2 – pelargonic acid + lemongrass oil)*

The mixtures of pelargonic acid and essential oils significantly reduced the germination of *Lolium rigidum* plants starting from day 3. The values being between 29-18%. PA2 treatment achieved the best results in *Lolium rigidum* plants compared to the control group. The values being between 34-29%.

Very good results were also obtained with EO1 treatment on the third and seventh day of treatment compared to the control group. The values being between 41-10%.

Table 3.

Results obtained in Avena sterilis plants

Treatment	Dry weight (%)			Height of plants (%)		
	Day 1	Day 3	Day 7	Day 1	Day 3	Day 7
PA1	36	33	33	38	36	35
PA2	27	24	23	29	27	24
PA3	48	44	41	53	46	42
PA4	33	30	31	36	33	32
EO1	42	28	7	44	31	12
EO2	36	31	32	37	34	34
EO3	39	35	32	42	37	35
MI	28	18	4	30	20	8
M2	43	25	17	36	25	19
LSD (0.05)	9	8	11	9	7	9
***p* value**	*	**	***	*	**	***

***(Legend:** PA1 – Pelargonic acid 18.67%; PA2 – Pelargonic acid 50%; PA3 – Pelargonic acid 3.102% + maleic hydrazide 0.459%; PA4 – Pelargonic acid 18.67% + maleic hydrazide 3%; EO1 – Manuka oil 5%, EO2 – Lemongrass 5%; EO3 – Pine oil 5%; MI – Pelargonic acid + manuka oil; M2 – pelargonic acid + lemongrass oil)*

In the case of sterile oat plants, germination was most inhibited with the PA2 treatment. The germination percentage of plants with values between 29%-23%. Also the treatment EO1 and M1 had a very strong impact on day 7. the germination values being between 7-4% and a plant height between the values of 12-8%. The M2 and PA4 treatments also showed observable effects.

Table 4.

Results obtained in Gallium aparine plants

Treatment	Dry weight (%)			Height of plants (%)		
	Day 1	Day 3	Day 7	Day 1	Day 3	Day 7
PA1	12	5	4	14	6	6
PA2	5	2	0	8	4	0
PA3	17	10	8	20	12	11
PA4	10	5	3	13	6	5
EO1	33	23	8	36	27	11
EO2	30	27	25	33	29	27
EO3	19	16	14	21	19	18
MI	22	12	0	25	13	0
M2	24	15	6	26	16	8
LSD (0.05)	8	6	9	8	7	9
p value	***	***	**	***	***	**

***(Legend:**PA1 – Pelargonic acid 18.67%; PA2 – Pelargonic acid 50%; PA3 – Pelargonic acid 3.102% + maleic hydrazide 0.459%; PA4 – Pelargonic acid 18.67% + maleic hydrazide 3%; EO1 – Manuka oil 5%, EO2 – Lemongrass 5%; EO3 – Pine oil 5%; MI – Pelargonic acid + manuka oil; M2 – pelargonic acid + lemongrass oil)*

The allelopathic potential present in *Ipomoea batatas* plants was tested by performing a laboratory bioassay with aqueous extracts from 17 sweet potato cultivars. The cultivars: *SP0, SP1, SP2, SP3, SP4, SP5, SP6, SP7, SP9, SP10, SP11, SP13, SP14, SP15, SP16, SP18 and SP19.*

The highest inhibition rates were calculated for the leaf extracts which significantly increased the values with increasing concentration.

The highest synthetic inhibition and allelopathic effect was recorded for cultivars *SP19, SP6, SP11* and *SP7* on sterile *Latuca sativa* plants.

Another study is defined by establishing the allelopathic relationship between parsley, fennel, onions, carrots and peppers, a study conducted in the laboratory. Extracts obtained from parsley, dill, carrot and onion significantly reduced the activity of pepper plants by stunting growth and root development. Fennel and carrot extract unexpectedly showed positive effects on the growth and development of seedlings, leading to their improvement.

A laboratory experiment with aqueous extracts of *Lantana camara* leaves showed negative results for pepper and carrot plants. The extracts inhibited *Daucus*

carota germination by 70%, and for *Capsicum annuum*, root growth was reduced by 49% and vegetative growth by 60%. *Lantana camara* is an invasive weed that impacts seed germination and seedling growth, increasing crop plant mortality.

A study on the allelopathic potential of *Helianthus sp.*, *Sorghum sp.*, and *Oryza sp.* on *Parthenium hysterophorus* plants showed favorable results. Sorghum extracts, especially from shoots, significantly inhibited weed germination, while root extracts were effective at 25% concentration. Sunflower extracts had inhibitory effects below 5%, and rice extracts showed the least inhibition, only at higher concentrations. [Javaid et. al., 2006].

CONCLUSIONS

Allelopathy has a very important impact on vegetable gardens and using it for practical purposes can facilitate their care or supervision.

Conducting this study arose from the need to deepen the information about the allelopathic effect and plants with allelopathic properties in order to use them as a bio-pesticide for the elimination of weeds and protection against diseases and pests.

Essential oils have a multitude of properties, among them is the inhibitory effect on the growth of common weeds in crops.

The use of the allelopathic effect and plants with allelopathic effects can considerably reduce the consumption of pesticides and the need for manual weeding in private gardens.

The use of plants with allelopathic effects can be beneficial for the future of organic crops for food production, by removing pesticides from use and replacing them.

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SOME ASPECTS IN THE CONTROL OF RAPE PESTS THROUGH THE USE OF PREPARATIONS BASED ON ACETAMIPRID 200G/L + LAMBDA-CYHALOTRIN 150G/L, IN THE CONDITIONS OF THE REPUBLIC OF MOLDOVA

UNELE ASPECTE ÎN COMBATEREA DĂUNĂTORILOR RAPIȚEI, PRIN UTILIZAREA PREPARATELOR PE BAZĂ DE ACETAMIPRID 200G/L + LAMBDA-CIHALOTRIN 150G/L, ÎN CONDIȚIILE REPUBLICII MOLDOVA

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Abstract.
If prevention and control measures are not applied, the harvest losses of rapeseed crops can reach 30-70% of the potential harvest. Taking into account the particularities of the rapeseed culture, it is important that chemical treatments are applied with selective phytopharmaceutical products, with little residue and a low degree of toxicity and only with warning in strictly necessary numbers, to avoid the formation of toxic residues. It is necessary to pay more attention to the activity of the numerous species of pests, which attack the rape crop during the entire vegetation period, from sowing to harvesting. As a result of the research carried out, it was demonstrated that, in the integrated complex of rape pest control, in the Republic of Moldova, chemical control plays an important role, and the composition of phytosanitary products must be constantly renewed. Thus, the chemical treatment of rape plants, with the insecticide with the active substance acetamiprid, 200 g/l + lambda-cihalotrin, 150 g/l, with a consumption rate of 0,2 l/ha, ensured an essential reduction in the numerical density of the species Meligethes aeneus F., (98,99 – 91,48%), Ceuthorychus quadridens Pany (100,00 – 90,20%) and Brevicoryne brassicae L., (97,76 – 91,17%).
Key words: : *OSR, Meligethes aeneus* F., *Ceuthorychus quadridens* Pany, *Brevicoryne brassicae* L., *Biological and control particularities.*

Rezumat.
Pierderile de recoltă, cauzate culturilor de rapiță, dacă nu se aplică măsuri de prevenire și combatere, pot ajunge la 30-70% din recoltă. Ținând cont de specificul culturilor de rapiță, este important ca

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tratamentele chimice să se aplice cu produse fitofarmaceutice selective, cu remanentă mică și un grad de toxicitate redus și numai la avertizare în număr strict necesar, pentru a evita formarea reziduurilor toxice. O atenție sporită este necesar de acordat activității numeroaselor specii de dăunători, care atacă cultura rapiței pe parcursul întregii perioade de vegetație, de la semănat până la recoltare. În rezultatul cercetărilor efectuate s-a demonstrat că, în complexul integrat de combatere a dăunătorilor rapiței, în Republica Moldova, un rol important prezintă combaterea chimică, iar componența produselor de uz fitosanitar trebuie permanent reînnoită. Astfel, tratarea chimică a plantelor de rapiță, cu insecticidul cu conținut de acetamiprid, 200 g/l + lambda-cihalotrin, 150 g/l, cu norma de consum 0,2 l/ha, a asigurat asigură o reducere esențială a densității numerice a speciilor Meligethes aeneus F., *(98,99 – 91,48%), Ceuthorychus quadridens* Pany, *(100,00 – 90,20%) și Brevicoryne brasicae* L., *(97,76 – 91,17%).*

Cuvinte cheie: Rapița de toamnă, *Meligethes aeneus* F., *Ceuthorychus quadridens* Pany, *Brevicoryne brasicae* L., *Particularități biologice și de combatere*.

INTRODUCTION

Autumn rapeseed, being one of the main crops for the production of vegetable oil used for both food and technical purposes, offers several advantages over sunflower: it ensures a higher and more stable yield; it has a shorter growing period; it prevents soil erosion; it does not require high cultivation costs; it has a high oil content; it allows early field clearance; and offers the possibility of producing biofuel [Zbancă *et. al.*, 2017].

However, for the most rational use of material and human resources, it is necessary to develop the cultivation technology for this crop, including an integrated pest management system. During its growing period, this crop can be attacked by a variety of polyphagous pests or, less frequently, pests with a narrower feeding specialization [Croitoru *et. al.*, 2016].

In autumn, rapeseed crops may be attacked by cabbage white butterflies, the second generation caterpillars of the cutworm (*Agrotis segetum* L.), the rapeseed sawfly (*Athalia colibri* Christ.), and adult crucifer flea beetles (*Phyllotreta atra* F., *Ph. nigripes* F., *Ph. nemorum*).

In early spring, rapeseed seedlings are attacked by the overwintering adults of the corn rootworm (Tanymecus dilaticollis Gyll.), the sand beetle (*Opatrum sabulosum* L.), and crucifer flea beetles (Ph*yllotreta atra F., Ph. nigripes F., Ph. nemorum*). During the same period, but later, the leaves, floral buds, and inflorescences are attacked by various species of aphids, the most common being: the gray cabbage aphid (*Brevicoryne brassicae* L.), the black bean aphid (*Aphis fabae* L.), and the green peach aphid (*Myzodes persicae* L.). Defoliating pests that can cause damage include the caterpillars of cabbage white butterflies (Pieris brassi*cae* L.), the cabbage moth (*Mamestra brassicae* L.), the rapeseed sawfly

(*Athalia colibri* Christ.), larvae and adult rapeseed weevils (*Ceuthorhynchus* spp.), the red turnip beetle (*Entomoscelis adonidis* Pall.), and the mustard beetle (*Colaphellus sophiae* Schall.) [Panuța *et. al.*, 2022].

During the summer, from the group of sucking pests, three species of aphids mentioned above can be found, along with crucifer bugs (*Eurydema oleracea L., E. ornata L., Dolycoris baccarum* L.). Defoliating pests are represented by the species listed above, including *Meligethes aeneus* F., *Ceuthorychus quadridens* Pany., *C. assimilis* Payk, the caterpillars of cabbage white butterflies (*Pieris* spp.), the cabbage moth (*Mamestra brassicae* L.), the diamondback moth (*Plutella maculipennis* Cust.), and sawflies (*Athalia colibri* Christ.).

In the integrated pest management system for rapeseed in the Republic of Moldova, chemical control plays an important role, and the composition of phytosanitary products must be constantly renewed.

Based on the above, the aim of the research is to study the biological efficacy of an insecticide containing acetamiprid, 200 g/L + lambda-cyhalothrin, 150 g/L, in controlling the complex of rapeseed pests.

MATERIAL AND METHOD

Experiments to determine the biological efficacy of the insecticide containing acetamiprid (200 g/l) + lambda-cyhalothrin (150 g/L) were conducted in 2023 in the autumn rapeseed field of SRL “Agro Panfil” in Plop village, Dondușeni district. The autumn rapeseed was sown in the first decade of September 2022, using a planting scheme of 20 x 15 cm and the Mercurii variety. The experiments were set up with 4 repetitions. Each plot measured 10 x 10 m, resulting in a total area of 100 m². The plots in the experimental field were compactly and randomly arranged [Croitoru *et al.*, 2022].

Four treatments were included in the experiment: V1 (control) - untreated; V2 (standard) - the insecticide with acetamiprid (200 g/l) + lambda-cyhalothrin (150 g/l) at a consumption rate of 0.15 l/ha; V3 - the same insecticide at 0.15 l/ha; V4 - the insecticide at a consumption rate of 0.20 l/ha. Throughout the research period, chemical treatments were applied using a portable sprayer. To maintain a unique differentiation between treatments and to avoid phytotoxic effects, all chemical treatments were carried out on the same day in the morning hours.

To detect the cabbage aphid and flea beetles, records were kept for 20 plants in each plot. The monitoring of cabbage white caterpillars and armyworms was done by counting caterpillars per plant, and for the green caterpillar, additional counts were made for caterpillars around the plants. Observations were conducted before treatment and on the 3rd, 7th, and 14th days after treatment. For the rape beetle, 20 model plants were marked in each plot. The number of flower buds and flowers per model plant, as well as the number of adults and larvae, was recorded.

The density of the soil beetle and corn rootworm was calculated based on pest monitoring in each plot through 3 surveys on the soil surface, each measuring 0.25 m². The influence of ecological factors on the development of harmful and beneficial fauna was assessed based on data from the meteorological station in Northern Moldova. The determination of the biological efficacy of the insecticides was carried out in accordance with the requirements and methodological guidelines for testing plant protection products and fertilizers (Chișinău, 2002).

RESULTS AND DISCUSSIONS

In 2023, from the broad complex of polyphagous and oligophagous pests, only the population of the pollen beetle and the cabbage stem weevil exceeded the Economic Damage Threshold (EDT). On the record from April 27, the density of the pollen beetle was 11.00–12.00 individuals per plant, while the numerical value of the cabbage stem weevil reached a maximum of 5.63–6.00 weevils per plant. Therefore, chemical treatment was applied on April 27th. The results of the records and observations are shown in Table 1. From the data presented in the table, it can be observed that before treatment, the pest density was uniform, ranging from 11.00 individuals per plant in the control variant to 12.00 in the fourth variant.

Research at 3, 7, and 14 days after treatment showed a significant reduction in overwintering adults across all treated variants. On day 3, the lowest pollen beetle density was in the fourth variant, significantly lower than in the control and third variants. By day 3, pest density in all experimental variants was reduced to 1.08-6.67% of initial levels, while the control reached 106.82%. The fourth variant showed a reduction of 98.99%, surpassing both the standard and third variant (94.93%). On day 7, only the fourth variant reduced pest density above 95%, with the third variant at 93.10%. By day 14, efficacy declined, but differences between variants remained.

Alongside the research aimed at determining the biological efficacy of two application rates of the insecticide containing 200 g/L acetamiprid + 150 g/L lambda-cyhalothrin against the pollen beetle, records were also kept on the cabbage stem weevil, whose numerical value also exceeded the economic damage threshold.

The results of the records and the calculation of the biological efficacy of the products are shown in Table 2. From the data in the table, it can be seen that prior to treatment, the density of adults varied from 5.63 individuals per plant in the control variant to 6.00 individuals per plant in the fourth variant. On the third day after treatment, the pest was not detected in the fourth variant. In the other experimental variants, adult density ranged from 0.50 individuals per plant in the standard variant to 0.38 individuals per plant in the third variant. In the control variant, after this time interval, the pest density reached 6.75 individuals per plant.

The results obtained on the seventh day after treatment demonstrate that the pest was detected in all experimental variants; however, the lowest density of overwintered adults was recorded in the fourth variant. In the third variant, this index was 0.50 individuals per plant, significantly lower than in the fourth variant and at the standard level.

The results recorded on the fourteenth day after treatment indicate that the efficacy of the products is still evident after this period. Thus, the lowest indices were marked in the fourth variant (0.63 individuals per plant). In the standard and the third variant, the density of weevils was 1.13 and 1.00 individuals per plant, respectively.

Table 1.

Biological efficacy of the insecticide containing 200 g/L acetamiprid + 150 g/L lambda-cyhalothrin in controlling the pollen beetle (2023)

Experimental Variants	Application Rate, L/ha	Numerical density of beetles per model plant				Pest density, as a percentage compared to the initial value, on the ... day after treatment (see below number)			Pest density reduction compared to the control variant, as a percentage, on the ... day after treatment (see below number)		
		Before treatment	On the ..... day after treatment (see below number)								
			3	7	14	3	7	14	3	7	14
V_1 (Control)	untreated	11.00	11.75	12.88	15.75	106.82	117.09	143.18	0.00	0.00	0.00
V_2 (Etalon, acetamiprid, 200 g/L + lambda-cihalotrin, 150 g/L)	0.15	11.25	0.75	1.00	1.88	6.67	8.89	16.71	93.76	91.89	86.33
V_3 (acetamiprid 200 g/L + lambda-cihalotrin, 150 g/L)	0.15	11.63	0.63	0.88	1.75	5.42	7.57	15.05	94.93	93.10	87.69
V_4 (acetamiprid 200 g/L + lambda-cihalotrin, 150 g/L)	0.20	12.00	0.13	0.25	1.25	1.08	2.08	10.42	98.99	98.10	91.48
DEM 95%, p.- 5%			0,45	0.59	0.49	3.12	3.84	4.27	3.25	4.06	3.59

Another criterion in determining the efficacy of the products is the pest density relative to the initial value. Comparing results based on this index across the three records, the lowest indices were observed in the fourth variant (10.50; 2.17; 0.00%).

It is well known that the most convincing criterion for determining the biological efficacy of the products is the reduction in pest density relative to the control, expressed as a percentage. Comparing the experimental variants based on this index shows that on the third day after treatment, absolute reduction was achieved in the fourth variant, which significantly surpassed both the standard and the third variant. This variant also showed a reduction of over 95% on the seventh day after treatment. Regarding the third variant, the reduction in pest density ranged from 94.61% to 84.13%, with these indices at the standard level but significantly lower than in the fourth variant.

Based on the research conducted during the growing season of 2023, it was found that the most effective insecticide against the cabbage stem weevil is the one containing 200 g/L acetamiprid + 150 g/L lambda-cyhalothrin, with an application rate of 0.2 l/ha, which ensures a reduction of the pest by 100.00 – 90.20% over 10-12 days after treatment. The same product, at an application rate of 0.15 l/ha, is significantly less effective than the fourth variant, being at the standard level.

Records taken after flowering revealed that the frequency of the gray cabbage aphid attack was above 5-10%, with a ratio of beneficial insects to aphids exceeding 1:30. In this context, the population of the gray cabbage aphid exceeded the Economic Damage Threshold (EDT) and was quite uniform. Therefore, after flowering, on May 20, a second chemical treatment was carried out to control this pest.

From Table 3, it can be seen that the density of the gray cabbage aphid before treatment was quite uniform, varying from 54.88 individuals per plant in the control variant to 56.25 individuals per plant in the fourth variant. Records taken on the third day after treatment demonstrated a significant reduction in the density of the gray cabbage aphid across all experimental variants, with densities of 3.63 individuals per plant in the standard variant, 1.38 individuals per plant in the fourth variant, and 3.50 individuals per plant in the third variant. In the control variant, this index reached 60.13 individuals per plant. In the following two records, the density of the pest continued to increase, reaching 4.88 – 8.00 individuals per plant in the standard variant and 2.13 – 5.38 individuals per plant in the fourth variant.

In the third variant, a reduction in the density of the gray cabbage aphid was also noted; however, this index was significantly lower than in the fourth variant and was at the standard level. In the control variant, the pest density on the fourteenth day after treatment reached 69.75 individuals per plant, which is 1.27 times higher than this index prior to treatment.

Table 2

Biological efficacy of insecticide with 200 g/L acetamiprid + 150 g/L lambda-cyhalothrin in controlling cabbage stem weevil (2023)

Experimental Variants	Application Rate, l/ha	No. density of beetles per model plant				Pest density, as % compared to the initial value, on the X day after treatment (see below no.)			Pest density reduction compared to control variant, as %, on the X day after treatment (see below no.)		
		Before treatment	On the X day after treatment (see below no.)								
			3	7	14	3	7	14	3	7	14
V_1 (Control)	untreated	5.63	6.75	7.00	7.50	119.89	124.33	133.21	0.00	0.00	0.00
V2 (Standard, acetamiprid, 200 g/L + lambda-cyhalothrin, 150 g/L)	0.15	5.75	0.5	0.63	1.13	8.70	10.96	19.65	92.75	89.43	81.66
V3 (acetamiprid, 200 g/L + lambda-cyhalothrin, 150 g/L)	0.15	5.88	0.38	0.5	1.0	5.46	8.50	17.01	94.61	91.8	84.13
V4 (acetamiprid, 200 g/L + lambda-cyhalothrin 150 g/L)	0.20	6.00	0.0	0.13	0.63	0.00	2.17	10.50	100	97.91	90.2
DEM 95%, p. - 5%			0.31	0.34	0.34	3.25	4.17	5.29	5.89	4.24	5.16

Table 3

Biological efficacy of insecticide with 200 g/L acetamiprid + 150 g/L lambda-cyhalothrin in control of gray cabbage aphid (2023)

Experimental Variants	Application Rate, l/ha	No. density of beetles per model plant				Pest density, as % compared to the initial value, on the X day after treatment (see below no.)			Pest density reduction compared to the control variant, as %, on the X day after treatment (see below no.)		
		Before treatment	On the ..... day after treatment (see below no.)								
			3	7	14	3	7	14	3	7	14
V1 (Control)	untreated	54.88	60.13	64.38	69.75	109.57	117.31	127.10	0.00	0.00	0.00
V2 (Standard, acetamiprid, 200 g/L + lambda-cyhalothrin, 150 g/L)	0.15	55.63	3.63	4.88	8.00	6.53	8.74	14.38	94.04	91.81	86.75
V3 (acetamiprid, 200 g/L + lambda-cyhalothrin, 150 g/L)	0.15	56.00	3.50	4.75	7.88	6.25	8.48	14.07	94.30	92.08	87.01
V4 (acetamiprid, 200 g/L + lambda-cyhalothrin, 150 g/L)	0.20	56.25	1.38	2.13	5.38	2.45	3.79	9.56	97.76	96.46	91.17
DEM 95%, p. - 5%			2.07	2.01	2.34	3.16	4.07	3.89	3.25	3.31	3.84

The analysis of the reduction in the density of the gray cabbage aphid compared to the initial value showed that both in the standard and in the fourth variant, a reduction was recorded, specifically from 6.53% to 14.38% and from 2.45% to 9.56%. Comparing these variants, it is clear that the deviation is significant. The third variant is significantly lower than the fourth variant and is at the standard level.

The calculation of the reduction of the gray cabbage aphid relative to the control revealed that the highest reduction was achieved in the fourth variant, where this index reached 97.76% on the third day after treatment, significantly exceeding the standard. In the third variant, a much lower reduction was marked, which is significantly lower than in the fourth variant but is at the standard level.

Generalizing the results obtained, it can be concluded that the most effective insecticide against the gray cabbage aphid is the one containing 200 g/L acetamiprid + 150 g/L lambda-cyhalothrin, with an application rate of 0.2 l/ha, which ensures a reduction of the pest at the level of 97.76% – 91.17% over 10-12 days, significantly surpassing the standard. The same product, at an application rate of 0.15 l/ha, provides a reduction of 94.30% – 87.01% over 7-10 days and is at the standard level, but is significantly lower than in the fourth variant

CONCLUSIONS

In 2023, favorable conditions were created for both the growth and development of autumn rapeseed and for the spread and development of the main pest species of this crop.

During the research period, the most intensive development was observed in the rapeseed weevil and the cabbage stem weevil, while after flowering, the gray cabbage aphid showed more intensive growth.

The insecticide containing 200 g/L acetamiprid + 150 g/L lambda-cyhalothrin, with an application rate of 0.15 l/ha, ensured a significant reduction of autumn rapeseed pests at the standard level.

The chemical treatment of rapeseed plants with the insecticide containing 200 g/L acetamiprid + 150 g/L lambda-cyhalothrin, at an application rate of 0.2 l/ha, achieved a reduction of the rapeseed weevil at the level of 98.99% – 91.48%, the cabbage stem weevil at 100.00% – 90.20%, and the gray cabbage aphid at 97.76% – 91.17%, over a period of 10-12 days.

Based on the research conducted and the results obtained, the insecticide containing 200 g/L acetamiprid + 150 g/L lambda-cyhalothrin can be included in the state register as an insecticide for controlling the rapeseed weevil, cabbage stem weevil, gray cabbage aphid, and other rapeseed pests, through 1-2 treatments at an application rate of 0.15 - 0.20 l/ha.

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BIOLOGICAL EFFICIENCY OF SOME INSECTICIDES CONTAINING ACETAMIPRID 200 G/L + LAMBDA-CYHALOMETRIN 150 G/L, IN THE CONTROL OF PLUM PESTS, IN THE CONDITIONS OF THE REPUBLIC OF MOLDOVA

EFICIENŢA BIOLOGICĂ A UNOR INSECTICIDE CU CONŢINUT DE ACETAMIPRID 200G/L + LAMBDA-CIHALOMETRIN 150 G/L ÎN COMBATEREA DĂUNĂTORILOR PRUNULUI, ÎN CONDIŢIILE REPUBLICII MOLDOVA

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Abstract.

The share of fruit crops in the national economy is due to the role that fruits have in food, in preventing and combating some diseases, as well as in increasing the national income. However, the orchards and fruit production are affected by numerous species of animal pests, which in some years multiply considerably, attack all the organs of the fruit trees and cause considerable damage. Plum plantations are attacked by various species of harmful, sucking, carpophagous or defoliating insects both during the vegetation period. The most dangerous pests, the density of which exceeded the economic damage threshold, were the plum saw wasp, the plum seed wasp, the gray plum louse and the plum worm. In combating plum pests, satisfactory results were obtained by using with the insecticide with the active substance acetamiprid, 200 g/L + lambda-cihalotrin, 150 g/L, with a consumption rate of 0.25 l/ha, which ensures a reduction of the species Hyalopterus pruni Geoffr. (96.32 - 88,11%), Cydia funebrana Tr., (94.50 – 92.56%), Hoplocampa spp. (92.07 - 92.93%) and Eurytoma schreineri Schr., (95.78%).

Key words: : OSR, Hyalopterus pruni Geoffr., Cydia funebrana Tr., Hoplocampa spp., Eurytoma schreineri Schr., Biological and control particularities

Rezumat.

Ponderea culturilor pomicole în economia națională se datorează rolului pe care au fructele în alimentație, în prevenirea și combaterea unor maladii, precum și în sporirea venitului național. Însă, plantațiile pomicole cât și producția de fructe, sunt afectate de numeroase specii

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de dăunători animali, care în unii ani se înmulțesc în masă, atacă toate organele pomilor fructiferi și produc pagube considerabile. Plantațiile de prun pe parcursul perioadei de vegetație sunt atacate de diverse specii de insecte dăunătoare. sugătoare, carpofage sau defoliatoare. Cei mai periculoși dăunători, densitatea cărora au depășit pragul economic de dăunare, au fost viespile cu ferestrău a prunelor, viespea semințelor de prun, păduchele cenușiu al prunului și viermele prunelor. În combaterea dăunătorilor prunului rezultate satisfăcătoare au fost obținute prin utilizarea insecticidului cu conținut de acetamiprid, 200 g/L + lambda-cihalotrin, 150 g/L, cu norma de consum 0,25 l/ha, care asigură o reducere considerabilă a speciilor Hyalopterus pruni Geoffr. (96,32 - 88,11%), *Cydia funebrana* Tr.,(94,50 - 92,56%), *Hoplocampa* spp. (92,07 - 92,93%) și *Eurytoma schreineri* Schr., (95,78%).

Cuvinte cheie: Rapiţa de toamnă, Hyalopterus pruni Geoffr., *Cydia funebrana* Tr., *Hoplocampa* spp., *Eurytoma schreineri* Schr., Particularități biologice și de combatere.

INTRODUCTION

Establishment and efficient operation of an orchard plantation, along with an in-depth study of the biology, ecology, and high-performance technologies for cultivating fruit tree species, requires detailed research into the species composition of harmful organisms and the development of integrated pest protection systems for fruit trees. Plum plantations are attacked by various species of sucking pests (plum gray aphid, plum scale insect), which, in addition to causing direct damage, cover all external plant organs with sugary excretions on which different fungi from the *Capnodium* genus develop, forming a layer of sooty mold over the affected areas. Many of these pests also serve as vectors for the transmission and spread of various viral diseases [Croitoru *et al.*, 2022].

Among the more commonly encountered defoliating pests are the plum leaf moth, oak processionary caterpillar, yellow-tailed caterpillar, and tortricid moths, among others. However, the most dangerous are considered to be fruit-eating pests, whose larvae attack the fruits, boring galleries that destroy both the pulp and seeds. After the attack, the fruits display galleries filled with excretions and gnaw marks. Among the most frequently encountered species harmful to plums are the black and yellow plum sawflies, the plum seed wasp, the plum worm, and the oriental fruit moth [Panuța and Pamujac, 2008].

Achieving high yields of plums in climatic conditions favorable to the development of pests is almost impossible without the use of insecticides, even if all alternative methods are followed. In such cases, chemical treatments are necessary to reduce pest population density [Croitoru *et al.*, 2021]. When the economic damage threshold is exceeded, several products with various active ingredients and mechanisms of action are approved for combating the main pests of plum trees. In this context, ongoing research is required to test and approve new

phytosanitary products, specifically to determine the biological efficacy of insecticide Lot No. 3, SC, in controlling plum pests.

MATERIAL AND METHOD

The investigation regarding the testing of the insecticide containing acetamiprid (200 g/L) + lambda-cyhalothrin (150 g/L) was carried out in 2023 in the northern region of the Republic of Moldova, specifically in the plum plantations of SRL "Agroselect Vasilcău" in the village of Vasilcău, Soroca district. The selected plantation had experienced fruit damage exceeding 2% in the previous year, with the Stanley variety, which is registered in Moldova. The planting scheme was 6 x 3.5 meters, providing 21 m² per tree. The experiment was conducted in three replications with a randomized, compact layout. Each plot was rectangular, consisting of 5 trees, with an area of 105 m². To isolate the plots, one tree was left between them, and the protective strip consisted of an entire row [Croitoru *et al.*, 2022].

The experiment included four variants: Variant 1 – untreated control; Variant 2 – standard, insecticide with acetamiprid (200 g/L) + lambda-cyhalothrin (150 g/L) at a rate of 0.25 L/ha; Variant 3 – insecticide with acetamiprid (200 g/L) + lambda-cyhalothrin (150 g/L) at a rate of 0.2 L/ha; Variant 4 – insecticide with acetamiprid (200 g/L) + lambda-cyhalothrin (150 g/L) at a rate of 0.25 L/ha.

Before treatment, each plot was marked with color-coded labels depending on the variant, attached to a branch of the trees. The label included information about the variant number, its contents, and the number of replications. The chemical treatments for the experimental lot were performed manually using a portable sprayer. To ensure consistency and to prevent plant burn, treatments were carried out on the same day in the morning during calm weather.

The influence of ecological factors on the development of harmful and beneficial fauna was assessed based on meteorological data from the northern region of Moldova. The biological efficacy of the insecticides was determined according to the requirements and methodological guidelines for testing phytosanitary products (Chișinău, 2002).

RESULTS AND DISCUSSIONS

Both in the northern region of the country and at the agricultural enterprise SRL "Agroselect Vasilcău" in the village of Vasilcău, Soroca district, the climatic conditions, characterized by scorching temperatures and a lack of precipitation that were below the multiyear average, were favorable for the development of pests affecting this crop.

Chemical treatments are most effective for controlling plum sawflies when adult populations and first-instar larvae exceed the economic damage threshold of 10 sawflies per tree or 2-3% of flowers/fruits attacked. Sawflies infest generative organs during flowering or the white bud stage. Female sawflies lay eggs in the sepals or receptacle, covered with a viscous secretion. In 2023, sawfly density exceeded the threshold, and treatments were applied: the first during white bud to early flowering on April 27, and the second to target larvae on May 5.

The assessment of fruit infestation by larvae in the tree canopy was conducted 10 days after the second spraying, on May 15th. For this, 100 fruits from four parts of the canopy of each model tree were examined. Additionally, for a more

thorough evaluation of the effectiveness of the treatments, fallen fruits were analyzed. To facilitate this, the area under the tree canopy was cleared of weeds and plant debris, and previously fallen fruits were removed. The monitoring was conducted twice after flowering, with an interval of 10 days (May 15th 2023, and May 25th, 2023).

