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CONTENT

INTEGRATION OF FRUIT SPECIES WITH HIGH ORNAMENTAL POTENTIAL IN URBAN LANDSCAPE DESIGN

INTEGRAREA SPECIILOR POMICOLE CU POTENTIAL ORNAMENTAL RIDICAT IN DESIGNUL PEISAGER URBAN

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Abstract. The research aims to integrate fruit species with high ornamental value into landscape design because this concept represents an increasingly appreciated approach that combines aesthetics, functionality and sustainability, also accessing resources regarding the marketing of these fruits, which have a high nutritional potential and an attractive taste. This practice transforms green spaces into productive environments, contributing to local food security, increasing biodiversity and improving the quality of life. Research in this area is crucial to optimize the benefits and overcome the challenges associated with this initiative. The theme addresses the visual perception of the public and the potential to create interesting landscape structures through the shape, color of flowers and fruits, as well as how these plants contribute to the creation of shade areas, spatial delimitation and attraction for local fauna.
Key words: fruit species, ornamental, landscape design, biodiversity.

Rezumat. Cercetarea urmăreşte integrarea speciilor pomicole cu valoare ornamentală ridicată în designul peisager deoarece, acest concept reprezintă o abordare tot mai apreciată, care îmbină estetica, funcționalitatea și sustenabilitatea, accesand si resurse privind comercializarea acestor fructe, care au un potențial nutrițional ridicat și un gust atractiv. Această practică transformă spațiile verzi în medii productive, contribuind la securitatea alimentară locală, la creșterea biodiversității și la îmbunătățirea calității vieții. Cercetarea în acest domeniu este crucială pentru a optimiza beneficiile și a depăși provocările asociate cu această inițiativă. Tema abordează percepția vizuală a publicului și potențialul de a crea structuri peisagere interesante prin forma, culoarea florilor și fructelor, precum și modul în care aceste plante contribuie la crearea de zone de umbră, delimitare spațială și atracție pentru fauna locală.
Cuvinte cheie: specii pomicole, ornamental, design peisager, biodiversitate.

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INTRODUCTION

The integration of fruit species into urban and rural landscape design is an increasingly appreciated approach that combines aesthetics, functionality and sustainability (Jones and Sanyang, 2009). This practice transforms green spaces into productive environments, contributing to local food security, increasing biodiversity and improving the quality of life. Research in this area is crucial to optimize the benefits and overcome the challenges associated with this initiative (Lauri et al., 2022; Sroka and, 2021). The theme addresses the visual perception of the public and the potential to create interesting landscape structures through the shape, color of flowers and fruits, as well as how these plants contribute to the creation of shade areas, spatial delimitation and attraction for local fauna.

Concept and Evolution. Traditionally, urban green spaces were dominated by strictly ornamental species. Currently, we are witnessing a reevaluation of the role of plants, with fruit trees increasingly being included in:

Street alignments: Use of decorative fruit species (e.g. ornamental cherries, some columnar pears, *Pyrus calleriana*) or even productive ones adapted to urban conditions.

Parks and public gardens: Creation of community orchards or inclusion of fruit trees as isolated or group pieces, which decorate with flowers (spring), foliage (autumn) and, in addition, provide fruit (Negrea et al., 2010 and 2011; Narandžić et al., 2023; Pașcu et al., 2022).

Private gardens and balconies: Popularity of low-growing varieties, such as columnar or dwarf fruit trees, which maximize the limited space.

The inclusion of fruit trees brings a triple **benefit**:

Ecological and Environmental: contributes to biological diversity (through flowers and fruits, they attract pollinators); improve air quality and provide necessary shade; contribute to regulating the urban microclimate (Hickman et al., 2021; Thierry et al., 2023; Dascalu et al., 2013).

Social and Community: Encourage the concept of community gardening and promote a healthy lifestyle; stimulate citizen responsibility and education in the field of environmental protection and food sources; contribute to better food security at the local level (Tsalikidis et al., 1999; Bernardis et al., 2022; Bălan et al, 2015).

Aesthetic and Functional: provide increased visual interest throughout the year (flowers, fruits, autumn colors); can be managed in artistic forms, such as palisades, adding architectural value to the landscape (Antić et al., 2021; Gullino et al., 2009; Istrate et al., 2025).

The success of this integration depends on the correct choice of species and varieties adapted to: difficult urban conditions: resistance to noxious substances, pollutants, compacted soils and extreme temperatures (Căpraru et al., 2009; Schippa et al., 2018; Padulosi et al., 2013; Ochoa et al., 2010). Also, maintenance needs: pest and disease management, specific pruning, may be greater than in the case of strictly ornamental species.

In conclusion, the integration of fruit species into the urban landscape is a modern strategy that transforms green spaces into multifunctional areas, which not only beautify the city, but also nourish it and make it more ecologically resilient.

MATERIALS AND METHODS

The research aims to integrate fruit species with high ornamental value into landscape design because this concept represents an increasingly appreciated approach that combines aesthetics, functionality and sustainability, also accessing resources regarding the marketing of these fruits, which have a high nutritional potential and an attractive taste.

We used an extensive bibliographic analysis and case studies to evaluate the potential for integration into urban landscaping and functional gardens.

As a planning tool SWOT analysis was used and it's focusing on the main Strengths, Weaknesses, Opportunities, and Threads of the location (Pașcu et al., 2018). The role was as to ascertain the feasibility of the research. Taking into consideration this opportunity, we consider opportune the development of a model of "green oasis". This implies the need for rehabilitation/development/construction works, in order to create a sustainable and environmentally friendly places for community.

RESULTS AND DISCUSSION

The results obtained from research on the inclusion of ornamental tree species in urban landscape design are multiple and relevant, addressing both aesthetic and ecological aspects, as well as socio-economic ones. Research on the inclusion of ornamental tree species in urban landscape design offers a wide range of valuable results, contributing to the development of more functional, aesthetic and sustainable urban green spaces.

Discussions on the inclusion of fruit species in landscape design focus on integrating functionality (fruit production) with aesthetics and ecological benefits. This approach is increasingly popular, especially in the context of sustainable development and urban green spaces.

Depending on the desired role, species of the following genera can be chosen:

- ***Malus*** and ***Pyrus***: Ornamental varieties with abundant flowers or small fruits, as well as classic fruit varieties.
- ***Prunus*** and ***Cerasus***: Spectacular spring flowers; sour cherry often has a smaller habit, suitable for confined spaces. *Prunus cerasifera* Nigra for leaf color, used in groups or alignments.
- ***Juglans*** and ***Corylus***: Used as a large tree for shade and fruit value.

For the successful integration of fruit species, specific aspects must be taken into account high aesthetic value (persistent fruits on branches even in the cold season), source of food for local fauna (especially birds) and good adaptability and resistance (table 1).

Species Selection: There are preferred varieties with adapted habit (dwarf, columnar or semi-dwarf) for small spaces or alignments (e.g., in cities). Resistance to diseases, pests and specific conditions of the urban environment (pollution, poor soils) is taken into account, although, in general, fruit trees require more careful phytosanitary care.
Location and Form: They can be used as isolated pieces (solitary) to highlight the shape of the crown or in groups to create shady areas. Artificial forms, such as palisade or trimmed crowns, provide an artistic touch and save space.
Maintenance: Requires regular pruning for shaping and fruiting, which must be integrated into the landscape maintenance plan. Fruit management (harvesting and cleaning) must be planned to avoid public sanitation problems (fallen fruit).

In figure 1 there are exemplified some ways of using tree species as mixed compositions for private gardens (a and b) or urban landscape design-squares (c and d).

Table 1

List of fruit tree species with high ornamental value for landscape design

Nr. crt.	Specie name	Ornamental element	The use in the design
1	*Aronia melanocarpa*	habitus, fruits	groups
2	*Castanea sativa*	habitus	alignments and groups for parks
3	*Cornus mas*	habitus, fruits	groups
4	*Cornus sanguinea*	habitus, branches	groups
5	*Corylus avellana* Contorta	habitus, branches	alignments and groups
6	*Ficus carica*	habitus	solitary, center of interest, groups
7	*Juglans regia*	habitus	alignments and groups for parks
8	*Malus floribunda*	habitus, flowers	solitary, center of interest
9	*Mespilus germanica*	habitus	groups
10	*Pyrus calleriana*	columnar habitus, leaves colour during autumn	street alignments
11	*Prunus cerasifera* Nigra	red leaves	street alignments, groups
12	*Rosa canina*	habitus,flowers, fruits	groups, pergolas
13	*Rosa centifolia*	habitus,flowers,	groups, pergolas
14	*Sambucus nigra*	habitus, flower, fruits	groups
15	*Sorbus aucuparia*	habitus, fruits	groups
16	*Vaccinum corymbosum*	habitus, fruits	groups
17	*Ziziphus jujuba*	habitus, fruits	groups

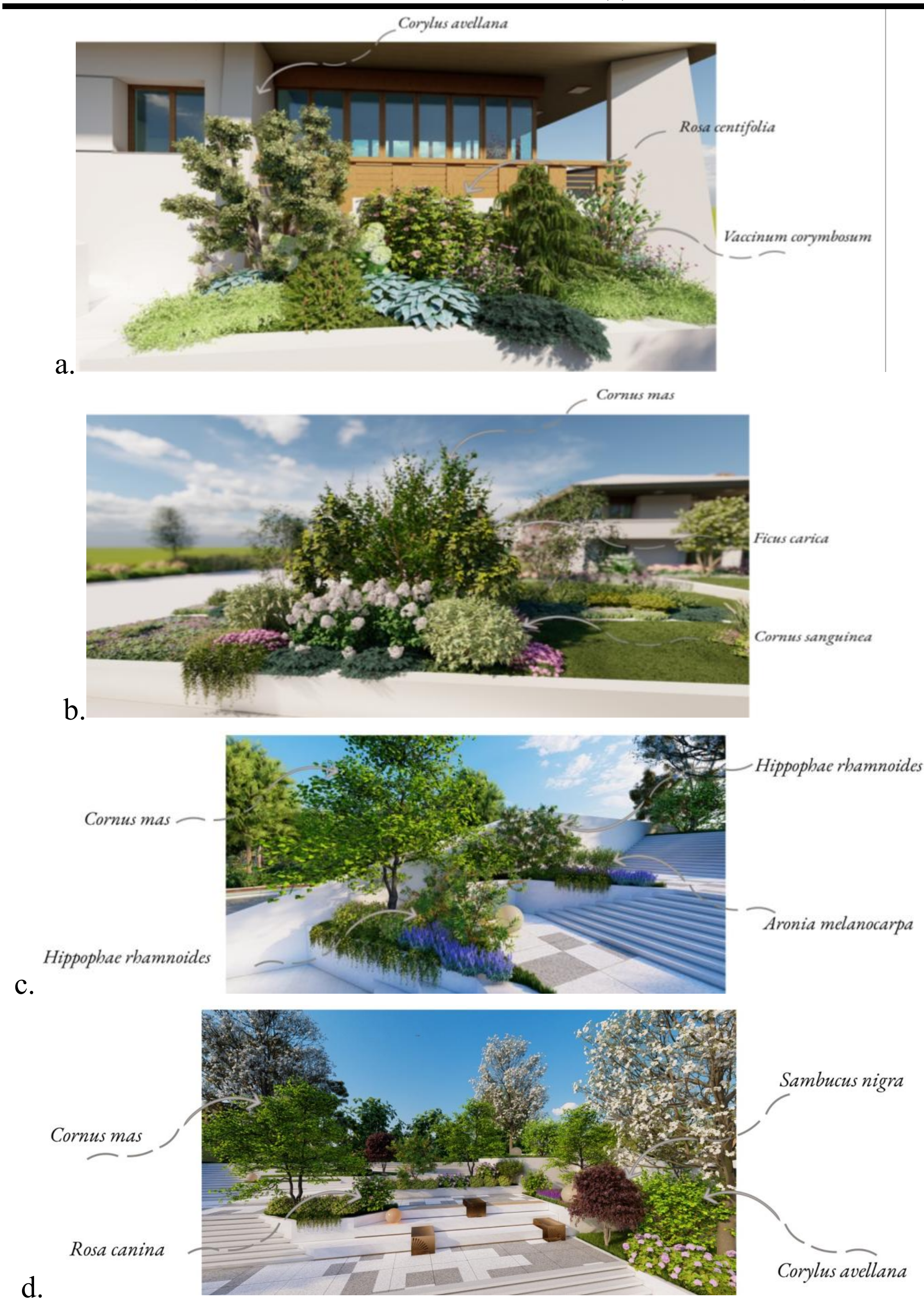

Figure 1. Examples of fruit species use in urban landscape design (photo: Ina Vladimir)

CONCLUSIONS

Revitalizing and renovating green spaces by introducing these concepts into parks and other urban developments are aspects of essential importance for creating a sustainable urban environment that meets the aesthetic, but also functional needs of users.

By integrating fruit species, a closer connection with nature is promoted, creating a friendlier and more harmonious space for the entire community and, at the same time, new sources of food, while ensuring biodiversity.

Activities that involve working outdoors with plants offer benefits for physical and mental health, such as increasing physical activity, reducing stress and improving mental well-being.

This could also bring opportunities and create jobs (in areas such as gardening, landscaping, food processing, distribution, etc.), but most importantly, it is educating new generations in the spirit of sustainability and environmental care.

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MULTIPLE USES OF EDIBLE PARTS IN ORNAMENTALS AND OTHER UNDERUSED TREE SPECIES

UTILIZĂRI MULTIPLE A PĂRȚILOR COMESTIBILE A UNOR SPECII ORNAMENTALE ȘI POMICOLE MAI PUȚIN UTILIZATE

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Abstract.
This paper explores the culinary potential of plants traditionally considered ornamental, highlighting the diversity of edible parts they can offer. We have considered several less used ornamental or fruit species with high ornamental value and their usable components, such as young leaves, flowers and fruits, discussing their nutritional profile and safety of consumption. In addition to the botanical aspects, the paper presents practical preparation methods, from salads and infusions to sweets and side dishes, offering innovative ideas for integrating them into everyday nutrition. Special emphasis is placed on the precautions necessary for the correct identification and avoidance of toxic species or those treated with chemicals. Finally, the study highlights the ecological and economic benefits of valorising these resources, promoting a more sustainable approach to our relationship with the plant world.
Key words: ornamentals, edible parts, valorisation, sustainability, fruits

Rezumat.
Această lucrare explorează potențialul culinar al plantelor considerate în mod tradițional ornamentale, evidențiind diversitatea părților comestibile pe care acestea le pot oferi. Am luat în considerare mai multe specii ornamentale sau pomicole mai puțin utilizate dar cu ridicată valoare ornamentala și componentele lor utilizabile, cum ar fi frunzele tinere, florile și fructele, aducând în discuție profilul lor nutrițional și siguranța consumului. Pe lângă aspectele botanice, lucrarea prezintă metode practice de preparare, de la salate și infuzii până la dulciuri și garnituri, oferind idei inovatoare pentru integrarea acestora în alimentația cotidiană. Un accent deosebit este pus pe precauțiile necesare pentru identificarea corectă și evitarea speciilor toxice sau a celor tratate cu substanțe chimice. În cele din urmă, studiul subliniază beneficiile ecologice și economice ale valorificării acestor

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resurse, promovând o abordare mai sustenabilă a relației noastre domeniul vegetal.
Cuvinte cheie: specii ornamentale, părți comestibile, valorificare, sustenabilitate, fructe

INTRODUCTION

Throughout history, the relationship between humans and plants has been fundamental, centred primarily on meeting the primary needs of food, shelter, and medicine. However, modern societies, especially those in urban areas, have begun to place increasing emphasis on the aesthetic and environmental role of plants, transforming public and private spaces into veritable green oases [Jahanshiri e*t al.,* 2020; Smyth, 2023]. This trend has led to a proliferation of ornamental species, chosen for the beauty of their flowers, foliage, or general shape [Negrea and Zlati*,* 2011]. Despite their undeniable landscape value, a significant number of these plants, along with other underutilized fruit species [Istrate *et al*., 2025], possess an often over looked potential: that of providing valuable food resources, exploitable through their various edible parts [Fernandes e*t al.,* 2017; Kalemba-Drożdż, 2016; Jakubczyk e*t al.,* 2022; Gupta e*t al.,* 2018; Martins-Loução *et al*., 2024].

Paradoxically, in the context of global concerns regarding food security, dietary diversification, and the promotion of sustainability, a large part of the plant biodiversity with sweetener potential remains unexplored or insufficiently exploited. Many of the species considered exclusively ornamental or those that grow spontaneously in diverse ecosystems have fruits, leaves, flowers, seeds or roots with remarkable nutritional and organoleptic properties, often superior to or complementary to those of traditional crops [Antić e*t al.,* 2021]. Moreover, these species can often be more resistant to adverse climatic conditions, less demanding on soil and less susceptible to diseases and pests, thus offering viable and sustainable alternatives to current agricultural systems [Thierry *et al*., 2023; Amăriuței *et al*., 2023; Bernardis *et al*., 2022 and 2023; Pașcu *et al*., 2021].

This research paper aims to explore and synthesize existing knowledge on the "multiple uses of edible parts of ornamental plants and other underutilized fruit species". By identifying and characterizing these plant resources, the paper aims not only to shed light on their gastronomic and nutritional potential, but also to promote a more integrated and sustainable approach to landscape design and natural resource management. Particular attention will be paid to species with demonstrated potential, analysing aspects related to their nutritional composition, consumption safety, preparation methods and potential applications in human nutrition and, implicitly, in the diversification of small-scale and large-scale agricultural production.

Ultimately, this research aspires to contribute to a better understanding and a broader valorisation of plant biodiversity, opening new perspectives for food security and human well-being.

MATERIALS AND METHODS

Samples

There was analysed three types of jams purchased from a local producer in Iași, *Conacul Goruni* (Figure 1).

This unit processes various horticultural products and manufactures jams, marmalades, juices and sauces.

Fig. 1. Analysed jams samples https://conaculgoruni.ro

Chemical parameters

The soluble solid content was assessed by the refractometric method, using a Refractometer (Optika HR-150N), and the results were expressed in °Brix. Titratable acidity (also called total acidity) was determined by the titrimetric method [Beceanu, 2010; Murariu *et al*., 2017].

Samples were homogenized with distilled water and titrated with 0.1 N NaOH solution [Buțerchi *et al*., 2025; Ciurlă *et al*., 2025].

The results were expressed in the prevailing acid, namely, % malic acid.

The pH of the sample was determined using a pH-meter from Hanna Instruments. The analyses were realised in triplicate according to Irimia [2021] and the means were represented in Table 1.

Sensory analyses

Sensory evaluation was performed by a panel of 40 untrained consumers (20 men and 20 women of 20 to 60 years old).

Members were chosen to identify the level of acceptance of jams. Using a 0–10 point hedonic scale, panel members rated the product's appearance, colour, smell, sweetens, bitterness, acceptability (1 - strongly dislike; 10 - strongly like).

The results were represented by means value in chart (Figure 2).

RESULTS AND DISCUSSION

The jam samples have been analysed in terms of chemical parameters according to the standards applied in food industry.

In terms of total soluble solids content, the highest value was obtained by the lilac flower jams sample (58°Brix), followed by elderflower jams 56°Brix, and the lowest value in mint jams 51°Brix. According to jam standards confirmed also by Irimia [2013], the final concentration must reach 70-75 refractometric degrees to ensure proper preservation of the product. All three samples are below the mentioned limit. This result can be attributed to the adaptation of the manufacturing technology, using a recipe with lower sugar content.