Results from the records and the calculation of the biological efficacy of the chemical products are presented in Table 1. According to the data, the proportion of fruit attacked by plum sawflies in the tree canopy ranged from 1.13% in Variant 4 to 14.25% in the control variant. The lowest number of attacked fruits was found in Variant 4, and this index is at the level of the standard.

The results obtained in Variant 3 (2.93%) demonstrate that the level of fruit attack is 4.86 times lower compared to the control, and this index is significantly lower than both the standard and Variant 4.

In the analysis of fallen fruits attacked by sawflies, it was found that the smallest number of damaged fruits was in Variant 4 (2.88 fruits per tree), which matches the standard (3.00 fruits per tree). In Variant 3, there were 4.25 fruits per tree, which is 9.59 times lower than in the control, but still significantly higher than both Variant 4 and the standard.

The calculation of the reduction in fruit attack compared to the control revealed that the highest biological efficacy was achieved in Variant 4, with a reduction of 92.07% in attacked fruits in the tree canopy and 92.93% reduction in fallen fruits attacked by sawflies. These indices significantly exceed those of Variant 3 and are on par with the standard. In Variant 3, the biological efficacy was 79.44% and 89.57%, which is significantly lower than both Variant 4 and the standard.

Based on the results above, it can be concluded that the most effective treatment for controlling plum sawflies is the insecticide containing acetamiprid 200 g/L + lambda-cyhalothrin 150 g/L, with an application rate of 0.25 L/ha, which ensures a biological efficacy of 92.07% and 92.93%.

The chemical treatments applied in the experimental lot for controlling sawfly larvae were also aimed at managing the gray plum aphid. The results presented in Table 2 show that the density of gray plum aphids was quite high and uniform. ranging from 35.63 aphids per meter of shoot in the control variant to 37.13 aphids per meter of shoot in Variant 4.

The results of observations conducted at various periods after treatment demonstrated that the lowest population of the plum grey aphid was recorded in the 4th variant. which is at the standard level. In the 3rd variant. the aphid density is significantly higher and exceeds both the 4th variant and the standard.

Analyzing the data on the reduction of the plum grey aphid population compared to the control, it can be observed that the highest values were reached in the 4th variant, and this index is at the standard level. In the 3rd variant, a reduction in pest density of over 90% was achieved only on the third day after treatment,

while in subsequent periods, this index significantly fell behind both the standard and the 4th variant.

Thus, it was established that satisfactory results in controlling the plum grey aphid were achieved in the 4th variant, where the trees were treated with an insecticide containing acetamiprid, 200 g/L + lambda-cyhalothrin, 150 g/L, with a consumption norm of 0.25 l/ha. The plum seed wasp is a species with high ecological plasticity, found on more than 60% of the plantations in the Republic of Moldova. Crop losses caused by this pest can reach up to 80%, and in small plantations, it can cause the total loss of fruit. For accurately determining the timing of chemical treatments, observations were made on the appearance of adults, particularly females, who can lay eggs from the first days. In the year of the research, the beginning of flowering at SRL "Agroselect Vasilcău" in the village of Vasilcău, Soroca district, occurred between April 25-27, with 25-75% petal fall recorded on May 1-2. The first egg-laying was observed on April 26. Therefore, the first treatment to combat the plum seed wasp was carried out on April 27, with the second treatment performed on May 5.

It is well-established that mass fruit drop caused by the plum seed wasp, in mid-ripening varieties, occurs before ripening, corresponding to the third decade of June or early July. Based on this information, during this period, fallen fruit was collected to determine the biological efficiency of chemical treatments. To facilitate this process, weeds and plant debris around the trees were removed 25-30 days prior. To determine the degree of infestation, 100 fallen fruits were collected from four sides under the canopy of each tree in the plot.

The results of the observations and the calculation of biological efficacy are presented in Table 3. From the data, it can be seen that the percentage of fruits attacked by the plum seed wasp varied from 2.75% in the 4th variant to 65.13% in the control variant. The lowest number of attacked fruits was recorded in the 4th variant, and this index is at the standard level. The results obtained in the 3rd variant (5.13%) demonstrate that the level of fruit infestation is 12.70 times lower than in the control variant, although this index significantly lags behind both the 4th variant and the standard.

The calculation of the reduction in fruit infestation compared to the control allowed us to conclude that the highest biological efficiency was achieved in the 4th variant, where this index reached 95.78%, aligning with the standard level. In the third variant, this index was 92.12%, which is significantly lower than both the fourth variant and the standard. Based on the results obtained and the conclusions drawn, it can be observed that the most effective method for controlling the plum seed wasp is to perform two treatments with the insecticide containing acetamiprid (200 g/L) + lambda-cyhalothrin (150 g/L), at a consumption rate of 0.25 l/ha, which ensures a biological efficacy of 95.78%.

Table 1

Biological Efficacy of the Insecticide Containing Acetamiprid 200 g/L + Lambda-Cyhalothrin 150 g/L in Controlling Plum Sawflies

	Consumption norm, L/ha	Number of fruits analyzed per 1 tree, e.g.	From these attack, ex	Number of fallen fruits, ex	From this		Reduction of fruit attack compared to the control, %	
					attacked by plum saw wasps	%	in the crown of the trees	of attacking fallen fruit
V_1 (Control)	Treated with water	100.0	14.25	43.88	40.75	92.87	0.00	0.00
V_2 (Standard, acetamiprid, 200 g/L + lambda-cyhalothrin, 150 g/L)	0.25	100.0	1.25	3.75	3.00	80.00	91.23	92.64
V_3 (acetamiprid, 200 g/L + lambda- cyhalothrin, 150 g/L)	0.2	100.0	2,93	5.88	4.25	79.44	79.44	8957
V_4 (acetamiprid, 200 g/L + lambda- cyhalothrin, 150 g/L)	0.25	100.0	1.13	3.50	2.88	82.29	92.07	92.93
DEM 95%, p-5%			1.53		1.18		4.88	289

Table 2.

Results of Gray Plum Aphid Assessment in the Experimental Lot for Testing the Insecticide Containing Acetamiprid 200 g/L + Lambda-Cyhalothrin 150 g/L (2023)

The variants of the experience	Consumption norm, L/ha	Aphid density per 1 meter of shoot					Reduction in adult density as a percentage compared to the control			
		Before treatment	On observation days				3	5	7	14
			3	5	7	14				
V_1 (Control)	untreated	35.63	39.13	43.50	47.63	51.75	0.00	0.00	0.00	0.00
V_2 (Standard, acetamiprid, 200 g/l + lambda- cyhalothrin, 150 g/L)	0.25	36.25	1.63	2.38	3.25	5.88	95.91	94.09	91.81	87.52
V_3 (acetamiprid, 200 g/l + lambda-cyhalothrin,150 g/L)	0.2	36.88	3.63	4.50	5.88	7.13	91.04	89.02	85.44	83.75
V_4 (acetamiprid, 200 g/l + lambda-cyhalothrin,150 g/L)	0.25	37.13	1.50	2.25	3.13	5.25	96.32	94.55	92.30	88.11
DEM 95%, p-5%			1.89	2.07	2.48	1.69	3.27	3.89	4.07	3.04

Table 3.

Biological Efficiency of the Insecticide Containing Acetamiprid 200 g/l + Lambda-Cyhalothrin 150 g/L in Controlling the Plum Seed Wasp (2023)

The variants of the experience	Consumption norm, L/ha	Number of fruits analyzed per tree, pcs.	Out of these			Reduction in fruit infestation compared to the control, %
			Attacked by the plum seed wasp	Physiologically fallen	Other factors	
V_1 (Control)	untreated	100.0	65.13	6.38	28.49	0.00
V_2 (Standard, acetamiprid, 200 g/L + lambda- cyhalothrin, 150 g/L)	0.25	100.0	2.88	11.75	85.37	95.58
V_3 (acetamiprid, 200 g/L + lambda- cyhalothrin,150 g/L)	0.2	100.0	5.13	12.88	81.99	92.12
V_4 (acetamiprid, 200 g/L + lambda- cyhalothrin,150 g/L)	0.25	100.0	2.75	11.63	85.62	95.78
DEM 95%, p-5%			2.17			3.28

To determine the presence of plum worms and the population density of this pest, and to establish the timing for chemical treatments, two pheromone traps were set up in plantation at the end of April. Monitoring the males in the traps ,15.0 males were captured per trap per day.

Subsequent observations showed that the population dynamics of the first generation of plum worms were increasing, reaching a maximum of 40.0 males per trap per day by May 15. Consequently, the first treatment against the plum worm larvae was carried out on May 25.

It is noteworthy that ongoing observations revealed a fairly uniform density of plum worms, with the maximum value not exceeding 5.4 males per trap per day. The subsequent three treatments were performed on June 10, June 25, and July 15.

To evaluate the biological efficacy of the insecticides, after the second wave of fruit drop, all weeds and previously fallen fruits were removed from under the tree canopies, and the soil was levelled. Fallen fruits were collected and analyzed every five days. After the final observation, which was done a day before harvest, the total number of fallen fruits was calculated, allowing for the determination of the average percentage of fruit infestation per model tree.

During the harvest period, 300 fruits were collected from each model tree, and the proportion attacked by the plum worm was determined. The calculation of biological efficacy, based on the percentage reduction of damage compared to the control, was performed using the previously mentioned formula.

The results of the observations and the calculation of biological efficacy are shown in Table 4. From the table, it can be seen that, out of the total number of fruits collected from a model tree (300 pcs.), the highest level of infestation was recorded in the control variant (75.13 pcs.), which constitutes 25.04%. The lowest number of attacked fruits was found in the fourth variant, where this index was 4.13 pcs. per tree, constituting 1.38% and aligning with the standard level. In the third variant, the number of attacked fruits was 7.88 pcs. per tree, which is 9.53 times lower than in the control variant, but this index still falls short of both the fourth variant and the standard.

The analysis of fallen fruits revealed that the lowest number of fruits attacked by the plum worm was found in the fourth variant, and this index is at the standard level. The calculation of biological efficacy showed that the highest reduction in infestation, both for fruits from the tree and gathered from under the tree canopies, was observed in the fourth variant, with these indices being 94.50% and 92.56%, respectively, aligning with the standard level. In the third variant, the reduction in fruit infestation is ssignificantly maller in the fourth variant and the standard. It is worth mentioning that unique instances of scale insects and other pest species identified before treatment were completely eradicated through chemical treatments aimed at controlling carpophagous pests.

Table 4

Biological efficacy of the insecticide containing acetamiprid 200 g/L + lambda-cyhalothrin 150 g/L, in combating plum borer (2023)

Experimental variants	Consumption norm, L/ha	Number of fruits collected from one tree, pcs.	Out of these			Number of fallen fruits analyzed	Of these, specimens		Reduction in fruit infestation, % compared to the control at harvest	
			Healthy, pcs.	Attacked by the plum worm	In %		Attacked by the plum worm	Affected by other factors	From the tree canopies	Fallen
V_1 (Control)	Untreated	300	224.77	75.13	25.04	100.0	63.88	36.12	0.00	0.00
V_2 (Standard, acetamiprid, 200 g/L + lambda- cyhalothrin, 150 g/L)	0.25	300	295.75	4.25	1.42	100.0	4.88	95.12	94.34	92.36
V_3 (acetamiprid, 200 g/L + lambda- cyhalothrin,150 g/L)	0.20	300	292.12	7.88	2.63	100.0	7.38	92.62	89.51	88.45
V_4 (acetamiprid, 200 g/L + lambda- cyhalothrin,150 g/L)	0.25	300	295.77	4.13	1.38	100.0	4.75	95.25	94.50	92.56
DEM 95%, p-5%				3.59			2.43		4.07	3.89

CONCLUSIONS

During the 2023 growing season, conditions favorable for the development of pests on plum plantations were created.

The most dangerous pests, which exceeded the economic threshold of damage, were the plum sawflies, the plum seed wasp, the plum grey aphid, and the plum worm.

To control these plum pests, six insecticide treatments were conducted in the experimental plot throughout the growing season.

Satisfactory results in pest control were achieved using an insecticide containing acetamiprid (200 g/L) + lambda-cyhalothrin (150 g/L) at a consumption rate of 0.25 l/ha. This treatment provided a reduction in plum grey aphid populations ranging from 96.32% to 88.11% over 10-12 days, a reduction in fruit infestation by plum worms at 94.50% and 92.56%, sawflies at 92.07% and 92.93%, and plum seed wasps at 95.78%.

Based on the conducted research and obtained results, it is recommended to include the insecticide containing acetamiprid (200 g/L) + lambda-cyhalothrin (150 g/L), with a consumption rate of 0.25 l/ha, in the State Register of Phytosanitary Products and Fertilizers. It should be applied in 1-2 treatments against sawflies, plum grey aphid, plum seed wasps, and 2 treatments for controlling plum worms when pest density exceeds the economic threshold.

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THE EFFECT OF ALTERNATIVE TREATMENT METHODS ON THE POPULATION EVOLUTION OF *ARANEAE* IN GOOSEBERRY CULTURE

EFECTELE METODELOR ALTERNATIVE DE TRATAMENT ASUPRA EVOLUȚIEI POPULAȚIEI DE *ARANEAE* ÎN CULTURA DE AGRIȘ

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Abstract.
This paper presents the effects of alternative treatment methods on the population dynamics of spiders in three gooseberry varieties: Invicta, Captivator, and Hinnonmaki Red. The presence of entomophagous spiders is influenced by factors such as prey availability, plant odor, the phenophase of the host plant, climatic conditions, and the type of treatment applied. The treatments were carried out using infusions of Urtica dioica, Mentha piperita, Thymus serpyllum, and Mentha pulegium. The effects of these treatments on the population of entomophagous spiders were studied and compared. Differences were noted based on both the treatment's influence on prey and the odor of the plants used.
Key words: enthomophgous spiders, *Ribes* spp., *Thymus serpyllum, Urtica dioica, Mentha spp.*

Rezumat.
În lucrare sunt prezentate efectele metodelor alternative de tratament asupra evolutiei populației de păianjăni, în cazul a trei soiuri de agriș: Invicta, Captivator și Hinnonmaki roșu. Studiile au fost efectuate în perioada 2023-2024. Prezența păianjănilor entomofagi este influențată de: prezența prăzii, mirosul plantelor, fenofaza plantei-gazdă, condițiile climatice și tipul de tratament aplicat. Tratamentele efectuate au fost făcute cu infuzii de: Urtica dioica, Mentha piperita, Thymus serpyllum și Mentha pulegium. S-au studiat și s-a comparat efectele tratamentelor asupra populației de păianjăni entomofagi. Diferența a fost făcută atât de influența tratamentului asupra prăzii cât și de mirosul plantelor utilizate.
Cuvinte cheie: *Mentha spp*., păianjăni entomofagi, *Ribes* spp., *Thymus serpyllum, Urtica dioica*

INTRODUCTION

Predatory arthropods keep pest populations under control [Michalko *et al.*, 2019]. Among arthropods, spiders play a significant role both in terms of their

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numbers and the diversity of species they feed on [Nadeem *et al.*, 2023]. They appear in crops before other beneficial arthropods, often in sufficient abundance to control pests [Schmidt-Jeffris *et al.*, 2022].

Araneae is the largest order of arachnids, comprising 113 families, 4033 genera, and 46499 species [Selden, 2017]. The architectural and mechanical properties of spider webs are specific to each species [Su *et al.*, 2021]. Spiders migrate from the edge of the crop field towards the center. The effort involved in constructing a web hinders a spider's easy migration and the creation of a new web [Markó *et al.*, 2009].

Globally, research and actions have been undertaken regarding the conservation of predatory spider species. Surveys among experts from different regions of the world have highlighted factors significantly contributing to the decline and extinction of predatory spider species: agriculture, climate change, urbanization, and pollution [Branco Vasco & Cardoso, 2020].

Climate change influences the growth and development time of spiders, their longevity and adult size, and their reproductive capacity [Li & Jackson, 1996]. High temperatures hinder egg hatching - e.g., temperatures above 35 °C affect *Misumenops tricuspidatus* from the *Thomisidae* family. The quality of food also impacts spiders [Li, 2002].

Measures necessary for the conservation of predatory spider species include integrated management practices and highlighting the importance of predatory spiders in controlling harmful entomofauna through education and awareness [Branco, 2020].

Studies conducted by Nelson *et al.* [2021] have demonstrated that:

- spiders without webs feed on a wider range of insect genera than web-weaving spiders.
- in addition to the presence of pests, the spider population is influenced by the odor of plants.

The spider population is also influenced by the phenophase of the host plant [Saksongmuang *et al.*, 2024]. The application of pesticides directly affects predatory spiders—impacting their viability and reproductive capacity—and indirectly by eradicating prey. The abundance of harmful insects promotes the proliferation of spider populations [Markó *et al.*, 2009; Marc *et al.*, 1999].

Web-less spiders are more sensitive to pesticides than web-weaving spiders [Bostanian *et al.*, 2012]. Pesticides affect the nervous system of spiders and, consequently, their sensory system [Barth, 2002].

International Organization for Biological Control (IOBC) rarely includes spiders in testing the non-target effects of pesticides, and only one species is tested per report [Schmidt-Jeffris *et al.*, 2022].

Spiders are indicators of environmental pollution. Based on spider population composition, several European countries have methods for ecological classification of natural habitats [Marc *et al.*, 1999].

MATERIAL AND METHOD

The research was conducted in the experimental field in Domnești commune, Ilfov County. The coordinates of the location are: latitude 44°24'18.4"N, longitude 25°55'45.5"E. The altitude above sea level is approximately 90 meters. The experimental field was established in 2021 in an area where there are no longer gooseberry crops.

The planting distances were 2 meters between rows and 1 meter between rows. The rows were mulched with Geotextile fabric, and the space between rows was mowed.

The experiment was conducted with five variants, each with three replicates, and each replicate had three gooseberry plants (Invicta, Captivator, and Hinnonmaki Red). The treatments used were: infusion of *Urtica dioica*, infusion of *Mentha piperita*, infusion of *Thymus serpyllum*, and infusion of *Mentha pulegium*. The study was conducted in 2023-2024. Treatments were applied monthly, from April to July. One row served as the control.

The technical materials used were: the camera of the Huawei P30 Lite phone and the Olympus OM-D camera with the Olympus ED MSC macro lens.

To achieve the proposed aims and objectives, the following general methods were used: documentary study on the level of knowledge of the research topic, data and biological material analysis and synthesis, field observations, spider and pest identification, preparation of infusions, comparison, and experimentation.

RESULTS AND DISCUSSIONS

In the experimental field, spiders were identified on the ground, stems, and foliage of the gooseberries, which do not spin webs.

Spiders that do not spin webs are harder to observe due to the dense foliage of the gooseberries. Spider webs, regardless of their type, are easier to observe.

Analyzing potential prey was difficult due to the abundance of gooseberry foliage, which made observations possible only on visible spider specimens. The study was conducted without affecting the webs and without analyzing the prey under a microscope.

Various genera of aphids were observed in the spider webs. The difference between the appearance of green aphids, the first spider web, and non-web-spinning spiders is about one week in April.

One month after the appearance of spiders, the first foam of *Philaenus spumarius* **larvae was observed.**

Larvae and adult specimens of *Philaenus spumarius* **were identified in the spider webs.**

In 2023, spider webs were observed on all gooseberry varieties as follows:

a) for the Invicta variety:

- on the control variant, no spider webs were present.

- on the repetition treated with *Urtica dioica* - 2 out of 3 bushes had one web each on each gooseberry.
- on the repetition treated with *Mentha piperita* - a single spider web on one gooseberry.
- on the repetition treated with *Thymus serpyllum* - 3 spider webs on one bush.
- spider specimens do not prefer plants treated with *Mentha pulegium*.

b) for the Captivator variety:

- on the control variant, no spider webs were present.
- on the repetition treated with *Urtica dioica* - all bushes had one spider web each on each gooseberry.
- on the repetition treated with *Mentha piperita* - 2 spider webs on one gooseberry.
- on the repetition treated with *Thymus serpyllum* - 2 spider webs on one gooseberry.
- *the treatment with Mentha pulegium did not positively influence the presence of spiders.*

c) For the Hinnonmaki Red variety:

- on the control variant, spider webs were present on 2 bushes.
- on the repetition treated with *Urtica dioica* - none were observed.
- on the repetition treated with *Mentha piperita* - 1 spider web on a single gooseberry.
- on the repetition treated with *Thymus serpyllum* - 1 spider web on a single gooseberry.
- *the treatment with Mentha pulegium did not positively influence the presence of spiders.*

The presence of spider webs on plants of the Invicta, Captivator and Hinnonmaki Red variety, in 2023 is show in fig.1.

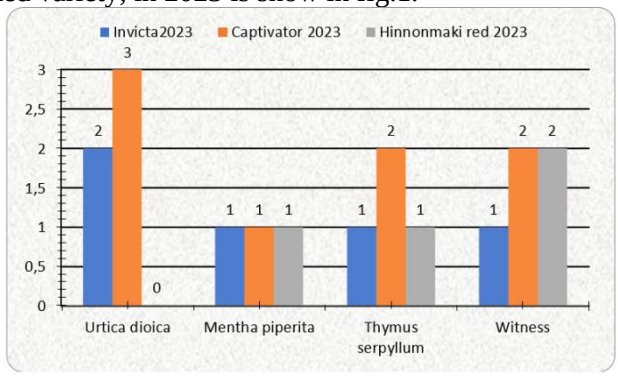

Fig. 1. Presence of spider webs on plants of the Invicta, Captivator and Hinnonmaki Red variety, in 2023

In 2024, spider webs were observed on all gooseberry varieties as follows:

a) for the Invicta variety:

- on the control variant, 2 spider webs on a repetition.
- on the repetition treated with *Urtica dioica* - 4 spider webs on 2 plants.
- on the repetition treated with *Mentha piperita* - 1 spider web on each of 2 bushes.
- on the repetition treated with *Thymus serpyllum* - 5 spider webs in total on all 3 plants.
- spider specimens do not prefer plants treated with *Mentha pulegium*.

b) for the Captivator variety:

- on the control variant, 2 spider webs on a single plant.
- on the repetition treated with *Urtica dioica* - 4 spider webs on 2 gooseberries.
- on the repetition treated with *Mentha piperita* - 6 spider webs on 3 gooseberries.
- on the repetition treated with *Thymus serpyllum* - 2 spider webs on a single gooseberry.
- *the treatment with Mentha pulegium did not positively influence the presence of spiders.*

c) for the Hinnonmaki Red variety:

- on the control variant, no spider webs were observed.
- on the repetition treated with *Urtica dioica* – 4 spider webs on 2 gooseberries.
- on the plants treated with *Mentha piperita* – 10 spider webs on 3 gooseberries.
- on the plants treated with *Thymus serpyllum* – 6 spider webs on 3 gooseberries.
- *the treatment with Mentha pulegium did not positively influence the presence of spiders*.

The presence of spider webs on plants of the Invicta, Captivator and Hinnonmaki Red variety, in 2024 is show in fig.2.

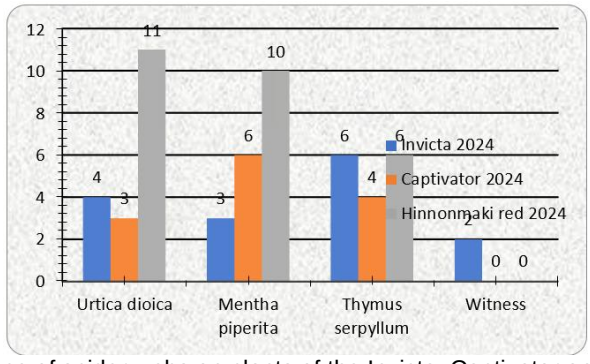

Fig. 2. Presence of spider webs on plants of the Invicta, Captivator and Hinnonmaki Red variety, in 2024

The overall view of the variants and repetitions for the period 2023-2024 is as follows - fig.3 for the Invicta variety, fig.4 for the Captivator variety, fig.5 for the Hinnonmaki red variety :

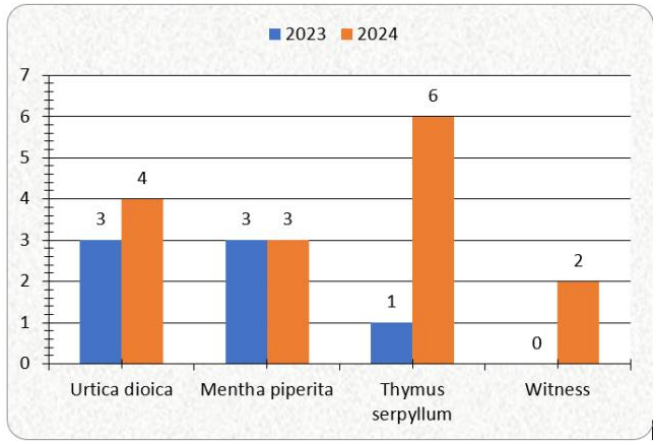

Fig. 3. Situation of spider webs in 2023 and 2024 for the Invicta variety

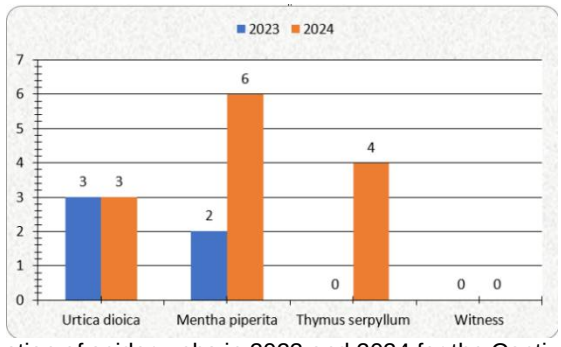

Fig. 4. Situation of spider webs in 2023 and 2024 for the Captivator variety

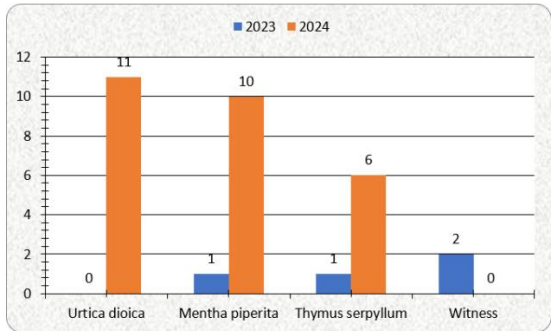

Fig. 5. Situation of spider webs in 2023 and 2024 for the Hinnonmaki Red variety

CONCLUSIONS

Chemical products for plant protection used in conventional treatments for gooseberries are not approved for such crops. Under these conditions, the period of residue in fruits is unknown. Global studies highlight the adverse effects of active chemical substances on humans and beneficial anthropofauna.

The plants used in the alternative treatment methods covered in this study (*Urtica dioica, Mentha piperita, Thymus serpyllum and Mentha pulegium*) have beneficial effects on humans.

Urtica dioica, Mentha piperita, Thymus serpyllum and Mentha pulegium – have different odors and effects on prey and host plants. They have differently influenced the spider population.

It was observed that the spider population was higher in the host plants treated with Urtica dioica, Mentha piperita, and Thymus serpyllum compared to the control plants. The treatment with Mentha pulegium did not positively influence the presence of spiders. Gooseberries treated with Urtica dioica and Mentha piperita had a higher spider population than the untreated variant. The active substances in these treatments did not achieve maximum efficacy against gooseberry pests. In this case, the spiders' prey also included harmful insects.

It was noted that although the treatment with *Thymus serpyllum* was maximally effective against gooseberry pests, the spider population was greater than in the untreated variant. This suggests that:

- the spiders' prey could included insects that do not affect gooseberries.
- the higher spider population in plants treated with *Thymus serpyllum* compared to untreated plants could provide better protection against potential pests.

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THE EFFECT OF ALTERNATIVE TREATMENT METHODS ON THE POPULATION EVOLUTION OF METCALFA PRUINOSA IN GOOSEBERRY CULTURE

EFECTUL METODELOR ALTERNATIVE DE TRATAMENT ASUPRA EVOLUȚIEI POPULAȚIEI DE *METCALFA PRUINOSA* ÎN CULTURA DE AGRIȘ

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Abstract.
European level research has shown that Metcalfa pruinosa attacks over 300 plant species. The results of this research on the effect of alternative pest control methods in gooseberry cultivation could be applied to other plants of the more than 300 species attacked by Metcalfa pruinosa. The attack capacity of Metcalfa pruinosa is influenced by the following factors: variety tolerance, the phenological stage corresponding to the attack, climatic conditions and the type of treatment applied. The alternative treatment methods investigated in this study involved the application of infusions of: Urtica dioica, Mentha piperita, Thymus serpyllum and Mentha pulegium, plants that have beneficial effects on humans. The applied treatments had different effects, with the most effective being the infusion of Thymus serpyllum across all variants.
Key words: *Mentha* spp., *Metcalfa pruinosa*, *Ribes* spp., *Thymus serpyllum, Urtica dioica*

Rezumat.
În lucrare sunt prezentate efectele metodelor alternative de tratament asupra evolutiei populației de Metcalfa pruinosa, in cazul a trei soiuri de agriș: Invicta, Captivator și Hinnonmaki roșu. Studiile au fost efectuate în perioada 2021-2024. Capacitatea de atac a speciei Metcalfa pruinosa este influențată de: toleranța soiului, fenofaza corespunzătoare atacului, condițiile climatice și tipul de tratament aplicat. Tratamentele efectuate au fost făcute cu infuzii de: Urtica dioica, Mentha piperita, Thymus serpyllum și Mentha pulegium. S-au studiat și s-a comparat efectele tratamentelor asupra Metcalfa pruinosa. Tratamentele aplicate au avut efecte diferite, iar eficacitatea cea mai bună în cazul tuturor variantelor a avut-o infuzia cu Thymus serpyllum.
Cuvinte cheie: *Mentha spp., Metcalfa pruinosa*, *Ribes spp., Thymus serpyllum, Urtica dioica*

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INTRODUCTION

Metcalfa pruinosa is an insect from the order *Homoptera*, family *Flatidae*, a polyphagous species that causes significant economic losses in countries from Europe, Asia, and North America.

Studies conducted in southern Romania concluded that *Metcalfa pruinosa* attacks 204 species from 56 families [Bărbuceanu *et al*., 2015]. European-level research has shown that *Metcalfa pruinosa* attacks over 300 plant species [Vlad, 2016].

The first appearance of *Metcalfa pruinosa* in Italy was reported in 1979. In Romania, it was first reported in 2009 [Chriceanu and Gutue, 2011] at Constanța. In western Romania, *Metcalfa pruinosa* was observed in 2010 [Grozea *et al*., 2015; Vlad, 2016]. Its presence was reported in Bucharest in 2011 and in Slatina in 2014 [Bărbuceanu *et al*., 2015]. In Ukraine, the first appearance was recorded in Kyiv in 2016 [Kushnir and Bondareva, 2022]. Global warming will favor the spread of *Metcalfa pruinosa* in the northern areas of the continents [Byeon *et al*., 2018].

Metcalfa pruinosa moves naturally at a speed of 0.5 km/year but can be spread when infested plants are supplied or traded [Vlad, 2016].

In Europe, there are over 22 parasites and predators, the most important of which is *Neodryinus typhlocybae* [Vlad, 2016]. Korean researchers [Baek *et al*., 2024] mentioned that in their country, there are no natural predators for *Metcalfa pruinosa*, but the species can be parasitized by the wasp *Neodryinus typhlocybae*.

Metcalfa pruinosa is a univoltine species with five larval stages, the last two of which are nymph stages. The species does not exhibit sexual dimorphism. The larval development period, under optimal conditions, lasts 42 days. Nymphs appear in May-July, and adults in August [Vlad, 2016]. Adults lay 90 eggs in August [Vlad, 2016]. It overwinters as eggs in the bark of branches on the trees or shrubs it parasitizes. The biological threshold is 10.1°C [Kim *et al*., 2021].

Insect development is limited by a minimum air temperature of 17-20°C, but it is also influenced by other factors [Kushnir and Bondareva, 2022]. There is no correlation made with relative air humidity.

Climate change leads to alterations in the biology and ecology of insects: physiology, population density, adaptation, distribution, and voltinism [Musoli and Saulich, 2012].

Weather conditions favoring the spread of *Metcalfa pruinosa* include temperature and precipitation [Zhao *et al*., 2024].

The invasion of *Metcalfa pruinosa* is favored by hot and dry summers, and large populations have been observed in shaded habitats [Bărbuceanu *et al*., 2015]. *Metcalfa pruinosa* promotes the dissemination of bacteria *Erwinia amylovora* [Bărbuceanu *et al*., 2015], *Pseudomonas syringae pv. actinidiae* and phytoplasmas [Zhao *et al.*, 2024].

MATERIAL AND METHOD

The research was conducted in the experimental field in Domnești commune, Ilfov County. The coordinates of the location are: latitude 44°24'18.4"N, longitude 25°55'45.5"E. The altitude above sea level is approximately 90 m. The experimental field was established in 2021, in an area where there are no other gooseberry crops.

The planting distances were 1 m within the row and 2 m between rows. The rows were mulched with geotextile fabric, and the space between the rows was mowed.

The experiment was carried out with three gooseberry varieties - Invicta, Captivator, and Hinnonmaki Red, in five variants with three repetitions, each repetition containing three plants.

The treatment variants used were infusion of: *Urtica dioica, Mentha piperita Thymus serpyllum* and *Mentha pulegium.* The treatments were applied monthly during the period from April to July. One row was used as a control.

The treatments were applied monthly during the period from April to July. Meteorological data for Domnești (minimum and maximum temperature, minimum and maximum relative humidity, daylight duration, ultraviolet intensity) were taken daily from the website www.weather.com.

To achieve the proposed goals and objectives, the following general working methods were used: documentary study on the level of knowledge regarding the research topic addressed – both nationally and internationally, analysis and synthesis of data and biological material, observation in the experimental field, identification of pests, preparation of infusions, comparison and experimentation.

RESULTS AND DISCUSSIONS

During the 2021-2022 period, no specimens of *Metcalfa pruinosa* were observed in the experimental field. *Metcalfa pruinosa* appeared in the experimental field in 2023.

The periods during which the first specimens and wax coating of *Metcalfa pruinosa* were observed in 2023 and 2024 were different due to varying weather conditions.

At the end of March 2023 and 2024, there were three consecutive days with temperatures above 10 °C. However, in April 2023, a cooling period followed, with daily average temperatures between 5.5-6.5°C, which delayed the hatching of eggs and favored the diapause of larvae that might have emerged. The first specimen of *Metcalfa pruinosa* was observed on the gooseberry variety Invicta on May 15, 2024, before the treatment was applied. The evolution of temperatures and the biological threshold are show in fig.1.

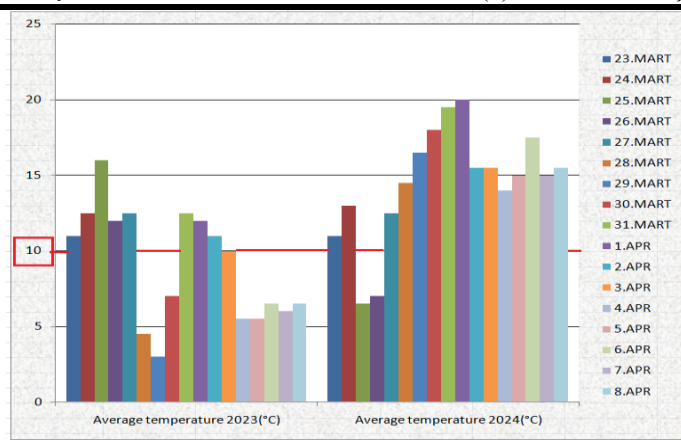

Fig.1. Evolution of temperatures from March 23, 2023, to April 6, 2023, and March 23, 2024, to April 6, 2024

The average daily temperatures were higher in 2024 than in 2023. This influenced both the biology of the gooseberry plants and the *Metcalfa pruinosa* species.

In 2023, the first wax coating/specimens were observed in the first decade of July, while in 2024, they appeared earlier, at the beginning of June.

The air temperature was higher in 2024 compared to 2023, while the air humidity was lower.

The evolution of temperatures is show in fig.2.

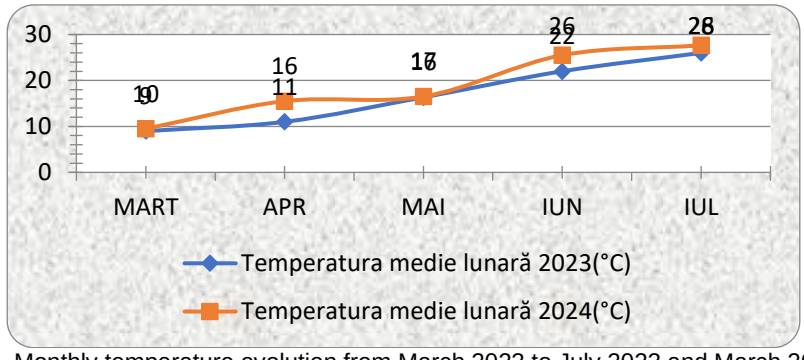

Fig. 2. Monthly temperature evolution from March 2023 to July 2023 and March 2024 to July 2024

From March to July of the years 2023-2024, the relative humidity of the air exhibited the following trend (fig.3):

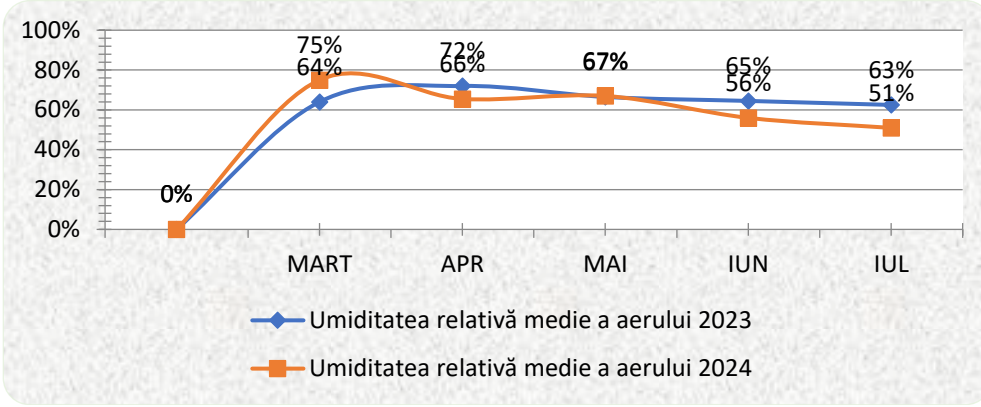

Fig. 3. Average relative humidity of the air from March to July in the years 2023 and 2024

In 2023, in the experimental field, a population of *Metcalfa pruinosa* was observed in July. It attacked the Captivator and Hinnonmaki Red varieties, predominantly on the fruits. The Invicta variety is early, and by the time *Metcalfa pruinosa* was reported, the fruits had already been harvested.

The experiment was carried out with three gooseberry varieties - Invicta, Captivator, and Hinnonmaki Red, in five variants with three repetitions, each repetition containing three plants.

The situation of plants on which specimens of *Metcalfa pruinosa* or wax have been identified is as follows (fig.4):

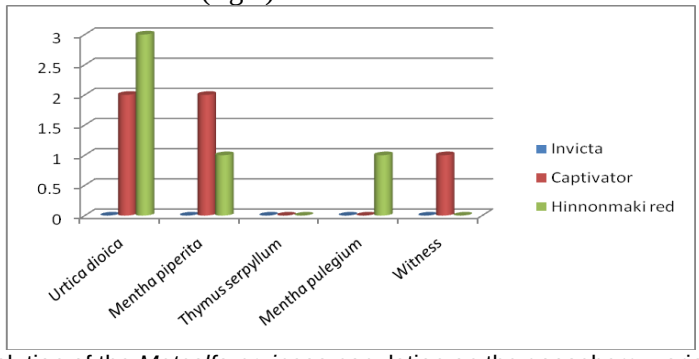

Fig. 4. Evolution of the *Metcalfa pruinosa* population on the gooseberry variety Invicta, Captivator and Hinnonmaki red in July 2023, across treatment variants

In 2024, the *Metcalfa pruinosa* population was reported on the variants treated with *Urtica dioica*, *Mentha piperita* and *Mentha pulegium*. The pest was not observed on the control variant or on the variants treated with *Thymus serpyllum*. The evolution of *Metcalfa pruinosa* population is show in fig.5.

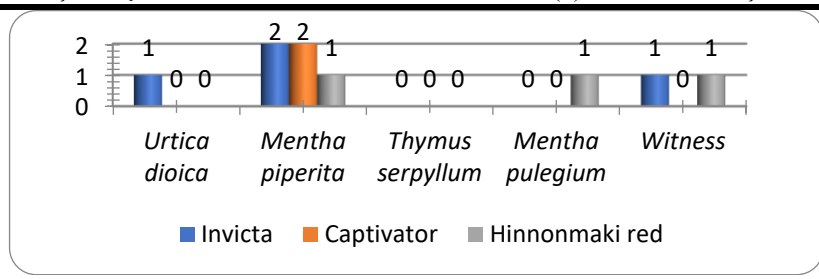

Fig. 5. Evolution of the *Metcalfa pruinosa* population on the gooseberry variety Invicta, Captivator and Hinnonmaki red in June 2024, across treatment variants

Determination of the attack level was performed using the Preda and Solka method, specific to bushes with dense foliage [Vlad, 2016]. This method is based on the severity of the attack and the presence of specific symptoms.Determination of the attack level was performed using the Preda and Solka method, specific to bushes with dense foliage [Vlad, 2016]. This method is based on the severity of the attack and the presence of specific symptoms.

For the gooseberry variety Invicta, the attack levels were as follows:

In 2023: *Metcalfa pruinosa* prefers fruits. The research conducted in 2023 showed that *Metcalfa pruinosa* appeared after the early harvest of the Invicta variety fruits. Consequently, in 2023, the attack level of *Metcalfa pruinosa* on Invicta gooseberries was 0. In 2024: isolated individuals were observed on variants treated with *Urtica dioica* and *Mentha piperita* (attack level 1). Variants treated with *Thymus serpyllum* and *Mentha pulegium* had an attack level of 0.

For the gooseberry variety Captivator, the attack levels were as follows: In 2023: the bushes treated with *Mentha piperita*, *Thymus serpyllum*, and *Mentha pulegium* were not attacked (attack level 0). In the variant treated with *Urtica dioica*, *Metcalfa pruinosa* appeared two weeks after treatment (attack level 1). In the control variant, the attack level was 1 at the beginning of July, and one week later, it increased to 2. In 2024: The bushes treated with *Urtica dioica*, *Thymus serpyllum*, and *Mentha pulegium* were not attacked (attack level 0). Isolated *Metcalfa pruinosa* individuals were observed on the variant treated with *Mentha piperita* four weeks after treatment. The control variant had an attack level of 1 in the first decade of June.

The evolution of attack level is show in fig.6.

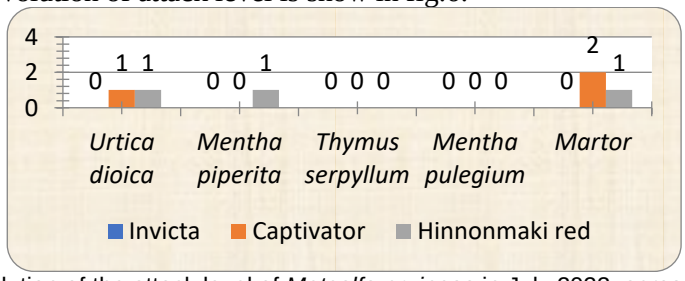

Fig. 6. Evolution of the attack level of *Metcalfa pruinosa* in July 2023, across treatment variants

For the gooseberry variety Hinnonmaki Red, the attack levels were as follows: In 2023: The bushes treated with *Thymus serpyllum* were not attacked (attack level 0). In the variant treated with *Urtica dioica*, *Metcalfa pruinosa* appeared one week after treatment. In the variant treated with *Mentha piperita*, *Metcalfa pruinosa* appeared one week after treatment. The untreated variant had an attack level of 1 (fig.7). In 2024: The bushes treated with *Urtica dioica*, *Mentha piperita*, *Thymus serpyllum*, and *Mentha pulegium* were not attacked (attack level 0). The control variant had an attack level of 1 in the first decade of June.

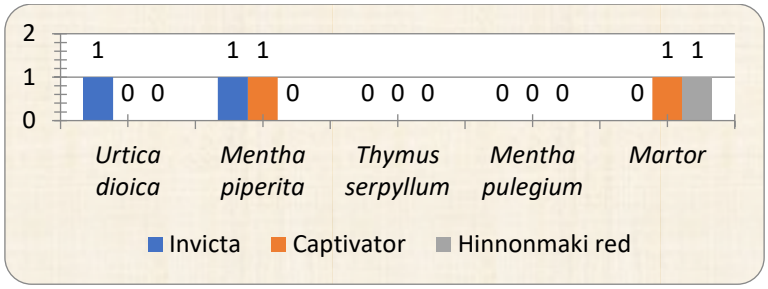

Fig. 7. Evolution of the attack level of *Metcalfa pruinosa* in June 2023, across treatment variants

CONCLUSIONS

The research conducted on gooseberries could also be applied to other plants among the more than 300 species attacked. In the first two years after the establishment of the experimental field, no specimens of *Metcalfa pruinosa* were observed. The appearance of *Metcalfa pruinosa* occurred in the third year after establishment.

Since *Metcalfa pruinosa* overwinters as an egg in the bark, it is important to apply treatments during the dormant period.

The alternative treatment methods investigated in this study involved the application of infusions of *Urtica dioica*, *Mentha piperita*, *Thymus serpyllum*, and *Mentha pulegium*, which have beneficial effects on humans. The treatments were applied monthly.

Metcalfa pruinosa prefers fruits. The research conducted in 2023 showed that *Metcalfa pruinosa* appeared after the early harvest of the Invicta variety fruits. Consequently, in 2023, the attack level of *Metcalfa pruinosa* on Invicta gooseberries was 0. Due to changes in climatic conditions, specifically increased temperatures, in 2024 *Metcalfa pruinosa* appeared earlier than the previous year, and gooseberry fruits ripened earlier. In 2024, the attack level on the Invicta variety was 1 for variants treated with *Urtica dioica* and *Mentha piperita*, and 0 for variants treated with *Thymus serpyllum* and *Mentha pulegium*.

For the Captivator variety, both in 2023 and 2024, no specimens of *Metcalfa pruinosa* and pruine were observed on variants treated with *Thymus serpyllum* and *Mentha pulegium*. For the Hinnonmaki Red variety, both in 2023 and 2024, no

specimens of *Metcalfa pruinosa* and pruine were observed on the variant treated with *Thymus serpyllum*.

The previous research indicates that regardless of the gooseberry variety studied (Invicta, Captivator, Hinnonmaki Red), the treatment with *Thymus serpyllum* had the highest efficiency. However, *Mentha pulegium* has proven to be less effective.

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EVALUATION OF THE TECHNOLOGICAL POTENTIAL OF SOME OLD AUTOCHTHONOUS GRAPEVINE VARIETIES (*VITIS VINIFERA* L.) IN THE CURRENT CLIMATE CONDITIONS OF NORTHEASTERN ROMANIA

EVALUAREA POTENTIALULUI TEHNOLOGIC AL UNOR SOIURI AUTOHTONE VECHI DE VITA DE VIE (*VITIS VINIFERA* L.) ÎN CONDIŢIILE CLIMATICE ACTUALE DIN NORD-ESTUL ROMANIEI

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Abstract.

Old Romanian grapevine varieties are currently preserved in ampelographic collections or planted on very small areas. In the context of recent climate changes, technological characteristics of three old Romanian grapevine varieties (Vitis vinifera L.) for white wines (Rară Albă, Alb Românesc and Plăvaie) were evaluated in the climatic conditions of the northeastern Romania (Copou-Iasi wine-growing center) in two consecutive years (2023-2024). Ripening the grapes in the second part of September, the analyzed varieties produced medium - large grapes (140-220 g), leading to high yields (>19 t/ha), with good sugar accumulations (>185 g/L) and a balanced total acidity (>4.5 g/L as tartaric acid). Analyzed in relation to the current climate conditions, autochthonous varieties showed superior technological characteristics indicating their potential use of for the production of quality white wines in the northeastern area of Romania, also, providing important genetic material for future breeding programs.

Key words: climate change, grape yield, Romanian varieties, technological indices, white wine.

Rezumat.

Soiurile vechi de viță de vie românești sunt menținute în prezent în colecții ampelografice sau se regăsesc plantate pe suprafețe restrânse. În contextul schimbărilor climatice actuale, caracteristicile tehnologice a trei soiuri vechi românești de viță de vie (Vitis vinifera L.) pentru vinuri albe (Rară Albă, Alb Românesc și Plăvaie) au fost evaluate în condițiile climatice din nord-estul României (centrul viticol Copou-Iași), în doi ani consecutivi (2023-2024). Maturarea strugurilor a avut loc în a doua jumătate a lunii septembrie, soiurile analizate producând struguri mijlocii - mari (140-220 g), fiind obținute producții ridicate (>19 t/ha),

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cu acumulări bune de zaharuri (>185 g/L) și aciditate echilibrată (>4,5 g/L acid tartric). Analizate în raport cu condițiile climatice actuale, soiurile autohtone au prezentat caracteristici tehnologice superioare, care au indicat posibilitatea utilizării acestora pentru producerea de vinuri albe de calitate în zona de nord-est a României, de asemenea, oferind un material genetic valoros pentru viitoarele programe de ameliorare a viței de vie.

Cuvinte cheie: indici tehnologici, productivitate, schimbări climatice, soiuri românești, vinuri albe.

INTRODUCTION

Although initially cultivated on small areas, nowadays grapevine occupies a global surface area estimated to 7.2 mha, mainly in the temperate climate of the northern hemisphere [OIV, 2024]. Currently, Romania is one of the world's largest wine producers (4.4 mhL) and fifth-largest among European wine-producing countries [OIV, 2024]. In Romania, there are still growing varieties that date back to the Roman era, when Dacia was populated by Roman colonists who brought new varieties of grapevine, as well as new cultivation procedures and winemaking methods [Puşcă, 2006]. As the number of varieties increased, were selected and multiplied only those that met certain quality and yield conditions. Thus, some varieties disappeared or remained planted only in small areas, requiring a specific temperature regime to reach their biological potential and grape maturity.

Climate change is currently the greatest threat to the viticultural environment, but fortunately, various grapevine varieties managed to adapt to different climate conditions. As proof, today grapevine grows on six out of seven continents [Santos *et al*., 2020]. Recent studies revealed for the Copou-Iasi wine-growing area a significant increase in the average air temperature in the last 50 years, more pronounced in the last 10 years [Filimon *et al*., 2024]. In the last decade, days with extreme temperatures (>30 °C) have increased more than 3.5 times compared to the multiannual average. The rise in air temperature over the past 40 years has been strongly linked to earlier grape ripening and harvest dates for V. vinifera L. white cultivars. This study aims to assess the adaptation of older V. vinifera varieties to the changing climate in northeastern Romania, contributing to global efforts to mitigate the effects of climate change on grapevine cultivation and ensure sustainable vineyard management.

MATERIAL AND METHOD

The study has been carried out on three *Vitis vinifera* L. Romanian varieties for white wines: Rară albă, Alb românesc and Plăvaie, during the 2023 and 2024 growing seasons (Table 1). All varieties are growing in the Ampelographic collection of the Research and Development Station for Viticulture and Winemaking Iasi, Romania; Iasi vineyard, Copou-Iasi wine-growing center, NE of Romania (47°10’ N; 27°35’ E).

Table 1

Origin and pedigree of the studied autochthonous *V. vinifera* L. grapevine cultivars

Variety	Rară Albă	Alb Românesc	Plăvaie
VIVC no.*	9916	3267	9553
Pedigree	Schiras Dr. Houdbine × Chasselas Blanc	Unknown	Beala Debela × Iordan
Grape aspect			

*VIVC: Vitis International Variety Catalogue (www.vivc.de)

Grapevines were 30 years old, with planting distances of 2.2 m between rows and 1.2 m between plants (cca. 3700 plants/ha), grafted on the hybrid rootstock Kober 5 BB. Meteorological data were collected daily by means of a weather station located in the experimental plot, using an AgroExpert® software. Actual heliothermal index (IHr), hidrothermal coefficient (HC), bioclimatic index (Ibcv) and oenoclimate aptitude index (IAOe) were calculated according to the formulas presented by Zaldea *et al*. (2021). Total acidity (g/L as tartaric acid) and soluble solids (°Bx) were determined according to the OIV's Compendium of international methods (OIV, 2019). Gravimetric analyses were conducted using an EW-600 technical balance (Kern, Germany). The assessed technological indices were: grape composition index (berry weight/bunch weight ratio), berries index (number of berries in 100 g of grapes), berry composition index (pulp weight/skin weight + seed weight), yield index (grape must weight/skin weight + seed weight) and glucoacidimetric index (sugar/total acidity ratio). Relative productivity index (no. of grapes/total no. of shoots × medium grape weight) and absolute productivity index (no. of grapes/no. of fertile shoots × medium grape weight) were calculated. Phenological stages were evaluated according to the methodology proposed by Eichhorn and Lorenz (1977). The results were presented as a two-years average data (2023 and 2024), with standard deviation.

RESULTS AND DISCUSSIONS

The climate of the Copou-Iasi wine growing center is temperate continental, with large contrasts between seasons. In the two years of study, the average air temperature of the growing season was higher by about 1.5 to 3 °C compared to the multiannual average (Table 2). The sum of the active temperatures was up to 600 °C higher compared to the multiannual averages, indicating important changes in the thermal regime of the vineyard and higher favorability for varieties with longer vegetation period (increase bioactive period).

Table 2

The values of the main bioclimatic indices during the growing season (april-september) in the Copou-Iaşi wine-growing center (2023-2024)

Climatic elements	2023	2024	Multiannual average (1980-2010)
Average air temperature (°C)	18.7	20.35	17.20
The sum of positive temperatures (Σt°g; °C)	3427.0	3725.8	3168.4
The sum of active temperatures (Σt°a; °C)	3273.5	3669.7	3048.9
The sum of effective temperatures (Σt°u; °C)	1673.5	1909.7	1386.0
Average temperature of: July (°C)	23.0	25.0	21.0
August (°C)	24.6	24.4	20.3
September (°C)	19.9	19.1	15.6
Rainfall during vegetation period (mm)	349.3	400.2	398.1
No. of days with temperatures > 30°C	43	56	17.3
Length of bioactive period (days)	180	176	169.0
Actual heliothermal index (IHr)	2.43	2.88	2.0
Hidrothermal coefficient (HC)	1.07	1.09	1.3
Grapevine bioclimatic index (Ibcv)	8.30	7.86	7.1
Oenoclimate aptitude index (IAOe)	4592.0	5027.5	4106.1

Note: Σt°a - the sum of growing season average temperatures >10°C; Σt°u - the sum of differences between average daily temperatures >10°C and grapevine biological threshold (10 °C); HC = growing season precipitations / (the sum of active temperatures × 10); IHr = hours of real insolation in the growing season × Σt°u x 10^6; Ibcv = (real insolation × Σt°a)/ growing season precipitations × the number of days in the growing season with temperatures >10°C)/10; IAOe = real insolation + Σt°a – (average precipitations – 250).

Ibcv, recommended for the temperate climate, registered an upward trend, from 7.0 (1980-2010) to 8.3 (in 2023), indicating an increase in the humidity deficit, and, at the same time, an abundance of heliothermic resources in the vineyard. Also, the IHr and IAOe values revealed the possibility of producing quality red wines in the Copou-Iasi wine growing center. Moreover, in both years of study, the number of days with temperature >30 °C in the growing season was over 2.5-fold higher compared to the multiannual value. Under these conditions, the bud burst of the analysed varieties was initiated in the mid-April 2023 and earlier in 2024, under the influence of a higher sum of effective temperatures (Table 2).

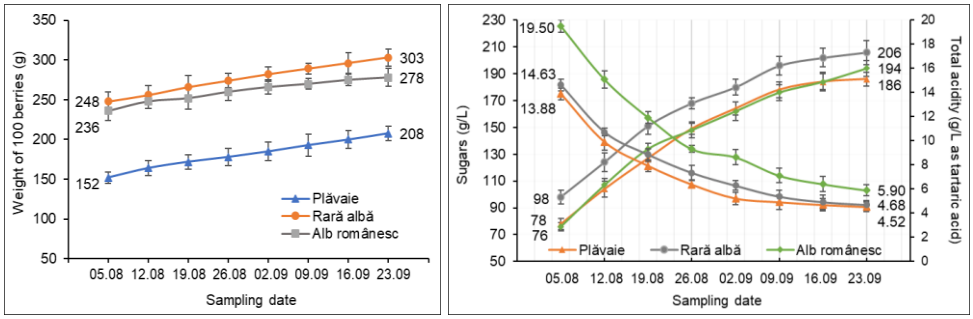
Table 2

The phenological spectrum of the autochthonous grapevine varieties

Variety / Year		Bud burst		Flowering		Veraison		Grape maturity	
		Date	Σt°u (°C)	Date	Σt°u (°C)	Date	Σt°u (°C)	Date	Σt°u (°C)
Plăvaie	2023	22.04	6.0	07.06	273.0	11.08	786.6	04.10	630.9
	2024	05.04	26.9	28.05	295.3	01.08	880.8	23.09	647.9
Rară albă	2023	25.04	13.3	08.06	276.6	08.08	745.1	02.10	650.3
	2024	07.04	34.9	28.05	287.3	29.07	844.2	25.09	705.9
Alb Românesc	2023	25.04	13.3	08.06	276.6	13.08	798.1	07.10	624.6
	2024	05.04	26.9	31.05	317.4	02.08	874.3	26.09	664.1

Note: Σt°u - the sum of temperatures >10°C.

In order to establish the optimal time to harvest, the evolution of the weight of 100 berries (Fig. 1 a), as well as the accumulation of sugars in parallel with the decreasing of total acidity (Fig. 1 b) was studied during the grapes maturation.



(a) (b)

Fig. 1. Grape ripening dynamics of the autochthonous grapevine varieties – weight of 100 berries (a) and sugars vs. total acidity (b)

Thus, at grape maturity, the Rară albă variety, together with the Alb românesc cv., showed the highest weight of 100 berries (>270 g) and the highest concentration of sugars in the must (>190 g/L). Total acidity remained balanced, with lower values in the grapes of the Rară albă and Plăvaie varieties (Table 3).

Table 3

The chemical composition of the grape must at harvest

Variety	Total sugars (g/L)	Total acidity (g/L tartaric acid)	pH	Sugar/acidity ratio	Alcoholic potential (% vol.)
Plăvaie	186±14	4.68±0.42	3.54±0.09	39.74	10.90±0.82
Rară albă	206±11	4.52±0.36	3.68±0.06	45.57	12.10±0.64
Alb românesc	194±6	5.90±0.45	3.32±0.04	32.88	11.40±0.35

Note: Values are presented as the mean of two years data with standard deviation (±).

The Alb românesc variety presented the highest weight of a grape (>230 g), in parallel with a smaller number of grapes per plant, ensuring, similar to Plăvaie variety, a high calculated yield per hectare (>24 t/ha) (Table 4).

Table 4

The production elements of the varieties studied

Variety	Average grape weight (g)	Productivity indices		No. of grapes per plant	Actual yield (kg/plant)	Calculated yield (t/ha)
		RPI	API			
Plăvaie	142±12	139	169	45±4	6.39±1.12	24.10
Rară Albă	178±21	146	221	29±6	5.16±0.96	19.50
Alb Românesc	234±34	218	288	28±7	6.55±1.26	24.84

Note: RPI - relative productivity index; API - absolute productivity index.

The berries of the Alb românesc and Plăvaie varieties had a thicker skin (6.8 % of the berry structure) (Table 5). The Rară albă variety showed the highest value of the composition index (15), closer to those of table grape varieties.

Table 5

Technological indices of grapes at harvest

Variety	Grape composition index	Berries index	Berry composition index	Berry structure			Grape yield index
				Skin (%)	Seeds (%)	Pulp (%)	
Plăvaie	12.78±1.02	49±3	9.04±0.96	6.73	3.22	90.05	3.54
Rară albă	14.61±1.21	32±2	15.03±1.04	4.95	1.29	93.76	3.16
Alb românesc	14.56±1.42	36±4	9.10±0.90	6.83	3.06	90.11	2.62

Note: Values are presented as the mean of two years data with standard deviation (±).

CONCLUSIONS

In relation to the current climatic conditions of the NE Romania, the studied old autochthonous *V. vinifera* L. varieties matured their white medium - large grapes in the second part of September, ensuring high grape yields (>19 t/ha), a good sugar accumulation and a balanced total acidity. Obtained values of the main technological indices indicate the potential use of these old varieties for the production of quality white wines in the Copou-Iaşi wine-growing center, especially of the Rară albă variety, also, providing important genetic material for future breeding programs.

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RESEARCH ON THE POSSIBILITY OF CULTIVATION EXTENSION IN THE NORTH-EAST AREA OF MOLDOVA OF SOME VARIETIES FOR TABLE GRAPES OBTAINED BY ROMANIAN VITICULTURE RESEARCH

CERCETĂRI PRIVIND POSIBILITATEA EXTINDERII ÎN CULTURĂ ÎN AREALUL DE NORD - EST AL MOLDOVEI A UNOR SOIURI PENTRU STRUGURI DE MASĂ OBȚINUTE DE CERCETAREA VITICOLĂ ROMÂNEASCĂ

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Abstract. *The structural improvement of viticultural varieties with varieties for table grapes has always been a concern of breeding researchers. In the context of the climate changes of the last decades, it is necessary to permanently update the knowledge regarding the climatic favorability for table grapes and the expansion of their cultivation area. The paper presents preliminary results regarding the agrobiological and technological value of seven vine varieties obtained by Romanian viticultural research (Gelu, Paula, Muscat Timpuriu de București, Timpuriu de Pietroasa, Auriu de Ștefănești, Argesis, and Mara), for or the highlighting of the most valuable, adapted to the climatic conditions and from the north-eastern area of the country, in order to improve the assortment of varieties for table grapes.*

Key words: table grapes, variety, climate change

Rezumat. *Îmbunătățirea structurală a sortimentelor viticole cu soiuri pentru struguri de masă a constituit în permanență o preocupare a cercetătorilor amelioratori. În contextul schimbărilor climatice din ultimile decenii, este necesară o reactualizare permanentă a cunoştinţelor privind favorabilitatea climatică pentru strugurii de masă şi extinderea arealului de cultură a acestora. În lucrare sunt prezentate rezultate preliminarii privind valoarea agrobiologică și tehnologică a șapte soiuri de viță de vie obținute de cercetarea viticolă românească (Gelu, Paula, Muscat Timpuriu de București, Timpuriu de Pietroasa, Auriu de Ștefănești, Argesis și Mara), pentru evidențierea celor mai valoroase, adaptate condițiilor climatice și din zona de nord-est a țării, în vederea îmbunătățirii sortimentului de soiuri pentru struguri de masă.*

Cuvinte cheie: struguri de masă, sortiment, schimbări climatice

INTRODUCTION

The need to extend the consumption period of fresh grapes and diversify the assortment in viticultural areas with lower thermal conditions have been study

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objectives and continue to concern scientific research [Rotaru *et al*., 2010; Damian *et al*., 2022]. The varietal conveyor for table grapes is established for each vineyard, including only those varieties that best exploit their production potential under the existing ecological conditions. From the analysis of the structure of the table grape variety assortment in Romania, there is a lack of very early and very late ripening varieties, which leads to inefficient use of early ripening potential in regions highly favorable for table grape cultivation [Cichi *et al.*, 2019].

Expanding grapevine varieties for table grapes in cultivation or introducing varieties into a specific area requires an assessment of ecological favorability and thorough studies of their behavior in the context of climate change [Stroe *et al*., 2014]. This paper presents preliminary results regarding the agrobiological and technological value of seven grapevine varieties developed by Romanian viticultural research, highlighting the most valuable ones with superior productive and qualitative potential compared to those currently in cultivation, adapted to climatic conditions, with high commercial value that ensures profitability for growers and meets consumer demands.

MATERIAL AND METHOD

The study was conducted under the climatic conditions of the 2023–2024 viticultural year, with the plant material represented by the grapevine varieties Gelu, Paula, Muscat Timpuriu de București, Timpuriu de Pietroasa, Argessis, Auriu de Ștefănești, and Mara. Among these, only Gelu and Paula are included in the official list of varieties recommended for cultivation in the Copou Iași viticultural center (Table 1).

Table 1

Table grape varieties studied at SCDVV Iași

Variety name	Parents	Authors
Gelu	Coarnă neagră	Calistru Gheorghe, Damian Doina
Paula	Bicane x Aromat de Iași	Calistru Gheorghe, Damian Doina
Muscat Timpuriu de București	Coarnă albă x (Regina viilor x Muscat Perlă de Csaba)	Constantinescu Gherasim, Negreanu Elena
Timpuriu de Pietroasa	Alphonse Lavallee x Regina viilor	Toma Otilia
Auriu de Ștefănești	Frumoasă albă x Augusta	Popa Camelia, Smaranda Gheorghe, Bădițescu Margareta
Argessis	Moldova x Augusta	Bădițescu Margareta, Popa Camelia
Mara	Seyve -Villard 12.303 x Ozana	Damian Doina, Calistru Gheorghe, Nechita Ancuța, Savin Costică.