Table 1

Chemical parameters of jam samples

Samples	Total soluble solids content (TSS, °Brix)	pH	Total acidity (g acid malic/100 g product)
Liliac flower jam	58	4.1	0.31
Elderflower jam	56	3.7	0.44
Mint jam	51	3.9	0.36

Elderflower jam has the lowest acidity (lower pH), 3.7, in accordance with the requirements for gelling, which requires a favourable pH of 3.0-3.4. The other two samples have a slightly higher pH, 3.9 (mint jam) and 4.1 (liliac flower jam) which can affect gelling and preservation properties [Hosseini Bai *et al*., 2025; Gąsecka *et al*., 2023; Tóth *et al*, 2016].

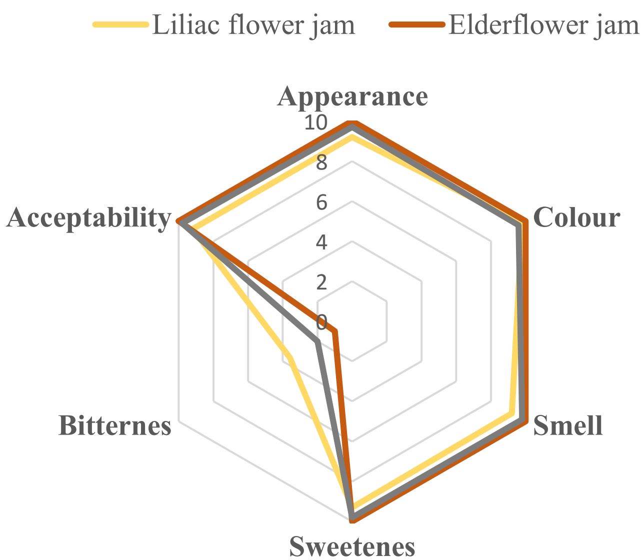

Fig. 2. Sensory characteristics of jams

The sensory analysis (Figure 2) shows that elderflower jam achieved the highest scores for all evaluated parameters, with perfect ratings and minimal bitterness, indicating superior consumer preference. Mint jam also scored highly, though a slightly higher bitterness (2.0) may have slightly reduced its acceptability compared to elderflower. Lilac flower jam received good ratings for appearance and aroma but showed the highest bitterness (3.6), which affected its overall acceptability. These results suggest that bitterness has a strong influence on consumer's preferences.

The sensory evaluation of the unique aromatic trio contrasted the vibrant and mentholated freshness of the mint assortment with the subtly floral and effervescent sweetness of the elderberry one, in addition to the fine, enigmatic and spring-like note specific to the lilac flower jam.

When it comes to flowers, it is clear that the list could extend in terms of preferences but it's essential to only use edible flowers and make sure they haven't been treated with pesticides. If you want to try recipes with unusual flowers, it's always safest to buy them from growers who specialize in edible plants (Table 2).

Table 2

List of ornamentals and underutilized trees jams available on market

Nr. crt.	Specie name	Part of the plant	Common name	Source
1	*Viola odorata*	Flowers	Spanish violet	https://delicatessen.ro https://www.souschef.co.uk
2	*Syringa vulgaris*	Flowers	Lilac	https://conaculgoruni.ro
3	*Jasminum officinale*	Flowers	Jasmine	https://delicatessen.ro
4	*Citrus × sinensis*	Flowers	Orange	https://delicatessen.ro
5	*Paeonia officinalis*	Flowers	Peony	https://quartzboutique.fr
6	*Robinia pseudoacacia*	Flowers	Acacia	https://pink-skink.com
7	*Papaver somniferum*	Flowers	Poppy	https://www.foodturkiye.com
8	*Ziziphus jujuba*	Fruits	Jujube	https://www.casoinonline.it https://www.iltomolo.it
9	*Mespilus germanica*	Fruits	Medlar	https://www.casoinonline.it
10	*Arbutus unedo*	Fruits	Strawberry tree	https://www.casoinonline.it
11	*Cornus mas*	Fruits	Cornelian cherry	https://www.fromaustria.com
12	*Rosa canina*	Fruits	Rosehip	https://www.fromaustria.com
13	*Sambucus nigra*	Fruits Flowers	Elderberry	https://www.fromaustria.com https://conaculgoruni.ro

Elderflower jam delights the senses with an unmistakable, intensely floral and fresh aroma, complemented by a sweet-fragrant taste, often with a subtle sour note given by lemon, and a delicate texture of the flowers infused in syrup.

Lilac flower jam stands out for its intense, floral and eccentric aroma, a refined taste that combines the sweetness of the syrup with a distinctive, slightly bitter note (similar to that of bitter cherries), and the fine petals add a precious and delicate texture.

Mint jam offers a unique balance, combining the sweetness of the well-bound syrup with an intense, invigorating and mentholated freshness, which leaves a pleasant sensation of coolness, while being particularly aromatic.

CONCLUSIONS

This research work has deepened the concept of multiple uses of edible parts from underutilized ornamental plants and fruit tree species, demonstrating a significant, often neglected, and potential for diversifying food resources and promoting sustainability. The analysis revealed that a considerable number of species cultivated predominantly for their aesthetic value or considered "unconventional" possess remarkable nutritional and organoleptic properties, comparable to or even superior to traditional crops. One of the main strengths highlighted is the resilience of many of these species. They often adapt better to varied climatic conditions, to less fertile soils and are less susceptible to diseases and pests, thus reducing the need for intensive chemical interventions. This gives them a crucial role in the context of climate change and the need to develop more robust food systems and less dependent on external inputs.

Were identified various edible parts – from fruits and leaves, to flowers and seeds – that can be integrated into human diets, contributing to food security and nutritional diversification. The use of these resources contributes not only to an intake of vitamins, minerals and bioactive compounds, but also to a unique culinary experience, stimulating interest in local gastronomy and sustainable food practices.

However, the large-scale integration of these species into food systems requires overcoming some challenges. It is essential to continue research on the exact nutritional composition, food safety (identification of potential anti-nutritional or toxic compounds under certain conditions) and the development of optimal harvesting and processing protocols. It is also imperative to educate the public and agricultural and landscape specialists to recognize and value these resources.

In conclusion, the undoubted potential of ornamental plants and underutilized tree species to contribute to our food systems is undeniable. Through multidisciplinary approaches that combine botany, agronomy, nutrition and horticulture, we can unlock this "hidden treasure" of biodiversity. Investment in research and dissemination of knowledge will pave the way to urban and rural landscapes that are not only beautiful, but also productive, resilient and sustainable, offering multiple benefits for both the environment and human well-being. We believe that promoting the use of these species represents an important step towards a more harmonious and fruitful relationship with the plant world.

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LUCRĂRI ŞTIINŢIFICE SERIA HORTICULTURĂ, 68 (1) / 2025, USV IAŞI

REHABILITATION OF A SPACE THAT INCLUDES SPECIFIC ELEMENTS OF THE NEOROMANIAN STYLE

REABILITAREA UNUI SPATIU CE INCLUDE ELEMENTE SPECIFICE STILULUI NEOROMÂNESC

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Abstract.
This study explores the principles and methodologies for the rehabilitation of natural spaces surrounding buldings that incorporate elements of the Neoromanian style. Originating in the late 19th century, the Neoromanian style represents a synthesis of traditional Romanian folk architecture, Brâncovenesc influences, and Byzantine aesthetics. This architectural and artistic movement aimed to define a national identity and is characterized by specific elements such as semicircular arches, loggias, columns with basket capitals, and the use of natural materials like brick and stone. The research focuses on the landscape rehabilitation of the associated garden, arguing that the outdoor space is an integral part of the Neoromanian design philosophy. The approach centers on the use of traditional horticultural species, particularly native trees and shrubs, to recreate a rustic, yet elegant, atmosphere. The study proposes a framework for designing and implementing these green spaces, emphasizing the importance of respecting the historical context. The paper concludes with a case study that applies these principles to a specific project that is located in Cotnari, Iași. The findings offer a comprehensive guide for landscape designers, and cultural heritage specialists seeking to preserve and revitalize spaces that embody the rich aesthetic and historical values of the Neoromanian style.
Key words: rehabilitation, garden, Neoromanian style, landscape, rustic.

Rezumat.
Acest studiu explorează principiile și metodologiile pentru reabilitarea spațiilor naturale aferente unor construcții ce încorporează elemente ale stilului neoromânesc. Originar de la sfârșitul secolului al XIX-lea, stilul neoromânesc reprezintă o sinteză a arhitecturii populare tradiționale românești, a influențelor brâncovenești și a esteticii bizantine. Această mișcare arhitecturală și artistică a avut ca scop definirea unei identități naționale și se caracterizează prin elemente specifice precum arcade semicirculare, loggii, coloane cu capiteluri în formă de coș și utilizarea materialelor naturale precum cărămida și piatra. Cercetarea se

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concentrează pe reabilitarea peisagistică a grădinii asociate, argumentând că spațiul exterior este o parte integrantă a filosofiei de design neoromânesc. Abordarea se concentrează pe utilizarea speciilor horticole tradiționale, în special a arborilor și arbuștilor nativi, pentru a recrea o atmosferă rustică, dar elegantă. Studiul propune un cadru pentru proiectarea și implementarea acestor spații verzi, subliniind importanța respectării contextului istoric. Lucrarea se încheie cu un studiu de caz care aplică aceste principii, si detaliaza amenajarea unei grădini din comuna Cotnari, județul Iași. Rezultatele oferă un ghid cuprinzător pentru designerii peisagiști și specialiștii în patrimoniu cultural care doresc să conserve și să revitalizeze spațiile care întruchipează bogatele valori estetice și istorice ale stilului neoromânesc.

Cuvinte cheie: reabilitare, gradina, stilul neoromânesc, peisaj, rustic.

INTRODUCTION

The neo-Romanian architectural style embodies a self-awareness of the romanian people and is manifested through components based on traditional values that reinterpret vernacular, brâncovenești and byzantine elements to create a harmonious national style [Dinulescu, 2009]. Constructive parts such as semicircular arches, columns and carved capitals, geometric and floral ornaments, as well as natural materials - stone, wood and brick - have been consistently recognized as defining features of the style [Hoinărescu, 2023; Lowe, 2001]. All these specific elements constitute the national cultural heritage, which is why their proper conservation within rehabilitation projects is of major importance. Therefore, due to the cultural value it encompasses, a space containing neo-Romanian elements and structures requires a rehabilitation process based on a methodology that offers conservation approaches applicable to the style [Baera *et al.*, 2023].

Despite the historical importance of neo-Romanian architectural elements, the deterioration of many of these structures is currently occurring at an increasingly rapid pace. This trend can be attributed to two major causes, namely - the lack of proper maintenance and natural functional ageing of buildings, respectively to inappropriate technical modifications that affect the initial stylistic authenticity [Nistor, 2000]. Similar to this phenomenon, there is an increased vulnerability of the plant environment, which once formed the indispensable entourage characteristic of neo-Romanian villas and buildings, the garden representing an indispensable extension of the house. The mentioned vulnerabilities clearly indicate the need to develop rehabilitation strategies that would provide not only rigid conservation of form and vegetation, but also adapt the spaces to contemporary functional standards through a sensitive reinterpretation of the landscape [Nestoriuc *et al.*,2025].

The aim of the paper is to investigate the methods through which a space with neo-Romanian elements can be rehabilitated, while preserving its stylistic and cultural value. In this sense, the research proposes the analysis of an applied case study that details the design of a garden integrated into the grounds of a rehabilitated neo-Romanian style house in Cotnari commune, Iasi county.

MATERIAL AND METHOD

The methodology used combines architectural and landscape analysis of neo-Romanian heritage. It is based on the study of specialized literature and images retrieved from the Ziarele Arcanum and the Biblioteca Digitală archives showing the historical gardens associated with neo-Romanian architectural complexes, in order to catalog the plant species used, the compositional distribution of the alleys, the inventory of specific materials and traditional elements that can be reinterpreted in the proposed case study.

The initial analysis of the case-study site shows the advanced deterioration of architectural features such as masonry and wooden elements due to exposure to adverse weather conditions and the lack of necessary care. The study of the existing vegetation shows the loss of traditional species, the appearance of areas with unkempt vegetation, associated with soil compaction and deterioration of the alleys (Figure 1).

Fig. 1. The initial analysis of the site

RESULTS AND DISCUSSIONS

The first stage of the process was the restoration of the building. Wood was used as the main element, intervening both on the exterior and in the interior design with wooden elements inspired by traditional, vernacular elements of romanian architecture (Figure 2).

Fig. 2. The proposed wood elements in exterior (1,2,3) and interior design (4,5,6)

The second stage consisted of the realization of the garden design concept. It aims at the reinterpretation of the spatial organization characteristic of a neo-Romanian style garden. To this end, the main interventions proposed were the restoration of the visual relationship between the reconfigured space of the loggia and the garden space, the reintroduction of characteristic traditional plants and the restoration of the alleys by using materials compatible with the original design (Figure 3).

Fig. 3. The proposed garden design concept

Relaxation Area Inspired by the Loggia

The design of the relaxation area is inspired by the architectural element of the loggia, a structure that harmoniously integrates traditional aesthetics into a contemporary space. It offers a functional area of rest and shade, while also creating an intermediate space that ensures a harmonious connection between the house and the garden. As in the built ensemble of the building, the exterior elements are also made of wood - as the main material, reflecting the traditional craftsmanship of neo-Romanian architecture (Figure 4).

Fig. 4. The relaxation area inspired by the Loggia

Restoration of pathways and natural stone elements

It was proposed to integrate alleys made of cubic stone, in order to preserve the historical aspect of the site and to highlight the continuity of the tradition in landscape design. These alleys will contribute to maintaining the harmonious connection between the general concept of the garden and the neo-Romanian architectural style of the building, while ensuring functionality and accessibility in the outdoor space (Figure 5).

a. The concept design presentation **b.** The implementation stage

Fig. 5. The restoration of pathways

Creating plant compositions using traditional species

To recreate the authentic spirit of neo-Romanian gardens, it is proposed to use a traditional plant palette, which includes species frequently found in historical gardens around romanian houses.

The proposed species are listed in the table below.

Table 1.

List of proposed species

Platanus acerifolia	*Rosa sp.*
Syringa vulgaris	*Lavandula angustifolia*
Forsythia intermedia	*Viburnum opulus*
Buxus sempervirens	*Prunus laurocerasus*
Cedrus deodara	*Berberis thunbergii*
Buddleja davidii	*Rudbeckia fulgida*

The selected species contribute to the rendering of the historical atmosphere by using plant textures specific to romanian landscapes from the beginning of the 20th century. Their use in the plant design contributes to the shaping of the stylistic identity of the garden, creating a continuity between architecture and landscape [Bernardis *et al.,* 2022].

Trees and shrubs such as *Platanus acerifolia*, *Cedrus deodara*, *Viburnum opulus* and *Prunus laurocerasus*, provide a structural framework for the composition, creating volume and areas of shade. These species recall the mature vegetation in the gardens of old romanian villas. Research into the historical archives of these villas demonstrates that the species of *Syringa vulgaris, Rosa* sp. or *Forsythia x intermedia*, are indispensable in the traditional landscape, bringing with them a special seasonal chromatic variation through abundant flowering, deeply integrated in the popular memory and associated with the historical heritage (Figure 6).

Fig. 6. The representation of planting compositions

The species of *Buxus sempervirens* and *Berberis thunbergii* contribute to the ordering of the compositions through their formal appearance, and decorative perennials such as *Lavandula angustifolia*, *Rudbeckia fulgida* or *Buddleja davidii* complete the composition with color accents, thanks to the beloved flowers used in both formal historical spaces and in the contemporary landscape (Figure 7).

Fig. 7. The representation of planting compositions

The stage of placing plants in the field is an essential one in the rehabilitation process (Figure 8). A rigorously executed implementation contributes to the recreation of the historical environment, while ensuring a harmonious coexistence of species, implicitly a sustainability of the landscape composition. Scientific studies confirm that the use of native species, organized according to ecological principles, increases their ecological resistance [McKinney, 2002; Căpraru and Zlati, 2009; Istrate *et al.,* 2025; Zlati and Gradinariu, 2010]. In this way, a functional balance between the plant components is ensured, highlighting the need to integrate traditional species in the restoration process [Zlati *et al*., 2024)]

Fig. 8. The on-site arrangement of plants

CONCLUSIONS

The rehabilitation process of a space with neo-Romanian features requires a strategy that treats the site as a coherent ensemble, combining the conservation of built elements with landscape heritage. The restoration with attention to detail of the decorative elements and the traditional plant community ensures an authentic reconstruction of the house-garden ensemble, thus maintaining a balance between the cultural and ecological sides of the process.

Respect for heritage is not a rigid reconstruction of the past but a sensitive reinterpretation of traditional architectural and landscape elements. This process allows the preservation of the historical character, while adapting the site to the challenges and pressures of the present.

Looking beyond the direct interventions of rehabilitation of a degraded space, the process can be considered an example of cultural and ecological education. By bringing traditional species back to the forefront, the project significantly contributes to highlighting the value of cultural heritage, demonstrating its importance in the resilience of a cultural landscape.

The integration of traditional elements into the rehabilitation process contributes to the reactivation of national identity and the connection with our heritage. Moreover, the methods applied within it can serve as examples of good practice, which can be replicated in other sites with neo-Romanian specificity to achieve balanced projects in terms of authenticity, functionality and sustainability.

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GREEN TERRACES – A PLANT BASED SOLUTION FOR GREENER CITIES

TERASE VERZI – O SOLUȚIE BAZATĂ PE PLANTE PENTRU ORAȘE MAI VERZI

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Abstract.
This research paper investigates the potential of green terraces as a sustainable, plant-based solution for mitigating urban environmental challenges and promoting greener cities. As urban populations continue to grow, cities face increasing pressures from climate change, air pollution, and the urban heat island effect, coupled with a significant loss of biodiversity. Green terraces, which include living roofs, rooftop gardens, and vertical green walls, offer a practical and scalable strategy to address these issues by integrating nature directly into the built environment. The study examines the multifaceted benefits of green terraces from several perspectives: environmental, economic, and social with focus on several on site exemples. Through a review of existing literature, case studies, and quantitative data, this paper aims to provide a comprehensive overview of the design, implementation, and maintenance of green terraces. It also discusses policy frameworks and incentives that can encourage their widespread adoption. The findings demonstrate that green terraces are not merely aesthetic additions but are essential components of a resilient and sustainable urban infrastructure, offering a tangible pathway towards creating healthier, more livable, and truly greener cities..
Key words: green terraces, green city, sustainability, landscape.

Rezumat.
Această lucrare de cercetare investighează potențialul teraselor verzi ca soluție durabilă, bazată pe plante, pentru atenuarea provocărilor de mediu urban și promovarea unor orașe mai verzi. Pe măsură ce populațiile urbane continuă să crească, orașele se confruntă cu presiuni tot mai mari din partea schimbărilor climatice, a poluării aerului și a efectului de insulă termică urbană, împreună cu o pierdere semnificativă a biodiversității. Terasele verzi, care includ acoperișuri vii, grădini pe acoperișuri și pereți verzi verticali, oferă o strategie practică și scalabilă pentru a aborda aceste probleme prin integrarea directă a naturii în mediul construit. Studiul examinează beneficiile multiple ale teraselor

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verzi din mai multe perspective: de mediu, economice și sociale, concentrându-se pe câteva exemple la fața locului. Printr-o analiză a literaturii existente, a studiilor de caz și a datelor cantitative, această lucrare își propune să ofere o imagine de ansamblu cuprinzătoare asupra proiectării, implementării și întreținerii teraselor verzi. De asemenea, discută cadrele de politici și stimulentele care pot încuraja adoptarea lor pe scară largă. Concluziile demonstrează că terasele verzi nu sunt doar completări estetice, ci sunt componente esențiale ale unei infrastructuri urbane rezistente și durabile, oferind o cale tangibilă către crearea unor orașe mai sănătoase, mai locuibile și cu adevărat mai verzi

Cuvinte cheie: terase verzi, oraș verde, sustenabilitate, peisaj.