The mentioned varieties are found in the research unit's plantations, cultivated on 80 cm high trunks, using a bilateral cordon training system with short pruning, ensuring 32–40 buds per vine. The applied technology follows the recommendations of viticultural agrotechnics, so all varieties benefit from the same ecopedoclimatic conditions. To assess these varieties' biological production and quality potential, the research focused on observations and measurements regarding the progression of vegetative phenophases, fertility and productivity, and the quantity and quality of the harvest, in direct relation to ecological factors.

RESULTS AND DISCUSSIONS

From the analysis of climate element values, it is observed that in the winter and spring of 2024, the thermal regime was significantly higher, and during June, July, and August, temperatures frequently exceeded 30ºC, making it a very hot summer (Figure 1).

Fig. 1. The evolution of the climatic factors recorded in the Iași Vineyard

The absolute minimum temperatures were within normal limits, without dropping below the frost threshold for grapevine buds, the lowest temperature being -15.5°C in January. Between April and August, a precipitation deficit was recorded each month, totaling 77.4 mm. However, due to the very large amounts of rainfall in September (150.2 mm compared to 56.9 mm), the total precipitation during the active growing season was 400.2 mm, exceeding the multiannual average of 384.3 L/m².

Given the climatic conditions described, the studied varieties went through all the phenophases specific to the active growing season, starting with bud burst, which occurred between April 3rd and 9th, under a cumulative useful thermal balance (Σt°u) between 20.5 and 51.3 °C (Table 2).

Table 2

The progression of the vegetative phenophases of table grape varieties cultivated in the Iași Vineyard under the climatic conditions of the year 2024

Variety name	Bud burst		Flowering		Veraison		Ripening	
	date	Σt°u	date	Σt°u	date	Σt°u	date	Σt°u
Gelu	3.IV	20.5	01.VI	337.8	22.VII	720.1	23.VIII	442.1
Paula	5. IV	26.9	27.V	289.8	13.VII	613.5	09.VIII	380.8
Muscat Timpuriu de București	3. IV	20.5	26.V	290.1	14.VII	635.5	09.VIII	358.8
Timpuriu de Pietroasa	4. IV	23.7	27.V	293.0	19.VII	722.2	12.VIII	324.2
Auriu de Ștefănești	5. IV	26.9	29.V	300.7	16.VII	660.7	12.VIII	358.6
Argessis	9. IV	51.3	01.VI	307.0	05.VIII	898.1	11.IX	505.6
Mara	5. IV	26.9	28.V	295.3	31.VII	867.2	16.IX	612.0

Flowering took place between May 26th and June 1st, when the cumulative useful thermal balance values exceeded 289.8 °C, and grape veraison was marked by the Paula variety (July 13th), followed by Muscat timpuriu de București (July 14th) and Auriu de Ștefănești (July 16th). The physiological processes that condition the ripening phase were influenced by the high temperatures, allowing the grapes to be consumed starting from the first decade of August, specifically August 9th (Paula and Muscat timpuriu de București), and after September 11th for the late-ripening varieties, Argessis and Mara, from ripening stages IV–V.

The fertility and productivity of the varieties, assessed through the percentage of fertile shoots, fertility coefficients, and productivity indices, were normal, reflecting the known biological potential of each variety. The absolute fertility coefficients were above 1.0 for all varieties, with Gelu (1.31) and Mara (1.43) showing superior values, while the relative coefficients ranged between 0.48 and 1.32. The results regarding the fruiting capacity indicate that these varieties show good adaptability to the conditions of the Copou Iași viticultural ecosystem (Table 3).

Table 3

Fertility and productivity elements of table grape varieties

Variety name	Fertile shoots, %	Fertility coefficients		Productivity indices	
		relative	absolute	relative	absolute
Gelu	62	0.81	1.31	250.95	405.38
Paula	63	0.62	1.04	272.00	461.22
Muscat timpuriu de București	48	0.48	1.00	158.23	327.00
Timpuriu de Pietroasa	56	0.58	1.05	317.33	571.20
Auriu de Ștefănești	60	0.60	1.00	188.40	314.00
Argessis	57	0.63	1.12	318.57	562.18
Mara	76	1.32	1.43	327.36	355.83

The high temperatures and water deficit during the grape growth and ripening period influenced the yield and its quality parameters (Table 4).

Table 4

The production potential of the studied table grape varieties

Variety name	No. of bunches per vine	Average mass of a bunch, g	Actual yield, kg/vine	Estimated yield, t/ha	Marketable yield, %
Gelu	17	310	5.27	19.96	89
Paula	20	315	6.30	23.86	88
Muscat timpuriu de București	10	327	3.27	12.38	84
Timpuriu de Pietroasa	9	544	4.90	18.54	86
Auriu de Ștefănești	14	314	4.40	16.65	83
Argessis	11	503	5.53	20.95	81
Mara	26	248	6.45	24.42	95

The production potential, determined by the level of elements such as the average number of bunches per vine, the average weight of a bunch, and the effective and calculated yield per hectare, places the Mara variety in first place with 6.45 kg per vine, followed by Paula with 6.30 kg per vine. The effective yield of

grapes achieved by the other genotypes ranged from 3.27 kg per vine for the Muscat timpuriu de București variety to 5.53 kg per vine for the Argessis variety, values that differentiate the varieties in relation to their genetic potential and interactions with environmental factors.

The assessment of commercial value through the percentage of marketable production indicates that the majority of varieties produced over 80% of grapes that meet the requirements for fresh market sales. The qualitative characteristics of the grapes, evaluated by the average weight of 100 berries, sugar concentration, and acidity in the must, along with the gluco-acidimetric index and pulp consistency, complete the knowledge about the behavior of the studied varieties (Table 5).

Table 5

Qualitative characteristics of table grape varieties

Variety name	Average weight of 100 grapes (g)	Sugars (g/L)	Total acidity (g/L tartaric acid)	Gluco-Acidimetric Index	Pulp consistency
Gelu	515	188	3.9	4.8	Crunchy
Paula	390	180	4.4	4.1	Semi-crunchy
Muscat timpuriu de București	505	170	3.9	4.3	Crunchy
Timpuriu de Pietroasa	403	164	4.0	4.1	Crunchy
Auriu de Ștefănești	487	166	4.1	4.0	Crunchy
Argessis	562	160	4.0	4.0	Crunchy
Mara	260	178	4.5	3.9	Semi-crunchy

The sugar accumulations at the time of harvest exceeded 160 g/L for all varieties, while the acidity expressed in g/L of tartaric acid ranged from 3.9 to 4.5, typical for table grape varieties, ensuring a harmonious and pleasant balance highlighted by the value of the gluco - acidimetric index. The pulp consistency was semi-crunchy for the Paula and Mara varieties and crunchy for the other studied varieties.

The qualitative value of the grapes was also assessed through physical-mechanical analyses of one kilogram of grapes (Table 6). The mechanical composition varied from one variety to another, being a genetic characteristic influenced by the specific climatic conditions of the 2023–2024 viticultural year.

Table 6

Physical-mechanical analysis of one kilogram of grapes

Determinations	Gelu	Paula	Muscat timpuriu București	Timpuriu Pietroasa	Auriu de Ștefănești	Argessis	Mara
No. of berries, of which	229	252	354	256	191	158	386
- normal	215	238	220	228	164	130	374
- small, underdeveloped	14	14	134	28	27	28	12
Mass of berries, g	975.02	969.5	980.2	970.8	978.8	962.8	975.2
Mass of rachis (stem), g	24.98	30.5	19.8	29.2	21.2	37.2	24.8
Mass of must, g	703.91	689.3	640.0	580.1	704.0	638.9	704.0
Volume of must, cm^3	654	665	610	540	640	590	700

Mass of pomace, g	269.09	280.2	340.2	390.7	274.8	332.9	271.2
Number of berries/ 100 g of bunch	21	29	21	21	23	14	40

The number of berries per kilogram of grapes ranged from 191 for Auriu de Ștefănești to 386 for the Mara variety, with their total mass being between 962.8 g and 980.2 g. The volume of must obtained from micro vinification of the berries ranged from 540 to 700 cm^3.

The data obtained allowed for the assessment of the technological characteristics of the studied varieties by calculating indices that express their technological, economic, and commercial value, complementing their quality attributes (Table 7).

Table 7

Technological indices of grapes at harvest

Variety name	Bunch Structure Index	Berry Index	Berry Composition Index	Yield Index
Gelu	39.03	21	13.1	2,6
Paula	31.79	29	10.5	2.5
Muscat Timpuriu de București	49.51	21	4.70	1.9
Timpuriu de Pietroasa	33.25	21	5.96	1.5
Auriu de Ștefănești	46.17	23	7.0	2.6
Argessis	25.88	14	14.3	1.9
Mara	39.21	40	9.8	2.6

The values of the technological indices place the studied genotypes in the category of valuable table grape varieties, both quantitatively and qualitatively.

CONCLUSIONS

1. The studied table grape varieties went through the entire phenological spectrum under the conditions of the Copou Iași viticultural ecosystem, specific to the 2023–2024 viticultural year.

2. Fertility and productivity fell within the specific limits for table grape varieties, particularly highlighting the genotypes created at SCDVV Iași. The values of the elements defining quality, especially the size of the bunches, the gluco-acidimetric index, as well as the technological indices, demonstrate that these varieties have adapted well to the eco climate conditions.

3. The production potential realized under the climatic conditions of the 2023–2024 viticultural year confirms the productive capacity of the studied table grape varieties and underscores the need to continue research to highlight the most valuable varieties that are well adapted to climatic conditions, to expand the assortment of recommended and authorized table grape varieties in the Iași vineyard and in the viticultural areas of North-Eastern Romania.

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HEAT CONSUMPTION DURING SELECTIVE PROCESSING OF WHOLE GRAPES FOR RED JUICES

CONSUMUL TERMIC LA PROCESAREA SELECTUVĂ A STRUGURILOR ÎNTREGI PENTRU SUCURI ROȘII

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Abstract.
The processing of grapes of black berry varieties traditionally proceeds according to the in-red method with fermentation on the marc, fully utilizing the phenolic compounds from the solid phase (for red wines).In the case of juices in the absence of the fermentation process, the extraction of biologically active substances (BAS) is problematic. Hygienically valued red juices are almost absent from the market. This study aligns with the series of research projects, and focuses the objective on determining the heat consumption in the selective processing of whole grapes by plasmolysis of the skin, cell destruction and rapid release of anthocyanins, followed by cooling and crushing, separation of the pigmented red juice in the subsequent conservation process. Technical calculations and comparative analysis of thermal consumption and the priorities of applying innovative technology in the production of diet juices in the Republic of Moldova, are presented.
Key words: grapes, juice, innovative technology, calculations, economics.

Rezumat.
Procesarea strugurilor soiurilor cu bace negre decurge tradițional după metoda în-roșu cu fermentația pe boștină, valorificând complet compușii fenolici din faza solidă (vinuri roșii), or în cazul sucurilor în absența procesului fermentativ extracția substanțelor biologic active (SBA) este problematică. Sucurile roșii valoroase igienic aproape că lipsesc pe piață. Acest studiu se aliniază în seria de cercetări și anume, focusează obiectivul determinării consumului termic la procesarea selectivă a strugurilor întregi prin plazmoliza pieliței, destrucția celulară și cedarea rapidă a antocianilor, urmată de răcire și presare, separarea sucului roșu pigmentat în procesul de conservare următor. Sunt prezentate calcule tehnice și analiza consumului termic și prioritățile aplicării tehnologiei progresive în producția de sucuri dietice din R. Moldova.
Cuvinte cheie: struguri, suc, tehnologie inovatoare, calcule, economie.

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INTRODUCTION

The expansion of the areas with red varieties of grapes generates the rise of production. The processing basically proceeds through phase contact during maceration-fermentation on the mark to extract phenolic compounds from the skin of the grapes, which is known to have an antioxidant, anti-radioactive, heart protective effect [Carpov, 1989]. The increase in surfaces, followed by the increase in the volume of the raw material, has also driven to the modernization of the extraction process of biologically active substances (BAS). New innovations such as solid phase agitation, maintenance of the semi-flow regime, used of the roto-vinifier, new-systems under CO_2 equipped with a recirculating system of the must for irrigating the top cap during fermentation. The installations that increase productivity, force the unloading of the container. At the same time, a higher degree of oxidation is observed, along with a loss of aromatic substances and contamination with indigenous microflora [Вакарчук, 1990; Olivieri *et al.*, 1984; Quetsch, 1987].

The technical-economic analysis and the search for a more advantageous processing technology for red grapes, as well as a new product variety, have led us to propose the production of diet red juices using a shortened technology. When heating the skin, thanks to the selective thermal process, ensures the rapid diffusion of pigments, the decontamination of microflora is confirmed and additionally we save energy, and the scheme of the apparatus is abbreviated [Vacarciuc, 2015; Ganea *et al.*, 2010].

First of all, the factors that influence plasmolysis were studied: the temperature, the time of the thermal action, which denote the possibility of diversifying the processing of red grapes in the direction of using at the red juices [Griza and Vacarciuc, 2023**;** Griza *et al.*, 2022]. Thus, the aim of the work is to determine the energy consumption in relation with traditional technologies, having the following objectives: intensifying diffusion, reducing expenses, creating a varied assortment of juices.

MATERIALS AND METHODS

Experiences with various red grape varieties (Alexandrina, Ametist, Negru de Ialoveni, Izabella, Codrinschi) from the "*Codru*" wine region (Botanica, Stăuceni, Ialoveni, Zaicana), harvested at sugar levels between 160-190 g/dm^3 and titratable acidity 8-11 g/dm^3, have allowed to test the juice variants and practically try to call the simplified the technological scheme [Griza *et al.*, 2022]. Grapes of red varieties represent a multi-phase system in which diffusion processes take place due to the penetration of the liquid phase into the capillaries of the solid phase depending on the technological factors: time, temperature, pH and agitation. In the case of the juices production, the following factors are excluded: alcohol, sulfur dioxide, yeast enzymes, etc. (present in wines). The amount of anthocyanins extracted depends on the bio-ecological factors: variety, degree of ripening and the reserve of phenolic compounds in certain microzones.

The short-term selective thermal action (on the skin) on whole grapes (15-20 min./70-80 °C) treated consecutively double: with water and hot juice that ensures cellular plasmolysis with guaranteed release of pigments. It was followed by hydraulic or pneumatic pressing (attenuated), followed by selecting the red must in a volume between 40...50 dal/ton (depending on the variety), which was then directed to clarification and storage. It was used Negru de Ialoveni variety. The grapes were de-stemmed and the crushed must was thermally treated (65 °C, for 2-4 hours), obtaining red juices for conservation and storage. Laboratory analyzes were performed according to standard methods described in the literature.

As a result, the thermo-technological calculations were carried out to determine the energy consumption for whole grapes (per 1 t of processed grapes), in relation to the same mass during the thermo plasmolysis of the crushed must with the heat transfer of the total mass. The thermotechnical calculation was applied according to the methodology - *Processes and separates*, as well as *Technological Equipment in the Food Industry* [Ganea *et al.*, 2010].

$$\mathbf{Q_t = Q_p + G_a + G_{ra} + G_i + G_n}, \qquad (1)$$

The thermal balance is presented – Q_t, in relation to heat consumption (1): t – total; p - product; a -water; ra - radiation; i - installation; n - line losses. Given the presence of the last 4 Gs in both technologies (G_a; G_{ra}; G_i; G_n, the -s are omitted).

Initial dates for the thermal treatment: grapes and must are in relation (2) calculation, from experience grapes - must, m_p - mass of the product, 1000 and 960 kg; specifying the thermal values for the 2 variants: t_1; t_2 (15; 80 °C), at must t_1^*; t_2^* (15, 70) c_p – the specific heat of products: for mustache 4263.82 kg/sec; for grapes 4273.97 kg/sec.

$$\mathbf{Q\,p = G_p\,x\,c_p(t_2 - t_1)} \qquad (2)$$

A comparative thermal calculation of the heating process for the must (M - control) and the grapes (Ex - experimental), using hot water at 90-95 °C was performed. The heat requirement for heating the must or grapes from 15 °C up to 70-80 °C, and the pulp – at 37 °C, that is why the mass was divided into three components: skin (10 %), bunches (4%) and pulp (86 %), respectively: skin 100 kg, bunches 40 kg and pulp 860 kg. In case (M) – the clusters do not participate in the process; the must has an initial temperature of 15^0C, the mass without bunches is uniformly heated to 70 °C. In case (Ex) - thermal treatment of whole grapes, processing of 1000 kg from the temperature of 15 °C (t_2), skin – 100 kg has 80 °C, the bunches - 40 kg reach 60^0C, and the pulp reaches a temperature of 37 °C (t_2^*).

RESULTS AND DISCUSSION

The control variant (same variety, same mass) of grapes - the Negru de Ialoveni grapes were processed by crushing and undergoing a thermal treatment of the must without sulfiting or fermentation. The volume of red juice was experimentally chosen 40 dal per initial ton of grapes, and the pressing was carried out after cooling to 30 °C. In the second case the whole grapes were processed and performed directly in the press tank for heat treatment in laminar - film mode. At the phase boundary the process takes place in 3 phases: heat transfer, mass endo transfers and mechanical diffusion at initial and final determined temperatures.

From table 1, containing the data of the physico-chemical analysis, we observe a higher content of leucoanthocyanins in the experimental samples, compared with the control, but the content is lower of anthocyanins.

The color intensity varies slightly, depending on the degree of maturation and the amount of must used. In contrast, the polymerization index in the experimental juices with limited phase contact was twice lower, they cleared faster and were not subject to phenolic-colloidal disturbances. In terms of quality, the samples of the tasted juices, assessed according to the simple scale of 10 points, the samples had a grade above 8,0 with the aroma of pomace, with a soft balanced taste, which indicates that both juices correspond to the typicality. The temperature analysis in the region of the skin is 70 °C, and in the flesh 37 °C, while in the control 70 °C for the whole meal received. The data according to the content of leucoanthocyanins, phenolic substances and dyes are presented in the table nr. 1

Table 1

Physico-chemical composition and quality of red juice, prepared from the Negru de Ialoveni variety

Physico -chemical indices	BLANK Negru de Ialoveni, 65 °C	Black from Ialoveni 80 °C
Initial temperature, ^{0}C	15	15
Pulp temperature ^{0}C	65	37
Juice temperature ^{0}C	65	37
Mass concentration of:		
- titratable acids, g/dm ^{3}	8.4	8.4
- phenolic substances (F), g/dm ^{3}	0.8	1.3
- leucoanthocyanins (L), mg/dm ^{3}	85.0	180
- anthocyanins (A), mg/dm ^{3}	180.0	170
Color intensity (I), 3mm	0.5	0.7
Key (T)	0.32	0.6
IP* = [(D_{520} -D_{420}) / D_{420}] x 100.% Tasting	150.0	81.0
grade, points, 10	8.0	8.3

*IP – polymerization index

Variant M: 1000 kg of grapes were thermally treated, the must (Q_M) with the initial temperature - (t_1 =15 °C), reaches a temperature of 70 °C in the working room (t_1), and after processing it cools down up to 30 °C (part of the energy is recovered). Next, the heat balance of the grape heating process was determined. Initially, the heat flow given off by the hot agent was calculated:

$$\mathbf{Q_M = G_M / 3600 \times C_M (t_1' - t_1)} \qquad (3)$$

Q_M – the heat flow given off by the hot agent (whistles), W
G_M – mass flow rate, kg/s
C_M – specific heat of combustion, 4263.82 J/(kg·K)
t_1 – the initial temperature of the must, ^{0}C
t_1' – the final temperature of the must, ^{0}C

Thus, according to (3) we calculate:

$Q_M = G_M / 3600 \times C_M (t_1' - t_1) = 960/3600 \times 4263,82 \times 70 - 15 =$ **62536,0 W.sec**

Variant Ex: l a processing of whole grapes 1000 kg, the skin - G_p =100 kg had 80 ^{0} C,

bunches - G_c = 40 kg reached 60 °C, and the pulp - Gpl = 860 kg 37^{0}C, according to (3) we get:

$Q_p = G_p / 3600 \times C_p (t_1' - t_1) = 100 / 3600 \times 4273,97 \times (80 - 15) = 7716,9$ W. sec

$Q_c = G_c / 3600 \times C_c (t_1' - t_1) = 40 / 3600 \times 4273.97 \times (60 - 15) = 2137,0$ W. sec

$Q_{pl} = G_{pl} / 3600 \times C_{pl} (t_1' - t_1) = 100 / 3600 \times 4273.97 \times (37 - 15) = 22462,1$ W. sec

Total Qt = 7716,9 + 2137,0 + 22462,1 = **32316,0 W.sec**

The superimposed calculation of the applied technologies demonstrates the difference in the energy consumed:

$Q = Q_t - Q_m = 62536,0 - 32316,0 =$ **30220,9** W.sec for every 1t of raw material

Taking into account the time consumed, at M = 2 hours (7200 sec), and at Ex = 20 min, and the conversion factor W in kcal, we obtain:

$Q_M = 62536,0 \times 7200 = 45025920$ W x 0,860 = 38722291 kcal

(If 1 Gcal is equivalent to 1 million kcal, then: 38722291/1000000 = **38,723 Gcal**.)

With the new technology:

Qt = 32316,0 x 1200 = 3877900 x 0,860 = 33350112/1000000 = **33,35 Gcal**

The thermal economy is: 38,723 – 33,350 = **5,373 Gcal**, gigocalories per 1 ton of processed grapes.

CONCLUSIONS

From *economic and nutritional* perspectives, it is proposed to diversify the assortment of juices, especially the red ones in the *Codru region, which is characterized by favorable* eco - climatic conditions.

The processing of grapes according to the abbreviated scheme ensures the full extraction of BAS from skin cells, and the diffusion of anthocyanins is in the proportion of 50...60% of the initial content.

The proposed method reduces the energy consumed by 5,373 Gcal, maintains the and significantly decreases the degree of contamination with microflora, although it remains to be specified by how much in future research.

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THE DYNAMICS OF SOIL MOISTURE IN THE VINEYARD PLANTATIONS IN THE IAȘI VINEYARD UNDER CONDITIONS OF WATER AND THERMAL STRESS

DINAMICA UMIDITĂȚII SOLULUI ÎN PLANTAȚIILE VITICOLE DIN PODGORIA IAȘI ÎN CONDIȚII DE STRES HIDRIC ŞI TERMIC

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Abstract. *Drought periods lasting 2-3 years are those with serious consequences for wine plantations, because the effects are felt from the following year, and the restoration of the plantations takes another two to three years. From the analysis of the multiannual data recorded at the SCDVV Iaşi, an increase in the frequency of dry years is noted. The lack of precipitation and their uneven distribution associated with the ever-higher temperatures, led to a sharp decrease in the accessible moisture values from the soil and an increase in the deficit, in certain periods, up to a depth of 150 cm. The paper presents the precipitation regime in the viticultural ecosystem of the Iași vineyard from 2022 to 2024, compared to the multi-year averages, as well as the dynamics of accessible humidity and soil water deficit in conditions of water and thermal stress.*
Key words: precipitation, vines, accessible moisture, soil

Rezumat. *Perioadele de secetă cu durata de 2-3 ani sunt cele cu urmări grave pentru plantaţiile viticole, deoarece efectele se resimt încă din anul următor, iar refacerea plantaţiilor durează alți doi – trei ani. Din analiza datelor multianuale înregistrate la SCDVV Iaşi se constată o creştere a frecvenţei anilor secetoşi. Lipsa precipitaţiilor şi distribuţia lor neuniformă asociată cu temperaturile tot mai ridicate, au dus la scăderea accentuată a valorilor umidităţii accesibile din sol şi creşterea deficitului, în anumite perioade, până la adâncimea de 150 cm. În lucrare este prezentat regimul de precipitaţii din ecosistemul viticol al podgoriei Iaşi din perioada 2022 – 2024, comparativ cu mediile multianuale, precum și dinamica umidității accesibile şi deficitul de apă din sol în condiţii de stres hidric şi termic.*
Cuvinte cheie: precipitații, viță-de-vie, umiditate accesibilă, sol

INTRODUCTION

Vine plantations that are in their fruit-bearing stage are quite resistant to drought due to their deep root systems, which explore the soil for water supply,

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especially if sufficient moisture accumulated in the soil during the autumn and winter, derived from rain and snow [Alexandrescu *et al.*, 1998].

In the Copou Iași vineyard center, in recent years, we have witnessed a decrease in the amount of precipitation and a very uneven distribution of it throughout the year. It has also been observed that after rainy periods of 1-2 years, 1-2 dry or excessively dry years follow, interspersed with normal years [Zaldea *et al*., 2008].

The increasing frequency of drought events can have destructive effects on vineyards when there is a precipitation deficit in the autumn and winter of the previous year, and the quantities recorded in the spring are not sufficient to replenish the water reserves in the deep soil layers from which the vine stumps draw their water [Zaldea *et al*., 2017; Zaldea *et al*. 2021].

The optimal soil moisture for vine cultivation is between 50-80% of the soil's available water capacity (UWC), with higher values being favorable for shoot growth and lower values for berry ripening [Moțoc, 1968].

MATERIAL AND METHOD

For the analysis of precipitation and temperatures, data recorded at the Agroexpert automatic station of SCDVV Iași and the Moldova Iași Regional Meteorological Center were used. To determine soil moisture, samples were taken in layers every 10 cm down to a depth of 150 cm, for each month during the growing season. The results were first expressed as percentages relative to the weight of the dry soil, then as volume percentages.

Using the values of hydro-physical indices, the accessible moisture present in the soil at a given time (Macc) was calculated, expressed in mm, and the deficit in m³/ha and %. To determine the level of available moisture for plants, the current moisture (Macc) was compared to the available water capacity (UWC), previously calculated for the Copou Iași vineyard center

RESULTS AND DISCUSSIONS

Drought periods lasting 2-3 years have serious consequences for vineyards because the disastrous effects of drought are recorded in the second or third year of the drought period, and the recovery of the plantations takes another two to three years. This means that for a period of about six years, grape production cannot cover the expenses incurred. Such a situation has occurred in the last three years, with each year having different characteristics.

The precipitation amounts recorded during the period 2022-2024 were far below normal, resulting in a very uneven distribution. There were months when very low amounts of precipitation were recorded compared to normal, only 4.8 mm in January and 8.2 mm in March 2022, as well as only 5.8 mm in March and 8.6 mm in September 2023 (Table 1).

The rainfall regime during the active growing season (April – September) was only 295.8 mm in 2022 and 349.3 mm in 2023. In 2024, the rainfall regime was 400.2 mm, compared to the normal 384.3 L/m², due to the very large amounts

of rain that fell in September (150.2 mm compared to the normal 56.9 mm).

The total amount of precipitation in 2022 was only 416.8 mm, resulting in a deficit of 172 mm compared to the normal (588.8 mm), while in 2023 it was 509.1 mm, with a deficit of 79.7 mm. It is also worth noting that in the northeastern part of the country, atmospheric and soil drought began in September - October 2021, continued through the winter months, and persisted during the first seven months of 2022. According to our statistics, between 1971 and 2021, a similar situation occurred in 1973, when a precipitation deficit was recorded in every month.

Table 1

Rainfall regime during the period 2022 - 2024

Month	Multiannual value	Rainfall, mm / Year		
		2022	2023	2024
January	27.3	4.8	12.1	61.4
February	26.8	10.0	23.3	15.6
March	34.4	8.2	5.8	53.8
April	46.5	73.6	157.7	34.6
May	63.9	29.2	25.6	59.6
June	81.1	26.6	33.2	65.4
July	81.8	27.8	107.8	61.4
August	54.1	69.0	16.4	29.0
September	56.9	69.6	8.6	150.2
October	49.6	12.6	16.2	-
November	34.1	69.2	92.4	-
December	32.3	16.2	10.0	-
Annual precipitation	**588.8**	**416.8**	**509.1**	**-**
Precipit. vegetation period	**384.3**	**295.8**	**349.3**	**400.2**
Year characteristics		**Very dry**	**Excessively dry**	

Based on the annual and growing season precipitation amounts, as well as the alternation of dry months with normal or rainy ones, the observed years were characterized as "very dry" (2022) and "excessively dry" (2023) [Topor, 1964].

The lack of precipitation during the growing season, combined with high temperatures, often exceeding 30°C, led to the occurrence of atmospheric drought followed by soil drought.

In the Iași vineyard, the lack of precipitation at the end of 2021 and in the first months of 2022, specifically from January to March, resulted in very low levels of accessible moisture starting in April, down to a depth of 150 cm.

Under normal conditions, accessible soil moisture values at the beginning of the growing season should range between 70–90% at depths of 0–100 cm, with an excess of moisture at 100–150 cm. However, the water reserves in the soil were not replenished during the dormant period, as would have been normal (Table 2).

In June, the lack of precipitation led to the worsening of soil drought. Accessible soil moisture at depths of 0–100 cm recorded values between 6–22%, falling within the range between 25% of the active moisture interval (AMI) and the wilting coefficient (WC), which is characterized as "*severe water stress*".

In the following period, the soil water reserve gradually decreased from

month to month due to the increasingly low amounts of precipitation recorded, far below normal values (50–80%), and the soil water deficit increased (Table 3). Thus, in June, July, and August, accessible moisture in the 0–20 cm layer was close to the wilting coefficient (6–17%), and at depths of 20–150 cm, water was difficult or very difficult for plants to access.

Table 2

Accessible soil moisture during the growing season

Depht, cm	IV		V		VI		VII		VIII		IX	
	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%
2022												
0 - 20	32.75	69	22.79	48	2.63	6	6.30	13	7.99	17	11.25	24
20 - 50	50.79	69	44.59	60	9.49	13	30.22	41	13.50	18	16.84	23
50 -100	71.23	66	50.56	47	24.10	22	42.35	40	30.50	28	33.97	32
100 - 150	45.82	71	45.25	70	17.10	27	34.62	54	30.69	48	25.19	39
2023												
0 - 20	23.96	50	13.63	29	23.61	50	14.19	30	9.87	21	1.88	4
20 - 50	48.64	66	51.80	70	41.84	57	26.02	35	16.96	23	8.63	12
50 -100	105.08	98	84.68	79	59.16	55	57.06	53	18.86	18	24.28	23
100 - 150	94.31	146	89.33	139	47.87	74	61.98	96	33.61	52	23.34	36
2024												
0 - 20	29.64	62	24.25	51	13.01	27	9.01	19	2.44	5	30.78	65
20 - 50	50.10	68	38.63	52	14.46	20	6.93	9	10.26	14	58.88	80
50 -100	80.82	75	57.73	54	52.93	49	14.24	13	16.56	15	74.93	70
100 - 150	69.23	107	52.91	82	54.51	85	26.82	42	27.29	42	43.42	67

A similar situation regarding precipitation amounts and accessible soil moisture was recorded in the first months of 2023. However, in April, the first month of the growing season, solid precipitation was recorded in the form of snow (157.7 L/m² compared to the 46.5 L/m² multi-annual average). This helped restore the soil water reserve, and accessible moisture values were in the range of easily and very easily accessible water at depths of 0–100 cm, with excess moisture from 100–150 cm (Table 2).

In May, accessible moisture values dropped significantly in the first layer (0–10 cm), falling within the range of very difficultly accessible water, with values around 29%. In the 10–100 cm layer, accessible moisture values were within optimal limits for the vine, while at 100–150 cm there was an excess of moisture, with values over 90% (Table 2).

Based on the level of accessible water for the vine, in June, accessible soil moisture values were within optimal parameters, between 50–74%.

In July, despite large amounts of precipitation being recorded (107.8 L/m²), accessible moisture values in the 0–70 cm depth dropped below 50%. From this point, we can say that the phenomenon of soil drought was established (Table 2).

In August and September, soil drought worsened due to very low precipitation amounts -16.4 mm compared to 54.1 mm and only 8.6 mm compared to 56.9 mm, respectively. Accessible moisture continued to decrease, reaching values close to the wilting coefficient (WC) in the 0–20 cm layer. In the 20–90 cm

layer, moisture values were between 25% of the active moisture interval (AMI) and the wilting coefficient (WC), which is characterized as "*severe water stress*". From 90–150 cm, soil moisture ranged between 50% and 25% of AMI, described as "*incipient water stress*". The soil water deficit gradually increased along the depth of the profile, up to 150 cm (Table 3).

Table 3

Soil water deficit during the growing season

Depht, cm	IV		V		VI		VII		VIII		IX	
	mc/ha	%	mc/ha	%	mc/ha	%	mc/ha	%	mc/ha	%	mc/ha	%
2022												
0 - 20	148	31	247	52	449	94	412	87	396	83	363	76
20 - 50	232	31	294	40	645	87	438	59	605	82	571	77
50 -100	359	34	566	53	831	78	648	60	767	72	732	68
100 - 150	186	29	192	30	474	73	298	46	338	52	393	61
2023												
0 - 20	236	50	339	71	239	50	334	70	377	79	457	96
20 - 50	254	34	222	30	321	43	480	65	570	77	654	88
50 -100	21	2	225	21	480	45	501	47	883	82	829	77
100 - 150	-	-	-	-	166	26	25	4	309	48	411	64
2024												
0 - 20	179	38	233	49	345	73	385	81	451	95	168	35
20 - 50	239	32	354	48	595	80	671	91	637	86	151	20
50 -100	264	25	495	46	543	51	929	87	906	85	322	30
100 - 150	-	-	115	18	100	15	376	58	372	58	210	33

In 2024, at the beginning of the growing season, due to precipitation levels close to normal in the Copou Iași viticultural center, accessible soil moisture in the 0–100 cm layer was optimal, between 62–75%, and from 100–150 cm, there was excess moisture.

In the following months (May–August), as a result of increasingly low precipitation levels, soil moisture gradually decreased from month to month. By the end of August, accessible soil moisture levels were far below optimal for the vine throughout the soil profile. The presented data shows that average values in the 0–100 cm layer ranged between 5–15%, placing them in the range of water very difficultly accessible for the vine, between 25% of AMI and the wilting coefficient (WC), which is characterized as "*severe water stress*".

In September, due to very large amounts of precipitation being recorded - more than double the normal values (150.2 mm compared to 56.9 mm) - soil moisture was restored throughout the soil profile (0–150 cm), with values in the range of very easily accessible water (65–80%).

CONCLUSIONS

1. Drought can be predicted as a destructive phenomenon for the vine, especially when a precipitation deficit is recorded in the fall and winter of the

previous year, and spring rainfall is insufficient to restore water reserves in the deeper soil layers from which the roots draw nourishment.

2. In the years 2022–2024, the lack of precipitation during the growing season, combined with high temperatures, often exceeding 30°C, led to the occurrence of atmospheric drought followed by soil drought. Thus, the observed years were characterized as "*very dry*" and "*excessively dry*".

3. Drought periods lasting 2–3 years are particularly detrimental to vineyards, as the effects on vegetative growth and productive potential of the vines are noticeable starting from the second or third year of drought.

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THE BEHAVIOR OF SOME APPLE VARIETIES CULTIVATED IN SUPERINTENSIVE SYSTEM, IN FĂLTICENI FRUIT GROWING BASIN

STUDIUL COMPORTĂRII UNOR SOIURI DE MĂR, ÎN SISTEM SUPERINTENSIV ÎN BAZINUL POMICOL FĂLTICENI

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Abstract.
The purpose of this work is to follow the production of new apple varieties, grafted on a rootstock of low vigor (M9) cultivated in an area devoted to this species, the Fălticeni orchard basin. The work starts from the characterization of the natural environment in which the orchard is located, taking into account measurements regarding the growth vigor of the trees, the resistance to the limiting factors of production, the phenophases of the fruiting organs. However, the most important thing at the end of a fruit growing year is the economic yield given by the plantation, therefore it is important to determine the annual production obtained for each variety. For the observed year, production was satisfactory for all varieties, varying between 42.74 t/ha for the 'Golden D. Reinders' variety and 58.67 t/ha for the 'Szampion' variety. Although the quantity of fruits is important, their quality is equally important, therefore the physico-chemical properties are not a factor to be ignored and that is why periodic analyzes are carried out. Thus, the variety with the highest malic acid content is the 'Szampion' variety with 0.43 g/l ac. malic, at the same time this variety recorded the highest content of soluble dry matter 12.60°Bx.
Key words: apple varieties; productivity; quality; limitative factors.

Rezumat.
Scopul prezentei lucrări este de a urmari producția unor soiuri noi de măr, altoite pe un portaltoi de vigoare mică (M9) cultivate într-un areal consacrat acestei specii, bazinul pomicol Fălticeni. Lucrarea pornește de la caracterizarea cadrului natural în care se află exploatația pomicolă, avand in vedere măsurători privind vigoarea de creștere a pomilor, rezistența la factorii limitativi ai producției, fenofazele organelor de fructificare. Totuși, cel mai important lucru la finalul unui an pomicol îl reprezintă randamentul economic dat de plantație, de aceea este importantă determinarea producției anuale obținute la fiecare soi. Pentru anul urmărit producția a fost una satisfăcătoare pentru toate soiurile, variind între 42,74 t/ha la soiul 'Golden D. Reinders' și 58,67 t/ha la soiul 'Szampion'. Deși cantitatea de fructe este una importantă, la fel de

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importantă este și calitatea acestora, de aceea însușirile fizico-chimice nu sunt un factor de ignorat și de aceea se realizează analize periodice. Astfel, soiul cu cel mai ridicat conținut în acid malic este soiul 'Szampion' cu 0,43 g/l ac. malic, în acelasi timp acest soi a înregistrat și cel mai mare conținut de substanță uscată solubilă 12,60°Bx.
Cuvinte cheie: soiuri de măr, productivitate, calitate, factori limitativi.

INTRODUCTION

Apple culture is the most well-known and widespread in areas with a temperate climate and apples occupy the 1st place both in terms of production volume, qualitative-food value and their demand on the markets. Culture system has an important influence on the productivity of the apple, on their quality and on the efficiency of the whole system [Ogata *et al*., 1986]. The assortment, together with the climatic, edaphic and biotic factors, represents a determining element in the apple culture, its decisive contribution being reflected both in the quantity and in the quality of the production [Cârdei *et al*., 2007]. For these reasons, the apple assortment was in a permanent dynamic, the cultivated varieties being better and better in terms of productivity and fruit quality [Platon *et al.*, 2014].

The present study involved a series of observations and determinations regarding aspects related to the particularities of growth and fruiting, focusing on: the phenology of the growth and fruiting organs, the vigor of tree growth and the type of fruiting, productive potential and fruit quality. The aim of this study was to improve the assortment of apples for the Fălticeni area, by introducing new varieties from abroad. The general objective was to study the agricultural productivity of four new apple varieties, grown in a super-intensive system, in the pedoclimatic conditions of the Fălticeni orchard basin. In order to achieve this goal we studied tree growth vigor, the phenophases of the fruiting organs stages, fruit production obtained, calculation of the productivity index, the resistance to the limiting factors of production and the analysis of the physico-chemical properties of the fruits of some apple varieties.

The natural setting in which the research took place

Among the factors that play a large role in creating the apple culture biotope, the most important are: the geographical position of the area, the relief, the soil, the climate and the water resources [Branişte *et al*., 1989].

Fălticeni orchard basin is located in the hilly area with the limits of the left bank and the middle course of the Moldova river and on the opposite side, the western limit of the Suceava plateau, which stretches over three terraces between the Șomuzul Mare stream and the Buciumeni stream, the average altitude being 320 m.

Due to its geographical position, the climate in this orchard basin has a continental character with harsh winters and hot and dry summers, generally relatively mild temperate climate. Average temperature is 7-8°C, average annual precipitation is 621 mm, the humidity relative air temperature varied between 74-81%, with a maximum in winter and a minimum in summer, but without affecting the physiological processes in the apple. The dominant winds are those from the N-

W, followed by those from the East and North-East. Considering the major influence of climatic conditions on the growth and fruiting of apple varieties, an analysis of the main climatic factors (temperature, precipitation, relative humidity) and climatic accidents (haze and late spring frosts) that occurred in Fălticeni area is necessary, where the adaptability and behavior study of the recently introduced varieties was completed. The climatic conditions regarding the temperature and relative humidity of the air, from the year 2023 are presented in Figure 1. Predominant soils are argillaceous brown cambic chernozems and podzolite browns.

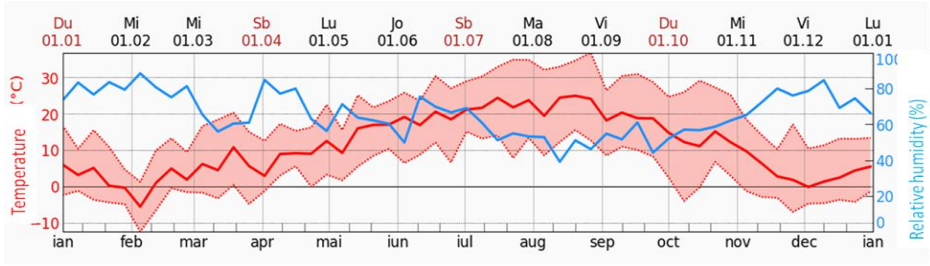

Fig 1. Temperature and relative humidity for Fălticeni, in 2023 (Surce: www.meteoblue.ro)

MATERIAL AND METHODS

The study on the behavior of some apple varieties was carried out in a super-intensive apple plantation, established in 2008, located in the village of Spătărești, Fântâna Mare commune, in the immediate vicinity of Fălticeni Municipality.

The experiment was organized in 2023, within the Florea Orchard, on a cambic chernozem type soil, with a 2.7% humus content, hydrolytic acidity 1.45, nitrogen index 2.32, pH = 5.9- 7.2 the topography of the terrain, the slope is 8%. The plantation was established at a distance of 4 x 1 m, with a density of 2500 trees/ha and the shape of the crown is spindle type.

The biological material used includes 4 varieties of apple (variants): Szampion Arno, Gloster, Golden D. Reinders and Rubinstar. Each variant includes 20 trees, with four repetitions of 5 trees, and the placement of the variants was linear.

The trellis with 4 wires spaced 50 cm apart was used as a means of support.

The soil maintenance system was the weeding of the intervals between the rows and the field worked on the row of trees. The irrigation system used was drip irrigation.

Phytosanitary treatments were carried out to combat the main apple diseases and pests: apple scab (*Venturia inaequalis*), powdery mildew (*Podosphera leucotricha*), apple worm (*Cydia pomonella*), San José scale (*Quadraspidiotus perniciosus*), mining moths (*L. blancardella, L. scitella*), defoliating insects (*Limantria dispar*, *Hedia nubiferana*), acarus (*Panonychus ulmi*, *Tetranychus urticae*). The intensity of the attack used the method described by Bodi and Cârdei [1998] and Istrate *et al.* [2006].

During the experimentation period, observations and determinations were made regarding: the growth vigor of the trees; the phenophases of the fruiting organs stages, the fruit production obtained; productivity index; the fertility coefficient through free pollination and self-fertility; productivity index; resistance to frost and diseases; the physico-chemical properties of the fruits.

RESULTS AND DISCUSSIONS

The main elements for assessing the vigor of the trees were the increase in the area of the trunk section, the length of the annual growths and the height of the trees.

Until the trees begin to bear fruit, the growth of the trunk is greater, being different from one variety to another depending on the biological particularities, the rootstock and the degree of affinity between the variety/rootstock.

After the entry of the trees into the fruit, the increase in the growth of the surface of the trunk section registers low values, as a consequence of the influence of the environmental factors and the fruit production obtained. Knowing the biological particularities of apple varieties, allows the adoption of technologies differentiated by culture depending on: the ecological zone, the vigor and the type of fruiting of the trees; crown shape and planting distance.

Trees growth vigor (expressed by the area of the trunk coross section) in the 15th year from planting for the apple varieties taken in the study recorded values between 49.36 cm^2 ('Golden D. Reinders') and 73.57 cm^2 ('Gloster') (table 1). Celelalte soiuri au avut valori de 53.40 cm^2 ('Szampion') and 72.61 cm^2 ('Rubinstar') (Table 1).

Table 1

Shoot and height growth, TCSA and trunk diameter, in studied apple tres

Variety	Shoot growth (cm)	Trees high growth (m)	Trunk Cross-Sectional Area (TCSA) (cm^2)
'Gloster'	27.43	3.28	73.57
'Szampion'	23.85	2.85	53.40
'Golden D. Reinders'	22.27	2.54	49.36
'Rubinstar'	29.22	3.42	72.61
Average	25.69	3.03	62.24

The length of the annual growth on the tree is a criterion that must be taken into account regarding the vigor of the trees, constituting an index of characterization of apple varieties, being dependent on the combination of variety-rootstock, environmental conditions, crown shape, agricultural techniques used, the level of the harvest obtained which directly influences vegetative growth [Istrate and Rominger, 1992].

It is the indicator that suggests how the trees vegetated in the previous year. Depending on this, the method of intervention in the tree crown is established in the spring, namely how maintenance and fruiting pruning will be applied.

The average and total length of the annual growth is influenced by the amount of fruit on the tree, the state of the soil supply with water and nutrients, the number and especially the efficiency of phytosanitary treatments

The average length of the annual growth is influenced by the variety, but also by the agricultural techniques applied, being at the same time an indicator of the correlation between the synchronous processes of growth-differentiation-fruiting.

Analyzing the data on the average length of annual growth recorded in the apple varieties studied, the 'Rubinstar' variety stands out with 29.22 cm, followed by 'Gloster' (27.43 cm), 'Szampion' (23.85 cm), the last being 'Golden D. Reinders' with 22.27 cm (Table 1).

The highest values of tree height were recorded for the 'Rubinstar' variety with 3.42 m, followed by 'Gloster' (3.28 m), 'Szampion' (2.85 m) and the lowest values for the 'Golden D. Reinders' variety with 2.54 m (Table 1).

Observations on the phenology of the varieties highlighted the fact that the onset, progress and duration of the vegetation phases were closely linked to the climatic conditions of each year (Table 2).

The beginning of flowering in the apple varieties studied was recorded between 1st of May and 10th of May, and the flowering period overlaps in the four varieties, thus ensuring cross-pollination.

The duration of flowering was 10 days, being influenced by the climatic conditions of this period. In deficient years, the duration of flowering was longer by over 5 days than normal, prolonging the consumption of reserve substances during flowering, with a negative influence on the percentage of set fruits, reducing the production of sour cherries.

For the development of the pollination and fertilization process in good conditions, moderate temperatures of 15 - 17ºC are preferred, which maintain the viability of the stigma, pollen for a longer period of time and allow the flight of bees. In years with late spring, temperatures are sometimes too high and speed up the succession of phenophases, dry out the stigma and shorten the optimal period for pollination and fertilization.

Table 2

Fruiting phenophases of studied varieties, data for 2023

Variety	Start of budding (dates)	Start of of the swelling of the fruit buds (dates)	Blossoming (Limit dates)		Intensity of flowering (grades)	Fruit ripening (interval)
			Start	End		
'Gloster'	5-10th of April	15-20th of April	1st of May	5th of May	4	1-5th of October
'Szampion'					5	15-20th of Seprember
'Golden D. Reinders'					5	20-25th of Seprember
'Rubinstar'					4	25-30th of Seprember

Regarding the intensity of flowering, the 'Szampion' and 'Golden D. Reinders' varieties recorded a very abundant flowering (grade 5) while the 'Gloster' and 'Rubinstar' varieties showed abundant flowering (grade 4).

Regarding the fruit ripening period (harvest season) it also has different dates, falling within the calendar interval 15 IX-5 X. The first variety to be harvested of the 4 is 'Szampion' (15-20 IX), followed by 'Golden D. Reinders' (20-25 IX), 'Rubinstar' (25-30 IX) and the last is 'Gloster' (1-5 X).

Productivity, along with the quality of the harvest, is the main elements pursued in a fruit orchard and on which the economic efficiency of the crop ultimately depends. Studies show that fruit production is influenced by several factors: variety, age, degree of differentiation of fruit buds, fruit setting, crown volume and climatic conditions of the previous year and the harvest year (Table 3).

The production obtained from the apple varieties studied ranged between 18.91 kg/tree (42.74 t/h) for the 'Golden D. Reinders' variety and 25.96 kg/tree (58.67 t/ha) for the 'Szampion' variety.

Table 3

Fruit production and average fruit weight, data for 2023

Variety	Fruit production		Average fruit weight (g)
	Kg/tree	t/ha	
'Gloster'	21.53	48.66	162
'Szampion'	25.96	58.67	183
'Golden D. Reinders'	18.91	42.74	155
'Rubinstar'	20.23	45.72	187
Average	21.66	48.95	171

In terms of productivity, the 'Szampion' variety stood out, with a production of 58.67 t/ha, followed by the 'Gloster' varieties (48.66t/ha), 'Rubinstar' (45.72 t/ha) and 'Golden D. Reinders' (42.74 t/ha).

The average fruit weight (g) recorded the highest values for the 'Rubinstar' variety (187g), followed by the 'Szampion' variety (183 g), 'Gloster' (183 g) and 'Golden D. Reinders' (155 g).

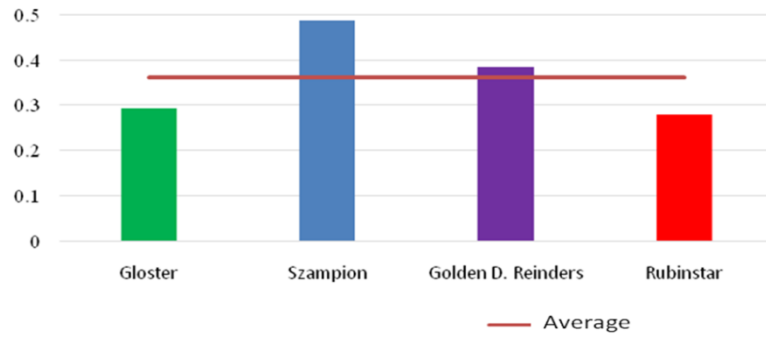

Fig. 2. Productivity index at studied apple varieties, kg fruit/cm^2

The productivity index is calculated as the ratio between the average fruit production in kilograms per tree and the cross-section of the tree trunk in cm^2. The

value of the productivity index is closely related to the increase in fruit load, implicitly the applied agrotechnics. The productivity index obtained falls between the values of 0.486 kg fruit/cm2 for the 'Szampion' variety and 0.278 kg fruit/cm^2 for the 'Rubinstar' variety, the average of the resulting values being 0.360 kg fruit/cm2 (Figure 2).

To determine the physico-chemical properties of the studied four apple varieties, three determinations were made, acidity, firmness and soluble dry substance content (Table 4).

Knowing the malic acid content in apples is important because it determines the taste and state of freshness of the analyzed product. Malic acid content is an important factor for the taste and state of freshness of the product.

From the analysis of the data presented in table 4, it appears that the acidity recorded values between 0.175 g/l malic acid ('Gloster') and 0.425 g/l malic acid ('Szampion'), in the other two varieties, the acidity had values of 0.370 g/l malic acid ('Golden D. Reinders') and 0.280 g/l malic acid ('Rubinstar').

Tabel 4

Fruits physico-chemical characteristics

Variety	Acidity (g/l malic acid)	Firmness (kg f/cm$^{2)}$	Solubile dry matter (°Bx)
'Gloster'	0.175	2.60	12.60
'Szampion'	0.425	1.42	12.55
'Golden D. Reinders'	0.370	2.10	11.87
'Rubinstar'	0.280	2.00	12.20
Average	0.320	2.03	12.31

Firmness is an important characteristic, it helps in determining the direction of valorization and represents the interdependence link between structure and texture. [Irimia, 2013] Fruit firmness recorded values between 1.42 kg f/cm^2 ('Szampion') and 2.60 kg f/cm^2 ('Gloster' variety). The other varieties recorded intermediate values, respectively 2.10 kg f/cm^2 ('Golden D. Reinders') and 2.10 kg f/cm^2 ('Rubinstar').

Knowing the malic acid content in apples is important because it determines the taste and the state of freshness in which the analyzed product is found.

The soluble dry matter content is a characteristic that determines the degree of ripening of the fruit, the more sugars the fruit has, the more ripe the fruit is. Analyzing the apple varieties in terms of soluble dry matter content, 'Gloster' stands out for its high values (12.6°Bx), followed by the 'Szampion' (1255°Bx), 'Rubinstar' (12.2°Bx) and 'Golden D. Reinders' (11.87°Bx).

Analyzing the data on frost resistance, it can be seen that of the 4 varieties, 3 of them ('Szampion', 'Rubinstar' and 'Golden D. Reinders') have a frost resistance rating of 4 (very weakly affected by frost), while the 'Gloster' variety has a rating of 5 (completely resistant) (Table 5).

For drought resistance the situation is identical, 3 of the 4 varieties (‘Szampion’, ‘Gloster’ and ‘Golden D. Reinders’) have a resistance of 4 (very weakly affected by drought) while the ‘Rubinstar’ variety has a score of 5 (completely resistant to drought).

Regarding the intensity of the attack by scab and powdery mildew, the situation differs.

For the attack by scab 3 of the 4 varieties (‘Gloster’, ‘Rubinstar’ and ‘Golden D. Reinders’) have a score of 1 (attacked area between 1-3%), the only variety with a score of 2 (attacked area 4-10%) being the ‘Szampion’ variety.

While for the powdery mildew attack the situation is balanced, 2 of the varieties (‘Gloster’ and ‘Szampion’) have a score of 1 (attacked area between 1-3%) and the other 2 varieties (‘Rubinstar’ and ‘Golden D. Reinders’) have a score of 2 (attacked area 4-10%).

Table 5

Resistance to frost, drought and the intensity of the attack of apple scab and powdery mildew

Variety	Frost resistance (Grade)	Drought resistance (Grade)	Intensity of apple scab attack (Grade)	Intensity of apple mildew attack (Grade)
‘Gloster’	5	4	2	1
‘Szampion’	4	4	1	1
‘Golden D. Reinders’	4	4	2	2
‘Rubinstar’	4	5	2	2

* - the grade for the intensity of the attack on a scale from 1 to 6: 1 for 3 % attacked surface; 2 for 10 %, 3 for 25%, 4 for 50 % and 6 for 100 %.

**frost and drought resistance is appreciated using grades from 0 to 5: 5-completely resistant to frost/drought; 4- very weakly affected; 3- weakly affected; 2-medium resistant; 1- heavily affected; 0- very strongly affected by frost/drought.

CONCLUSIONS

The **pedoclimatic conditions** in this fruit growing basin are among the most favorable for apple culture, the only negative aspect being the uneven distribution of precipitation during May-July interval.

Under the aspect **of productivity**, the variety ‘Szampion’ stood out, with a production of 58.67 t/ha, followed by ‘Gloster’ (48.66 t/ha), ‘Rubinstar’ (45.72 t/ha) și ‘Golden D. Reinders’ (42.74 t/ha).

Average fruit weight (g) registered the highest values in ‘Rubinstar’ variety (187 g), followed by ‘Szampion’ (183 g), ‘Gloster’ (183 g) and ‘Golden D. Reinders’ (155 g).

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TECHNICAL ACTIONS ON THE APEX OF TREES TO OBTAIN ANTICIPATED BRANCHING IN THE AREA OF CROWN FORMATION IN THE FRUIT NURSERY

ACȚIUNI TEHNICE ASUPRA APEXULUI POMILOR PENTRU A OBȚINE RAMIFICAȚII ANTICIPATE IN ZONA FORMARII COROANEI ÎN PEPINIERA DE POMI

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Abstract.

In order to determine the reaction of Gala Schniga SchniCo Red grafted on the biotype M9T337 to different intervention techniques on the tree apex to increase the degree of bud emergence of the anticipated shoots in field II of the tree nursery, the following variants were studied: 1. Free growth (control); 2. Progerbalin LG, 25 ml; 3. Progerbalin LG, 25+25 ml; 4. Progerbalin LG, 25 ml + apical leaf break; 5. Progerbalin LG, 25+25 ml + apical leaf breakage. It was established, that the higher number of anticipated branches in the area of crown formation was registered in the variant treated with the product Progerbalin LG, 25+25 ml (8.0 pcs), as well as their total length was higher in this variant (373.6 cm).

Key words: Apex, variety, treatment, branching.

Rezumat.

Pentru stabilirea reacției soiului Gala Schniga SchniCo Red altoiți pe biotipul M9T337 la diferite tehnici de intervenție asupra apexului pomului pentru sporirea gradului de emitere a lăstarilor anticipați în câmpul II al pepinierii de pomi au fost studiate următoarele variante: 1. Creștere liberă (martor); 2. Progerbalin LG, 25 ml; 3. Progerbalin LG, 25+25 ml; 4. Progerbalin LG, 25 ml + ruperea frunzelor apicale; 5. Progerbalin LG, 25+25 ml + ruperea frunzelor apicale. S-a stabilit, că număr mai mare de ramuri anticipate în zona formării coroanei a fost înscrisă în varianta tratată cu produsul Progerbalin LG, 25+25 ml (8,0 buc), precum şi lungimea lor însumată a fost mai mare în varianta respectivă (373,6 cm).

Cuvinte cheie: Apex, soi, tratare, ramificare.

INTRODUCTION

The Horticulture Development Program for the years 2021-2025 and the Action Plan regarding its implementation consists in the gradual replacement of old-type orchards with new high-density plantations, with a modern assortment, advanced technologies, ecologically balanced, with productions of up to 50-60 t/ha of quality

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fruits destined for export [Babuc *et. al.*, 2013; Peşteanu and Bostan, 2019].

A modern intensive apple plantation is characterized by the implementation of high-performance cultivar/rootstock associations, the use of branched planting material, with superior biological values, which ensure early entry of the trees into fruit and a high, constant productivity of quality fruits [Babuc *et. al*. 2013; Gudumac *et. al*., 2010; Peşteanu and Gudumac, 2010].

The formation of the crown of trees in the nursery from early shoots is the technological operation that determines the height of the trunk and the shape according to which the tree will be led in the orchard [Babuc *et. al*., 2013; Peşteanu and Bostan, 2019].

If it is planned to form the crown from early shoots on apple trees in field II of the apple nursery, a decisive role is played by the hereditary ability of the varieties to emit anticipated shoots [Babuc *et. al.* 2013; Gastol *et. al*., 2012; Peşteanu and Bostan, 2019].

Currently, in countries with advanced fruit growing, to form early shoots in the crowning zone, various technical methods are used such as: breaking the apical leaves of the tree or spraying with growth regulators [Basak and Sozcek, 1986; Gastol *et. al*., 2012; Peşteanu and Bostan, 2019].

In order to increase the degree of emission of early shoots at the base of the crown in apple trees in field II of the orchard, it was proposed to combine the breaking of the apical leaves with the treatment with the growth regulators Progerbalin LG and Gerba 4LG and to study the influence of these techniques on the mentioned index [Basak and Sozcek, 1986; Gastol *et. al*., 2012; Hrotko *et. al*., 1996; Peşteanu and Bostan, 2019].

MATERIAL AND METHOD

The research was carried out during the years 2021-2022 by establishing an experience in the fruit tree nursery of the LLC "Vindex Agro" enterprise, Mălăiesti village, Orhei district. The trees of the Gala Schniga SchniCo red apple variety, grafted on the M 9 rootstock, served as the object of research.

Planting of the rootstocks in field I was carried out in the spring of 2021, in open wells with the help of the hydraulic perforator. The rootstock M9, used for grafting, was of the certified biological category, free of viruses, being imported from the Netherlands. The grafting method used in field I of the tree nursery was the eyelet in plywood. Planting distance – 80x35 cm.

In order to establish the reaction of the variety to different techniques of intervention on the apex of the tree to increase the degree of emission of anticipated shoots in field II of the tree nursery, the variants were studied: V-1. Free growth (control); V-2. Progerbalin LG, 25 ml; V-3. Progerbalin LG, 25+25 ml; V-4. Progerbalin LG, 25 ml + breaking of apical leaves; V-5. Progerbalin LG, 25+25 ml + breaking of apical leaves. The treatment was carried out with the help of a sprayer.

The research was carried out according to the methods recommended for carrying out the experiments under field conditions in the fruit nursery. Each variant of the experiments included 4 repetitions of 20 plants each.

The main results obtained were processed statistically by the dispersion analysis method

RESULTS AND DISCUSSIONS

The development of apple trees in the nursery has an obvious importance on the quality of this planting material, as well as on its behavior after planting in the orchard.

The data obtained regarding the height of the Gala Schniga SchniCo red trees show that the index studied is influenced by the crown formation method (Table 1). Lower values of the studied index were recorded in the control variant (177.0 cm) compared to the other variants (186.0-210.0 cm). Within the variants with a different crown formation method, higher values were obtained in the variants treated with the Progerbalin LG product and where the apical leaves were additionally broken (203.0-210.0 cm) compared to those where regulators of height (186.0-191.0 cm). Within the variants treated with the product Progerbalin LG, a higher height of the trees (210.0 m^3) was recorded when two treatments of 25 ml each plus the breaking of the apical leaves were performed.

The trunk height recorded higher values in the control variant (60.1 cm), while in the variants with the use of different crown formation methods in the school of trees no significant difference was recorded, and the studied index varied from 54.7 to 57.9 cm.

The length of the crown formation zone was directly correlated with the number of anticipated branches formed in that zone. Smaller length of the crown formation zone on the stem was registered in the control variant (15.3 cm), but in the variants where the apex was intervened by various methods, the index in the study varied from 23.0 to 30.1 cm. Lower values of crown formation area within the product Progerbalin LG were recorded within the variants V 4 (23.0 cm) and V 5 (24.1). Within the variants V 2 and V 4, the length of the crown formation zone was 27.8 and 30.1 cm, respectively.

Table 1

The structure of the tree stem by height depending on the method used to form the crown

The method of forming the crown	Tree height	Trunk height	The lenght of the crown zone	The length of the arrow
V 1 (m)	177.0	60.1	15.3	101.6
V 2	186.0	55.0	27.8	103.2
V 3	191.0	54.7	30.1	106.2
V 4	203.0	56.8	23.0	123.2
V 5	210.0	57.9	24.1	128.0
LSD 5%	7.01	2.43	1.23	4.73

The length of the arrow of the trees on the variants taken in the study was correlated with the height of the trees, the length of the trunk and the zone of crown formation and varied from 101.6 to 128.0 cm. Lower values of the index under study were entered in the V 1 variants; V 2; V 3 (101.6-106.2 cm) but higher parameters were obtained in V 4 and V 5 variants (123.2-128.0 cm).

Since the purpose of the research is to obtain trees with a crown formed by anticipated branches through various interventions on the apex, the diameter of the rootstock below and of the graft above the eyes, such as below the first branching and above the last branch in the crown, was studied.

The diameter of the rootstock (19.0-22.0 mm) recorded higher values within the structure of the tree. Within the variants studied, a smaller diameter was obtained in the trees of the control variant (19.0 mm) and Progerbalin LG 25ml + the breaking of apical leaves, and larger in the variants V 2 (22.0 mm) V 3 (21.0 mm) and V 5 (22.0 mm) (Table 2).

Table 2

The diameter of different elements in apple trees of the Gala Schniga SchniCo red variety, in field II of the nursery depending on the crown formation method

The method of forming the crown	Diameter			
	rootstocks	grafted	under the crown	above the crown
V 1 (m)	19.0	14.0	11.0	10.0
V 2	22.0	14.0	13.0	11.0
V 3	21.0	16.0	15.0	11.0
V 4	19.0	14.0	13.0	11.0
V 5	22.0	14.0	13.0	9.0

Further studying the influence of the crown formation method on the investigated index, we note that the trees from the variants where the product Gerba 4LG was used (22.0-26.0 mm) had a more developed diameter compared to the growth regulator Progerbalin LG (19.0 -22.0 mm).

Higher values of the diameter of the graft were obtained within the variant treated with the product Progerbalin LG in the variant V 3 (16.0 mm).

The study carried out on the diameter recorded under the crown of the tree highlights a decrease in the index taken in the research, but the legality previously exposed is valid (11.0-15.0 mm).

The diameter of the axis above the crown recorded the lowest values (9.0-11.0 mm) and was correlated with the development of the trees, but also with the number of branches in the area of crown formation. The larger diameter above the crown was recorded within the product Progerbalin LG in the variants V 2, V 3 and V 4, where the studied index was 11.0 mm.

A lower number of anticipated branches was obtained in the control variant (2 pcs/tree), where it was not recorded on the apex of the eyelet, it grew freely. Higher numbers of branches compared to the control variant were recorded in all the other variants studied, ranging from 4.0 to 8.0 pieces/tree (Table 3).

More obvious effectiveness on the formation of anticipated branches in the crown area of the trees in the Gala Schniga SchniCo red variety was obtained in the V 3 variant, when the apex of the tree was treated 2 times with the product Progerbalin LG in a dose of 25 ml. The single treatment with the product Progerbalin LG in the dose of 25 ml recorded lower values than in the previous

version (6.0 pcs/tree).