INTRODUCTION

Urban space is experiencing numerous social and ecological problems, linked to population migration that causes the accelerated expansion of cities, a phenomenon responsible in turn for an increasing urban densification, which culminates in the emergence of unprecedented ecological changes [Zlati and Pascu, 2021]. The observation of this continuous cyclical process has allowed the formulation of global projections that show that two-thirds of the global population will live in urban areas by 2050, putting even greater pressure on the infrastructure and resources in these areas [United Nations, 2025]. Specifically speaking, these pressures are manifested in the increase in air pollution levels, the expansion and worsening of the urban heat island phenomenon, the decrease in the capacity to manage urban waters and the accelerated decline in biodiversity [Grimm *et al*., 2008; IPCC, 2022]. Overall, these processes not only affect environmental resilience, but also population health and quality of life in general [WHO, 2021].

The evolution of these challenges has generated the emergence of nature-based solutions (NbS) that have attracted increasing attention through the proposed approach. Namely, these solutions represent integrated strategies based on natural processes, arising in response to current environmental problems, bringing with them other related benefits [IPBES, 2019; Bernardis *et al.,* 2022].

In this context, green terraces - including green roofs, balcony gardens, green walls - all these components have emerged as promising solutions that incorporate vegetation into the built environment [Zlati *et al.,* 2022]. Compared to conventional green spaces, which occupy areas at ground level, green terraces occupy already built, otherwise unused areas, with the aim of increasing their ecological capacity without affecting the natural space [Oberndorfer *et al*., 2007; Francis and Lorimer, 2011; Căpraru and Zlati, 2009; Draghia *et al*., 2009].

From an ecological perspective, green terraces contribute to reducing surface and ambient temperatures, thus reducing the urban heat island effect [Santamouris, 2014; Zlati *et al.,* 2024]. At the same time, they also improve air quality, due to the absorption of pollutants and suspended particles [Currie and Bass, 2008]. And from a biodiversity perspective, they create habitats for pollinators, birds and insects, favoring the creation of an ecological connection in dense urban areas [Köhler, 2008; Zlati *et al.*, 2019, Istrate *et al.,* 2025].

Also from a mental health perspective, green spaces are associated with increased levels of psychological well-being. And when designed for the community, they can serve to social cohesion between different categories of users, encouraging socialization and belonging [Guitart *et al*., 2012].

MATERIAL AND METHOD

In this context, this paper aims to conduct an analysis of the potential for the creation and implementation of green terrace projects in the city of Iasi, as a long-term solution that could improve the effects of urban center congestion and support the transition to greener cities.

Following a synthesis of specialized literature and field investigations of existing green terrace models, plant compositions considered suitable for use on green terraces were proposed, based on which the most effective options for the design, implementation, and maintenance of a green terrace can be analyzed.

RESULTS AND DISCUSSIONS

Following the analyses carried out, the paper proposes four typologies of planting strategies:

1. Vegetative compositions organized around a major structural element
2. Mixed compositions of shrubs of various sizes
3. Compositions of decorative grasses or mixed with grasses and shrubs
4. Vertical systems with climbing plants

Instead of focusing on the individual performances of the species used, the study aims to analyze the contribution of vegetation ensembles.

1. Vegetative compositions organized around a major structural element

Compositions organized around a dominant dendrological element provide a vertical structure and impose a spatial hierarchy. Examples proposed for terraces include compositions such as: *Magnolia grandiflora* combined with spheres of *Prunus laurocerasus* and *Photinia x fraserii* at its base; *Acer palmatum* integrated with *Spiraea japonica*, *Euonymus fortunei* and *Cornus alba*; bamboo vegetable curtains (Figure 1). These are usually placed in large containers to provide a sufficient amount of substrate for root development. In all three examples, these groupings serve as a focal point, defining spatial boundaries, and the shrub vegetation at the base adds seasonal decoration through flowers or leaves, for a textural contrast.

Fig. 1. The illustration of the proposed compositions

From an ecological point of view, compositions organized around a dominant dendrological element represent the most complex plant structure, and the placement of vegetation on height levels resembles natural habitats, which helps to integrate into the natural urban network. The presence of dendrological specimens improves the degree of shading of built surfaces, reduces surface temperature, contributes to wind protection and increases the thermal comfort of terraces exposed to high solar radiation.

2. Mixed compositions of shrubs of various sizes

Compositions made up of a mix of shrub species offer a visual point at eye level, and combinations of deciduous and coniferous species bring interest and dynamism throughout the year. Typical examples used are: *Ligustrum*, *Photinia*, *Lavandula*, *Cotoneaster*, *Spiraea*, *Berberis*, as well as various varieties of *Juniperus* or *Pinus*. Shrubs that decorate with flowers bring strong seasonal accents, and conifers - in the winter months. A successful association with these is the use of bamboo - as an architectural element, providing vertical accent but without having the visual weight of a more massive tree (Figure 2).

Fig. 2. The illustration of the proposed species

Shrubbery groups represent a harmonious structural element from a compositional point of view, combining both ecological benefits and the feasibility of their use on terraces. The height and moderate maintenance requirements offer more extensive possibilities for the use of shrub species on terraces.

From an ecological point of view, flowering species have an important role in supporting pollinators, and evergreen species provide habitat for insects and other small creatures.

From a design perspective, shrubs are more flexible in compositions, making it possible to choose species that correspond to the location, environmental factors, and user needs as accurately as possible. The low maintenance requirement combined with a high aesthetic performance leads to the favoring of this type of compositions, especially in residential or institutional spaces.

3. Compositions of decorative grasses or mixed with grasses and shrubs

In plant compositions made from decorative grasses or in mixed compositions that also include decorative grasses, species such as *Calamagrostis acutiflora*, *Pennisetum alopecuroides*, *Stipa tenuissima*, *Festuca glauca*, *Miscanthus sinensis* are used (Figure 3). These can be combined with each other or in a mix with shrubs.

This type of compositions shows a great adaptation to the conditions of a terrace, having a good resistance both to high temperatures and to other stress factors such as exposure to strong air currents. From an aesthetic point of view, it offers an ever-changing character throughout the year, also contributing through its form to the creation of a natural dynamism [Negrea and Zlati,2013].

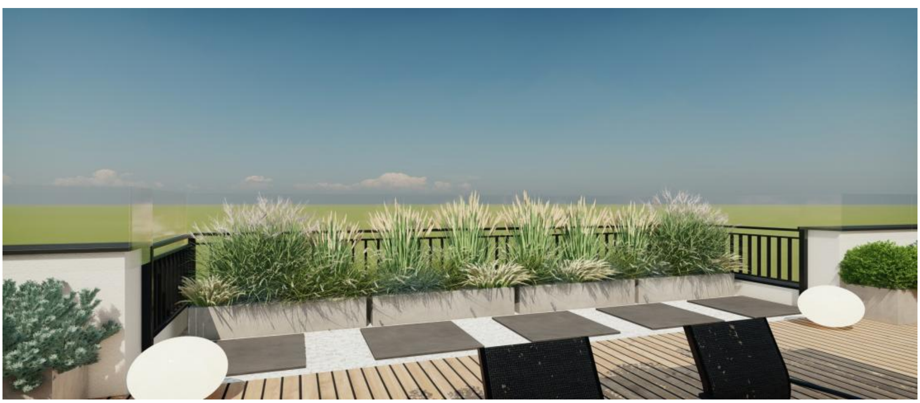

Fig. 3. The use of decorative grasses

The compositions made of ornamental grasses align with the principles of nature-inspired design, especially with the concept of urban lawns. Ecologically speaking, these species are resistant to the thermal factor, require a lower amount of irrigation, while providing a sensory experience for the users of the space.

4. Vertical systems with climbing plants

Climbing species are especially used on various types of supports, being systems that offer a high degree of shade and protection without the need for a large amount of substrate or massive planters. From an ecological point of view, species such as *Hedera helix* or *Wisteria sinensis* are resistant to solar radiation, bringing comfort and elegance to the terrace (Figure 4).

Fig. 4. The use of vertical systems with climbing plants

From a social point of view, the space located under a pergola can be arranged for socializing, encouraging residents to spend time outside the rooms.

These observations and vegetation groupings demonstrate the need for clearly defined, context-appropriate design directions when implementing a green terrace design. This way, they can function not only as static design elements, but as components of highly resilient and biodiversity-rich urban infrastructure.

CONCLUSIONS

This study shows that it is necessary to change the perspective on green terraces, viewing them not only as decorative elements, but as multifunctional solutions based on nature. Regardless of the type of composition used, they contribute to a greater or lesser extent to improving environmental conditions.

Also, the structure of plant compositions has an influence not only on the ecological element of the environment, but also on the practical part of implementation, so special importance must be given to context-specific design strategies, and not to treating each site with a general approach.

Beyond the ecological benefits, a green terrace represents a place for informal socialization, encouraging interaction with the outdoor environment and representing a suitable example of urban sustainability.

For the large-scale inclusion of green terraces as an important element in a sustainable urban infrastructure, it is necessary to generate policies that stimulate future planning approaches of a built structure. In conclusion, it is necessary that future urban regeneration strategies prioritize green terraces, as scalable interventions at different sizes, capable of simultaneously improving both the ecological and social aspects of the environment.

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PLANTING DESIGN FOR RESILIENT LANDSCAPES: THE ROLE OF CONIFERS, DECIDUOUS AND PERENIAL PLANT GROUPINGS IN ECOLOGICAL LANDSCAPE ARHITECTURE

COMPOZIȚII VEGETALE PENTRU PEISAJE REZILIENTE: ROLUL GRUPĂRILOR DE CONIFERE, ARBORI FOIOȘI ȘI PLANTE PERENE ÎN ARHITECTURA PEISAJULUI ECOLOGIC

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Abstract.
Resilient landscapes represent a hot topic in current research and rely on the integration and planning of plant groupings that provide not only beauty but also significant ecological value. Responding to the growing emphasis on resilient landscapes, the study assesses the contribution of conifers, deciduous trees, and perennial plants in harmonizing visual impact with the ecological benefits provided to the space. Based on design principles for different categories of spaces, several compositions were proposed and their impact on visual quality, as well as the ecological benefits generated, were evaluated. The study demonstrates that certain aesthetic and ecological effects arise only from specific groupings or species, and altering even a single element can compromise the outcome. This knowledge guides the proper mixing of plant groupings in both public and private designed spaces. Moreover, integrating this understanding into large-scale management strategies enables the creation of ecologically rich landscapes.
Key words: resilient landscapes, planting design, ecological benefits

Rezumat.
Peisajele reziliente reprezintă un subiect de interes major în cercetările actuale și se bazează pe integrarea și planificarea grupărilor de plante care oferă nu doar frumusețe, ci și o valoare ecologică semnificativă. Ca răspuns la accentul tot mai mare pus pe peisajele reziliente, studiul evaluează contribuția coniferelor, arborilor foioși și plantelor perene în armonizarea impactului vizual cu beneficiile ecologice aduse spațiului. Pe baza principiilor de design pentru diferite categorii de spații, au fost propuse mai multe compoziții, iar impactul acestora asupra calității vizuale și beneficiile ecologice generate au fost evaluate. Studiul demonstrează că anumite efecte estetice și ecologice apar doar din

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grupări sau specii specifice, iar modificarea chiar și a unui singur element poate compromite rezultatul. Această cunoaștere ghidează mixarea corectă a grupărilor vegetale în spațiile amenajate publice și private. Mai mult, integrarea acestei înțelegeri în strategiile de management la scară largă permite crearea unor peisaje bogate ecologic.
Cuvinte cheie: peisaje reziliente, compoziții vegetale, beneficii ecologice

INTRODUCTION

The term resilient landscape expresses the convergence of ecological performance and aesthetic experience. Landscape design is often analyzed from two antagonistic perspectives – aesthetic or scientific, rarely a synthesis of the two. Given the pressures of the present and climate issues, it is imperative that the landscape schoud be able to respond to both cultural and ecological needs without compromising the historical value of the plant heritage [Yang *et al*., 2014; Cervetto *et al*., 2025].

This paper aims to investigate the interaction between the aesthetic and ecological dimensions of a landscape. The study aims to introduce the concept of a functional framework [Tveit and Ode Sang, 2014] for the analysis of existing or planned plant compositions in a historical landscape site, demonstrating its applicability in a case study, namely the Copou Garden in Iași.

We argue that to enhance the resilience of a heritage landscape, is needed an interdisciplinary approach that combines ecological function, aesthetic character and social dynamics. Historic landscapes - although often perceived as a passive element of an environment - fulfill the role of an active system, contributing intensively to the sustainability, well-being and ensuring the continuity of an ecosystem [Swaffield and McWilliam, 2013]. But to maintain viability, a heritage site requires an integrated methodology that addresses the cultural perception of the population, the appropriate use of space and ecological resilience.

The three interdependent aspects underlie the recommendation of the six key elements of the proposed functional framework to be used as a practical tool in landscape resilience analysis.

MATERIAL AND METHOD

The methodology of the study in question included three main stages: the study of bibliographic literature, historical photo-documentation and the realization of field observations. An investigation of the specialized sources that address the theme of the study was carried out, achieving an interdisciplinary synthesis of information from fields such as – urban ecology, landscape architecture, urbanism, vegetal design. This analysis allowed the identification of key elements, relevant for defining an analysis system, with the aim of correlating the aesthetic dimension with the ecological one.

In order to determine both aesthetically and ecologically efficient landscaping solutions, field investigations would be conducted, analyzing plant structures in parks, gardens or other urban spaces in Romania. The key elements pursued in the visual documentation were: the way plants are grouped in compositions, the association of textures and seasonal rhythms, the user's interaction with the plant framework.

A functional framework is a carefully structured method for analyzing the ecological resilience and cultural correspondence of existing or proposed landscapes [Yang *et al*., 2014]. The proposed six elements - Method, Application, Consequences, Association, Aesthetics, Necessity - offer a new perspective on landscape assessment and development.

For testing the respective matrix and conducting field observations, the Copou Garden in Iasi was selected.

RESULTS AND DISCUSSIONS

Copou Garden is considered the oldest public park in the city of Iași, its first beginnings dating back to 1832, with the application of the Organic Regulation, which raised the issue of implementing spaces with a specific character, intended either for parade squares or public promenade gardens [Ciubotaru, 2015].

The location chosen for the garden presented a major advantage in its subsequent evolution, being located on Podul Verde Street, where the houses of the most prominent aristocratic families were located, walks in the garden becoming true festivities, and the park - an aristocratic sitting translated into nature [Ciflâncă, 2006]. In the context of the vegetation study, we cannot fail to mention the various plant palette proposed for planting in the period 1840-1860, namely: ash trees, poplars, sycamores, elms, hazels, chestnuts, rowan trees, honeysuckle, birches, blood oaks, hornbeams, lime trees [Ciubotaru, 2015].

Following bibliographic research, we can conclude that historic gardens embody a strong historical significance, being a true plant heritage, however, which faces current challenges related to resilience capacity. Among the consequences of this reality, we can observe the fragmentation of the spatial coherence of the site, the aging and degradation of secular vegetation and the lack of biodiversity (Figure 1).

Fig.1. The current state of the park

We affirm that in order to obtain both culturally and ecologically relevant landscapes it is imperative to use such analysis tools as the functional matrix (Figure 2). Starting from the Basic element, namely the Necessity - the analysis will start from the ecological need of the space, which will establish the basic requirements that condition the viability and sustainability of the analyzed or proposed for the implementation landscape.

To determine this need, the analysis must be structured using appropriate methods depending on the role and characteristics of the analyzed landscape.

Application represents the transposition of the analysis results into concrete solutions.

Consequences reflect the effects generated by the intervention, serving as indicators for evaluating ecological and social performance, and their interpretation is carried out through perceptual (Aesthetic) and cultural (Association) filters.

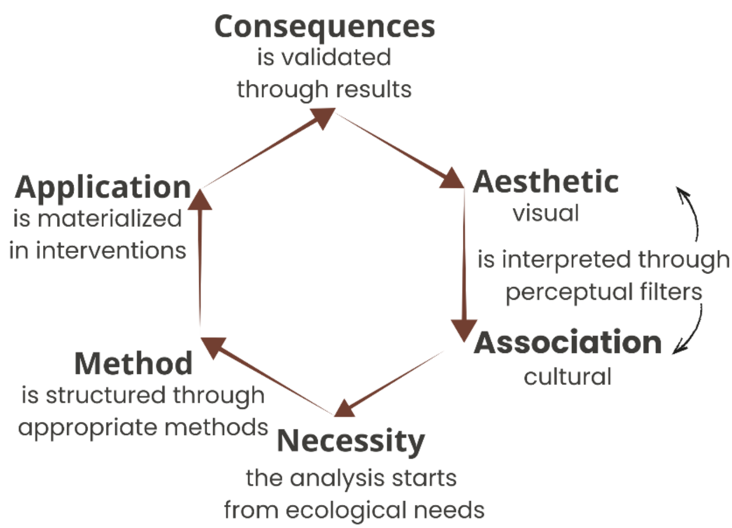

Fig.2. The proposed methodological framework

Although the historical character of the park is largely preserved spatially, without significant changes, we observe that its ecological resistance remains insufficiently addressed, and unsuitable maintenance methods reduce the lifespan of the site.

Bibliographic studies demonstrate that a historical park requires not only static conservation, treating it as a monument - but as a dynamic organism, with spatial, ecological and social relationships [Lian *et al*., 2024]. Thus, although we preserve the incipient spatial structuring of the park, its design and maintenance practices must target the most diversified plant structures, capable of supporting essential functions such as pollination, microclimate regulation and being, at the same time, adapted to urban stres [Fernandes *et al.*, 2025].

Essential aspects missing in Copou Park (Figure 3) concern the absence of a coherent green register, which would allow the inventory, assessment and monitoring of the state of existing vegetation, including changes regarding the appearance or disappearance of some species, as well as the condition of the root system. This lack reduces the capacity for substantiated intervention and adaptive management of the space.

At the same time, there is an excessive use of annual plants, which requires frequent horticultural work and generates a constant disturbance of the soil structure. Their inadequate positioning leads not only to a plant composition lacking visual coherence and functional stratification, but also to the direct damage to mature trees, through plantings carried out in the immediate proximity of the trunks, which involves repeated digging and damage to the root system.

In addition, the expansion of lawn areas, recognized as a major consumer of water and maintenance resources, increases the pressure on the park's ecosystem, contrary to current principles of sustainability and ecological regeneration.

Fig.3. The inadequate plant choises and the expansion of lawn areas

Regarding the analysis method, it is recommended to carry out a spatial mapping of the site, using tools such as GIS, which would allow a detailed understanding of the way in which space is used and the distribution of vegetation over time. The ecological assessment would facilitate the observation of the evolution of relevant factors, such as tree vitality, the presence and dynamics of biodiversity, as well as pedological changes.

In addition, functional mapping would contribute to the identification of areas heavily frequented or avoided by users, sectors exposed to sun or shade and to the analysis of the distribution and functioning of the alley network.

The application of the necessary interventions, established following the methods used, will generate concrete design strategies and policies – specific for historical parks. Studies [Russo *et al*., 2025; Hüttl *et al*., 2019] demonstrate that the sustainability of heritage gardens is based on the integration of plant compositions formed by species adapted to current conditions, on the achievement of an appropriate zoning of the site and on soil regeneration methods. In particular, for the Copou Garden we propose the introduction of layered compositions (Figure 4) and the redefinition of the shrub layer, the integration of conifer species with cultural symbolism, the reduction of water consumption and the protection of historical trees.