The variant treated once with Progerbalin LG in a dose of 25 ml (V4) and twice (V5) with the same amount of product plus the breaking of the apical leaves in both variants had a negative influence on the formation of lateral branches, constituting 4.0 and, respectively, 5.0 pcs/tree.

Results obtained in the framework of the research carried out in the Republic of Moldova by Pește anu A., Bostan M. (2019) within the varieties Golden Reinders, Gala Buckeye and Red Jonaprince grafted on the M9 rootstock, where the tree was intervened by breaking the leaves in the area only once the apex when the height of the tree was 65-70 cm in combination with the application of two treatments with the growth regulator Gerba 4LG in a dose of 25 ml/liter of water, the number of anticipated branches formed in the area of crown formation was 8.0; 10.0 and 12.0 pcs/tree, respectively.

A lower value of the average length of the annual branches was recorded in the control variant (27.0 cm) compared to the variants where the Progerbalin LG product was used. This increase in average length is explained by the fact that the product Progerbalin LG consists of two active substances as 1.8% BA and 1.8% GA4+7, where gibberellic acid intensifies the growth vigor of the anticipated branches formed in the area of crown formation.

The method of crown formation based on the number of treatments carried out with the product Progerbalin LG in a dose of 25 ml/liter of water, and in some variants also through additional intervention on the apical leaves, led to obtaining in the area of crown formation the anticipated branches with different developmental length. Shorter length of the anticipated branches within the crown formation zone was obtained in the V 2 variant (39.7 cm) then in the growth was placed the V 5 variant (41.2 cm), the V 3 variant (46.7 cm) and variant V 4 (54.5 cm).

Table 3

The number of anticipated branches, their average and total length in field II of the tree nursery depending on the method of crown formation in the variety Gala Schniga SchniCo red

The method of forming the crown	Number of anticipated branches, pcs/tree	Length of anticipated branches	
		Average, cm	Total, cm/tree
V 1 (m)	2.0	27.0	54.0
V 2	6.0	39.7	238.2
V 3	8.0	46.7	373.6
V 4	4.0	54.5	218.0
V 5	5.0	41.2	206.0
LDS 5%	0.26	1.91	10.15

The total length of anticipated branches formed in the coronation zone is directly correlated with the number of branches in that zone and their average length. Within the variants treated with the product Progerbalin LG, higher values of the index taken in the study and confirmed by statistical data were recorded when

the apex of the trees was treated with a single treatment at a dose of 25 ml/liter of water (238.2 cm) and with two doses of 25 ml/liter of water at an interval of 5 days from the previous one (373.6 cm). The previously mentioned variants, but additionally the breaking of the bee leaves was carried out before the treatment, essentially decreased the values of the index taken in the study (206.0 - 218.0 cm).

CONCLUSIONS

The producers of apple trees in the second field of the tree nursery, in the variety Gala Schniga SchniCo red to the formation of the base of the crown from branches anticipated to intervene on the apex of the tree when it is 60-65 cm high by treating twice with the growth regulator Progerbalin LG in the dose of 25 ml/liter of water.

When planning a larger number of anticipated branches in the area of crown formation, to intervene on the apex of the tree by apical breaking of the terminal leaves when it has a height of 60-65 cm plus treatment twice with the growth regulator Progerbalin LG in a dose of 25 ml/liter of water. The first treatment to be carried out simultaneously with the breaking of the apical leaves, and the next at an interval of 5-7 days from the previous one.

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RESEARCH ON THE MODIFICATION OF PHYSICOCHEMICAL VALUES OF WALNUT FRUITS FROM HARVEST (GREEN) TO STORAGE (DRY)

CERCETĂRI PRIVIND MODIFICAREA VALORILOR FIZICO-CHIMICE A FRUCTELOR DE NUC DE LA RECOLTARE (ÎN VERDE) PÂNĂ LA PĂSTRARE (ÎN USCAT)

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Abstract.

This paper analyzes the physicochemical characteristics of fruits from the moment of harvest to their storage under controlled conditions. The study focuses on the changes occurring in the composition and quality of fruits during various stages of post-harvest. The analysis includes parameters such as soluble solids, acidity index, titratable acidity, and moisture content, and explores how these parameters evolve throughout the post-harvest process. Observations indicate an increase in the value of soluble solids during the storage (drying) of walnut kernels. Regarding total acidity content, it is higher at harvest and decreases during fruit dehydration. However, some varieties exhibited an increasing trend in acidity, with higher levels of organic acids during storage, due to natural drying of the kernel. Varieties with a high acidity index showed greater concentrations of oleic acids or they may have higher levels of rancidity. This paper contributes to a better understanding of the physicochemical changes in fruits post-harvest and provides recommendations for optimizing handling and preservation processes, aimed at maintaining fruit quality and nutritional value over time.

Key words: walnuts, fruit quality, preservation.

Rezumat.

Lucrarea de față analizează caracteristicile fizico-chimice ale fructelor de la momentul recoltării până la păstrarea acestora în condiții controlate. Studiul se concentrează pe modificările care apar în compoziția și calitatea fructelor în diverse etape ale post-recoltării. Analiza include parametri precum substanța uscată solubilă, indicele de aciditate, aciditatea titrabilă și conținutul de umiditate și explorează modul în care acești parametri se modifică pe parcursul procesului de post-recoltare. Observațiile efectuate indică o creștere a valorii substanței uscate solubile pe parcursul păstrării (uscării) miezului de nucă. În ceea ce privește conținutul acidității totale, acesta este mai ridicat la recoltare și scade pe parcursul deshidratării

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fructelor. Totuși, unele soiuri au avut o evoluție crescândă a acidității, cu un conținut mai ridicat în acizi organici pe parcursul păstrării, datorită uscării pe cale naturală a miezului. Soiurile cu indicele de aciditate ridicat, prezintă o concentrație mai mare în acizi oleici și se poate spune că acestea au cel mai mare conținut în acizi oleici, ori au un grad de râncezire mai accentuat. Lucrarea contribuie la o mai bună înțelegere a modificărilor fizico-chimice ale fructelor post-recoltare și oferă recomandări pentru optimizarea proceselor de manipulare și conservare, în scopul menținerii calității și valorii nutritive a fructelor pe termen lung.
Cuvinte cheie: nuci, calitatea fructelor, păstrare.

INTRODUCTION

Research on the post-harvest quality of horticultural crops has emphasized the importance of monitoring chemical changes, such as acidity, soluble solids, and lipid stability, to maintain freshness and nutritional value [Kader, 2013]. Studies on nuts and fruits, like walnuts and pistachios, highlight that lipid degradation and changes in acidity levels are indicators of quality loss over time, influenced by storage conditions [Patraș and Dorobanțu, 2010; Ozkan and Koyuncu, 2005]. In walnuts, for instance, high lipid content (up to 70%) and its tendency to oxidize affect both shelf life and flavor, making parameters like the acidity index critical for evaluating post-harvest quality [Ozkan and Koyuncu, 2005].

Similarly, acidity levels, including titratable acidity and malic acid content, are essential for determining flavor profiles and consumer preference, as these attributes impact both taste and perceived freshness [Patraș and Dorobanțu, 2010]. Changes in acidity can signal ripening or spoilage, which is particularly important in storage and transport settings where temperature and humidity fluctuations may accelerate these transformations [Kader, 2013]. This literature underlines the need for multi-parameter analysis to optimize storage practices, aiming to extend the shelf life of high-quality produce while preserving its sensory and nutritional properties.

MATERIAL AND METHOD

The material consisted of 10 native and foreign walnut varieties, cultivated in the Northeast region of Romania at the Iasi Research and Development Station for Fruit Growing. Samples were collected at consumer maturity; some were prepared for analysis at harvest, in their fresh state, while others were stored for later analysis in a dry state.

Various physicochemical indicators were analyzed, including: soluble dry substance (SUS%), acidity index (IA), titratable acidity (AT), and moisture content in the walnut kernels.

Soluble Dry Substance (SUS) - For solid products lacking natural juice, the soluble dry substance is measured by extracting water-soluble compounds (such as sugars and acids) from a finely ground sample. Distilled water is added to the ground sample, allowing these soluble compounds to dissolve. The mixture is then filtered to obtain a clear solution.

This solution is analyzed using a refractometer, which measures the refractive index based on the concentration of dissolved solids. The SUS value is read in degrees

Brix, reflecting the percentage of soluble substances (SUS) in the original product. [STAS 145/20-88, 1988].

Acidity Index (IA) - measures the content of free fatty acids in the oil extracted from the walnut kernel, reflecting the degree of lipid degradation. Acidity is determined by titrating the oil with a standard solution of potassium hydroxide (KOH) or sodium hydroxide (NaOH) in the presence of an indicator (phenolphthalein) [Maskan and Karatas, 1998]. The oil obtained from the kernel is dissolved in an alcohol-ether mixture and titrated with the hydroxide solution until the indicator's endpoint. The result expresses the amount of KOH needed to neutralize the free fatty acids, relative to the sample's weight [Savage *et al.,* 2001].

Titratable Acidity (AT) - measures the total amount of organic acids present in the walnut kernel. This is determined by titrating a sample suspension with an alkaline solution (typically NaOH) to a specific pH, using a pH indicator. The ground sample is mixed with distilled water, and the resulting solution is titrated with NaOH to pH 8.1 (or until the indicator shows the specified color), expressing acidity in acid equivalents per 100 g of product [Anonymous 1990 and 1991].

Moisture content - determined by the gravimetric method, where the kernel sample is heated in a dryer at a specific temperature to evaporate the free water. The weight loss of the sample is used to calculate moisture content. A precise amount of kernel is weighed, dried at 103°C (or according to the applicable standard method) until constant weight, and the weight loss is considered the water content in the sample, expressed as a percentage [Anonymous 1990 and 1991].

These methods allow for evaluating the quality of the walnut kernel, providing information on its storage stability and preservation potential.

RESULTS AND DISCUSSIONS

Soluble Dry Substance (SUS) represents soluble compounds (sugars, acids) and serves as an indicator of maturity and flavor concentration. In January, most varieties showed an increase in SUS, suggesting a higher concentration of soluble compounds due to water loss during storage. Varieties with significant increases include Miroslava (from 10.5 to 13.97), Ovidiu (from 7 to 10.87), and Sibișel (from 10 to 11.73), indicating a sweeter and more concentrated flavor profile after storage.

Table 1

Soluble Dry Substance (SUS) from harvest to dry

Varieties	SUS % at Harvest	SUS % Dry
Anica	**6^{g}**	**9.90^{d}**
Bortko	**6.2^{g}**	**8.97^{f}**
Danirenko	**9.7^{b}**	**9.53^{d}**
Germisara	**8.2^{c}**	**9.52^{d}**
Jupânești	**7^{e}**	**10.07^{c}**
Miroslava	**10.5^{a}**	**13.97^{a}**
Ovidiu	**7^{e}**	**10.87^{c}**
Prezident	**7.8^{d}**	**10.47^{c}**
Sibișel	**10^{a}**	**11.73^{b}**
Velnița	**6.7^{f}**	**10.23^{c}**

Titratable acidity reflects the total level of organic acids. Changes between November and January vary across varieties.

Significant increases in AT were observed in varieties such as Anica (from 3.58 to 3.81) and Prezident (from 3.55 to 4.74), suggesting an intensification of acidic characteristics.

Notable decreases were recorded in varieties like Bortko (from 3.94 to 1.82) and Danirenko (from 3.17 to 2.02), which may indicate a reduction in acidity, possibly associated with a loss of freshness.

Varieties with high SUS values tend to have stable or slightly increased titratable acidity, indicating a balance in flavor between sweetness and acidity.

Table 2

Titratable Acidity (AT) from harvest to dry

Varieties	AT (meq/100 g prod) at Harvest	AT (meq/100 g prod) Dry
Anica	**3.58^{a}**	**3.81^{b}**
Bortko	**3.94^{a}**	**1.82^{f}**
Danirenko	**3.17^{a}**	**2.02^{e}**
Germisara	**3.14^{a}**	**2.75^{c}**
Jupânești	**3.17^{a}**	**3.04^{b}**
Miroslava	**3.17^{a}**	**3.30^{b}**
Ovidiu	**2.91^{a}**	**2.24^{d}**
Prezident	**3.55^{a}**	**4.74^{a}**
Sibișel	**3.87^{a}**	**3.10^{c}**
Velnița	**2.59^{b}**	**3.58^{b}**

Malic acid contributes to the perception of acidity and the overall taste of the product. Varieties like Prezident (from 0.24 to 0.32) and Velnița (from 0.17 to 0.24) show an increase, suggesting an intensification of acidic flavor during storage. Bortko and Danirenko recorded decreases (e.g.: from 0.26 to 0.12 for Bortko), indicating a reduction in freshness or a shift in the acidic profile.

Varieties with high AT values tend to exhibit stable or slightly increased malic acid levels, suggesting a more balanced flavor profile and a potential improvement in acidity perception.

Table 3

Malic Acid from harvest to dry

Varieties	AT (ac. malic/100 g prod) at Harvest	AT (ac. malic/100 g prod) Dry
Anica	**0.24^{a}**	**0.26^{b}**
Bortko	**0.26^{a}**	**0.12^{g}**
Danirenko	**0.21^{b}**	**0.14^{f}**
Germisara	**0.21^{b}**	**0.18^{d}**
Jupânești	**0.21^{b}**	**0.20^{c}**
Miroslava	**0.21^{b}**	**0.22^{b}**
Ovidiu	**0.20^{c}**	**0.15^{f}**
Prezident	**0.24^{a}**	**0.32^{a}**
Sibișel	**0.26^{a}**	**0.21^{e}**
Velnița	**0.17^{d}**	**0.24^{b}**

The acidity index (IA) reflects the level of free fatty acids and, thus, the degree of lipid oxidation, which impacts freshness and stability. Varieties like Danirenko (from 0.73 to 1.77) and Jupânești (from 1.06 to 1.42) showed substantial lipid degradation during storage. Varieties such as Prezident and Sibișel also experienced moderate increases, indicating stable quality over the medium term.

An increase in IA is inversely correlated with SUS, particularly in varieties like Bortko, where a decrease in soluble acids (AT and malic acid) corresponds to accelerated lipid degradation.

Table 4

Acidity Index (IA) from harvest to dry

Varieties	IA (mg KOH/1g prod) at Harvest	IA (mg KOH/1g prod) Dry
Anica	**0.63^{c}**	**1.21^{b}**
Bortko	**0.95^{b}**	**1.03^{c}**
Danirenko	**0.73^{b}**	**1.77^{a}**
Germisara	**1.10^{a}**	**0.91^{d}**
Jupânești	**1.06^{a}**	**1.42^{b}**
Miroslava	**0.84^{c}**	**1.16^{b}**
Ovidiu	**1.08^{a}**	**1.08^{b}**
Prezident	**0.77^{b}**	**1.33^{b}**
Sibișel	**0.90^{b}**	**1.25^{b}**
Velnița	**0.50^{d}**	**1.01^{c}**

Significant differences between varieties indicate that certain cultivars possess distinct chemical characteristics that can influence product quality and stability during storage.

Storage significantly impacted the analyzed parameters, with noticeable changes in the ranking of varieties between harvesting and storage.

Varieties with high stability, such as Miroslava and Sibișel, maintained elevated SUS and acidity levels, making them suitable for long-term storage.

Varieties with significant variations, such as Bortko and Danirenko, exhibited notable decreases or increases in specific parameters, suggesting greater sensitivity to storage conditions.

CONCLUSIONS

Most varieties showed an increase in SUS from harvesting to dry, indicating a natural maturation process and sugar concentration. Varieties like **Miroslava** and **Sibișel** maintained high SUS values, suggesting superior sweetness and quality, which correlates with the improved taste over time.

Acidity levels generally increased, especially in varieties like **Prezident** and **Velnița**, showing stronger acidic profiles. This suggests a balance between sweetness (indicated by SUS) and acidity, which may improve the flavor complexity of these varieties during storage.

Prezident and **Velnița** showing significant increases in malic acid content. These changes reinforce the trends seen in the titrable acidity table, where rising

acidity levels align with the increase in malic acid, enhancing the perceived tartness of these varieties.

Varieties such as **Danirenko** and **Prezident** showed substantial increases in the acidity index, suggesting lipid degradation and the release of free fatty acids, which can affect overall quality. This increase in the acidity index correlates negatively with the product's freshness, possibly reducing the shelf life of these varieties.

In summary, the data indicates that while sweetness and acidity balance improve in certain varieties, lipid degradation (as shown by the acidity index) could negatively impact the overall quality and storage potential of some products.

General conclusions

Variations in acidity and chemical composition:

The data shows significant changes in terms of acidity and the acidity index for some varieties between harvest to storage. Varieties with large increases in acidity or in the acidity index may indicate a deterioration in product quality or faster ripening.

Stability of certain varieties:

Varieties like Miroslava and Prezident showed stable increases in their characteristics, which may suggest superior quality and good adaptability in storage conditions.

Decreases in acidity:

In some varieties, such as Bortko and Ovidiu, the decreases in acidity may be a sign of freshness loss or biochemical transformations that have reduced the initial product quality.

This interpretation suggests that it is important to monitor these variations in order to adjust storage conditions and determine which varieties are the most stable and offer consistent quality over the long term.

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RESEARCH ON THE ECO-PHYSIOLOGICAL EVOLUTION OF SOME SWEET CHERRY CULTIVARS UNDER THE INFLUENCE OF CLIMATE CHANGES

CERCETĂRI PRIVIND EVOLUȚIA ECO-FIZIOLOGICĂ A UNOR SOIURI DE CIREȘ SUB INFLUENȚA SCHIMBĂRILOR CLIMATICE

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Abstract.
Knowing the vegetation course of the sweet cherry cultivars is a major desideratum and a basic condition in the zoning of a fruit crop in order to capitalize on the biological production potential. The research of this study was carried out during the years 2022 and 2023 and aimed at the development of the phenological stages, the quantification of the sum of the temperature degrees and the total amount of precipitation, the stomatal conductance at the leaf level as well as the evaluation of the fruit quality and the productivity of three cultivars of sweet cherry trees ('Van', 'Andreiaș' and 'Margonia') from the Research Station for Fruit Growing Iași, located in the N -E area of Romania. The climatic conditions of the studied years (2022-2023) confirm the global context of climate change, the average annual temperature having values of 11.4°C, with a positive deviation of +1.7°C more than the multi-annual average (2000-2020) and total precipitation totaled 440 mm, with a deficit of -77.5 mm from the reference value, thus influencing the phenological patterns, physiological processes and productivity of the sweet cherry crop.
Key words: stomatal conductance, phenophases, productivity, *Prunus avium* L., temperature

Rezumat.
Cunoașterea parcursului de vegetație al soiurilor de cireș reprezintă un deziderat major și o condiție de bază în zonarea soiurilor în vederea valorificării potențialului biologic de producție. Cercetările din cadrul acestui studiu s-au desfășurat pe parcursul anilor 2022 și 2023 și au vizat desfășurarea stadiilor fenologice, cuantificarea sumei gradelor de temperatură și a cantității totale de precipitații, conductanța stomatală la nivel foliar precum și evaluarea calității fructelor și a productivității a trei soiuri de cireș ('Van', 'Andreiaș' și 'Margonia') din cadrul Stațiunii de Cercetare - Dezvoltare pentru Pomicultură din Iași. Condițiile climatice ale anilor studiați (2022-2023) confirmă contextul global al schimbărilor climatice, temperatura medie anuală având valori de 11,4 °

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C, cu o abatere pozitivă de +1,7 ° C mai mult decât media multianuală (2000-2020) iar precipitațiile totale au însumat 440 mm având un deficit de -77,5 mm față de media multianuală influențând astfel modelele fenologice, procesele fiziologice și productivitatea culturii de cireș.
Cuvinte cheie: conductanță stomatală, fenofaze, productivitate, *Prunus avium* L., temperatură.

INTRODUCTION

Physiological and biochemical agro-productive performance, growth and competitive capacity of fruit trees are increasingly affected by the effects of global climate changes, very different at the regional level, which mainly cause considerable changes in the water regime [Kreuzwieser and Gessler, 2010]. Sweet cherry (*Prunus avium* L.) has become one of the most valued and economically prolific fruit crops around the world which is mainly grown in areas with about 550 mm of annual precipitation but in the last decade, these areas have experienced a dramatic reduction in the water regime, which has led to some adaptation changes for sweet cherry trees.

In the current context of global warming, a better understanding of the limitations of sweet cherry's optimal climatic conditions is essential, especially when warmer and more variable winters occur and flowering occurs earlier [Vosnjak *et al*., 2021].

Tree phenological events fluctuate from year to year and are strongly influenced by variations in environmental factors, so long-term records of phenological data (sum of temperature degrees, winter cold accumulation) as well as their influence on physiological processes but also of fruit production and quality are valuable, because they can be used to estimate the influence of climatic variations on plant development and the calendar of vegetation cycles [Blanke and Kunz, 2009].

The aim of the present study was to evaluate the unfolding of the phenological stages, the quantification of the sum of the temperature degrees and the total amount of precipitation, the stomatal conductance at leaf level during the growing season as well as the fruit quality and the productivity of three varieties of cherry under the impact of the conditions climatic.

MATERIAL AND METHOD

This study was conducted in the period 2022-2023 in the experimental field of Research Station for Fruit Growing (RSFG), located in North-Eastern Romania using as research material three cultivars of sweet cherry ('Van', 'Andreiaș' and 'Margonia') grafted on *Prunus mahaleb* L. seedlings as rootstock and planted at a distance of 5×4 m and training as open vase shape/ open center, without irrigation system.

The local weather conditions and other climatic features were obtained from the meteorological AgroExpert system, located in the experimental field. The average annual temperature of the studied years (2022 and 2023) was 11.3 °C, and the total precipitation was 430.3 mm with a deviation of 87.5 mm from the multiannual values.

In order to obtain results regarding the influence of climate change on sweet cherry genotypes, the observation and statistical processing of data were used as research methods.

Phenological observations followed the development of phenophases of growth and flowering by recording data according to milestones BBCH scale [Meier, 2001]: buds swelling (51 BBCH), bud burst (53 BBCH), full flowering (65 BBCH), fruit growth, 50% (75 BBCH) and fruit ripening (89 BBCH). The determining factor for phenology stages is the heat and the rainfall quantity, so that, for starting certain phenophases is necessary the cumulative sum of active temperatures (Σt°a), in the days when it is more than 5 °C [Wenden *et al*., 2016].

Σt°a = ΣT atd – BL, in which:

ΣT atd - sum of average temperature of days between two subsequent phenological stages;

BL - the biological limit of fruit tree species.

In order to estimate the transpiration process and the rate of gas exchange through the stomata of the leaves, measurements of the stomatal conductance were carried out with a portable foliar porometer (Model SC-1, Decagon Devices Inc., Pullman, WA) using the method described by Pietragalla and Pask [2012] of determining the flow of water vapor from the surface of the leaf in atmosphere in local conditions. Ten readings were taken for each replicate, on three phenological stages.

Fruit production and quality were assessed by weighing with a Radwag electronic scale (0.01g sensitivity) and measuring diameters with a digital caliper. Soluble dry solids (SDS) content was measured using a digital refractometer (Hanna Instruments HI96804) and expressed in °Brix. Measurements were taken in triplicate annually and analyzed using Duncan's multiple comparison test, with significant differences at $p < 0.05$. The Pearson correlation coefficient (r) was calculated to evaluate relationships between water regime parameters and fruit production and quality.

RESULTS AND DISCUSSIONS

To assess the adaptability of sweet cherry cultivars in North-East Romania, key phenophases of vegetation and fruiting were recorded, along with temperature and precipitation data (Table 1). In 2023, vegetation began 16–21 days earlier than in 2022, increasing the risk of late frosts due to February temperature increases, known as winter "windows" [Wenden et al., 2016]. Flowering occurred in mid to late April, depending on the cultivar. The heat sum for fruit ripening ranged from 810.6°C (‘Van’, 2022) to 1628.8°C (‘Margonia’, 2023). Precipitation deficits during fruit growth negatively affected fruit quality and next year's productivity [Burzo et al., 1999].

Table 1

The development of the main phenophases and required the sum of active temperatures (SAT) and total rainfall (RSFG Iași - Romania, 2022-2023)

Cultivar	Year	Phenological stage (data)					Σ t°a	Σ rainfall
		51 BBCH	53 BBCH	65 BBCH	75 BBCH	89 BBCH	(°C)	(mm)
Van	**2022**	30.03	06.04	19.04	19.05	30.05	**810.6**	**150.6**
	2023	09.03	18.03	16.04	15.05	01.06	**893.5**	**45.8**
Andreiaș	**2022**	26.03	05.04	17.04	20.05	15.06	**1271.6**	**227.0**

	2023	11.03	23.03	18.04	18.05	20.06	**1263.7**	**53.8**
Margonia	**2022**	20.03	06.04	25.04	26.05	30.06	**1557.4**	**248.0**
	2023	07.03	20.03	22.04	28.05	26.06	**1623.8**	**53.8**

*BBCH-Phenological growth stages (Meier, 2001): 51 (buds swelling); 53 (bud burst); 65 (full flowering); 75 (fruit growth, 50%); 89 (fruit ripening).

Stomatal conductance measures gas exchange during transpiration and stomatal responses to environmental factors like soil water, light, humidity, temperature, and CO_2 concentration [Damour et al., 2010]. In 2022-2023, under North-East Romania's conditions, average stomatal conductance ranged from 7.78 m^2s/mol at stage 65BBCH to 7.04 m^2s/mol at stage 75BBCH, peaking at 10.40 m^2s/mol at stage 89BBCH. Seasonal variations were influenced by leaf humidity, with minimum values during fruit growth (75BBCH). Statistically significant differences occurred between cultivars and monitoring years. Seasonal changes and stomatal responses to drought in sweet cherry are linked to fruit development and ripening [Yoon & Richter, 1990]. A fact also highlighted in this case, where all cultivars registered a visible increase in sap flow during the ripening period (89BBCH).

Also, a small decrease in stomatal conductance may reveal a protective mechanism against water and heat stress, allowing plant water conservation and improving plant water use efficiency.

Table 2

Stomatal conductance at foliar level in the main phenological stages in the studied sweet cherry cultivars (RSFG Iasi, Romania 2022-2023)

Cultivar	**Year**	**65BBCH**	**75BBCH**	**89BBCH**
		(m^2s/mol)		
Van	**2022**	8.65 ^{a}	7.09 ^{ab}	10.88 ^{bc}
	2023	7.81 ^{ab}	6.85 ^{ab}	8.20 ^{d}
Andreiaș	**2022**	8.35 ^{a}	7.17 ^{ab}	11.43 ^{b}
	2023	7.28 ^{bc}	6.60 ^{b}	9.14 ^{d}
Margonia	**2022**	7.88 ^{ab}	7.67 ^{a}	12.52 ^{a}
	2023	6.70 ^{c}	6.83 ^{b}	10.25 ^{c}
Average		**7.78**	**7.04**	**10.40**
STDEV		**0.71**	**0.37**	**1.56**
COVAR		**9.10**	**5.28**	**15.03**
Min.		**6.70**	**6.60**	**8.20**
Max		**8.65**	**7.67**	**12.52**

*****-Different letters after the number correspond with statistically significant differences for *p* 5% - Duncan test, n=3.

**- BBCH-Phenological growth stages (Meier, 2001): 65 (full fowering); 75 (fruit growth); 89 (fruit ripening);

An analysis of the productivity of the trees, on average per tree (kg) was presented in Table 3. Thus, among the analyzed cultivars, the highest amount of fruits was recorded at 'Andreiaș' cultivar in the two years of the study, exceeding 30 kg /tree in the year 2023.

Drought conditions in the years of the study influenced the growth and productivity of the studied cultivars differently, in 2022, registering a lower productivity.

The weight and the dimensions of the fruits in diameter (width, thickness and length) are very important properties, being the parameters that give the commercial appearance. Sweet cherry cultivars with large fruits (both in size and weight) are increasingly valuable, but these parameters are strongly influenced by climatic conditions and the cropping system applied [Sirbu *et al*., 2018], and may vary from year to year even by 4 g [Hayaloglu and Demir, 2016].

The weight of the fruits of sweet cherry fruits during the studied period varied between 7.95 g ('Margonia', year 2022) and 10.52 g ('Andreiaș', year 2023). Soluble sugar content varied annually, on average over the course of the study, with average values between 18.5°Brix and 22.5°Brix. Depending on the cultivar, the SDS content of the fruit during maturity, according to numerous studies [Girard and Kopp, 1998; Guarino *et al*., 2010], can have minimum values of 13.2°Brix and can reach maximum values of 25.5°Brix.

Table 3

Production and characteristic of the fruits in the studied sweet cherry cultivars (RSFG Iasi, Romania 2022-2023)

Cultivar	Year	Production (kg/tree)	Weight (g)	Diameter (mm)	SDS (°Brix)
Van	**2022**	22.53 ^{c}	8.40 ^{b}	18.62 ^{b}	20.4 ^{b}
	2023	28.30 ^{b}	9.02 ^{b}	19.58 ^{b}	22.53 ^{a}
Andreiaș	**2022**	27.67 ^{b}	9.28 ^{b}	22.63 ^{a}	20.4 ^{b}
	2023	33.43 ^{a}	10.52 ^{a}	22.57 ^{a}	21.93 ^{a}
Margonia	**2022**	25.83 ^{bc}	7.95 ^{c}	17.8 ^{c}	18.5 ^{c}
	2023	27.51 ^{b}	8.64 ^{b}	18.00 ^{bc}	20.23 ^{b}
Average		**27.55**	**8.97**	**19.87**	**20.67**
STDEV		**3.56**	**0.89**	**2.21**	**1.42**
COVAR		**12.92**	**9.94**	**11.10**	**6.88**
Min.		**22.53**	**7.95**	**17.80**	**18.50**
Max		**33.43**	**10.52**	**22.63**	**22.53**

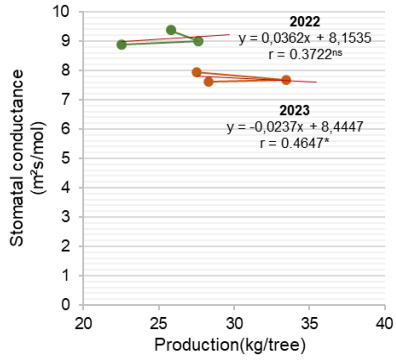
*****-Different letters after the number correspond with statistically significant differences for *p* 5% - Duncan test, n=3.

In order to determine the dependence relationship between the physiological indicator of stomatal conductance and the quantity and quality of the production of

the three sweet cherry cultivars, the correlation coefficient (r) was calculated in the two years of the study, represented graphically.

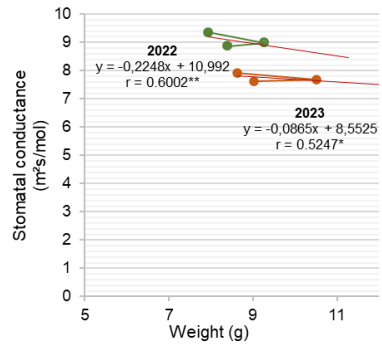
The obtained results highlight a correlation of stomatal conductance with fruit production per tree insignificant in the year 2022 and significant (r=0.4647) in the year 2023 (Figure 1.). In relation to the average fruit weight, a significant correlation coefficient (r= 0.4475) was obtained in 2023 and distinctly significant in 2022 (r= 0.6498) (Figure 2.), close values also found in the correlation with fruit diameter (Figure 3.).

A highly significant correlation was recorded between the stomatal conductance at leaf level and the content of soluble dry substances (Figure 4.), a coefficient r=0.9761 was obtained in 2022 and in 2023, r=0.9958. This type of correlation shows that if one variable increases in its values, the other variable decreases in its values by an exact linear rule [Ratner, 2009].



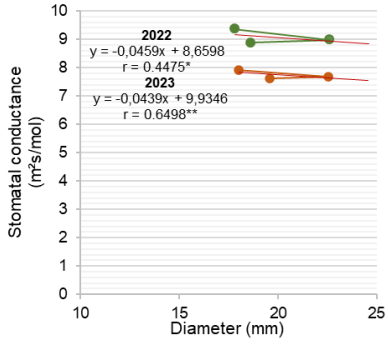
ns- insignificant correlation; *- significant correlation

Fig. 1. Correlation between leaf stomatal conductance and fruit production



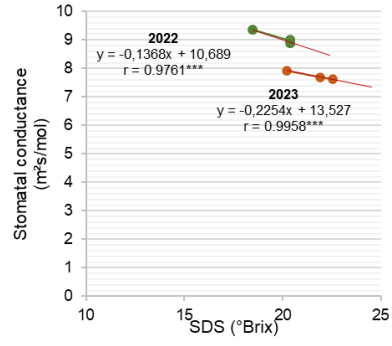
*- significant correlation; **-distinctly significant correlation

Fig. 2. Correlation between leaf stomatal conductance and fruit weight



*- significant correlation; **-distinctly significant correlation

Fig. 3. Correlation between leaf stomatal conductance and fruit diameter.