Fig.4. Exemples of layerd compositions

In this way, the consequences of the resilient design integrated into the site will balance ecological aesthetics with cultural continuity. As the sources emphasize [Olivadese and Dindo, 2022], complementing biodiversity with a place-specific sensory palette, intended to be permanently imprinted in the memory of visitors, will generate an emblematic landscape, capable of combining cultural value, visual experience and ecological function, offering continuity to future generations. Although the space evokes important symbols, such as the Eminescu Linden Tree, the potential of the garden goes beyond this individual element, so it is important to ensure both aesthetic functionality and national spirit of the entire space, redefining the Copou Garden as a living heritage landscape.

CONCLUSIONS

Historical parks should not be perceived as monuments unchanged over time, but as living ecosystems with interdependent structural, social and ecological relationships. To achieve this result, a change in conservation strategies is necessary, with an emphasis on ecological optimization and revitalization of the site's biodiversity.

It is imperative to move beyond the conventional categorisation of ecological and aesthetic aspects into two distinct categories. Instead, landscape resilience is about combining them in a context where beauty derives from the ecological coherence of the site, which in turn is supported by visual and cultural acceptance.

In the process of designing compositions with increased resilience, the careful integration of conifer, deciduous and perennial species represents a fundamental pillar in ecological landscape architecture.

The proposed methodological framework has the potential to be an applicable, practical and educational tool, useful for analyzing, creating and maintaining public green spaces as well as for study in specialized educational institutions.

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ASSESSING TEMPORAL VARIATION IN FISH COMMUNITIES IN THE LESPEZI SECTOR OF THE SIRET RIVER (2021–2025)

EVALUAREA VARIAȚIEI TEMPORALE A COMUNITĂȚILOR PISCICOLE ÎN SECTORUL LESPEZI AL RÂULUI SIRET (2021–2025)

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Abstract.
This study evaluates changes in fish biodiversity in the Lespezi sector of the Siret River by comparing data collected in 2023 and 2025. Abundance data, derived from scientific fishing surveys, were used to calculate multiple biodiversity indices, including Margalef's richness, Shannon–Wiener diversity, Simpson's dominance, and McIntosh's evenness, providing a comprehensive assessment of community structure. Although the results are subject to some limitations, as the captures reflect only those individuals caught during scientific fishing, the analysis highlights temporal variations in species richness and abundance over the two-year period, reflecting potential influences of environmental factors, anthropogenic pressures, and habitat changes. These findings offer insights into the ecological status of the Siret River fish communities and support sustainable management and conservation strategies for freshwater ecosystems.
Key words: Fish biodiversity, Ecological assessment, Population structure, Temporal comparison.

Rezumat.
Acest studiu evaluează modificările biodiversității piscicole în sectorul Lespezi al râului Siret prin compararea datelor colectate în 2023 și 2025. Datele privind abundența, obținute prin capturi științifice de pești, au fost utilizate pentru calcularea mai multor indici de biodiversitate, inclusiv numărul de specii Margalef, diversitatea Shannon–Wiener, dominanța

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Simpson și uniformitatea McIntosh, oferind o evaluare cuprinzătoare a structurii comunității. Deși rezultatele sunt supuse unor limitări, întrucât capturile reflectă doar indivizii prinși în cadrul pescuitului științific, analiza evidențiază variații temporale ale numărului și abundenței speciilor pe parcursul celor doi ani, sugerând influențe potențiale ale factorilor de mediu, presiunilor antropice și modificărilor habitatului. Aceste constatări oferă perspective asupra stării ecologice a comunităților piscicole din râul Siret și susțin strategiile de management durabil și conservare a ecosistemelor de apă dulce.

Cuvinte cheie: Biodiversitate piscicolă, Evaluare ecologică, Structura populațiilor, Comparare temporală.

INTRODUCTION

Covering a distance of 559 km from its entry into the country to its confluence, the Siret River is one of the most important tributaries [Romanescu, 2009] of the Danube River, with one of the largest drainage basins in Romania, approximately 28,000 km². The Siret River is not navigable. Due to multiple floods, intensified by climate change, such as those in 1991, 2004, 2005, 2008 [Obreja, 2013; Romanescu and Stoleriu, 2013], dams and reservoirs have been constructed along the river. Dams alter the balance of aquatic ecosystems by modifying the flow regime and reducing sediment transport, which directly affects available habitats and biological diversity [Petts and Gurnell, 2005; Salit *et al.*, 2015].

While in previous years the river experienced ice cover during winter, this process was no longer observed in the last few years [www.inhga.ro], suggesting a significant change in the hydrological and thermal regime of the water, with direct consequences for aquatic biodiversity, particularly the structure of the fish community.

Beyond fish communities, the river hosts a complex aquatic biodiversity, represented by phytoplankton and zooplankton, whose trophic structures and seasonal dynamics form the basis of the food web and directly influence ecosystem productivity [Tenciu *et al.*, 2004]. Hydrological alterations and pollution impact not only fish but also planktonic communities, which respond rapidly to changes in water quality and can serve as sensitive ecological indicators of ecosystem health.

The river's ichthyofauna consists of 52 fish species [Battes *et al.*, 2005], but its structure has been modified by anthropogenic factors such as pollution [Faciu *et al.*, 2014; Chidiac *et al.,* 2023] and hydrotechnical regulations [Battes *et al.*, 2005; Danalache *et al.*, 2020; WWF-Ukraine, 2023].

However, studies conducted on the Siret River are relatively few, and those specifically focusing on its ichthyofauna are almost nonexistent, highlighting a significant gap in the scientific literature and justifying the need for further research in this direction.

MATERIAL AND METHOD

Study area. Data on the fish community of the Siret River were collected over two years, 2023 and 2025, at the same monitoring station and during the same period: the Lespezi hydrometric station (Figure 1) – Siret km 387, during May–June, using electrofishing. Fish species were identified to the species level, and the number of individuals was recorded for each species. For each year, the total and relative abundance of each species was calculated. In addition, specimens were measured with an ichyometer (with a precision of ±0.01 cm) and weighed with the help of a field scale (±0.01g).

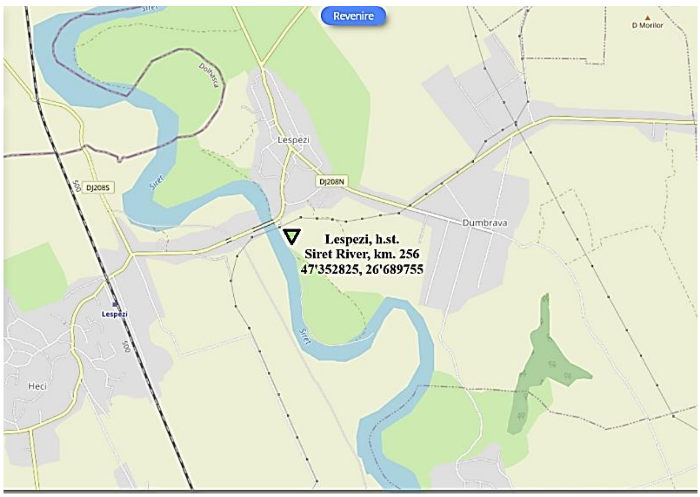

Fig. 1. Study area – Location of the Lespezi hydrometric station (Siret River).

Comparative analysis of biodiversity indices: 2023 vs. 2025. Based on the raw data, biodiversity indices were calculated to assess the richness, diversity, and evenness of the fish community:

- **Margalef (R):** a species richness index that considers the total number of species and the total number of individuals. It is calculated as: $R=(S-1)/\ln(N)$, where S = number of species, N = total number of individuals [Kitikidou *et al.,* 2024].
- **Simpson (D):** a dominance/diversity index reflecting the probability that two randomly selected individuals belong to the same species: $D = \sum p_i^2$, where p_i = proportion of individuals of species i. Values close to 0 indicate high diversity, while values close to 1 indicate strong dominance by a single species [Simpson, 1949]. Diversity is higher if species are evenly distributed [Gregorius and Gillet, 2008].
- **Shannon-Wiener (H'):** a diversity index that combines species richness and evenness of individual distribution: $H' = -\sum p_i * \ln(p_i)$, where p_i is the proportion of individuals of species i. Higher values indicate greater diversity [Kutsch *et al.*, 2001].
- **Berger-Parker (d):** a dominance index based on the most abundant species: $d = Nmax/N$, where N_{max} = number of individuals of the most abundant species,

N = total number of individuals. Higher values indicate stronger dominance [Kitikidou *et al.*, 2024].

- **Shannon's Equitability (E):** measures how evenly individuals are distributed among species: E = H′/ln(S), where H'= Shannon-Wiener index and S= number of species. Values range from 0 to 1, with 1 indicating a perfectly even distribution [Shannon and Weaver, 1963].
- **McIntosh (U):** an index combining species richness and individual distribution, calculated as: U = (N-sqrt(∑n_i^2))/(N-sqrt(N)), where n_i = number of individuals of species i, N = total number of individuals. Values close to 1 indicate a balanced community, while low values indicate dominance [McIntosh, 1967].

To test whether the community structure underwent significant changes between 2023 and 2025, a Chi-square test for species distribution independence was applied (df = 13, α = 0.05). The calculated χ^2values were compared with the critical value $\chi^2_{\text{crit}} = 9.49$. Since the Chi-square test is non-parametric, it does not require data normality.

The similarity between the fish communities in 2023 and 2025 was evaluated using the Jaccard index, which is based on species presence/absence. Values were transformed into a binary format, with 1 for present species and 0 for absent species, to calculate the proportion of species shared between the two communities. The index ranges from 0 (no species in common) to 1 (all species in common), providing an estimate of the degree of overlap in species composition between the two years. Additionally, similarity indices, such as Jaccard, were calculated to quantify changes in the composition and structure of the fish community.

For the evaluation of hydrological parameters of the Siret River, daily data corresponding to the study area were obtained from the National Institute of Hydrology and Water Management (INHGA). Based on these data, descriptive statistical indicators were calculated, including minimum and maximum values, mean, median, range (difference between maximum and minimum values), and standard deviation, for both water level and discharge, to characterize the monthly variability of the water level.

Hydrology–biodiversity correlation*.* To evaluate the relationship between hydrological variability and fish community structure, the monthly/yearly water level range and standard deviation were calculated. These variables were then correlated with biodiversity indices (Shannon–Wiener, Simpson, and Berger–Parker) using Spearman's correlation, due to the low number of observations and the lack of normality. This combined approach allows for the identification of both linear trends and monotonic relationships between hydrological variability and fish community structure.

Statistical analysis. Statistical analyses, data processing, and graphical representations (bar and boxplots) were performed using R software (version 4.5.1).

RESULTS AND DISCUSSIONS

Out of the 52 species reported in the literature [Battes *et al.*, 2005], 11 species were identified in our catches in 2023, while in 2025 only 7 species were recorded. This reduction in diversity suggests a possible degradation of ecological conditions in the Siret River, driven by both anthropogenic pressures and recent hydrological variations. The decrease in species number may reflect not only a decline in habitat quality and its fragmentation but also increased pressure on trophic resources, leading to a restructuring of the fish communities. Thus, the results indicate a trend toward simplification of the ichthyofauna structure and highlight the need for continuous monitoring to capture its dynamics in relation to environmental factors and human pressures.

Analysis of relative abundance highlights the distribution of individuals among species and emphasizes the dominant species. In 2023, *Carassius gibelio* [Bloch, 1782] represented approximately 30% of the community, followed by *Cyprinus carpio* [Linnaeus, 1758] and *Abramis brama* [Linnaeus, 1758] - 13% each), while the remaining species had lower abundances, indicating a moderately balanced community. In 2025, *Abramis brama* became the dominant species with 41%, and *Vimba vimba* [Linnaeus, 1758] contributed 26%, while the remaining species had much lower abundances, below 12% each, emphasizing the imbalance and loss of diversity. Figures 2 and 3 clearly illustrate these changes in community structure and allow visualization of the relative proportions of species between the two years.

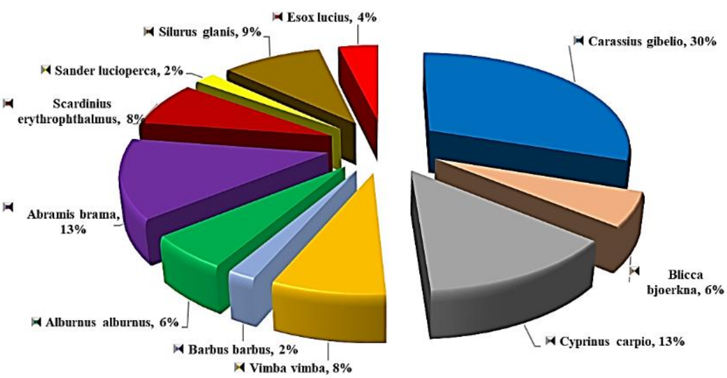

Fig. 2. Relative abundance of fish populations in the Siret River in 2023

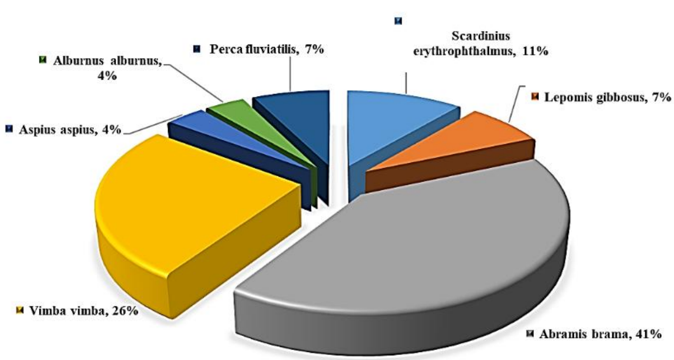

Fig. 3. Relative abundance of fish populations in the Siret River in 2025

Comparative analysis of biodiversity indices: 2023 vs. 2025

Comparing the fish communities of the Siret River in 2023 and 2025 highlights significant changes in both species' composition and the numerical structure of populations (Figure 4).

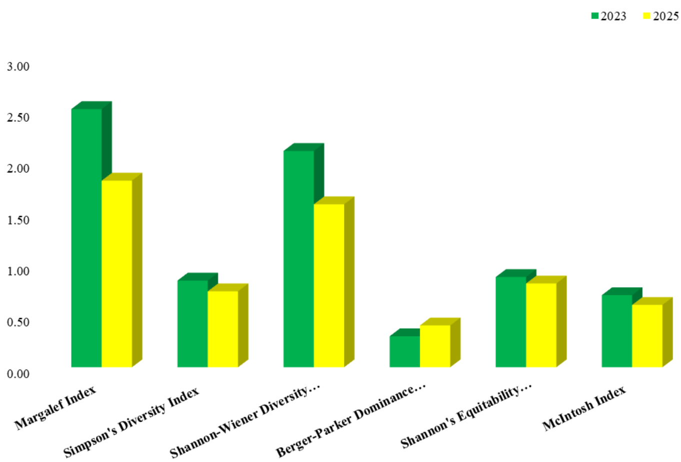

Fig. 4. Biodiversity variation in the fish communities of the Siret River (2023 and 2025)

- **Margalef index (R),** which reflects species richness by relating the total number of species to the logarithm of the total number of individuals, decreased from 2.52 in 2023 to 1.82 in 2025. This decline indicates a loss of rarer species and a general reduction in taxonomic diversity.
- **Shannon–Wiener index (H'),** which combines both richness and evenness of individual distribution among species, decreased from 2.11 to 1.59. This suggests that the community became less diverse, with a higher concentration of individuals in the dominant species.
- **McIntosh index (U),** which assesses community evenness by comparing each species' abundance with a perfectly uniform distribution, decreased from 0.70 to 0.61. A lower value indicates weaker evenness and a numerical structure where individuals are not evenly distributed among species.
- **Berger–Parker index,** which quantifies the dominance of the most abundant species, increased from 0.30 to 0.41, showing that a single species (*Abramis brama*) became more dominant in 2025, while the remaining species were less represented.

- **Shannon's Equitability (E),** which reflects the evenness of individual distribution, decreased from 0.88 to 0.82. This confirms that the proportions of individuals among species became more uneven, emphasizing the dominance of the main species.

Overall, these values indicate that between 2023 and 2025, the fish community of the Siret River became poorer in species and more unbalanced, with a clearly dominant species and the loss of some rarer species, which may reflect changes in ecological conditions, anthropogenic pressures, or shifts in available resources.

With only 29% similarity between the analyzed years, based on species presence, the Jaccard index indicates that the fish communities differ markedly in species composition. This conclusion was confirmed by statistical analysis using the Chi-square test, which highlighted a significant difference between the community structure in 2023 and 2025 ($\chi^2 = 38.46, df = 13, p = 0.00024$). The critical χ^2value for $\alpha = 0.05$ and $df = 13$ is 22.36, emphasizing that the observed differences are not random but statistically significant.

This change reflects a substantial decrease in species diversity and richness, with an increase in the dominance of certain species and the appearance of invasive species. The fish community changed significantly between 2023 and 2025: species such as *Carassius gibelio*, *Cyprinus carpio*, *Silurus glanis* [Linnaeus, 1758], *Esox lucius* [Linnaeus, 1758], *Barbus barbus* [Linnaeus, 1758], and *Sander lucioperca* [Linnaeus, 1758] disappeared from the catches, being replaced by *Aspius aspius* [Linnaeus, 1758], *Perca fluviatiles* [Linnaeus, 1758], and the invasive species *Lepomis gibbosus* [Linnaeus, 1758]. Dominance shifted from *Carassius gibelio* to *Abramis brama*, while species diversity and richness decreased, and the distribution of individuals among species became more uneven.

The transition in dominance from *Carassius gibelio* to *Abramis brama* suggests an improvement in environmental conditions and a return of community structures toward a balance closer to the natural state. This change is justified by the fact that the common bream (*Abramis brama*), a native benthivorous species, requires more stable habitats and higher benthic productivity [Persson and Brönmark, 2002], unlike the Prussian carp (*Carassius gibelio*), an invasive species tolerant of degraded habitats [Razlutskij *et al*., 2021].

Moreover, the presence of the pumpkinseed (*Lepomis gibbosus*), an invasive species, in 2025 (7% of the total) indicates the expansion of a non-native species within the fish community of the Siret River and may have a significant ecological impact: competition for food and habitat with native species, alteration of trophic relationships, and reduction of native species abundance [Meinam *et al*., 2023]. Although its current abundance is low, its appearance may serve as an early indicator of ecological imbalance and the risk of altering the structure of the fish community. The presence of this species in the aquatic ecosystem was first reported in 2005 [Battes *et al*., 2005], with the Siret River basin identified as one of the hotspots for non-native species, according to Drăgan et al. [2024], while two other invasive species were reported in 2016 by Ureche and Ureche [2019].

Analysis of hydrological parameters at the Lespezi station during April–June (2023 vs. 2025)

Comparing water level and discharge data for April–June in 2023 and 2025 reveals notable differences in the hydrological regime of the Siret River – Lespezi h.st (Table 1).

Table 1

Descriptive statistical summary (Lespezi, Apr–Jun)

Year	Month	Parameter	No. of days	Min (cm)	Max (cm)	Mean (cm)	Observations
2023	April	Level	30	22	200	86.2	Marked increase in water level with high amplitude; typical spring regime influenced by snowmelt.
		Discharge		21.6	234	77.51	High discharges, with peaks exceeding 200 m³/s, reflecting snowmelt and rainfall contribution.
	May	Level	31	-1	69	30.2	Lower water levels compared to April, indicating stabilization and a near-drought regime.
		Discharge		10.8	52.3	27.07	Moderate to low discharges, without flood events; decreasing trend compared to the previous month.
	June	Level	30	-7	95	22.7	Moderate oscillations with a few short-lived peaks; predominantly low values.
		Discharge		8.33	73.5	23.79	Low discharges, close to minimum values, suggesting an early-summer drought regime.
2025	April	Level	30	-10	100	41.83	Increased instability with high amplitude; oscillating levels reflecting the transition between low water and moderate floods.
		Discharge		8.2	78	35.71	Variable discharges, no extremes, but higher compared to the same month in 2023.
	May	Level	31	-6	232	60.77	Presence of significant flood episodes (up to +232 cm), alternating with low-water periods.
		Discharge		9.52	299	64.7	Very high discharge peaks, indicating extreme hydrological events.
	June	Level	30	-12	218	29.97	Wide oscillations; elevated levels dropped rapidly, returning to low stages.
		Discharge		7.68	271	33.64	High flows at the beginning of the month followed by a quick decrease; pronounced variability.

In 2023, water levels remained within a relatively stable range, with monthly averages between 22.7 cm (June) and 86.2 cm (April), while associated discharges varied between 23.8 m³/s and 77.5 m³/s. Both levels and discharges exhibited low variability, with minima close to zero and maxima of 200 cm (level) and 234 m³/s (discharge), and compact distributions with medians close to the monthly averages. These characteristics suggest a predictable hydrological regime without extreme fluctuations during the analyzed period, well below the flood defense level at the Lespezi station (450 cm).

In contrast, 2025 was marked by pronounced hydrological instability, reflected in both water level and discharge. Monthly average levels were higher in May (60.8 cm) but much lower in June (29.9 cm) compared to 2023. Discharges experienced major fluctuations, with monthly averages higher than in 2023, especially in May (64.7 m³/s), and much more pronounced maxima, with levels reaching 232 cm and discharges approaching 300 m³/s. Although these maxima remain below the flood defense threshold (450 cm), they represent more than half of this critical level, indicating a significant increase in flood risk. Minima were similar between years (approx. –10 cm for level and 8 m³/s for discharge), indicating the persistence of low-water periods, but the contrast between these minima and maxima was much steeper in 2025.

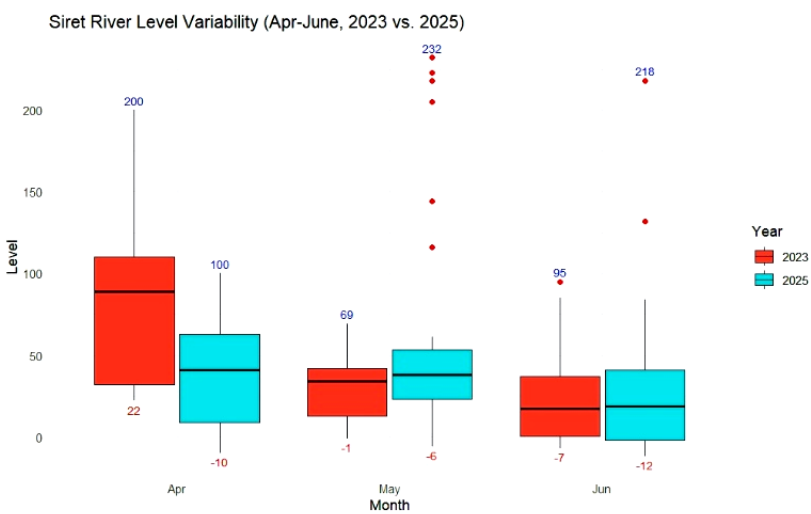

Fig. 5. River level variation during the analyzed period (2023 vs 2025)

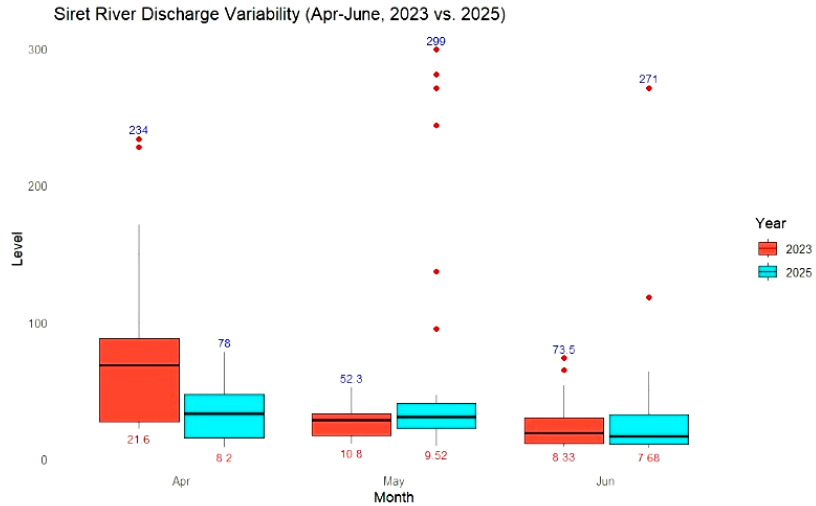

Fig.6. River discharge variation during the analyzed period (2023 vs 2025)

Boxplots clearly show that while the interquartile ranges in 2023 were compact and distributions uniform (Figures 5 and 6), in 2025 they were stretched and included multiple extreme values, particularly in May and June. This highlights a predisposition toward flood episodes and rapid oscillations between low and high-water levels and discharges.

In conclusion, 2023 reflects a stable and predictable hydrological regime, well within safe limits, while 2025 is characterized by pronounced variability and hydrological extremes, approaching critical levels (450 cm flood defense) with potential consequences for aquatic ecosystems and fish communities dependent on water stability.

Impact of Hydrological Variability on Fish Biodiversity in the Siret River (2023–2025)

The analysis of correlations between water level and discharge amplitudes and biodiversity indices (Shannon-Wiener, Simpson, and Berger-Parker) reveals important ecological trends, even though the results are not statistically significant ($p > 0.12$), likely due to the small number of observations (six months).

Spearman and Pearson correlations indicate that the amplitude of both water level and discharge negatively affects community diversity and numerical balance: Shannon and Simpson indices show negative values (-0.67 to -0.70), suggesting that periods with large fluctuations in water level and discharge are associated with reduced diversity and a more uneven distribution of individuals among species. The Berger-Parker index, with positive values (0.67–0.70), indicates that high hydrological fluctuations favor the dominant species, increasing its dominance and reducing the participation of other species.

Periods with high hydrological variability (increased amplitudes, peak water levels, and discharge) create unstable conditions for sensitive species, favoring tolerant or dominant species. In the Siret River, this effect is reflected in the decline of Shannon and Simpson indices and the increased dominance of *Abramis brama* in 2025 compared to 2023, when the community was more balanced and diverse. This indicates a simplification of community structure and a loss of rarer species, correlated with instability in the hydrological regime. The appearance of invasive species, such as *Lepomis gibbosus* and *Perca fluviatilis*, seems facilitated by these fluctuations, further increasing pressure on native communities.

Even though the p-values do not indicate statistical significance, the trends suggest that hydrological stability is crucial for maintaining fish biodiversity. Managing water resources, preventing extreme fluctuations, and continuous monitoring can help conserve an ecological balance closer to natural conditions. Maintaining water levels below the Lespezi flood protection level (450 cm) remains critical to prevent flood events that impact both diversity and community structure.

The correlation analyses for water level and discharge, together with observations from fish catches, indicate that changes in the Siret River's hydrological regime between 2023 and 2025 led to reduced diversity, numerical imbalance, and increased dominance of a single species. Although the statistical effects are not significant with the available data, the clear trend suggests an ecological link between water instability and fish community structure, highlighting the need for continuous monitoring and ecosystem protection measures.

CONCLUSIONS

Based on the analyses conducted, it can be concluded that during the period April–June 2025, the fish communities in the Siret River exhibited a significant reduction in biodiversity compared to 2023, with the number of species decreasing from eleven to seven. This decline in diversity was reflected in lower values of the Shannon-Wiener, Margalef, and McIntosh indices, accompanied by an increase in the Berger-Parker index, indicating a pronounced dominance of a single species.

The community structure changed, with *Carassius gibelio* being replaced by *Abramis brama* as the dominant species, while valuable species such as *Cyprinus carpio* and *Silurus glanis* disappeared, and were even replaced by invasive species, such as *Lepomis gibbosus*.

These changes coincide with a much more pronounced hydrological instability in 2025, characterized by alternating extreme floods (with water levels reaching +232 cm and maximum discharges of 299 m^3/s) and periods of very low water, whereas 2023 exhibited a more uniform regime.

Statistical correlations showed that increased water level amplitude is associated with a decrease in fish diversity, suggesting that extreme fluctuations favor the dominance of a few species and reduce community evenness.

Overall, these results highlight the effects of anthropogenic pressures and climate change on the ichthyofauna of the Siret River, confirming the trend toward simplification of the fish community and emphasizing the importance of implementing long-term monitoring and conservation programs.

Continuous monitoring of fish communities is essential, through systematic surveillance of species abundance and distribution at different hydrometric stations throughout the year, in order to capture seasonal variations and the effects of extreme hydrological events. It is recommended to implement measures for the protection of native species and control of invasive species, particularly *Lepomis gibbosus* and other non-native species that may alter the fish community structure and trophic resources. Additionally, conserving and restoring habitats favorable to valuable native species, such as *Cyprinus carpio* and *Silurus glanis*, is crucial.

Reducing anthropogenic pressures is a major objective, through policies aimed at limiting pollution and industrial and agricultural discharges in the Siret basin. At the same time, promoting sustainable water management practices is necessary to minimize the impact of flood and drought periods on fish habitats.

ACKNOWLEGMENTS

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SUNFLOWER (*HELIANTHUS ANNUUS L.*) TISSUE CULTURE: TRENDS AND ADVANCES

CULTURI DE ȚESUTURI LA FLOAREA SORARELUI (HELIANTHUS ANNUUS L.): TENDINȚE ȘI PROGRESE

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Abstract.
Between 2020 and 2025, research on in vitro culture of sunflower (Helianthus annuus L.) has led to the refinement of explant use, including cotyledons, cotyledonary nodes, and immature embryos. Murashige and Skoog (MS)-based media, supplemented with specific combinations of auxins (IAA, NAA) and cytokinins (kinetin, 6-BA), have been optimized to enhance organogenesis—the main regeneration pathway. Somatic embryogenesis remains difficult and inconsistent. A major limitation is the genotype-dependent response and the generally low regeneration efficiency. These challenges are being addressed through genotype-specific protocols and by investigating the expression of key genetic regulators of totipotency, such as SERK and BBM. Improved in vitro systems now allow efficient genetic transformation, particularly through Agrobacterium tumefaciens-mediated methods, facilitating the development of transgenic or genome-edited lines. Moreover, these technologies support the conservation of genetic resources from wild Helianthus species and the rapid clonal propagation of elite agronomic genotypes. Overall, these advances underpin the development of cutting-edge biotechnological strategies in sunflower breeding, with applications in sustainable production and improved tolerance to biotic and abiotic stress factors.

Key words: Explant sources, cotyledon segments, immature embryos, regeneration techniques, genetic transformation

Rezumat.
Între anii 2020 și 2025 cercetările privind cultura in vitro a florii-soarelui (Helianthus annuus L.) au condus la perfecționarea utilizării explantatelor, precum: cotiledoane, noduri cotiledonare și embrioni imaturi. Mediile bazate pe formularea Murashige și Skoog (MS), suplimentate cu combinații specifice de auxine (IAA, NAA) și citochinine (kinetină, 6-BA), au fost optimizate pentru a stimula organogeneza — principala cale de regenerare. Embriogeneza somatică rămâne dificilă și inconsistentă. O limitare majoră este răspunsul dependent de genotip și eficiența general scăzută a regenerării. Aceste provocări sunt abordate

[1] National Agricultural Research and Development Institute Fundulea, Romania

prin protocoale specifice genotipului și prin investigarea expresiei regulatorilor genetici-cheie ai totipotenței, precum SERK și BBM. Sistemele in vitro îmbunătățite permit acum transformarea genetică eficientă, în special prin metode mediate de Agrobacterium tumefaciens, facilitând dezvoltarea liniilor transgenice sau editate genomic. În plus, aceste tehnologii sprijină conservarea resurselor genetice din speciile sălbatice de Helianthus și multiplicarea clonală rapidă a genotipurilor agronomice de elită. Aceste progrese susțin dezvoltarea unor strategii biotehnologice de ultimă generație în ameliorarea florii-soarelui, cu aplicații în producția durabilă și în îmbunătățirea toleranței la factori de stres biotici și abiotici.

Cuvinte cheie: Surse de explant, segmente cotiledonare, embrioni imaturi, tehnici de regenerare, transformare genetică

INTRODUCTION

Sunflower is the fourth most important oilseed crop worldwide, cultivated across diverse agro-ecological zones [Vijay *et al.*, 2020]. Its oil is valued for high unsaturated fatty acid content, particularly oleic and linoleic acids, which contribute to cardiovascular health and industrial uses [Islam *et al.*, 2021]. Traditional breeding has generated hybrid cultivars with improved yields, yet remains constrained by the narrow genetic base and extended breeding cycles [Purwantoro *et al.*, 2018].

Plant tissue culture offers solutions through clonal propagation, in vitro conservation, genetic transformation, and haploid production [Blinkov *et al.*, 2022]. However, sunflower is recalcitrant to regeneration, with outcomes strongly dependent on genotype and influenced by tissue browning and hyperhydricity [Mendoza and González, 2016]. Over the last decade, advances in media optimization, the use of silver nitrate and antioxidants, and novel genome editing approaches have significantly improved in vitro outcomes [Chen *et al.*, 2024; Lebedeva *et al.*, 2025].

MATERIAL AND METHOD

A systematic literature review was performed covering studies published between 2015 and 2025, complemented with selected classical works. Databases included Scopus, PubMed, Web of Science, and Google Scholar. Keywords were: “sunflower tissue culture,” “organogenesis Helianthus annuus,” “somatic embryogenesis sunflower,” “CRISPR sunflower,” “haploid sunflower,” and “synthetic seed Helianthus.” Both experimental and review papers were included.

RESULTS AND DISCUSSIONS

Explant Sources and Regeneration Pathways

The choice of explant is among the most critical determinants of in vitro regeneration in sunflower, as morphogenic competence varies widely between tissue types and genotypes. Cotyledonary nodes are widely recognized as the most responsive explant, with regeneration efficiencies exceeding 90% in optimized conditions combining kinetin with low levels of auxins [Chen *et al.*, 2024]. Hypocotyls and leaf segments have been used extensively, although regeneration frequencies are more variable and strongly genotype dependent [Mendoza and González, 2016; Badouin *et al.*, 2017]. Immature embryos exhibit high plasticity and remain the most effective explants for somatic embryogenesis due to their undifferentiated meristematic tissues [Moradi *et al.*, 2018]. In wild relatives such as *H. verticillatus*, leaf explants have proven successful under cytokinin-auxin combinations, described in (Table 1), offering a pathway for conservation of rare species [Edwards *et al.*, 2020]. Interestingly, direct organogenesis from shoot tips and meristems provides a rapid and stable route with reduced somaclonal variation compared to callus-mediated regeneration [Shormee *et al.*, 2016]. Explant orientation and physiological stage at excision also influence outcomes, with juvenile tissues being more responsive than mature ones [Radova *et al.*, 2021]. In (Table 1) are presented all the explant sources that are commonly used, some of the main advantages and disadvantages along with the success rate. Collectively, understanding explant physiology and genotype-specific responses is essential to designing efficient, reproducible regeneration systems for sunflower and related Helianthus species.

Table 1

Comparative efficiency of regeneration pathways

Explant source	Regeneration pathway	Success rate (%)	Advantages	Disadvantages	References
Cotyledonary node	Direct organogenesis	70-95%	High regeneration frequency; stable; low somaclonal variation	Genotype-dependent; requires juvenile tissue	[Witrzens *et al.* 2004; Mendoza *et al.* 2016]
Hypocotyl	Indirect organogenesis	30-60%	Accessible; useful for transformation studies	Variable response; prone to callus-induced variation	[Singareddy *et al.* 2018; Garcia-Perez *et al.* 2021]
Leaf segment	Organogenesis / callus	10-35%	Non-destructive sampling; suitable for wild species	Low regeneration efficiency; high browning and necrosis	[Pavlović *et al.* 2020; Nowakowska *et al.* 2024]
Immature embryo	Somatic embryogenesis	60-85% (under optimized PGRs)	High morphogenic potential; ideal for synthetic seed production	Time-sensitive; labor-intensive; highly sensitive to culture conditions	[Ortiz *et al.* 2025; Martinez *et al.* 2021]

Explant source	Regeneration pathway	Success rate (%)	Advantages	Disadvantages	References
Meristem / shoot tip	Direct shoot regeneration	50-70%	Virus elimination; clonal fidelity	Low multiplication rate; technically demanding	[Ivanov *et al.* 2014]
Anther / pollen	Androgenesis (haploids)	<1-5%	Potential for DH line development; accelerates breeding	Very low efficiency; strong genotype dependency	[Singh *et al.* 2019; Blinkov *et al.* 2022]
Ovule / ovary	Gynogenesis (haploids)	<1-3%	Alternative to anther culture; possible DH production	Extremely low regeneration frequency; requires specialized protocols	[Meena *et al.* 2022]
Root segment	Callus induction only	<5%	Easy to obtain; good for metabolic studies	Very poor shoot regeneration; unsuitable for clonal propagation	[Radonic *et al.* 2015]

Organogenesis and Somatic Embryogenesis

Sunflower regeneration occurs primarily via two major morphogenic pathways: organogenesis and somatic embryogenesis. Direct organogenesis, typically from cotyledonary nodes, as shown in (Figure 1) is favored for its stability, shorter timelines, and reduced genetic variability [Mendoza *et al.*, 2016]. Cytokinins such as BA or kinetin, in combination with auxins like IAA or NAA, are the most effective in stimulating shoot organogenesis, as it is revealed in (Figure 2) [Purwantoro *et al.*, 2019]. Indirect organogenesis involves callus formation prior to shoot development and is useful for transformation but carries a higher risk of somaclonal variation [Edwards *et al.*, 2020]. Somatic embryogenesis, though less routine in sunflower compared to other crops, offers the potential for mass clonal propagation and synthetic seed production [Azadi *et al.*, 2021]. High sucrose concentrations and auxin analogs such as picloram or 2,4-D stimulate somatic embryo induction [Moradi *et al.*, 2018]. Stress factors, including osmotic stress and cold pretreatment, have also been shown to increase embryogenic competence [Ceriani *et al.*, 1992]. Although somatic embryos can germinate into viable plants, their conversion frequency remains a bottleneck, requiring optimization of maturation media and desiccation treatments. Future protocols may combine organogenesis for stable regeneration with embryogenesis for scaling-up, maximizing the potential of sunflower micropropagation systems.

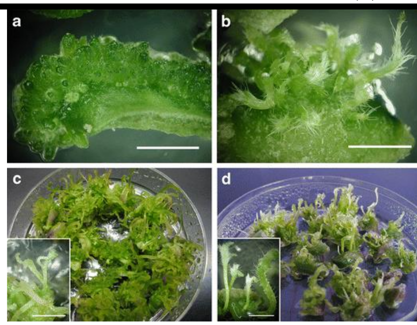

Fig. 1. Shoot organogenesis from cotyledons [Source: Zhang *et al.*, 2015]

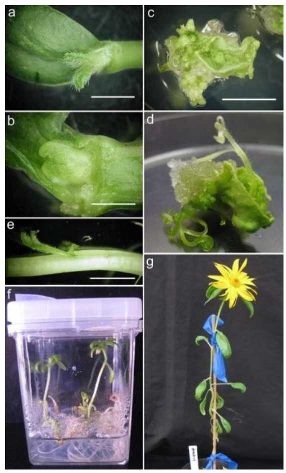

Fig. 2. Organogenesis from primary leaves of young seedlings preconditioned by cytokinin [Source: Zhang *et al.*, 2015]

Factors Influencing In Vitro Culture

Several intrinsic and extrinsic factors strongly influence the efficiency of sunflower tissue culture.