***-highly significant correlation

Fig. 4. Correlation between leaf stomatal conductance and fruit soluble dry substances

CONCLUSIONS

The presented results confirm the fact that climatic factors influence the development of the sweet cherry in the development of the phenophases but also the characteristics of the fruits as well as the water regime at the leaf level.

Values of sweet cherry trees water status indicators fluctuate and increase depending on environmental conditions, tree architecture, soil and varietal variability.

The studied cultivars showed a good ecological adaptability to the conditions in N-E Romania and a significant correlation of the qualitative and quantitative parameters at leaf and fruit level.

Following the study of the dynamics of the water regime, general patterns of water exchange in cherry leaves were established in the climatic conditions of N-E Romania without an irrigation system. From a physiological point of view, the results show a high efficiency of leaf water use, especially at times and in environments with high evapotranspiration requirements.

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INFLUENCE OF THE NAA PRODUCT ON THE PREMATURE GALA MAST FRUITS DROP AND QUALITY INDICES

INFLUENȚA PRODUSULUI PE BAZĂ DE NAA ASUPRA CĂDERII PREMATURE A FRUCTELOR DIN SOIUL GALA MAST ȘI INDICIELOR DE CALITATE

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Abstract.
The aim is to study the effectiveness of applying grow regulator Obsthormon 24a (NAA) to 'Gala Mast' cultivar in different doses and treatment periods to maintain the physiological balance in the plant and keep the fruit in the crown as much as possible at the time of fruit harvesting. To achieve the stated goal, the following variants were studied: (1) the control (trees sprayed with water only); (2) NAA 15 ppm; (3) NAA 22.5 ppm; (4) NAA 30 ppm; (5) NAA 37.5 ppm; (6) NAA 15+15 ppm; (7) NAA 15+22.5 ppm. To prevent premature fruit drop, to treat with NAA 30 ppm 15 days before harvest, or in two doses of 15 ppm. The first treatment to be applied in the first decade of July, when the differentiation of fruit buds on the apple starts, and the next one 15 days before harvest.
Key words: Firmness, fruit, NAA, productivity.

Rezumat.
Scopul a fost de a studia eficacitatea aplicării regulatorului de creștere Obsthormon 24a (ANA) la soiul „Gala Mast" în diferite doze și perioade de tratament pentru a menține echilibrul fiziologic în plantă și a păstra fructele în coroană pomilor perioadă mai îndelungată înainte de începerea recoltării. Pentru a atinge scopul preconizat, au fost studiate următoarele variante: (1) martor (pomi stropiți numai cu apă); (2) NAA 15 ppm; (3) NAA 22,5 ppm; (4) NAA 30 ppm; (5) NAA 37,5 ppm; (6) NAA 15+15 ppm; (7) NAA 15+22,5 ppm. Pentru a preveni căderea prematură a fructelor sa tratat cu NAA 30 ppm cu 15 zile înainte de recoltare, sau în două doze de 15 ppm. Primul tratament a fost aplicat în prima decadă a lunii iulie, când începe diferențierea mugurilor de rod la măr, iar următorul cu 15 zile înainte de recoltare.
Cuvinte cheie: Fermitate, fruct, ANA, productivitate.

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INTRODUCTION

Preharvest apple drop, which occurs before the fruit has reached optimal color, maturity or size, causes economic losses to the fruit industry. Excluding premature fruits drop during the pre-harvest and harvest period is a useful crop management tool that apple producers must consider every year [Babuc *et.al*., 2013; Peşteanu, 2014a, 2014b].

Premature fruits drop in apple is caused by a sudden increase in endogenous ethylene content at the level of the abscission zone formed between the peduncle and the fruit branch [Greene, 2010; Kuzin *et.al*., 2021].

Each apple cultivar is predisposed in its own way in terms of the tendency to drop before fruit harvest. There are more resistant cultivars and some in which the respective phenomenon is more intense [Peşteanu, 2014a; 2014b].

NAA is a synthetic auxin, hormonal type, which is applied in conditions that favor good foliar absorption, which retains the formation of the suber star in the abscission zone, the connection between the fruit peduncle and the fruit formations is better, which allows to control the preharvest drop [Kuzin *et. al*., 2021; Marini *et. al*. 1993; Peşteanu, 2014a].

Application of auxins has been shown to reduce fruit drop before harvest [Kuzin *et. al*., 2021; Marini *et. al*. 1993; Peşteanu, 2014a].

MATERIAL AND METHOD

The researches were carried out in the intensive apple orchard founded near the village of Paulești, Calarași district, in the drop of 2006 at the "Codru ST" LTD. The object of study was trees of the 'Gala Mast' cultivar grafted on the M9 rootstock. The crown tall spindle, planting distance was 3.5 x 1.2 m. The scheme of experiments to determine the effectiveness of the product Obsthormon 24a (NAA) for the prevention of dropping during the pre-harvest and fruit harvesting period included the following variants: (1) the control (trees sprayed with water only); (2) NAA 15 ppm; (3) NAA 22.5 ppm; (4) NAA 30 ppm; (5) NAA 37.5 ppm; (6) NAA 15+15 ppm; (7) NAA 15+22.5 ppm. The growth regulator was Obsthormon 24a.

On the experimental sector, in accordance with the scheme of experiences, in version one, no intervention was carried out on the trees. In variants two to five, a single treatment with the 1-naphthaleneacetic acid was carried out 15 days before harvest. In variants six and seven, two treatments with the 1-naphthaleneacetic acid were carried out, the first respectively in the first decade of July when the period of differentiation of the fruit buds in the apple culture starts, and the next one 15 days before harvest.

The placement of the plots was done in blocks, each variant having 4 repetitions. Each repetition consisted of 7 trees. At the boundary between the plots and the experimental repetitions, 1 tree was left untreated to avoid the overlap of some variants or repetitions during the treatments

The research was carried out under field and laboratory conditions according to accepted methods of carrying out experiments on fruit crops with growth regulators.

Data were processed using the ANOVA test and STATGRAPHICS Centurion 19.4.04 (Statgraphics Technologies, Inc., The Plains, VA, USA) program. The differences were considered statistically significant if the probability was greater than 95% (p-value < 0.05).

RESULTS AND DISCUSSIONS

The investments made show that the number of fruits in the crown of Gala Mast apple trees varied from 109.0 to 112.0 pcs. (Table 1). The total number of fruits in the crown of apple trees was obtained as a result of chemical fruit thinning supplemented with manual thinning during the period when the diameter of the central trunk in the inflorescence was 18-20 mm.

Regarding the number of fruits left in the crown of the trees, we note that the study indices for the Gala Mast variety ranged from 85.5 to 110.0 pcs.

Table 1

The influence of NAA treatment dose to the Gala Mast variety on the premature fall of fruits in the pre-harvest period in the apple orchard

Variants	Number of fruits, pcs/tree			Average fruit weight, g	
	Total	In the crown	Fallen from the crown	From the crown	Fallen from the crown
Control	109.5 a	96.5 d	13.0 a	154.7a	159.6 b
NAA 15 ppm	109.0 a	104.5 c	4.5 b	155.0a	163.0 a
NAA 22,5 ppm	111.0 a	108.5 a	2.5 c	153.6a	164.1 a
NAA 30 ppm	112.0 a	110.0 a	2.0 c	152.1 b	164.6 a
NAA 37,5 ppm	109.0 a	104.5 c	4.5 b	154.8 a	163.0 a
NAA 15+15 ppm	109.5 a	107.5 b	2.0 c	154.4 a	163.9 a
NAA 15+22,5 ppm	109.5 a	107.0 b	2.5 c	155.4 a	164.2 a
LSD 0.05	2.544	2.353	0.494	1.261	1.758

Also, the number of fruits in the crown of the trees is correlated with the amount of product administered per unit area. If, for example, in the Gala Mast variety, a smaller number of fruits in the crown of the trees was recorded in the control variant, without treatment (96.5 pcs), then higher values were obtained in the variant NAA 30 ppm (110.0 pcs). Insignificantly lower values compared to the previous variant were registered in the variants treated with NAA 15+22.5 ppm (107.0 pcs), NAA 15+15 ppm (107.5 pcs) and NAA 22.5 ppm (108.5 pcs). The variants treated with the NAA 15 ppm and NAA 37.5 ppm have registered recorded values of 104.5 pcs/tree.

The number of fruits that fell on the ground within the varieties taken in the environment in 2016-2017 was different. Higher values of the index were registered in the control variant (13.0 pcs/tree).

Continuing to study the influence of the 1-naphthaleneacetic acid on premature fruit drop in the Gala Mast variety, we note that lower values than in the control variant were recorded in the variants treated with NAA 15 ppm and NAA 30 ppm, where the final values were 4.0 pcs/tree.

In the case of the variants treated with NAA 22,5 ppm and NAA 15+22.5 ppm, the index in the study was 2.5 pcs/tree, and in the variants NAA 30 ppm and NAA 15+15 ppm, the number of fruits that fell to the ground under the crown of the tree was 2.0 pcs.

Higher values of the average weight of the fruits in the variants taken in the

study were registered within the apples that fell from the crown of the tree. For the Gala Mast variety, the given index was 159.5 -164.6 g.

The fruits that remained in the crown of the tree had a lower average weight compared to those that fell to the ground within and for the Gala Mast variety, the investigated index was 152.1 - 155.4 g.

Fruit production is the index for which fruit growers permanently choose to record high, constant values and competitive quality. The study shows that the total fruit production was in direct correlation between the total number of fruits and their average weight recorded during the research.

The total fruit production to the variety Gala Mast was 40.18 - 40.64 t/ha (Table 2). In the variants treated with the 1-naphthaleneacetic acid on both varieties, some legitimacy was not highlighted on the total fruit production per surface unit.

The study carried out further on the production of fruit from the crown of the tree and that which fell to the ground before the start of the harvesting process revealed a visible influence of the 1-naphthaleneacetic acid on the indices investigated.

Smaller productions of fruits registered in the crown of the tree at harvest was obtained in the control variant, without treatment in both varieties studied. If, for example, within the Gala Mast variety in the control variant the index in the study was 35.47 t/ha, then in the variants treated with the growth regulator Obsthormon 24a it was increasing and varied from 38.57 to 39, 84 t/ha, or an increase of 8.74 - 12.32% compared to the control variant.

Table 2

The influence of NAA treatment dose to the Gala Mast variety on premature fruit drop in the apple orchard

Variants	Production, t/ha			Share of fallen production, %
	fallen from the tree	left in the tree	total	
Control	40.42 a	35.47 c	4.95 a	12.25
NAA 15 ppm	40.33 a	38.57 b	1.76 b	4.64
NAA 22,5 ppm	40.64 a	39.66 a	0.98 c	2.41
NAA 30 ppm	40.64 a	39.84 a	0.80 c	1.97
NAA 37,5 ppm	40.28 a	38.53 b	1.75 b	4.34
NAA 15+15 ppm	40.18 a	39.52 a	0.66 c	1.64
NAA 15+22,5 ppm	40.42 a	39.45 a	0.97 c	2.40
LSD 0.05	1.147	0.875	0.310	-

Within the Gala Mast variety, the difference between the production registered in the control variant and the variants treated with the growth regulator is maintained only up to the variant treated with NAA 30 ppm.

Further increasing the dose up to 37.5 ppm recorded similar results to the variant NAA 15 ppm. The staggered treatment of the variants with the NAA also recorded values similar to the variants where the product administration dose was 22.5-30.0 ppm.

The production of fallen fruit from the crown of the trees depends on the amount of NAA administered per unit area. In the Gala Mast variety, this indicator decreases up to the NAA 30 ppm and in the staggered treated variants. The increase in the dose of the product to 37.5 ppm attracted a more massive fall of the fruits from the crown (4.34%).

The obtained results show that at the stage of treatment with 1-naphthaleneacetic acid, fruit firmness did not show essential differences, apart from the influence of the studied varieties (Table 3).

In the case of the Gala Mast variety, the firmness of the fruit pulp varied from 7.8 to 8.3 kg/cm^2. Lower pulp firmness values were recorded in the control variant, without treatment (8.3 kg/cm^2), compared to the variants treated with the 1-naphthaleneacetic acid (7.8-8.1 kg/cm^2), the difference being 0,3-0.5 kg/cm^2.

Table 3

The influence of NAA treatment dose to the Gala Mast variety on the fruit quality indices during the pre-harvest period in the apple orchard

Variants	Fruit firmness, kg/cm^2			Dry substance, %		Titratable acidity;%	
	On treatment	From the crown	Fallen from the crown	From the crown	Fallen from the tree	From the crown	Fallen from the crown
Control	9.6	8.3	7.0	14.2	15.7	0.30	0.26
NAA 15 ppm	9.6	8.1	7.0	14.3	15.8	0.29	0.26
NAA 22,5 ppm	9.5	8.0	6.8	14.4	15.9	0.29	0.25
NAA 30 ppm	9.7	8.0	6.8	14.6	15.9	0.27	0.24
NAA 37,5 ppm	9.6	7.8	6.6	14.6	16.1	0.26	0.24
NAA 15+15 ppm	9.6	8.1	6.9	14.2	15.9	0.29	0.25
NAA 15+22,5 ppm	9.7	8.0	7.0	14.3	15.8	0.29	0.26
LSD 0.05	0.234	0.185	0.168	0.226	0.224	0.014	0.011

A lower fruit firmness was recorded in the variant NAA 37.5 ppm (7.8 kg/cm^2) compared to the other treated variants (8.0-8.1 kg/cm^2). This is explained by the fact that ANA influences not only the hormonal disturbances that can occur within the trees, but in turn intensifies the production of ethylene, which is a precursor to fruit ripening.

In the case of the variants with staggered treatment with the 1-naphthaleneacetic acid in dose 15+15 ppm and 15+22,5 ppm, we note that pulp firmness is insignificantly lower compared to the variants with a single treatment based on 30 ppm and 37,5 ppm.

The treatment carried out with the 1-naphthaleneacetic acid in two rounds, i.e. staggered, recorded identical values as in the control variant (Gala Mast variety). Variants treated with higher doses of 1-naphthaleneacetic acid leave their mark on the degree of ripening of the fruits not only from the crown of the trees during the harvest period, but also those that have fallen to the ground.

Within the Gala Mast variety, the amount of dry matter accumulated by larger fruits was recorded in the variants NAA 30 ppm and NAA 37.5 ppm (14.6%)

while in the other variants, the studied index was identical, or slightly higher than in the control variant.

The staggered administration of the 1-naphthaleneacetic acid made it possible to make a greater amount of ANA available to the plants, to eliminate that hormonal imbalance that can be registered during the period until harvest and to obtain a rational co-ratio within the fruit between the dry substance and titratable acidity.

The study carried out over two years of research shows that the titratable acidity in fruits of the Gala Mast variety ranged from 0.26 to 0.30%. This legitimacy is also found in the case of fallen fruit, only the values obtained are much higher compared to the previous ones, constituting 0.24-0.26%.

There is a direct correlation between fruit dry matter content and titratable acidity. The higher the amount of dry matter in fruit decreases its titratable acidity. Increasing the dose of 1-naphthaleneacetic acid treatment resulted in a more intense ripening of the fruit and a decrease in its titratable acidity.

The amount of dry matter in the fruit fallen on the ground and the titratable acidity recorded constitute a more advanced degree of ripening of the fruit, which can then be used only for industrialization.

CONCLUSIONS

To prevent premature fruit drop, Gala varieties to must treat with NAA 30 ppm 15 days before harvest, or in two doses of 15 ppm. The first treatment must to do during the first decade of July and the second application 15 days before harvest.

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A REVIEW OF DIGITAL AND HAND-DRAWN RENDERING TECHNIQUES IN LANDSCAPE DESIGN: COMPARATIVE ANALYSIS OF EFFICIENCY, USABILITY, AND CREATIVE EXPRESSION

O ANALIZĂ A TEHNICILOR DE REDARE DIGITALĂ ȘI MANUALĂ ÎN PROIECTAREA PEISAGISTICĂ: ANALIZA COMPARATIVĂ A EFICIENȚEI, UTILIZABILITĂȚII ȘI EXPRESIEI CREATIVE

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Abstract.
This review examines the efficiency and user preferences of digital rendering software, Lumion® and Twinmotion®, in landscape design while considering traditional hand-drawn rendering. Rendering is crucial in visualizing landscape designs and transforming conceptual models into realistic representations. Lumion®, developed by Act-3D®, integrates seamlessly with CAD software and offers an extensive asset library, making it practical for large-scale projects. Twinmotion®, owned by Epic Games®, leverages gaming technology for real-time rendering and immersive experiences, including virtual reality. In contrast, though less efficient, hand-drawn rendering remains valued for its artistic expression and personal touch. This review highlights the strengths and limitations of each method in landscape design, focusing on user satisfaction and project efficiency.
Key words: rendering, visualization, efficiency, landscape design

Rezumat.
Această analiză examinează eficiența și preferințele utilizatorilor de software de randare digitală, Lumion® și Twinmotion®, în proiectarea peisagistică, luând în considerare, de asemenea, randarea tradițională desenată manual. In vizualizarea proiectelor peisagistice, randarea reprezinta un proces de bază prin care modelele conceptuale sunt transformate în reprezentări realiste. Lumion®, dezvoltat de Act-3D®, se integrează perfect cu software-ul CAD și oferă o bibliotecă extinsă de active, ceea ce îl face eficient pentru proiectele la scară largă. Twinmotion®, deținut de Epic Games®, valorifică tehnologia jocurilor pentru randare în timp real și experiențe captivante, inclusiv realitatea virtuală. În schimb, randarea desenată manual, deși mai puțin eficientă, rămâne apreciată pentru expresia sa artistică și pentru emoția pe care o transmite. Această analiză evidențiază punctele forte și limitele fiecărei metode în proiectarea peisagistică, concentrându-se pe satisfacția utilizatorului și pe eficiența proiectului.
Cuvinte cheie: randare, vizualizare, eficiență, proiectare peisagistică

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INTRODUCTION

Rendering is at the heart of landscape design. It is the process that allows designers to turn ideas into visual realities. Over the past decade, digital rendering tools have transformed the industry, making it easier and faster to create photorealistic images. However, hand-drawn renderings remain relevant because they allow designers to express themselves artistically in ways that digital tools sometimes cannot [Zhang & Wu, 2024].

The need for this research arises from the rapid development of digital rendering technologies, which are increasingly transforming the way landscape design is approached. Digital tools like Lumion® and Twinmotion® have become popular for their ability to produce highly detailed, realistic visualizations in a fraction of the time it would take to create hand-drawn designs. However, despite the efficiency of these digital tools, there remains a significant demand for artistic expression and personal creativity in landscape design, qualities often attributed to traditional hand-drawn techniques.

As landscape architecture continues to evolve, there is a gap in understanding the full impact of these two methods - digital versus hand-drawn - on the overall design process. Specifically, it is necessary to investigate how these tools affect efficiency and productivity, the creative process, and how designers express their visions.

This study explores and compares the effectiveness of digital rendering tools, such as Lumion® and Twinmotion®, with traditional hand-drawn rendering methods in landscape design. The study seeks to provide insights into the strengths and weaknesses of each approach, focusing on how they influence efficiency, usability, and creative expression.

MATERIAL AND METHOD

This review compares digital and hand-drawn rendering techniques in landscape design, focusing on two widely used software programs, Lumion® and Twinmotion®, and traditional hand-drawn methods.

Materials

The study utilizes the software Lumion® and Twinmotion®, both of which are widely used in landscape design due to their integration with CAD tools such as SketchUp®, AutoCAD®, and ArchiCAD®. Additionally, traditional hand-drawn rendering tools, such as pencils and markers, are considered for their role in the conceptual and detailed stages of landscape design.

Methods

The methods used in this review include a comparative analysis of the real-time rendering capabilities of Lumion® and Twinmotion®, focusing on performance metrics such as rendering speed, visual realism, and integration with CAD tools.

A literature review was conducted to gather existing research and case studies, exploring the technical capabilities of digital rendering tools and the creative advantages of traditional hand-drawn methods. Combining these approaches provides a comprehensive understanding of each rendering method's strengths and limitations in landscape design.

RESULTS AND DISCUSSIONS

Digital rendering: advantages and applications

The efficiency and accuracy offered by digital rendering tools, especially when integrated with CAD software, are significant. These tools enable the quick generation of 3D models, which improves the accuracy of designs and reduces the time needed for revisions [Yin & Yuan, 2024; Zang & Wu, 2024; Istrate *et al.*, 2023]. Rapidly adjusting and refining designs is a crucial advantage in large-scale landscape projects. Moreover, digital tools offer enhanced visualization through extensive libraries of pre-designed elements and realistic textures, which help communicate ideas more effectively to clients and stakeholders [Lallawmzuali & Pal, 2023].

A notable feature of digital tools like Lumion® and Twinmotion® is their integration with emerging technologies. Machine learning in CAD, for instance, optimizes the modeling process, ensuring that landscape designs align with functional requirements while maintaining aesthetic qualities. This technology integration enhances the technical side of landscape design and increases productivity by streamlining tasks that traditionally take much longer to complete manually [Lallawmzuali & Pal, 2023; Hangan *et al.*, 2023].

Hand-drawn rendering: artistic value and cultural significance

Despite the widespread use of digital rendering, hand-drawn techniques remain highly valued for their artistic qualities. Methods such as traditional Chinese ink painting can capture unique aesthetic characteristics that digital tools often struggle to replicate. This creative expression is significant in conveying emotional and cultural elements within a design [Li *et al.*, 2023].

Additionally, hand-drawn renderings carry significant cultural heritage. Many traditional design practices, passed down through generations, rely on manual techniques to convey a landscape's natural beauty and cultural context. These methods resonate with specific audiences, often preserving a personal touch that is sometimes lost in digital renderings. Given their cultural and artistic value, hand-drawn techniques continue to play a role in the early stages of landscape design, even as digital methods dominate the technical aspects of large-scale projects [Li *et al.*, 2023; Cojocariu *et al.*, 2023].

The role of rendering in landscape design

In landscape architecture, rendering is crucial for visualizing a project's spatial, aesthetic, and functional qualities. Whether using digital or hand-drawn methods, the aim is to create a realistic representation of the landscape concept. This visualization incorporates natural elements like terrain, vegetation, water, and lighting. These visualizations help designers communicate their ideas more effectively, ensuring clients, stakeholders, and construction teams understand the design vision [Ackerman *et al*., 2023; Coconu, 2008; Coconu *et al*., 2006].

Rendering also plays an essential role in improving communication between designers and clients and enables iterative design processes where feedback can be easily incorporated. Through this feedback loop, designs are refined and adapted to

meet specific needs and expectations, making rendering an essential step in ensuring that the final project aligns with the client's vision [Tarakci *et al.*, 2019].

Advanced visualization techniques

Recent advancements in digital rendering have further enhanced the design process. For example, GAN-based rendering (Generative Adversarial Networks) has been introduced to transform simple sketches into vibrant, color-rich designs, improving detail retention and speeding up the design process [Chen *et al*., 2024; Petrasova *et al.*, 2021]. This innovation is instrumental in urban landscape design, where time constraints often demand quick yet detailed visualizations.

Augmented reality (AR) also plays a growing role in landscape design. AR systems that utilize real-time ray tracing can reflect virtual models in physical environments, greatly enhancing communication between designers and clients by allowing them to experience the design within the real-world context. These technologies improve the accuracy of client feedback and provide immersive experiences that help bridge the gap between concept and reality [Chen *et al*., 2022; Shan & Sun, 2021].

Cultural and historical context in rendering

Another important consideration in landscape design is how cultural and historical contexts are represented. For example, non-photorealistic rendering (NPR) can effectively convey historical changes in landscapes. By utilizing more stylized, abstract renderings, designers can highlight the evolution of cultural heritage sites in ways that photorealistic images might not. This approach offers a more nuanced understanding of how landscapes have changed, making it particularly valuable in historical preservation projects [Ackerman *et al.,* 2023].

However, while these advanced techniques offer significant benefits, they also raise questions about the interpretation and accuracy of visualized landscapes. Especially in historical contexts, where some elements may rely on speculative or incomplete data, there is a risk that these renderings might inadvertently distort the viewer's perception of authenticity [Ackerman *et al.,* 2023].

Comparative analysis of digital rendering tools

In landscape design, two of the most popular digital rendering programs are Lumion® and Twinmotion®. Both are widely used for their ability to produce real-time rendering, allowing designers to visualize changes instantly and adjust their designs accordingly (Table 1).

Table 1

Comparison of Lumion® and Twinmotion® features

Feature	Lumion®	Twinmotion®
Integration with CAD tools	Excellent	Good
Real-time rendering	High performance	High performance
Asset library size	Extensive	Moderate
Virtual reality (VR) support	Limited	Excellent
Large-scale project support	Strong	Moderate

Lumion® is especially valuable for large-scale projects, where the integration with CAD programs like SketchUp® and AutoCAD® enables the efficient importation of complex models. Lumion® excels in creating detailed natural environments with a vast library of plants, trees, and water features, allowing landscape architects to build comprehensive visualizations quickly. However, some users report performance issues when working with larger models, especially when rendering higher resolutions [Ramdhaniati & Mulyanti, 2021; Yao, 2014].

Twinmotion®, which Epic Games® owns, distinguishes itself through its immersive and interactive features. It leverages Unreal Engine technology to create interactive walk-throughs, allowing clients to experience the design from within. While it may not have as extensive an asset library as Lumion®, Twinmotion® compensates with its focus on animations and virtual reality. This makes it particularly useful in projects where client presentations and interactivity are prioritized over detailed environmental simulations [Bordus, 2024; Lallawmzuali & Pal, 2023; Yao, 2014].

The relevance of hand-drawn rendering in modern practice

Despite the increasing dominance of digital tools, hand-drawn renderings are valued for their personal and expressive qualities. These drawings often serve as an essential step in the conceptual phase of a project, where ideas are still fluid and evolving. Sketching by hand encourages a deeper understanding of composition, proportion, and spatial relationships, resulting in images that evoke a more robust emotional response than many digital renderings [Luo *et al*., 2019].

In practice, many designers begin with hand-drawn sketches to develop the overall framework of their landscape designs before moving on to digital tools for more detailed and realistic visualizations (Figure 1). However, the main limitation of hand-drawn renderings is their time-consuming nature, especially when multiple revisions are necessary or when working with highly detailed projects [Corner, 1992].

Fig. 1. Workflow: from hand-drawn sketch to computer rendering

Artistic expression in landscape design

Hand-drawn sketches convey technical information and express the moods, atmospheres, and compositions envisioned by the designer. For example, Petra Blaisse's work [2022] highlights how collages and experimental drawing techniques

can offer a more intuitive and artistic approach to landscape design. Similarly, integrating artistic techniques, such as calligraphy or map art, enhances landscape architecture's educational and representational value [Eplényi & Oláh, 2011].

In contrast, NPR techniques in digital tools, like pen-and-ink illustrations, allow designers to simultaneously represent various aspects of a landscape. These stylized representations communicate complex environmental data in real-time, especially in interactive visualizations [Coconu *et al.,* 2006].

Combining traditional and digital techniques

A balanced approach to rendering in landscape design often involves combining traditional and digital techniques. Designers can begin with hand-drawn sketches to develop initial ideas and explore the creative aspects of their designs. Once the concept is finalized, digital tools like Lumion® or Twinmotion® can add realism, detail, and interactive elements, making the design more accessible to clients and stakeholders [Li *et al*., 2023].

This hybrid workflow allows designers to leverage the best qualities of both methods: the artistic freedom and personal touch of hand-drawn renderings combined with the efficiency and realism of digital tools [Kim *et al*., 2023].

CONCLUSIONS

Both digital and hand-drawn rendering methods have unique strengths and play essential roles in landscape design. Lumion® and Twinmotion® are powerful tools for creating realistic and immersive visualizations efficiently, with Lumion® excelling in detailed environmental features, while Twinmotion® offers a more interactive, client-focused presentation. Although digital methods are more efficient, hand-drawn rendering retains its value for artistic expression and the ability to communicate design ideas personally and evocatively.

The choice between digital and hand-drawn techniques depends on the project's specific needs, with hybrid approaches offering a balanced solution by combining the efficiency of digital tools with the creativity and flexibility of hand-drawn methods. Hand-drawn techniques remain valuable during the early conceptual phases, where artistic freedom is crucial in developing ideas.

This review represents the initial phase of a broader study. Based on the presented findings, a questionnaire will be developed to gather practical insights from landscape designers, assessing their preferences and experiences with digital and hand-drawn rendering methods. This subsequent step will provide empirical data to support the theoretical analysis further and contribute to a more comprehensive understanding of the best practices in landscape design rendering.

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INTEGRATING SENSORY PLANT COMPOSITIONS IN PUBLIC SPACES

INTEGRAREA COMPOZIȚIILOR VEGETALE SENZORIALE ÎN SPAȚIILE PUBLICE

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Abstract. Present study explores the basic concepts of sensory gardens design, highlighting their characteristics and qualities. It also presents the analysis of how sensory compositions can be integrated in different places, starting from case studies such as the sensory garden in the urban space, in special schools and in public institutions of daily care, addressed, for example, to the elderly. An essential part of the paper will be related to the theory of the five senses and how the therapeutic plantscape can influence these senses. This type of landscape is generally a plant-dominated environment intentionally designed to facilitate interaction with the healing elements of nature that promote human health and well-being. The research starts from the belief that every landscape has the ability to stimulate the five human senses, but landscapes with therapeutic plants in particular do so to a greater degree than others. The work will bring to the fore the importance of integrating sensory aspects in the design and arrangement of public spaces, offering a new perspective on how nature can be used for the benefit of health and leading to the creation of sustainable, inclusive communities for all social categories, in particular of the disadvantaged.
Key words: sensory gardens; urban spaces; sustainable communities.

Rezumat. Lucrarea exploraza conceptele de bază în amenajarea grădinilor senzoriale, evidențiind caracteristicile și calitățile acestora. De asemenea, prezintă analiza modului în care compozițiile senzoriale pot fi integrate în diferite locuri, plecand de la studii de caz precum grădina senzorială în spațiul urban, în școlile speciale și în instituțiile publice de îngrijire zilnică, adresate, de exemplu, seniorilor. O parte esențială a lucrării va fi legată de teoria celor cinci simțuri și modul în care peisajul vegetal terapeutic poate influența aceste simțuri. Acest tip de peisaj este, în general, un mediu dominat de plante conceput intenționat pentru a facilita interacțiunea cu elementele vindecătoare ale naturii care promovează sănătatea și bunăstarea umană. Cercetarea, pornește de la convingerea că fiecare peisaj are capacitatea de a stimula cele cinci simțuri umane, însă, în special, peisajele cu plante cu efecte terapeutice o fac într-un grad mai mare decât altele. Lucrarea va aduce în prim-plan importanța integrării aspectelor senzoriale în proiectarea și amenajarea spațiilor publice, oferind o perspectivă nouă asupra modului în care natura poate fi utilizată în beneficiul sănătății și conducând la creearea de comunități sustenabile, integratoare pentru toate categoriile sociale, în mod deoosebit a celor defavorizate.
Cuvinte cheie: grădini senzoriale, spații urbane, comunități sustenabile.

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INTRODUCTION

The paper *Integrating Sensory Plant Compositions in Public Spaces* explores the basic concepts in the design of sensory gardens, highlighting their characteristics and qualities. It also presents the analysis of how sensory compositions can be integrated in different places, starting from case studies such as the sensory garden in urban space, in special schools and in public day care institutions, addressed, for example, to seniors.

An essential part of the paper will be related to the theory of the five senses and how the therapeutic plant landscape can influence these senses. This type of landscape is, in general, a plant-dominated environment intentionally designed to facilitate interaction with the healing elements of nature that promote human health and well-being. I will explore how the sense of sight, touch, hearing, smell and taste can be stimulated and integrated in the design of green spaces, being the most direct ways in which people perceive external information and evaluate experiences, contributing to the creation of a more pleasant and therapeutic environment [Pallasmaa, 1994; Vítovská, 2015]. Plants with various health-enhancing functions are distributed and arranged in this environment in a manner that integrates science and art.

Therapeutic plant landscape designs are based on nature and ecology to promote human health and ensure the sustainability and resilience of larger ecosystems [Granö, 1929]. The research starts from the belief that every landscape has the capacity to stimulate the five human senses, but, in particular, landscapes with therapeutic plants do so to a greater degree than others.