- **Genotype dependency** is the most widely reported constraint, with some cultivars showing prolific regeneration while others fail under identical protocols [Nowakowska *et al.*, 2024].
- **Plant growth regulators** (PGRs) are pivotal: cytokinins such as BAP or kinetin promote shoot induction, while low concentrations of auxins (IAA, NAA) encourage rooting [Purwantoro *et al.*, 2019]. Thidiazuron (TDZ) at micromolar concentrations has also proven highly effective in inducing adventitious shoots [Shormee *et al.*, 2016].
- **Additives such** as silver nitrate and silver thiosulfate inhibit ethylene accumulation, reducing tissue necrosis and increasing regeneration frequency [Khalil *et al.*, 2015]. Main additive that are used are presented in Table 2. Antioxidants including ascorbic acid, glutathione, and citric acid

are used to counteract phenolic exudation and browning [Radova *et al.*, 2021].

Table 2

Key additives and their role

Additive	Role	Effect on culture response	References
$AgNO_3$ (Silver nitrate)	Ethylene inhibitor	Prevents explant necrosis, delays senescence, increases shoot induction	[Pai *et al.*, 2018; Khalil *et al.*, 2015]
Ascorbic acid	Antioxidant	Reduces browning and oxidative stress, improves callus survival	[Radova *et al.*, 2021; Garcia-Perez *et al.*, 2021]
Putrescine	Polyamine	Enhances embryo maturation, promotes somatic embryogenesis	[Inoka *et al.*, 2015;] [Martinez *et al.*, 2021]
Activated charcoal	Adsorbent of phenolics	Prevents medium browning, supports root induction	[Moradi *et al.*, 2018]
Glutathione (GSH)	Antioxidant	Protects tissues from oxidative stress, increases regeneration efficiency	[Sharma *et al.*, 2020]
Polyvinylpyrrolidone (PVP)	Adsorbent	Binds phenolic compounds, reduces tissue necrosis	[Pavlović *et al.*, 2020]
Myo-inositol	Vitamin / osmoprotectant	Enhances cell division, promotes shoot elongation	[Purwantoro *et al.*, 2019]
Coconut water	Natural growth supplement	Provides vitamins, sugars, hormones; enhances callus proliferation	[Mendoza *et al.*, 2016]
Casein hydrolysate	Amino acid source	Improves embryogenic callus induction, enhances shoot quality	[Blinkov *et al.*, 2022]
Silver thiosulfate (STS)	Ethylene blocker	Stronger ethylene inhibition than $AgNO_3$, prolongs morphogenic competence	[Li *et al.*, 2023]
TDZ (Thidiazuron)	Cytokinin-like growth regulator	Highly efficient in shoot induction, induces direct organogenesis; may reduce rooting if concentration too high	[Sharma *et al.*, 2020;] [Nowakowska *et al.*, 2024]

- **Environmental conditions** further modulate responses: light quality, photoperiod, osmotic stress, and temperature pretreatments all contribute to enhancing morphogenesis [Chraibi *et al.*, 1992]. Even medium composition, particularly the source and concentration of carbon (sucrose, maltose), influences both callus proliferation and embryo development. Understanding the interplay between genotype, PGR balance, and environmental factors is critical for optimizing protocols and ensuring reproducibility across different sunflower genotypes.

Genetic Transformation and Genome Editing

Genetic transformation in sunflower has historically been challenging due to genotype dependence, low regeneration frequency, and tissue necrosis during selection. Agrobacterium-mediated transformation (Figure 3) remains the most widely used approach, relying on the infection of cotyledonary nodes, hypocotyls, or leaf discs with *Agrobacterium tumefaciens*. Protocols combining vacuum infiltration, sonication-assisted infection, and antioxidant supplementation have significantly increased transient expression efficiencies, reaching >90% in optimized systems [Darqui *et al.*, 2021]. Stable transformation rates, however, remain limited to 5-10% depending on the cultivar [Tishchenko *et al.*, 2014]. Recent studies in cultivar ZADT reported reproducible stable transformants using EHA105 strain and kanamycin selection [Chen *et al.*, 2025]. Beyond Agrobacterium, particle bombardment and electroporation have been attempted, though with lower reproducibility and higher costs [Sosnowski *et al.*, 2023]. The advent of CRISPR/Cas9 technology has opened new frontiers for sunflower improvement. Knockout of the FAD2-1 gene via CRISPR led to altered fatty acid composition with elevated oleic acid content [Uslu *et al.*, 2022], while editing HaNSP1a disrupted strigolactone biosynthesis, conferring resistance to *Orobanche cumana* [Lebedeva *et al.*, 2025]. Multiplex CRISPR strategies could allow simultaneous editing of multiple traits, such as drought tolerance and disease resistance. Overall, genome editing is emerging as a transformative tool for functional genomics and targeted breeding in sunflower, complementing tissue culture-based regeneration systems.

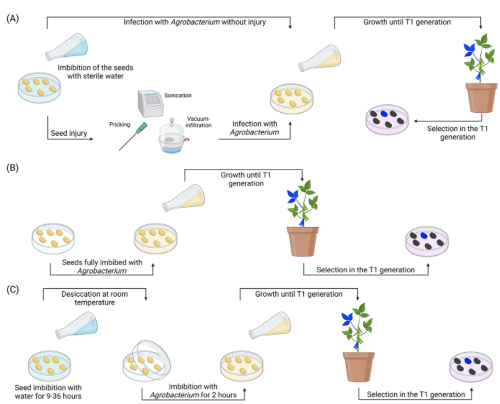

Fig. 3. Agrobacterium-mediated transformation [Source: Bélanger et al 2024]

Haploid and Double Haploid Systems

Haploid and double haploid (DH) technologies provide an accelerated route to homozygous lines, drastically reducing the breeding cycle from several generations to a single step. In sunflower, haploid production has been attempted through anther culture (Figure 4), isolated microspores, and irradiated pollen techniques, although success rates remain lower compared with cereals [Blinkov *et al.*, 2022]. Anther culture has occasionally yielded callus and plantlets, but the frequency of haploid plant recovery is typically <1% [Sosnowski *et al.*, 2023]. In vitro gynogenesis, involving unpollinated ovules cultured under stress conditions, represents a promising but underexplored pathway. Recent efforts have also focused on wide hybridization and in vitro rescue of haploid embryos from interspecific crosses, followed by chromosome doubling with colchicine [Zhang *et al.*, 2015]. Advances in flow cytometry and molecular markers now enable precise identification of haploid regenerants, facilitating their use in breeding. DH sunflower lines are particularly valuable for developing mapping populations and for producing stable homozygous parents in hybrid programs. Nevertheless, the strong genotype dependence and low reproducibility remain significant challenges, and integrating stress pretreatments with optimized PGR regimes may enhance efficiency. The development of reliable haploid induction systems in sunflower could be a game changer for genomics-assisted breeding.

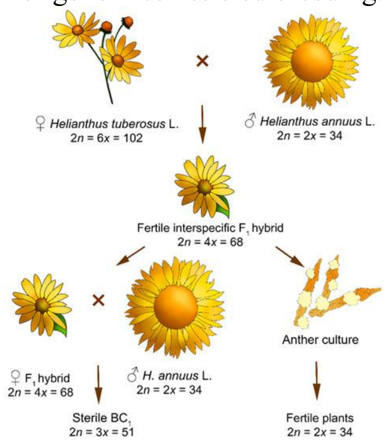

Fig. 4. Manipulation of ploidy level in the anther culture of an interspecific hybrid between cultivated sunflower and H. tuberosus L. [Source: Blinkov *et al.*, 2022]

Somaclonal Variation and Genetic Stability

Regeneration through callus culture, while enabling plant recovery, is often associated with somaclonal variation due to chromosomal rearrangements, point mutations, and epigenetic changes [Edwards *et al.*, 2020]. Although variation is undesirable in clonal propagation, it can generate novel traits for breeding, such as tolerance to abiotic stresses or altered metabolic profiles [Mendoza *et al.*, 2016]. The use of molecular markers such as SSRs, AFLPs, and SNP arrays has been instrumental in assessing the genetic fidelity of regenerants [Radova *et al.*, 2021]. Studies on *Helianthus verticillatus* micropropagated lines revealed moderate variation among regenerants, yet most retained morphological and physiological stability [Nowakowska *et al.*, 2024]. To minimize somaclonal variation, direct organogenesis from meristematic tissues is preferred over indirect pathways involving friable callus. Antioxidants such as ascorbic acid and glutathione have also been reported to reduce oxidative stress and DNA damage during culture [Finer *et al.*, 1987]. Cryopreservation of shoot tips may further safeguard genetic integrity in long-term conservation programs [Fu *et al.*, 2017]. Thus, balancing regeneration efficiency with genetic stability is crucial when designing tissue culture-based breeding pipelines in sunflower.

Biotechnological Innovations

Innovations in tissue culture are broadening the scope of sunflower biotechnology. Somatic embryos encapsulated in sodium alginate and calcium chloride solutions form synthetic seeds, which can be stored, transported, and germinated under controlled conditions [Azadi *et al.*, 2021]. Synthetic seed technology offers opportunities for germplasm exchange and large-scale propagation of elite lines, particularly in recalcitrant genotypes. Advances in encapsulation matrices enriched with nutrients, PGRs, and antifungal agents have improved synthetic seed germination and conversion rates to plantlets [Onișan *et al.*, 2025]. Parallel to this, bioreactor systems such as temporary immersion bioreactors (TIBs) and air-lift systems are being tested for large-scale sunflower regeneration [Witrzens *et al.*, 2004]. Bioreactors reduce labor costs, ensure uniform microenvironment conditions, and support automated scaling of plantlet production. Although sunflower-specific applications remain limited, successful implementation in other oilseed crops suggests strong potential. Moreover, coupling bioreactors with somatic embryogenesis protocols may facilitate mass production of synthetic seeds or uniform regenerants. Together, synthetic seed and bioreactor technologies represent promising frontiers to overcome current bottlenecks in sunflower micropropagation and conservation.

Conservation Applications

Beyond breeding, tissue culture plays a vital role in conserving sunflower germplasm and rare Helianthus species. In vitro propagation protocols for the endangered *H. verticillatus* have enabled successful shoot regeneration and acclimatization [Edwards *et al.*, 2020; Nowakowska *et al.*, 2024]. Conservation efforts also extend to cryopreservation, where shoot tips, embryogenic callus, and zygotic embryos are stored in liquid nitrogen for long-term germplasm banking [Voronova *et al.*, 2016]. Slow-growth storage under osmotic stress and reduced temperature further complements cryopreservation by allowing medium-term maintenance. Molecular fingerprinting of in vitro conserved lines ensures genetic integrity and aids in monitoring possible variation during long-term storage [Trigiano *et al.*, 2021]. Additionally, tissue culture facilitates the recovery of virus-free plants through meristem culture combined with thermotherapy or cryotherapy [Fernandez *et al.*, 2018]. These methods not only safeguard genetic diversity but also enable the clean exchange of germplasm between breeding programs. Given the increasing threats posed by climate change, habitat loss, and pathogen pressure, integrating tissue culture and cryobiology into sunflower conservation strategies is essential for ensuring the resilience and sustainability of both cultivated and wild germplasm.

Challenges in Sunflower Tissue Culture and Cropp

Despite the remarkable advances in sunflower tissue culture over the past decade, several challenges continue to limit its reproducibility, efficiency, and large-scale application.

- *Genotype dependency*- The single most significant barrier is the strong genotype effect on regeneration. While certain hybrids and inbred lines respond efficiently to organogenesis or embryogenesis, others fail under identical protocols [Kishor *et al.*, 2018]. This restricts the development of universal protocols applicable across breeding programs.
- *Low and variable transformation efficiency*- Agrobacterium-mediated transformation in sunflower remains inconsistent, with stable integration frequencies often below 10% [Marek *et al.*, 2019]. Factors such as explant age, bacterial strain, infection conditions, and plant genotype all contribute to poor reproducibility.
- *Somaclonal variation and genetic instability*- Regeneration via callus is frequently associated with karyotypic changes, transposon activation, and epigenetic alterations [Pavlović *et al.*, 2020]. While sometimes useful as a source of variation, it compromises clonal fidelity and trait stability.
- *Oxidative browning and phenolic exudation*- Sunflower explants often accumulate phenolic compounds upon wounding, leading to medium darkening, necrosis, and culture loss [Garcia-Perez *et al.*, 2021]. Although antioxidants and adsorbents (e.g., ascorbic acid, activated charcoal, silver nitrate) help, reproducibility remains a problem.
- *Limited efficiency of haploid technologies*- Despite potential for rapid breeding, haploid induction via androgenesis or gynogenesis is still inefficient (<5%) and highly genotype-dependent [Mushke *et al.*, 2019; Blinkov *et al.*, 2022].
- *Scalability constraints*- While synthetic seed technology and bioreactors are promising, their large-scale application in sunflower remains at the experimental stage, with cost, contamination risks and conversion efficiency as major obstacles [Li *et al.*, 2023].
- *Cryopreservation and germplasm stability*- Long-term conservation protocols are not yet standardized. While promising results exist for shoot tips and

embryos, genotype and cryoprotectant choice strongly influence survival and regrowth [Seiler *et al.*, 2017].

• *Integration with omics and genome editing*- Although transcriptomics and CRISPR have been applied to sunflower, integration into tissue culture pipelines is still in its infancy [Lebedeva *et al.*, 2025]. Establishing robust, genotype-independent protocols compatible with genome editing remains an unresolved challenge.

• *Herbicide resistance*- represents a central challenge but also an opportunity in sunflower production. The widespread use of herbicides for weed control has led to the selection of resistant weeds, while simultaneously creating demand for herbicide-tolerant sunflower hybrids. Conventional approaches to herbicide tolerance in sunflower have relied primarily on mutation breeding and natural variability within *Helianthus annuus* populations. The most prominent example is the development of imidazolinone-tolerant sunflower (Clearfield technology), which resulted from the identification of spontaneous mutations in the *AHAS* (acetohydroxyacid synthase) gene. These hybrids enabled effective weed control (Table 3) but raised concerns about the evolution of resistant weed populations [Bozic *et al.* 2015; Gaines *et al.*, 2020].

In vitro and biotechnological approaches have expanded the possibilities of generating herbicide resistance:

- *In vitro mutagenesis* combined with selection on herbicide-containing media has produced resistant calli and regenerants carrying point mutations in AHAS.
- *Somaclonal variation* has occasionally produced novel herbicide-tolerant phenotypes, though often at low frequency.
- *Transgenic and genome editing* approaches allow precise engineering of herbicide tolerance while avoiding undesired traits linked to random mutations [Lebedeva *et al.*, 2025].

Despite these advances, challenges remain. Clearfield hybrids face increasing weed resistance; public acceptance of GM crops is limited in some regions; and tissue culture bottlenecks restrict rapid deployment of engineered lines. Future strategies are likely to integrate CRISPR-based precise editing with conventional breeding to ensure durable herbicide tolerance.

Table 3

Conventional vs. in vitro approaches to herbicide resistance in sunflower

Approach	Mechanism	Advantages	Limitations	References
Conventional mutation breeding	Spontaneous/induced mutation in *AHAS*	Non-GMO; already commercialized (*Clearfield*)	Slow; resistance breakdown in weeds	[Bozic *et al.* 2015]

Approach	Mechanism	Advantages	Limitations	References
In vitro mutagenesis	Callus exposed to herbicide, resistant cells regenerated	Faster than field mutation; selectable markers	Low efficiency; somaclonal variation	[Brosnan *et al.* 2016]
Somaclonal variation	Spontaneous genetic/epigenetic changes	May produce novel herbicide tolerance	Rare, unpredictable; linked to instability	[Kaya, 2015]
Transgenic approaches	Transfer of resistant *AHAS* alleles	High precision, stable inheritance	Regulatory restrictions; low transformation rate	[Gaines *et al.*, 2020]
CRISPR/Cas9 genome editing	Targeted point mutation in *AHAS*	Precise, non-transgenic edits possible	Protocols not yet genotype-independent	[Lebedeva *et al.*, 2025]

- *Abiotic stresses* such as drought, heat, and salinity are increasingly critical under climate change, as sunflower is often cultivated in semi-arid regions with limited irrigation [FAO, 2020]. Furthermore, rising temperatures accelerate phenological development, reducing grain filling and oil accumulation.
- *Soil fertility constraints*- especially nitrogen and micronutrient deficiencies- reduce seed oil yield, and over-fertilization can lead to lodging and increased susceptibility to diseases [Khalil *et al.*, 2015].

Future Perspectives

The future of sunflower tissue culture lies in overcoming genotype dependency and achieving reproducible, genotype-independent regeneration systems. Advances in molecular biology and bioinformatics are paving the way for integrating omics-driven approaches (transcriptomics, proteomics, and metabolomics) to identify key regulators of morphogenesis [Bélanger *et al.*, 2024]. Such data-driven insights may allow the rational design of culture media and treatments tailored to specific genotypes or even universally applicable across diverse cultivars. CRISPR/Cas9-based genome editing is expected to expand beyond single-gene knockouts to multiplex editing, base editing, and prime editing, enabling fine-tuning of metabolic pathways such as oil biosynthesis and resistance against *Orobanche cumana* [Uslu *et al.*, 2022; Lebedeva *et al.*, 2025]. Moreover, coupling genome editing with haploid and doubled haploid systems will accelerate the development of homozygous edited lines, providing powerful resources for functional genomics and breeding [Blinkov *et al.*, 2022]. On the applied side, the integration of synthetic seed technology and temporary immersion bioreactors holds promise for scaling up propagation and reducing production costs [Witrzens *et al.*, 2004]. Conservation of wild Helianthus species through cryopreservation and in vitro slow-growth storage will further ensure genetic diversity in the face of climate change [West *et al.*, 2025]. Collectively, these innovations point toward a future where sunflower tissue culture becomes a routine and scalable platform for both basic research and applied crop improvement, bridging the gap between fundamental biotechnology and sustainable agriculture.

CONCLUSIONS

Over the past decade, sunflower tissue culture research has transitioned from being viewed as a niche and technically challenging field to becoming a central pillar of crop biotechnology. The refinement of regeneration systems using cotyledonary nodes and immature embryos, coupled with optimization of plant growth regulator regimes and additives such as silver nitrate and antioxidants, has substantially improved in vitro success rates [Khalil *et al.*, 2015; Trigiano *et al.*, 2021]. Parallel advances in Agrobacterium-mediated transformation and transient expression systems have laid the foundation for more efficient genetic manipulation, while CRISPR/Cas9 applications have demonstrated the feasibility of precise genome editing in sunflower [Uslu *et al.*, 2022; Lebedeva *et al.*, 2025]. The establishment of haploid and doubled haploid protocols, albeit limited in efficiency, offers promising avenues for rapid breeding. Somaclonal variation, once seen solely as a drawback, is now being reconsidered as a source of novel genetic diversity. Looking forward, integrating synthetic seed technology and bioreactor-based scaling with omics-driven media optimization will be crucial for industrial-scale applications. Moreover, in vitro conservation strategies, including cryopreservation, provide an essential safeguard for maintaining the genetic diversity of both cultivated and wild Helianthus species. Ultimately, overcoming genotype dependency and developing universally applicable regeneration and transformation protocols will be key to fully exploiting sunflower tissue culture in meeting the global demand for sustainable food and bioresources under changing climatic conditions.

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ASSESSMENT OF DIFFERENT PLUM CULTIVAR RESPONSES TO LATE SPRING FROST IN NORTH-EAST OF TRANSYLVANIA

EVALUAREA RĂSPUNSULUI DIFERITELOR SOIURI DE PRUN LA ÎNGHEȚURILE TÂRZII DE PRIMĂVARĂ ÎN NORD-ESTUL TRANSILVANIEI

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Abstract.
Late spring frosts represent a major threat to plum orchards, especially to early-flowering cultivars, with the risk amplified by climate changes. In spring 2025, six consecutive days of negative temperatures caused varying damage to reproductive organs. A study conducted on two experimental plots monitored 35 Romanian and foreign plum cultivars exposed to frost, with data analyzed using k-means and PCA. Cultivars were classified into four groups: very sensitive, sensitive, tolerant, and resistant, with direct effects on yield. The results provide a scientific basis for recommending frost-tolerant or resistant cultivars as a practical strategy to stabilize production in areas prone to late spring frosts.
Key words: plum, cultivars, risk, late spring frost, resistance

Rezumat.
Înghețurile târzii de primăvară reprezintă o amenințare majoră pentru culturile de prun, mai ales pentru soiurile cu înflorire timpurie, riscul fiind amplificat de schimbările climatice. În primăvara 2025, șase zile consecutive cu temperaturi negative au provocat daune variabile formațiunilor de rod. Un studiu realizat pe două loturi experimentale a vizat monitorizarea a 35 de soiuri de prun, românești și străine, expuse la îngheț, iar datele au fost analizate prin k-means și PCA. Soiurile au fost clasificate în patru grupe: foarte sensibile, sensibile, tolerante și rezistente, cu efect direct asupra producției. Rezultatele oferă o bază științifică pentru recomandarea soiurilor tolerante sau rezistente la îngheț, ca strategie practică de stabilizare a producției în zonele afectate de înghețuri târzii.
Cuvinte cheie: prun, soiuri, risc, înghețuri târzii de primăvară, rezistență

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INTRODUCTION

Frost injuries represent a major limiting factor in the cultivation and geographic distribution of horticultural species, particularly in temperate regions. Despite extensive research efforts, frost continues to cause greater economic losses in fruit and vegetable production than any other environmental or biological stressor. Furthermore, the physiological and molecular mechanisms underlying cold hardiness are still not fully elucidated [Rodrigo, 2020].

The plum is a widely cultivated stone fruit species in temperate climates, highly valued for its substantial genetic diversity. In Romania, the European plum (*Prunus domestica* L.) represents the most important fruit species, ranking second globally in plum production after China, and holding the leading position in Europe [FAOSTAT, 2025].

Climate change projections indicate potential constraints on the growth, productivity, and spatial distribution of many economically important plant species, including members of the *Prunus*. Climate changes influence plant dynamics, manifesting as phenological shifts in response to vulnerable environmental conditions. Consequently, phenological phases have advanced and, in some cases, shortened in duration. In certain regions, this advancement increases the risk of frost damage to actively growing tissues [Milošević and Milošević, 2023]. In plum, recent observations from the temperate continental climate of Romania reveal variations in flowering phenology, with several cultivars, including 'Centenar', 'Anna Späth', 'Minerva', and 'Stanley', exhibiting an earlier onset of blooming compared to previous records [Gitea *et al.,* 2019].

Some cultivars exhibit susceptibility to abiotic stress factors, particularly to late spring frosts. The frost constitutes one of the most critical threats to plum crops, directly impacting flower buds viability, with influence on fruiting potential [Muffler *et al.,* 2016]. The frost sensitivity of flower buds is closely linked to intensity and duration of the frost [Milošević and Milošević, 2023] and to their phenological stage. During the flowering period, reproductive organs are extremely vulnerable, often resulting in severe injuries and reduced yield potential. The risk of damage caused by frost increases significantly in genotypes that bloom and set fruit early [Muffler *et al.,* 2016]. Moreover, late spring frosts occurring a few days before or during budburst appear to be decisive for tree survival and overall fitness, as they coincide with the phase of minimal freezing resistance and an almost absent reacclimatization capacity [Vitra *et al.,* 2017]. According to a recent study, late spring frost can significantly delay phenology by reducing photosynthetic activity by 13.6%. This type of climatic event may consequently lower photosynthetic productivity in the year following its occurrence [Wang *et al.,* 2025].

Plum belongs to the category of early-flowering species; therefore, its generative organs exhibit sensitivity to late spring frosts. Flowers at the white bud stage (BBCH 57-59) can withstand temperatures down to -4.9°C, while open flowers tolerate temperatures as low as -3.2°C. Flower resistance may increase up to -6°C if several days of low temperatures occur prior to flowering. Among the floral organs, the pistil is the most sensitive to frost, followed by the ovary. Fruit set is damaged at temperatures around -1.1°C [Mitre, 2002]. According to Murray [2020], the extent of damage to fruit trees resulting from late spring frosts is determined not only by the severity of the critical temperatures and the phenological stage of the trees at the time of the frost event, but also by the duration of exposure to these temperatures. For instance, during the white bud to petal emergence stage in plum, damage was estimated at 10% at -3.3°C, increasing to 90% at -5.5°C [Murray, 2020].

The frost tolerance of plum cultivars is closely linked to their geographical origin and breeding region. Cultivars from Western Europe typically exhibit low to moderate frost resistance, as seen in cultivars such as 'Reine Claude Verte' and 'd'Agen', whereas cultivars originating from North America and China, including 'Opata', 'Sapa', and 'Waneta', demonstrate significantly higher frost tolerance [Sestraș, 2004].

This study aimed to assess the behavior of different plum cultivars under the ecological conditions of northeastern Transylvania, with particular focus on their response to late spring frosts and their overall frost resistance in the context of ongoing climate changes.

MATERIAL AND METHOD

Experimental field plots

The present study was carried out within two experimental plum trials at the Fruit Research and Development Station (FRDS) Bistrița. The first trial was initiated in 2020 on Myrobalan 29C rootstock, while the second one was established in 2021, on St. Julien rootstock. Together, these trials comprise a collection of over 35 plum cultivars, representing both indigenous and foreign genetic resources. The majority of cultivars under investigation are of Romanian origin, reflecting the valuable plum breeding heritage of the country (e.g., 'Diana', 'Centenar', 'Carpatin', 'Tuleu gras', 'Minerva', 'Agent', 'Flora', 'Gras ameliorat', 'Andreea', 'Matilda', 'Elena', 'Delia', 'Zamfira', 'Iulia', 'Jubileu 50', 'Ivan', 'Doina', 'Țița', 'Pescăruș', 'Silvia', 'Tuleu dulce', and 'Zandra'). Alongside these, several foreign cultivars are also included, some of them widely cultivated and well recognized at European level ('Joganta', 'Jofela', 'Tophit', 'Topper', 'Topend plus', 'Top five', 'Jojo', 'Anna Späth', 'Stanley', 'President', 'Reine Claude d'Althan', 'Blue free', and 'French improved'). By bringing together both Romanian cultivars and foreign plum cultivars, the trials provide a broad comparative framework for assessing their adaptation to the ecological conditions of northeastern Transylvania, as well as their susceptibility to late spring frosts in the context of climate change.

Sampling method

Flower bud sampling was conducted 10 days after the frost event to accurately assess the impact of late spring frost on plum cultivars. From each plum cultivar, one hundred of flower buds were randomly collected from three representative trees, ensuring that the samples reflected the overall variability within the experimental plot.

The flower buds were then examined to determine the proportion exhibiting frost damage, providing a quantitative measure of frost sensitivity for each cultivar. Additionally, fruit yield was assessed at harvest maturity and expressed as kilograms per tree, based on the average production recorded from six trees per cultivar.

Monitoring of climatic factors and extreme weather events

The evaluation of climatic stress effects on plum cultivars requires continuous monitoring of multiple risk indicators relevant for this species, including late spring frosts, winter frosts exceeding the species' resistance threshold, hailstorms, strong winds, low temperatures, precipitation and cloud cover during flowering, significant temperature fluctuations during the growing season, drought during fruit development, heat stress, and other abiotic factors.

At the FRDS Bistrița, climatic parameters are monitored using an automated weather station (Adcon Telemetry) equipped with AGROEXPERT software, which ensures continuous recording, storage, and analysis of air temperature, relative humidity, precipitation, and other meteorological variables of interest.

Although several climatic stress factors are systematically monitored, the present study focuses specifically on the impact of late spring frosts that occurred between April 6th and 11th, 2025. During this period, the plum cultivars were found in different phenological stages, ranging from green bud (56 BBCH for stone fruits) and white bud (57–59 BBCH), to beginning of flowering (60–62 BBCH) [Meier *et al.,* 2001]. These phenological differences are of particular importance, since the sensitivity of floral organs to frost varies greatly depending on the developmental stage. As a result, the recorded frost event provided a natural framework for evaluating the variability in frost susceptibility among the studied cultivars under real field conditions.

Statistical analyses

K-means clustering was performed to classify the data into four distinct clusters based on similarity in extent of floral organ damage, by comparing within and between group variances. The analysis was conducted with the following parameters: clustering criterion determinant (W), stop conditions iterations = 500, and convergence = 0.00001.

Principal component analysis (PCA) biplot was performed using values of BBCH scale for stone trees, flower bud load, and average yield as variables, in correlation with 35 plum cultivars classified with k-means. The k-means clustering and PCA analysis were conducted using software XLSTAT 2019.3.2.62913.

RESULTS AND DISCUSSIONS

Extreme weather events

During the analyzed period (Table 1), a sequence of frost events was recorded, with minimum air temperatures ranging between –0.7°C (April 10th) to –5.2°C (April 7th) over six consecutive days. The average daily temperature dropped below 0°C in three out of six days (April 7th, 8th, and 11th), indicating conditions highly unfavorable for phenological development of fruit trees in the spring of 2025. Relative humidity fluctuated between 54.9% to 83.9%, with higher values on two days. These, in relation with light precipitation, created an environment conducive to ice formation on flower buds and flowers. Precipitation occurred almost daily, with values between 0.8 mm to 2.2 mm, could amplify the risk of frost injury, especially under alternating freeze–thaw conditions.

Table 1

Weather data recorded during the frost period at FRDS Bistrița (2025)

Date	Temperature (℃)			Average relative humidity (%)	Precipitation (mm)
	Minimum	Maximum	Average		
April 6th	**-1.2**	4.3	1.1	69.4	1.6
April 7th	**-5.2**	1.1	**-1.4**	54.9	0.0
April 8th	**-4.8**	2.0	**-0.9**	**78.8**	0.8
April 9th	**-2.4**	7.9	2.8	62.3	0.0
April 10th	**-0.7**	4.4	2.0	59.5	**2.2**
April 11th	**-1.9**	0.4	**-0.5**	**83.9**	1.2

The persistence of negative temperatures for six consecutive nights for 2-12 hours (Figure 1) in the period of April, 6th-11th, 2025, sometimes combined with high humidity and intermittent rainfall, highlights the severity of this frost episode and its potential to cause significant damage to sensitive reproductive organs of plum cultivars at FRDS Bistrița.

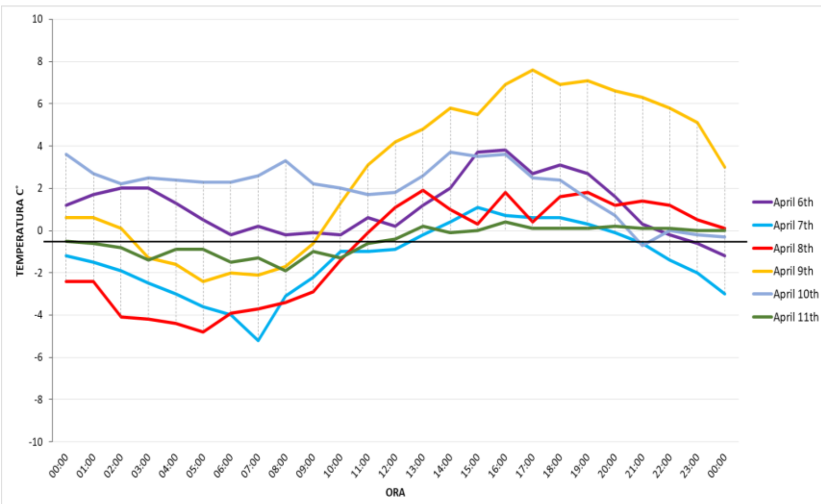

Fig. 1. Hourly temperature during the frost period of April 6th-11th, 2025

Plum cultivar responses to the spring frost events

The evaluation of plum cultivars at FRDS Bistrița during the April 2025 frost episode revealed distinct differences in their sensitivity to low temperatures, highlighting the genetic variability within the collection.

The k-means clustering analysis, based on extent of floral organ damage, allowed the classification of the 35 genotypes into four distinct clusters (Table 2). The first cluster/class included 14 cultivars, within-class variance was 26.44, and the average distance to centroid was 3.90. Taking into consideration these parameters and its large number of objects/cultivars, this cluster can be considered relatively cohesive. Second cluster/class included 10 cultivars and was characterized by lower within-class variance (17.88), and also by lower average distance to centroid (3.08), indicated that it was the most compact and homogeneous of all groups. The third cluster included 7 cultivars and exhibited the highest within-class variance (37.24) together with the largest average distance to centroid (4.61) suggesting a high degree of heterogeneity, despite of the smaller object number. The last one cluster/class exhibited no within-class variance and zero distances to centroid, suggesting that these 4 genotypes are nearly identical, forming an extremely uniform cluster.

Table 2

K-means clustering analysis results for four clusters

Class	1	2	3	4
Objects	14	10	7	4
Sum of weights	14	10	7	4
Within-class variance	26.44	17.88	37.24	0.00
Minimum distance to centroid	0.14	0.10	1.28	0.00
Average distance to centroid	3.90	3.08	4.61	0.00
Maximum distance to centroid	8.86	10.10	11.71	0.00

1. Frost-highly sensitive cultivars

Cluster 1 included **fourteen frost-highly sensitive cultivars**, which suffered extreme damage with significant loss of generative organs, particularly affecting the pistil, which is the most frost-sensitive floral organ and critical for successful fruit set. This large group of cultivars (Table 3) exhibited very high flower bud mortality (83–100%), independent of their initial flower bud load. Cultivars such as ‘Black Sun’, ‘Jojo’, ‘Andreea’, ‘French improved’, ‘Zamfira’, ‘Jofela’, ‘d’Agen’, ‘Topper’, ‘Flora’, ‘Zandra’, and ‘Diana’, recorded over 90% flower bud damage (Figure 2), resulting in negligible or very low yields (0–5 kg/tree). Also, several plum cultivars, such as ‘Agent’, ‘Tita’ and ‘Reine Claude d’Althan’, exhibited severe frost injury, with flower bud damage ranging from 83% to 85%. As a consequence, the fruit yield was considerably reduced, reaching only to 0.2-4 kg per tree (Figure 3).

Table 3

Frost-highly sensitive cultivars

Cultivar	BBCH scale for stone fruits	Flower bud load	Flower bud damaged by frost (%)	Average yield (kg/tree)
Black Sun	59	Normal	100	0
Jojo	59-60	High	99	0.4
Andreea	59	Normal	96	0.3
French improved	56	Low	95	0
Zamfira	59	Normal	93	5
Jofela	56	Low	91	0
d’Agen	59	Normal	90	0.1

Topper	59	Normal	90	3.8
Flora	56	Low	90	0.5
Zandra	56	Low	90	0.3
Diana	59	Normal	90	2.1
Agent	59	Normal	85	0.2
Tita	56-57	Normal	84	4
Reine Claude d'Althan	56	Normal	83	0.9

Fig. 2. Plum cultivars highly susceptible to frost, with bud damage exceeding 90%

Fig. 3. Plum cultivars susceptible to frost, with flower bud damage level of 83-85%

2. Frost-sensitive cultivars

Cluster 2 comprised **ten frost-sensitive cultivars**, which showed severe damage with low to moderate values of yield. Among the widely cultivated plum cultivars, 'Tophit', 'Anna Späth', 'Stanley', and 'President' recorded frost damage levels of 65–70%, reflecting a considerable susceptibility to low-temperature stress (Table 4). Similar patterns of injury were also observed in Romanian cultivars, such as 'Pescăruş', 'Minerva', 'Ivan', 'Tuleu dulce', 'Carpatin', and 'Silvia', exhibiting their vulnerability under severe frost conditions. Figure 4 presents representative plum cultivars from this group, which exhibited notable levels of frost susceptibility (damage level of 58-72%). The cultivars from cluster 2 exhibited low or very low yields (0.4-7.5 kg/tree).

Table 4

Frost-sensitive cultivars

Cultivar	BBCH scale for stone fruits	Flower bud load	Flower bud damaged by frost (%)	Average yield (kg/tree)
Pescăruș	56	Normal	72	5.2
Minerva	59	Normal	72	5.3
Tophit	56	Normal	70	2.4
Anna Späth	56	Normal	70	1.6
Stanley	56	Normal	70	0.9
Ivan	59	Normal	70	0.7
Tuleu dulce	56	Normal	68	1.1
Carpatin	56	Low	66	0.4
President	59	Normal	65	7.5
Silvia	59-61	Normal	58	1.9

Fig. 4. Plum cultivars susceptible to frost, with flower bud damage level of 58-72%

3. Frost-tolerant cultivars

Cluster 3 contained **seven frost-tolerant cultivars** which maintained a relatively acceptable fruiting potential despite exposure to low temperatures. Intermediate frost responses (Table 5) were observed in cultivars such as 'Iulia', 'Toppend plus', 'Top five', 'Gras ameliorat', 'Delia', 'Doina', and 'Joganta', which exhibited flower bud damage ranging from 33% to 50% (Figure 5). Although all these cultivars experienced partial losses due to frost, considerable differences were observed in their resulting yields. Notably, 'Iulia' recorded a remarkable fruit yield of 33.6 kg per tree, maintaining near-normal production even when 50% of the flowers were damaged. Similarly, 'Toppend plus' and 'Top five' combined a high fruiting potential with partial frost tolerance, producing substantial yields despite significant flower bud damage (19.1 kg/tree, respectively 16.1 kg/tree). By contrast, cultivars such as 'Joganta', 'Doina', 'Gras ameliorat', and 'Delia' exhibited low or very low yields (0.2-6.2 kg/tree) under similar frost conditions, likely due to a lower fruit set. These results indicate a relative tolerance to frost among the cluster 3 cultivars and highlight their suitability for cultivation under conditions prone to low-temperature stress.

Table 5

Frost-tolerant cultivars

Cultivar	BBCH scale for stone fruits	Flower bud load	Flower bud damaged by frost (%)	Average yield (kg/tree)
Iulia	56-59	Normal	50	**33.6**
Toppend plus	56	Normal	50	**19.1**
Top five	59	Normal	49	**16.1**
Delia	59-60	Normal	46	0.2
Gras ameliorat	56	Normal	43	6.1
Doina	60-61	Normal	42	1
Joganta	56	Normal	33	6.2

Fig. 5. Plum cultivars tolerant to frost, with flower bud damage level of 33-50%

4. Frost-resistant cultivars

In contrast, cluster 4 grouped **four frost-resistant cultivars**, which exhibited minimal or no injury on generative organs while preserving a very good capacity for fruit set. Thus, several plum cultivars including ‘Elena’, ‘Centenar’, ‘Jubileu 50’, and ‘Blue free’ showed no flower bud damage, demonstrating a remarkable level of frost resistance. Interestingly, in the case of ‘Centenar’, minor injuries were observed on the stamens, while the pistil and ovary remained completely unaffected (Figure 6). This selective organ-specific tolerance allowed successful fruit set and development, contributing to the cultivar’s high productivity despite partial floral organ injury.

Among the four cultivars, ‘Elena’ and ‘Centenar’, both exhibiting a normal flower bud load, recorded high yields of 19 kg and 20 kg per tree, respectively, highlighting their potential as reliable cultivars for regions prone to spring frosts

(Table 6). Although ‘Jubileu 50’ and ‘Blue free’ were also unaffected by frost, their relatively low flower bud load constrained the total fruit yield, illustrating that frost resistance alone does not always guarantee maximal productivity.