This work will bring to the forefront the importance of integrating sensory aspects in the design and arrangement of public spaces, offering a new perspective on how nature can be used for the benefit of health and leading to the creation of sustainable, integrative communities for all social categories, especially the disadvantaged [Koura *et all.*, 2010; Spence, 2020].

Starting from Shoemaker's statement, quoted by [Hussein Hasreena, 2011], according to which "A sensory garden cannot be designed without taking into account the human element. Unlike traditional gardens that are meant to be observed from a distance, sensory gardens attract the visitor to touch, smell and actively experience the garden with all the senses", I can emphasize that these gardens are different from traditional gardens and are suitable primarily for education but also for recreation, having deeply comforting effects on the beneficiaries.

Sensory gardens have gradually evolved, starting from the traditional concept of a garden for the blind [Krzeptowska-Moszkowicz *et al.*, 2021]. The element that distinguishes sensory gardens from the rest of the gardens is that they aim to appeal to all the senses in such a way as to provide maximum sensory stimulation.

MATERIAL AND METHODS

The present work aims to design and lanscape a sensory garden within the courtyard of the "Prof. Dr. N. Oblu" Emergency Clinical Hospital in Iași, in the Tătărași

neighborhood, with a private character, open to the public, the role of which is to contribute to improving the quality of life of patients, medical staff and visitors. The sensory garden will provide a therapeutic and relaxing space, designed to stimulate the senses and promote mental and physical well-being.

The site that is the subject of the project is located in the Tătărași neighborhood, Ateneului Street 2, within the courtyard of the "Prof. Dr. N. Oblu" Emergency Clinical Hospital, more precisely behind it (fig.1). The area proposed for arrangement currently serves as an outdoor space for patients, visitors and hospital staff, the site not having a well-defined purpose (fig. 2). The total area of the site is 3400 sq m.

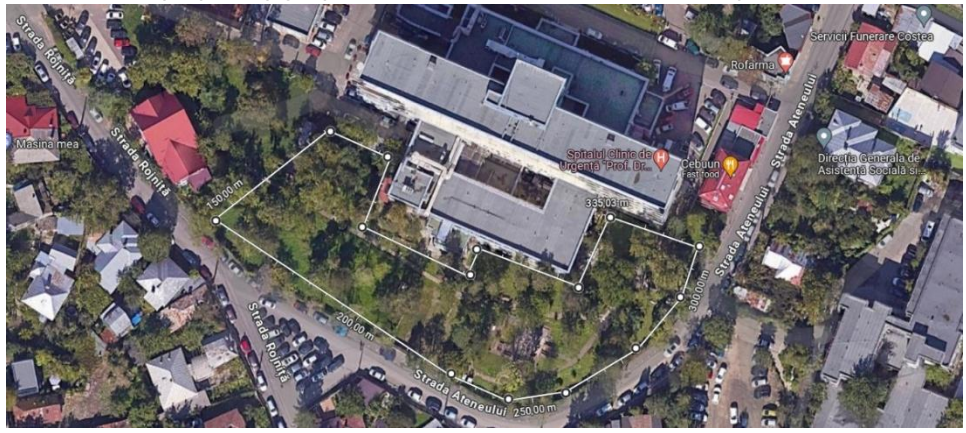

Fig 1. Sensory garden location, satellite view (maps.google.com)

Following detailed analysis processes, meticulously carried out on the project area of interest, it was possible to develop a list of strengths and weaknesses, both within the site and in the adjacent areas. These processes included precise measurements and in-depth studies of the structural elements and components of the area. Through this comprehensive approach, current needs were identified that will guide the development of the future sensory garden.

The studies carried out included the assessment of local biodiversity, the identification of existing plant and animal species, as well as the prevailing climatic conditions. This information is necessary to ensure that the sensory garden will be sustainable and beneficial for both the environment and the hospital community.

Fig 2. Current situation of the site

Next step was determining the necessary elements by identifying and selecting the essential elements for the sensory garden, such as plant types, materials for paths, water features, furniture and other necessary structures, respectively improving the existing situation by creating a functional zoning. Finalizing a judicious proposal for structuring and zoning the layout, materialized by developing a detailed structuring and zoning plan for the hospital garden, which provides a clear vision of the organization of the green space, establishing areas for relaxation, treatment and socialization, and the plant material is strategically placed to create a comforting environment. In addition to these methods listed above, another step consisted of executing the plan that is the basis for creating the sensory garden, which was created in RealTime.

RESULTS AND DISCUSSIONS

The proposal for the green space development aims to integrate sensory plant compositions into public spaces, focusing on capitalizing on the benefits brought by therapeutic plant landscapes for human health and well-being. It starts from the premise that every landscape has the ability to stimulate the five human senses – visual, tactile, auditory, olfactory and gustatory – but landscapes with plants with therapeutic effects do so to a higher degree. Through this project, we have integrated various areas dedicated to stimulating the human senses. The plan includes two entrances, large green spaces, a relaxation area, as well as various plant compositions, designed to create a therapeutic and pleasant environment for users.

Fig 3. General plan of the proposed sensory garden with zonning

Within the site, seven zones with distinct functions are identified (fig. 3 and 4). These zones are designed to fulfill various purposes, from relaxation and recreation to sensory stimulation and social interaction. Each zone is arranged taking into account its functional specificities, ensuring a diversified and pleasant experience for users. Also, around these main zones, various design elements are integrated that contribute to the coherence and harmony of the ensemble.

The design elements are selected and placed so as to complement and amplify the characteristics of each zone, while also providing visual and thematic continuity.

The first area, the entrance, was designed as a waiting space, offering visitors a pleasant and relaxing first contact. This area is marked by a central round, around which comfortable benches are arranged, which offer places to relax and rest for those entering the site. In the middle of the round is a diversified floral composition, meant to delight the eye and create a welcoming atmosphere, using species as *Viola wittrockiana*, *Alyssum* and *Campanula carpatica*, which add an explosion of color and texture, animating the entire space. Behind the benches, the plant compositions are made up of a variety of species, each contributing to a rich and diverse landscape (*Aster novi-belgii*, *Hydrangea sp.*, *Taxus baccata 'Repandens'* and *Picea glauca 'Conica')*. These plants are chosen not only for their beauty, but also for their ability to provide structure and visual depth, while ensuring a lush green backdrop throughout the year. This area serves not only as a place to relax, but also as an exciting introduction to the full experience of the site.

Zone 2, intended for the therapeutic plant landscape of the Rose Garden, based on the stimulation of the visual sense. This zone is specially designed to provide an intense and pleasant visual experience, using the beauty and diversity of roses. This zone is characterized by a series of pergolas, which are covered and fenced with species of *Rosa rampicante* and *Rosa floribunda*. The pergolas covered with climbing roses create spectacular flower arches, providing a picturesque setting and delicate shade for visitors.

Zone 3 is intended for the therapeutic plant landscape based on the stimulation of the auditory sense, having at its center a fountain and various pieces of flowing water. This area is designed to offer visitors a soothing auditory experience, through the relaxing sounds of water. The layout of this area is organized around a roundabout, divided into four distinct sections. Two of these sections are dedicated to aquatic elements, where species of water lilies can be found that add visual charm and contribute to creating a peaceful environment through the gentle movement of the water. The other two sections are lawned and decorated with arabesques formed by the species *Cineraria maritima* and *Iris cristata*, bringing a pleasant contrast between the green of the lawn and the colors of these plants. Groups of benches are placed around the roundabout, providing seating for visitors who want to enjoy the sounds of water.

Area 4 is designed as a space for outdoor relaxation and dining and offers visitors the opportunity to retreat and enjoy a moment of rest in the middle of nature. The layout of the area includes three groups of modular benches, each accompanied by tables, thus providing comfortable seating, harmonized with white stone inside, creating a pleasant contrast and giving an elegant and modern look to the entire space. In the center of the area there is a specimen of the *Acer macrophyllum* species, which adds a natural and decorative element to the landscape. With its rich foliage and vibrant colors during autumn, this tree offers a touch of charm and beauty around which visitors can gather and relax.

Zone 5 is designed to stimulate the sense of touch, offering visitors the opportunity to explore and interact with various textures and surfaces. This open space is designed to encourage sensory exploration through thoughtful and varied landscape design. Key elements of the zone include gravel surfaces, wooden edges, balance beams, and rocks of various sizes and shapes. These elements are strategically placed to create a diverse and engaging tactile experience. Visitors are invited to walk barefoot or touch the different surfaces to feel the varied textures and enjoy full sensory stimulation. The zone leads to a specially designed therapeutic walkway, built from ten distinct parts. Each part of the walkway offers a different texture, so people can experience a variety of tactile sensations. Materials used for this walkway include: medium gravel, clover, dried pine needles, sand, fine gravel, turf, tactile carpet, mulch, large gravel, and bark. This diversity of materials allows visitors to explore and appreciate tactile differences, contributing to a greater awareness of the sense of touch and a deeply therapeutic experience.

Fig 4. Details of the seven landscaped areas

Zone 6 is dedicated to the sense of smell, offering visitors a unique experience through a winding alley where they encounter various species of plants with distinct

and attractive scents.

The entrance to this olfactory space is through a series of arches adorned with species of *Clematis* and *Wisteria sinensis*, which, in addition to their visual beauty, also exude delicate aromas that welcome visitors in a charming way. Along the winding alley, various species of plants known for their special scents are strategically placed as *Gardenia jasminoides*, *Osmanthus heterophyllus 'Variegatus*' and *Rosa* sp., which offer a variety of delightful floral aromas. These are complemented by species such as *Rosmarinus officinalis* and *Lavandula angustifolia*, which add fresh and aromatic notes, creating a diverse olfactory palette. Around this alley other plants are strategically placed to enrich the olfactory experience and form a complete landscape (*Picea orientalis*, *Magnolia stellata*, *Lonicera*, *Pinus ponderosa*, *Pseudotsuga menziesii*, *Tilia tomentosa*, *Syringa reticulata* and *Corylus avellana*, *Viburnum plicatum)*. These plants not only add variety and texture to the landscape, but also contribute to the creation of a complex and captivating olfactory environment.

Zone 7 is designed to stimulate the sense of taste through a small fruit area. Here, various species of fruit trees are found, each contributing unique aromas and tastes. Plant species include: *Malus floribunda* - produces small, usually inedible fruits, but with high ornamental value; *Malus sylvestris* - whose small, sour fruits are edible and can be used in various preparations; Sorbus acuparia - the mountain ash, with edible red fruits used in jams and liqueurs; *Mespilus germanica* - the medlar, a tree with edible fruits that are eaten when they are well ripe or even fermented; *Amelanchier alnifolia* - a productive fruit shrub with vigorous growth; Prunus cerasifera nigra with small, sweet fruits, ideal for fresh consumption; *Ginkgo biloba* - whose seeds are edible after proper processing, although the tree is better known for its medicinal uses. In addition, the area dedicated to the sense of taste also includes an interactive alley. The goal of this area is not only to educate about biodiversity and horticulture, but also to provide a rich sensory experience, encouraging visitors to appreciate and enjoy the diversity of natural tastes.

Fig 5. Perspectives of the educational area in the field of horticulture

The area features educational containers for hands-on horticulture learning, focusing on planting, watering, care, and harvesting techniques. These containers are grouped and surrounded by vibrant Veronica species, along with *Acer circinatum* and *Clematis*. It also includes mini greenhouses that allow for observing plant life cycles, testing cultivation methods, and creating microclimates for different plants. Nearby, a plant composition of *Juniperus communis* and *Picea abies* enhances the learning environment, encouraging users to deepen their horticultural knowledge.

CONCLUSIONS

The theme of this research proposes the creation of a therapeutic and relaxing environment by stimulating the senses. Zoning involves dividing into areas dedicated to each sense, using sensory plant species to reach all the senses.

Plants were included that stimulate the visual sense through various colors and shapes, the olfactory sense through pleasant aromas, the tactile sense through various textures, the auditory sense through the delicate sounds of leaves and flowing water, and the gustatory sense through edible plants. This holistic approach transformed the garden into a space for recreation and sensory therapy, contributing to the physical and mental well-being of patients, visitors and medical staff.

The integration of sensory plant compositions and light horticultural activities in the design of the hospital garden highlights how landscaping can support the health and well-being of the community. The idea of this project can serve as a model for other medical institutions and public spaces, emphasizing the importance of the interaction between nature and the human experience.

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MORPHOLOGICAL AND BIOCHEMICAL CHARACTERISTICS OF SOME TAXA OF *LAVANDULA* L.

CARACTERESTICI MORFOLOGICE ŞI BIOCHIMICE ALE UNOR TAXONI DE *LAVANDULA* L.

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Abstract. *Among the various species within the Lavandula genus, Lavandula angustifolia (true lavender) and Lavandula × intermedia (lavandin) are considered the most significant, because they are grown both for their beauty as ornamental plants and for their essential oils, which are widely used in cosmetics, perfumery, and aromatherapy. This paper presents the results of a study carried out on plants in their second year of cultivation, from two varieties of lavender (`Little Lottie` and `Munstead`) and one variety of lavandin (`Grosso`), grown under the ecological conditions of NE Romania (city of Iași). The plants' decorative aspect (by determining some morphological characters) and the chemical composition of the organic extract obtained from the flowers were analyzed. Lavandin showed the highest growth in height (88.5 cm) and diameter (141 cm), as well as the highest number of inflorescences/plant (570 infl./pl.). The lavender varieties had 38.4-56.7 cm heights and bush diameters of 61.2-70 cm, with the highest values in `Munstead` and an almost identical number of inflorescences/plant (199.4-200.1). The chemical composition, evaluated by GC-FID-MS showed the presence of higher linalool amounts (maximum in lavandin), linalyl acetate, and lavandulyl acetate (maximum in `Munstead`), eucalyptol (maximum in lavandin), and camphor (only in lavandin).*

Key words: lavender, lavandin, morphological characters, organic extract.

Rezumat. *Dintre speciile genului Lavandula L., levănțica (L. angustifolia Mill.) și lavandinul (L. x intermedia Emeric ex Loisel) sunt considerate cele mai importante deoarece sunt cultivate atât pentru valoarea decorativă, cât și pentru uleiurile esențiale utilizate pe scară largă în cosmetică, parfumerie, aromaterapie. Lucrarea prezintă rezultatele unui studiu efectuat la plante aflate în anul doi de cultură, de la două soiuri de levănțica (`Little Lottie` și `Munstead`) și un soi de lavandin (`Grosso`), cultivate în condițiile ecologice din NE României (orașul Iași). A fost analizat aspectul decorativ al plantelor (prin determinarea unor caractere morfologice) și compoziția chimică a extractului organic esențial obținut din flori. Lavandinul a înregistrat creșterile cele mai mari în înălțime (88,5 cm) și diametru (141 cm), dar și numărul cel mai mare de inflorescențe (570 infl./pl.). Soiurile de levănțică au avut înălțimi de 38,4-56,7 cm și diametrul tufei de 61,2-70 cm, cu valori maxime la soiul `Munstead`, iar numărul de inflorescențe/plantă aproape identic (199,4-200,1). Compoziția chimică, determinate cu GC-FID-MS, a evidențiat prezența în cantități mai mari a linaloolului (maxim la lavandin), acetatului de linalil și acetatului de lavandulil (maxim la `Munstead`), eucaliptolului (maxim la lavandin) și camforului (numai la lavandin).*

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Cuvinte cheie: levănțică, lavandin, caractere morfologice, extract organic.

INTRODUCTION

The *Lavandula* L. genus (*Lamiaceae* family) comprises 47 species, numerous hybrids and about 400 varieties of herbaceous or subshrub plants native to the Mediterranean climate, many of them appreciated for their decorative appearance but also for their valuable volatile oil content, with uses in different fields (perfumery, cosmetics, pharmacology, traditional medicine, aromatherapy, food, etc.) [Aprotosoaie *et al.*, 2017; Pokajewicz *et al.*, 2021; Pokajewicz *et al.*, 2023]. The specific fragrance of plants of the genus is due to the presence of monoterpenes synthesized in the aerial parts of the plants, especially in flowers [Hassanpouraghdam *et al.*, 2011; Cantor *et al.*, 2018; Bogdan *et al.*, 2020; Nedeltcheva-Antonova *et al.*, 2022]. Some *Lavandula* species contain high amounts of camphor, which has antimicrobial and antifungal effects, while others have a high content of antioxidant substances (Cavanagh and Wilkinson, 2002).

Among the species of greater economic and ornamental importance are lavender or English lavender (*L. angustifolia* Mill.) and lavandin (*L.* x *intermedia* Emeric ex Loisel.), a hybrid between *L. angustifolia* and *L. latifolia* Medik. [Asci *et al*., 2019].

Lavender has lignified stems at the base, with an average height of approx. 40-60 cm, and forms compact, regular clumps. The leaves are linear or lanceolate, with wavy margins, silver-green, and covered with tomentum. The flower stems are unbranched, with the flowers arranged in compact terminal spikes organized in whorls of 3-5 flowers. The essential oil is of low toxicity, even undiluted, and can be used to treat wounds and burn infections. It is one of the species widely cultivated globally and is officially recognized by the European Pharmacopeia as a medicinal plant [Nedeltcheva-Antonova *et al.*, 2022; Kiprovski *et al.*, 2023].

Lavandin differs from lavender in its larger bush size, broader leaves and branched flower stems with flowers in lax spikes. Its primary use as a raw material for the extraction of essential oils, which are particularly rich in terpenoids (linalyl acetate, linalool), as it has a higher yield than lavender [Asci *et al.*, 2019].

The ISO (International Organization for Standardization) standards for lavender and lavandin are reliable reference points for assessing essential oil quality and authenticity [Wilson *et al.*, 2023].

The present work analyzes a number of morphological characters of ornamental interest, as well as aspects concerning the composition of organic extracts from fresh flowers of *L. angustifolia* Mill. and *L.* x *intermedia* Emeric ex Loisel.

MATERIAL AND METHOD

Two cultivars of *L. angustifolia* (`Little Lottie` and `Munstead`) and one cultivar of *L.* x *intermedia* (`Grosso`) were studied (fig. 1).

'Little Lottie' is a cultivar with white - pink flowers and height up to 40 cm (fig. 1.a), and 'Munstead' a variety with purple flowers, silver- green foliage that grows in dense bushes up to 60 cm high (fig. 1.b).

'Grosso' reaches a height of 90-100 cm, forms a globular bush, has green leaves and inflorescences of approx. 15 cm in length and 5 cm in diameter, with purple flowers (fig. 1.c).

The experimental cultures were established in 2022, in the field of the Floriculture discipline at the Iasi University of Life Sciences, Romania. Planting was done at distances of 50 cm between rows and 50 cm between plants per row. The experiment was single-factor, the experimental factor being the cultivar, with three graduations, resulting in three experimental variants, arranged in randomized blocks with three replicates (5 plants/replication).

a) 'Little Lottie' b) 'Munstead' c) 'Grosso'

Fig. 1. Appearance of studied taxa

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Biometric determinations considered total plant height from ground level, total length of flower stems, inflorescence length and number of inflorescences per plant. The results were statistically interpreted by determining the correlations between some morphological characters to establish their relationship. Correlation coefficients were calculated and linear regression through mathematical modeling from MS EXCEL application of MS Office 2019 package was used.

To determine the composition of the organic extract, 30 flowers were collected from each cultivar using tweezers, without pressing the calyx, and placed in 20 mL vials with 4 mL of ethyl acetate (Sigma). The hermetically sealed tubes were stored at 4°C until extraction. The extract containing volatile compounds from the flowers was collected and dried by adding anhydrous sodium sulfate (Sigma) (Guitton *et al.*, 2009). Analyses were performed with an Agilent 7890A gas chromatograph (GC) coupled with an Agilent 5975C quadrupole mass spectrometer (MS). A DB-WAXetr column with a length of 30 m, internal diameter of 0.32 mm and film thickness of 0.32 µm was used. The operating conditions were as follows: the helium flow rate was 5.0 mL min-1 and the oven temperature started at 65 °C, increasing to 170 °C at a rate of 1.5 °C min-1. The injection was done in splitless mode with a purge flow rate of 3 mLmin-1. Both injector and detector temperatures were set at 250 °C. The MS source was operated in electron ionization (EI) mode at an electron energy of 70 eV, and the ion source temperature was 200°C. Mass spectra were acquired in the mass range of 40-300 a.m.u. (atomic mass units) (Zagorcheva *et al.,* 2013). The constituents present in the EO samples were identified by comparing their relative retention indices, estimated using a mixture of a homologous series of aliphatic hydrocarbons from C_8 to C_{40} and MS fragmentation patterns with those from an Adams mass spectra library and NIST'08 (National Institute of Standards and Technology). The GC analysis was performed on an Agilent GC-7890A gas chromatograph (Agilent Technologies, USA) equipped with a flame ionization detector (FID) under the same conditions as described above. The FID temperature was maintained at 280 °C for the oil analyses. The relative composition of the investigated samples was

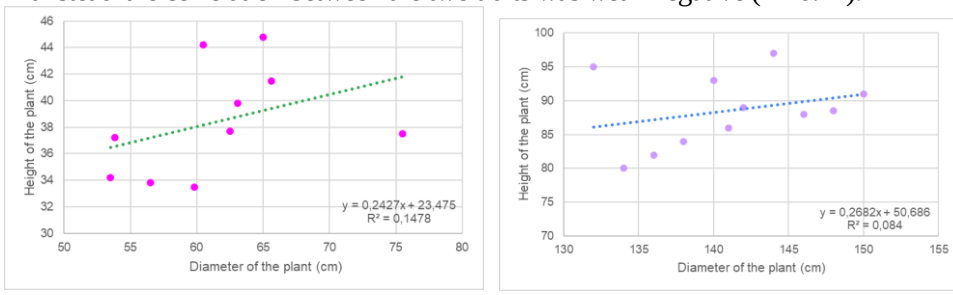
calculated based on the GC-FID peak areas (measured using the HP-5 ms column) without using a correction factor.

RESULTS AND DISCUSSIONS

Morpho-decorative characters

The study analyzed the correlations between different morpho-decorative characters of the three *Lavandula* taxa, constructed the corresponding linear regressions, wrote the regression equations and calculated the Pearson correlation coefficients. Results were interpreted according to the following significance intervals: r<0.25 weak correlation, 0.25<r<0.5 medium correlation, 0.5<r<0.75 strong correlation and r >0.75 very strong correlation.

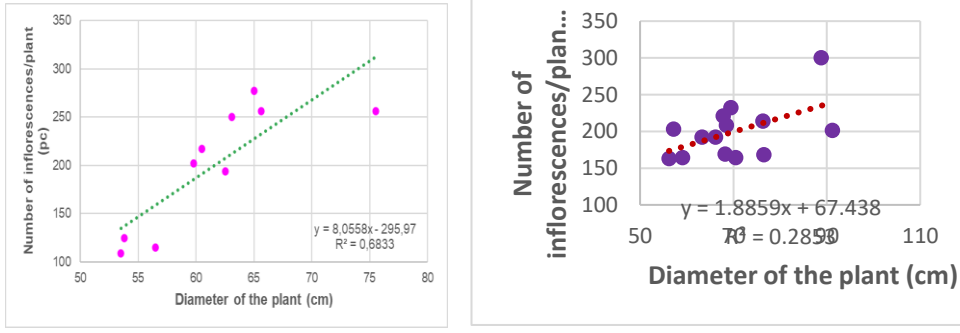
Between total plant diameter and total plant height (fig. 2), medium positive correlations were obtained for 'Little Lottie' (r = 0.38) and 'Grosso' (r = 0.29), while in 'Munstead' the correlation between the two traits was weak negative (r = 0.12).



a) 'Little Lottie' b) 'Grosso'

Fig. 2. Correlation between the diameter of the plant and the total height of the plant

In the case of plant diameter and number of inflorescences/plant (fig. 3), a strong positive correlation was identified for 'Little Lottie' (r = 0.83) and a medium to strong positive correlation for 'Munstead' (r = 0.53), while a non-significant negative correlation was identified for 'Grosso' (r = 0.02).

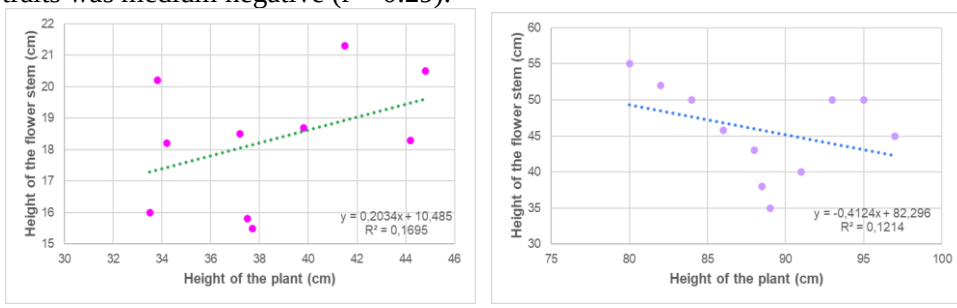


a) 'Little Lottie' b) 'Munstead'

Fig. 3. Correlation between the diameter of the plant and the number of inflorescences/plant

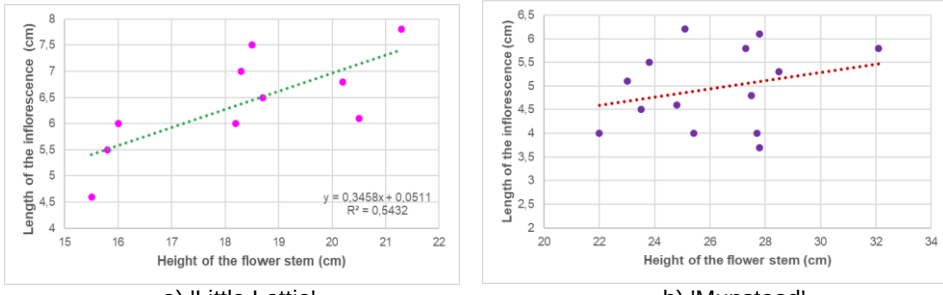
The pair of total plant height and flower stem height (fig. 4) correlated average positive for 'Little Lottie' (r = 0.41), average negative for 'Grosso' (r = 0.35) and non-significant in 'Munstead' (r = 0.09).

It was found that the correlations between flower-stem length and inflorescence length (Fig. 5) were strongly positive in 'Little Lottie' (r = 0.74), and medium in 'Munstead' (r = 0.28). In cv. 'Grosso', the correlation between the two traits was medium negative (r = 0.29).



a) 'Little Lottie' b) 'Grosso'

Fig. 4. Correlation between the total height of the plant and the height of the flower stem



a) 'Little Lottie' b) 'Munstead'

Fig. 5. Correlation between the total height of the plant and the length of the inflorescence

Composition of the organic extract

The study aimed to identify the main essential constituents—linalool, linalyl acetate, lavandulyl acetate, eucalyptol, and camphor—extracted from an organic sample, using a more accessible and cost-effective method. A comparative analysis was conducted using GC-MS to evaluate the extract obtained from fresh flowers alongside the essential oil. Essential oil extraction, performed using the Clevenger method, resulted in yields of approximately 2.9% for lavandin and 2.6% for lavender. These results are consistent with previous studies, such as Xiangyang and Pu (2020), which reported a lavender yield of 2.2%.

The extraction yield calculation was performed by relating the concentrations of volatile aromatic compounds identified in the essential oil to the corresponding values of the same analytes in flowers. Thus, by comparing the results obtained from the organic extract with ISO standards, the feasibility of oil extraction (the oil content being more concentrated) and the valorization potential of the cultivars could be detected.

Data are presented in table 1 of means, medians and standard deviations based on samples tested in triplicate.

The lavandin cultivar ('Grosso') showed the highest content of linalool (21.61±0.224%), a terpene known for its floral and slightly spicy aroma and valued for its calming and relaxing properties in aromatherapy. In the two cultivars of *L. angustifolia*, lower linalool content was observed: 15±3.168% in 'Munstead' and only 5.09±3.168% in 'Little Lottie'. Linalyl acetate recorded the highest concentration in 'Munstead' (39.93±6.548%), followed by 'Little Lottie' (11.82±0.111%) and 'Grosso' (2.42±0.049%).

Table 1

Concentrations of aromatic main constituents

Sp. / cv.	Ec.	Linalool (%)	Linalyl acetate(%)	Lavandulyl acetate(%)	Eucalyptol (%)	Camphor (%)
***L.* x *intermedia* 'Grosso'**	$\bar{x}$	21.61	2.42	0.43	12.56	2.05
	$\tilde{x}$	21.51	2.40	0.42	12.63	2.05
	σ_x	0.224	0.049	0.017	0.400	0.025
***L. angustifolia* 'Munstead'**	$\bar{x}$	5.09	39.93	2.99	0.34	-
	$\tilde{x}$	4.77	36.69	2.94	0.34	-
	σ_x	1.388	6.548	0.298	0.035	-
***L. angustifolia* 'Little Lottie'**	$\bar{x}$	15.00	11.82	1.45	0.37	-
	$\tilde{x}$	13.58	11.8	1.97	0.39	-
	σ_x	3.168	0.111	0.985	0.053	-

$\bar{x}$ - mean value, $\tilde{x}$ - median value, σ_x standard deviation

Lavandulyl acetate was the compound with much lower concentrations than linalyl acetate in all the taxa analyzed, in the same descending order: 'Munstead' with 2. 99±0.298%, followed by 'Little Lottie' (1.45±0.985%) and 'Grosso' (0.43±0.017%). Eucalyptol showed large differences between species, with the highest content being determined in the lavandin cultivar, 12.56±0.400%. The lavender cultivars had a much lower content, 0.37±0.053% in 'Little Lottie' and 0.34±0.035% in 'Munstead'. The lavandin cultivar 'Grosso' also stood out for its camphor content (2.05±0.025%), a component not identified in lavender cultivars. The average content (%) of the compounds identified in the organic extract of lavender and lavandin cultivars is shown in fig. 6.

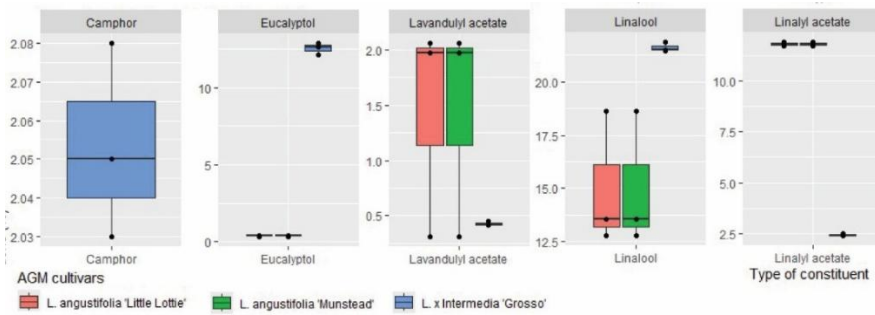


Fig. 6. Main aromatic constituents (concentrations %)

L. angustifolia premium oils (ISO 3515:2002) should contain 25–38% linalool, 25–45% linalyl acetate, 3.4–6.2% lavandulyl acetate, and 0.5–1% camphor. Both analyzed varieties had lower linalool levels; 'Munstead' met the linalyl acetate range, while 'Little Lottie' did not. Neither met the lavandulyl acetate standard.

Lavandin 'Grosso' oils (ISO 8902:2009) require 24–35% linalool, 28–38% linalyl acetate, 1.5–3% lavandulyl acetate, and 6–8% camphor. The study found all compounds below these limits, except for relatively better linalool (21.61%) and camphor (2.05%), but very low linalyl acetate (0.43%), suggesting reduced aromatic quality.

CONCLUSIONS

1. The intensity and direction of the correlation coefficient between the morphological characters analyzed were different between species and cultivars of *Lavandula*. In the two *L. angustifolia* cultivars, 'Little Lottie' showed direct correlations with medium and high intensity (r>0.38) for all pairs of characters, whereas 'Munstead' showed negative correlations with weak or insignificant values for the character pairs plant diameter/height and plant height/flowered stem length, respectively medium positive correlations for the other character pairs. In the case of lavandin ('Grosso'), the correlations were negative, insignificant or of medium intensity, except for the character pair bush diameter/plant height where the correlation was positive.

2. The variety of morpho-decorative characters such as plant size, number of inflorescences, color, as well as the intensity of the fragrance, make the studied cultivars suitable for ornamental purposes.

3. 'Grosso' had terpene levels that were partially aligned with the ISO standards for lavandin (by linalool content), and 'Munstead' had values close to the ISO specifications for *L. angustifolia*, in terms of linalyl acetate and lavandulyl acetate.

4. Use in aromatherapy recommends cv. 'Grosso' for its linalool content and cv. 'Munstead' for its linalyl acetate content.

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