Overall, among all cultivars studied, ‘Elena’ and ‘Centenar’ displayed the optimal combination of frost resistance and high productivity, making them particularly suitable for cultivation in frost-prone areas. Notably, the ‘Iulia’ cultivar, classified in the frost-tolerant group, recorded the highest yield among all 35 genotypes evaluated, despite experiencing partial flower bud damage. Additionally, the cultivar ‘Toppend Plus’, also classified within the frost-tolerant group, achieved a yield comparable to that of ‘Elena’ and ‘Centenar’. Importantly, three of these four cultivars (‘Centenar’, ‘Elena’, and ‘Iulia’) are the result of Romanian breeding programs, which confers particular significance both in terms of agronomic performance and in strengthening the national fruit-growing heritage. These findings emphasize their dual role as valuable genetic resources for future breeding efforts and as reliable options for orchard establishment in regions where late spring frosts remain a critical limiting factor for plum production.

Fig. 6. Plum cultivars resistant to frost

Table 6

Frost-resistant cultivars

Cultivar	BBCH scale for stone fruits	Flower bud load	Flower bud damaged by frost (%)	Average yield (kg/tree)
Elena	56	Normal	0	**20**
Centenar	59-60	Normal	0	**19**
Jubileu 50	56-59	Low	0	0.7
Blue free	56	Low	0	1.2

Principal Component Analysis of frost response and agronomic traits in plum cultivars

Figure 7 presents a biplot derived from principal component analysis (PCA), illustrating the distribution of 35 plum cultivars based on three variables. The PCA explained 85.03% of the total variance in the dataset (50.38% F1 and 34.65% F2). The biplot highlights the relationship between the variables (the BBCH scale for stone fruits, flower bud load, and average yield), plum cultivars being classified according to frost-induction susceptibility.

F1 axis is associated with flower bud load and BBCH scale, showing that cultivars with normal or high flower bud load generally were in an advance phenology stage. The F2 axis is more strongly correlated with average yield, showing a tendency toward higher yield performance.

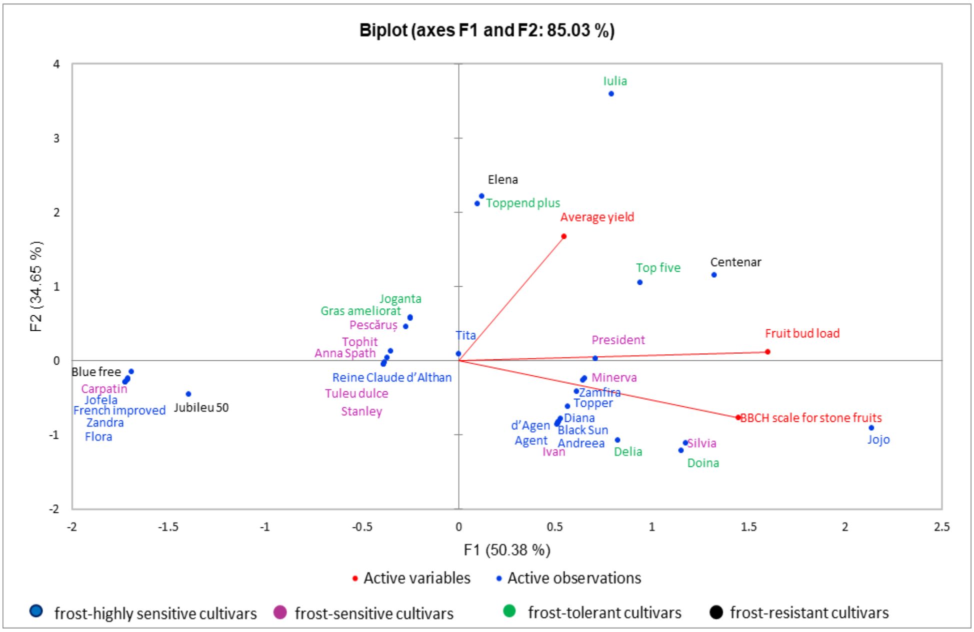

Fig. 7. PCA of 35 plum cultivars and flower bud damage by frost, BBCH scale for stone fruits, flower bud load and average yield correlation

Frost-highly sensitive cultivars (blue) are clustered mostly in the lower right quadrant (e.g. 'Jojo', 'Zamfira', 'Topper', 'Diana', 'Black Sun',' d`Agen', 'Agent', and 'Andreea'), being strongly associated with moderate values of average yield, advanced phenological stage and normal flower bud load, with the exception of 'Jojo', which exhibit a high flower bud load. Other cultivars, such as: 'Jofela', 'French improved', 'Zandra', and 'Flora' were characterized by low flower bud load, early phenological stage and low average yield. A normal flower bud load and early phenological stage were observed for 'Tita' and 'Reine Claude d`Althan', however 'Tita' cultivar showed moderate value yield. Overall, these cultivars proved to be the most sensitive to frost-induce flower bud damage, which was largely correlated with early phenology stages and low flower bud load.

Frost-sensitive cultivars (magenta): 'Pescaruş', 'Tophit', and 'Anna Späth' were grouped closer to the origin, indicating moderate performance across variables without strong association to extreme traits. In contrast, 'Tuleu dulce', and 'Stanley' were associated with low average yield, all being susceptible to frost. 'Minerva', 'President' 'Ivan' and 'Silvia' cultivars had showed advanced phenological stages correlated with frost sensitive, however only 'Minerva' and 'President' exhibited moderate values for average yield. 'Carpatin' cultivar was negatively correlated with all variables.

Frost-tolerant cultivars (green): 'Joganta' and 'Gras ameliorat' cultivars were in an early phenological stage directly correlated with tolerance to frost, and moderate values for average yield. Cultivars from upper right quadrant ('Toppend plus', 'Iulia', and 'Top five') had showed the highest average yield, and distinct phenology stages with low degree of flower bud frosted. In contrast 'Delia' and 'Doina' cultivars despite their advanced phenology stage, normal flower bud load and low values for yield, had showed low flower bud damaged by frost.

Frost-resistant cultivars (black): 'Elena' and 'Centenar' are located in the positive F1/F2 quadrant, characterized by normal flower bud load and higher values of average yield, even the 'Centenar' cultivar were in an advance phenology stage, did not showed flower bud damaged. 'Blue free' and 'Jubileu 50' cultivars were positioned on the negative side of F1/F2 and were characterized by low flower bud load directly correlated with low average yield values, and early phenological stage.

The PCA highlights clear associations between frost tolerance and phenological status, flower bud load and average yield traits in plum cultivars. The biplot thus provides a useful classification tool for cultivar selection in frost-prone environments.

The frost episode acted as a strong differentiating factor, clearly separating cultivars into four resilience categories. Frost-highly sensitive cultivars suffered complete or almost complete reproductive loss, frost-sensitive cultivars exhibiting significant sensitivity to low temperature stress, while frost-tolerant cultivars displayed an intermediate performance. Frost-resistant genotypes preserved both bud viability and substantial yields when flower bud load was adequate.

These results underline the importance of selecting frost-resistant or tolerant cultivars such as 'Centenar', 'Elena', 'Iulia' and 'Toppend Plus' for sustainable plum production in frost-prone areas.

Previous studies provide further evidence of the differential response of plum cultivars to spring frost. Dimitrova et al. [2021] reported that cultivars such as 'Stanley' and 'Tophit Plus' sustained only minor injuries to flower buds and pistils, suggesting a relatively higher tolerance to low temperatures. In contrast, 'Toptaste', 'Topgigant Plus', and 'Topper' proved highly sensitive, with frost damage ranging from 59.6% to 75.8% at −3°C. Similarly, Butac [2020] found that exposure to temperatures between −1.7°C and −3.4°C induced 70–80% flower bud mortality in the cultivars 'd'Agen' and 'Anna Späth'.

Other studies have shown that although during three consecutive years of late spring frosts negative temperatures were recorded on only one day, plum cultivars exhibited variable responses [Nesheva and Bozhkova, 2021]. During the first spring frost episode, plum cultivars were at beginning of flowering, a high degree of frost damage was recorded for 'Toptaste' (51%), 'Topking' (30%), and 'Bellamira' (20%) cultivars at −2.8°C. The lowest damage was observed in 'Tophit plus', 'Cacanska Najbolja', and 'Stanley' cultivars, with approximately 11% of flower buds affected. During the second spring frost episode, the plum cultivars were not affected at −2.8°C. During the third spring frost episode, cultivars were in full bloom or in the flowering-fading stage and the temperature recorded was -5°C. Complete frost damage (100%) was observed in 'Jojo', 'Pacific', 'Sirma', 'Pagane' cultivars, and the plum hybrid HL 20-30. The lowest damage was recorded in 'Tita' cultivar (6%), followed by the 'Stanley' cultivar (12%). Low frost damage was also observed in 'Top First', 'Toptaste', 'Topstar Plus', 'Robelle', and 'Piteștean' cultivars.

The analysis of our field data from 35 plum cultivars, assessed across phenological stages, revealed only minor differences in frost damage between the green bud stage and the white bud/beginning of blooming (Figure 8).

Specifically, the incidence of damage was 61.9% at the green bud stage and 67.3% at the white bud/beginning of bloom stage, a difference of only 5.4% between the two stages. These values suggest that under conditions of severe and prolonged frost, with minimum temperatures reaching -5.2°C and remaining below freezing for six consecutive days, early floral stages do not benefit from significant protection against frost damage. Thus, the intensity and persistence of low temperatures proved decisive, reducing the sensitivity differences between phenophases.

This categorization provides valuable insights for both breeding programs and practical recommendations to growers, especially under the increasing frequency of late spring frosts associated with climate change.

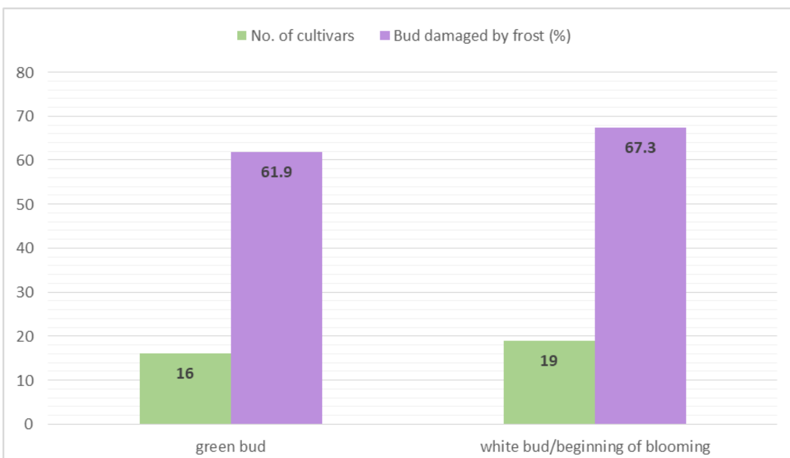

Fig. 8. Phenological stages in relation to frost damage

CONCLUSIONS

The comprehensive assessment of 35 plum cultivars under spring frost stress revealed pronounced genotypic variability in flower bud survival and yield stability. Responses ranged from highly sensitive cultivars, exhibiting near-total flower bud mortality, to resistant genotypes that preserved reproductive potential and maintained satisfactory production levels. Multivariate analyses (cluster analysis and PCA) enabled the classification of cultivars into four distinct groups (highly sensitive, sensitive, tolerant, and resistant), thus providing a robust methodological framework for discriminating frost-resilience levels within germplasm collections.

Particularly, cultivars such as 'Centenar', 'Elena', 'Iulia', and 'Toppend plus' combined frost resistance or tolerance with acceptable yield performance, underscoring their suitability for cultivation in frost-prone environments. These findings not only contribute valuable insights for breeding programs aimed at enhancing resilience to abiotic stress but also support the strategic selection of cultivars for sustainable plum production under changing climatic conditions.

ACKNOWLEGMENTS

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ROMANIAN JUJUBE (*ZIZIPHUS JUJUBA* MILL.) GENOTYPES: AN INTEGRATIVE ANALYSIS FOR ROOTSTOCK SELECTION AND ENVIRONMENTAL INSIGHTS

GENOTIPURI ROMÂNEȘTI DE JUJUBE (*ZIZIPHUS JUJUBA* MILL.): O ANALIZĂ INTEGRATIVĂ PENTRU SELECȚIA PORTALTOILOR ȘI PERSPECTIVE DE MEDIU

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Abstract.
Knowledge of valuable Romanian jujube (Ziziphus jujuba Mill.) genotypes is fragmented across separate morphological and biochemical studies. This integrative analysis uses Pearson correlations and PCA on twelve genotypes to link their physical, chemical, and mineral traits. A strong negative correlation was found between fruit size and bioactive compound concentration. The difference between genotypes was clear. 'Mahmudia 2' produced small fruits packed with polyphenols, while the large fruits from 'Ostrov' had much lower levels. The fruit`s location also mattered, as higher lead and cadmium were found in genotypes originating from Danube sites. The integrated data defined chemo-morphological rootstock "ideotypes": 'Jurilovca III 1' for quality (sugars, calcium) and 'Mahmudia 2' for resilience (polyphenols).
Key words: chinese jujube; local populations; fruit traits; bioactive compounds; ideotypes.

Rezumat.
Cunoașterea genotipurilor valoroase de jujube românești (Ziziphus jujuba Mill.) este fragmentată, provenind din studii morfologice și biochimice separate. Această analiză integrativă folosește corelațiile Pearson și analiza componentelor principale (PCA) pe douăsprezece genotipuri pentru a lega trăsăturile lor fizice, chimice și minerale. Analiza a relevat o corelație negativă puternică între mărimea fructului și concentrația de compuși bioactivi. Diferența dintre genotipuri a fost clară. Genotipul 'Mahmudia 2' a produs fructe mici, bogate în polifenoli, în timp ce fructele mari de la 'Ostrov' au avut niveluri mult mai scăzute. Proveniența fructelor a fost de asemenea importantă. Genotipurile din zonele dunărene au prezentat concentrații mai mari de plumb și cadmiu. Datele integrate au definit „ideotipuri" chemo-morfologice pentru portaltoi: 'Jurilovca III 1' pentru calitate (zaharuri, calciu) și 'Mahmudia 2' pentru reziliență (polifenoli).

[1] Research Station for Fruit Growing, Constanța

Cuvinte cheie: curmale chinezești; populații locale; trăsăturile fructelor; compuși bioactivi; ideotipuri.

INTRODUCTION

Ziziphus jujuba Mill., known as jujube or Chinese jujube, is one of the oldest cultivated fruit tree species, with a history spanning thousands of years [Liu *et. al.*, 2020]. Its fruits are valued not only for fresh or processed consumption but also for their role as a traditional and functional food, owing to a remarkable nutritional profile [Stoli and Stănică, 2023]. They contain a wide range of bioactive compounds, including polysaccharides, polyphenols, triterpenic acids, amino acids, and vitamins, which give them antioxidant, anti-inflammatory, and immunomodulatory properties [Lu *et. al.*, 2021**]**. A distinctive feature of the jujube is the presence of 23 amino acids, a diversity rarely found in other fruits, which reinforces its "superfruit" status. Furthermore, the species exhibits high natural resistance to diseases and pests, allowing for cultivation with a reduced number of phytosanitary treatments, a considerable advantage in the context of sustainable agriculture [Shahrajabian *et. al*., 2019]. These attributes have spurred a growing global interest in leveraging jujube in the functional food and nutraceutical industries [Ding *et. al*., 2016].

The Dobrogea region of Romania holds a particularly valuable genetic heritage for *Ziziphus jujuba*. The species was introduced to this area approximately two millennia ago by Greek and Roman colonists near ancient fortresses such as Argamum (Jurilovca), Salsovia (Mahmudia), and Vicina (Ostrov) [Stănică, 2019]. Over time, these populations adapted and naturalized, evolving under semi-spontaneous conditions and giving rise to distinct local biotypes. These genotypes, including 'Ostrov', 'Jurilovca', 'Mahmudia', and 'Bugeac', represent a unique genetic reservoir specifically adapted to the region's pedoclimatic conditions [Stoli and Stănică, 2025]. The conservation and in-depth characterization of this germplasm are essential not only for preserving biodiversity but also for identifying valuable traits, such as stress adaptability, superior biochemical profiles, or compatibility as rootstocks, which can be integrated into modern breeding programs.

A first study deepened this knowledge by performing a comprehensive biochemical and mineral analysis [Stoli and Stanica, 2023]. This research highlighted genotypes with exceptional chemical profiles: 'Jurilovca III 1' stood out for its very high sugar content, 'Mahmudia 2' for its exceptional concentration of total polyphenols and antioxidant capacity, and 'Jurilovca III 1' also demonstrated a superior mineral content. However, although these two studies offer excellent and detailed characterizations in their specific domains, they remain disjointed analyses. Previous research laid the groundwork for understanding these valuable local genotypes. A second study conducted a detailed morphological characterization of fruits and stones, revealing significant variability among genotypes. That study highlighted the 'Ostrov' genotype for its large-sized fruits, suitable for fresh consumption, and identified the 'Bugeac', 'Jurilovca', and 'Mahmudia' genotypes as having high potential for use as generative rootstocks due to their small fruits and viable seeds [Stoli and Stănică, 2025].

The major knowledge gap lies in the absence of an integrative analysis to explore the relationships and correlations between these datasets. Currently, it is unknown how the physical characteristics of the fruits (mass, diameter) correlate with their biochemical richness (polyphenol content, sugars, antioxidant capacity).

Furthermore, the link between the mineral profile of the fruits and their morphological or qualitative traits has not been investigated, nor has the potential influence of local geochemistry on mineral composition. This lack of an integrated perspective limits the strategic and efficient use of these valuable genotypes in breeding programs, cultivation selection, or the development of value-added products.

MATERIAL AND METHOD

To perform the integrative statistical analysis, quantitative data from both source publications were centralized. This approach allowed for the calculation of correlations between morphological parameters (*e.g.*, fruit weight) and biochemical parameters (*e.g.*, polyphenol content). The statistical analysis of this consolidated data matrix was performed using the following methods:

- descriptive statistics: Mean, standard deviation, and range were calculated for all quantitative variables to provide an overview of the dataset.
- correlation analysis: The Pearson correlation coefficient (r) was applied to quantify the degree of linear association between pairs of variables of interest (*e.g.*, Fruit Mass vs. Total Polyphenols; Calcium Content vs. Soluble Solids).

The statistical significance threshold was set at $p<0.05$.

To evaluate the multivariate relationships, a Principal Component Analysis (PCA) was performed on a focused subset of 10 key morphological and chemical variables discussed in the text.

RESULTS AND DISCUSSIONS

The morphological characteristics of the fruits for the twelve genotypes are detailed in Table 1. Considerable differences were recorded, particularly between the local genotypes and the cultivated varieties. Fruit weight ranged from a minimum of 1.47 g in the local genotype 'Mahmudia 2' to a maximum of 19.97 g in the cultivar 'Taigu Ban'. Among the local genotypes, 'Ostrov' had the largest fruits (4.73 g).

Table 1

Morphological characteristics of jujube fruits

Genotype	Fruits length (mm)	Fruits diameter (mm)	Fruits weight (g)	Pulp weight (g)
Jurilovca I 1	23.29	19.97	3.08	2.79
Jurilovca I 2	23.76	20.33	3.3	3.02

Jurilovca III 1	18.34	16.75	2.18	1.97
Mahmudia 1	21.24	18.62	2.66	2.37
Mahmudia 2	16.48	14.64	1.47	1.33
Ostrov	25.3	22.19	4.73	4.46
Bugeac	19.65	18.78	3.25	2.95
Taigu Ban	44.16	37.61	19.97	18.17
Hu Ping	43.53	35.95	15.64	14.24
Xuan Chen Jiang Zao	41	33.85	13.98	12.53
Jun Zao	43.81	37.03	18.67	17.07
Hongan	33.72	30.04	12.49	11.34

The results of the biochemical analyses are presented in Table 2. The local genotype 'Mahmudia 2' stood out with the highest content of total polyphenols (1020 mg GAE/100g) and the greatest antioxidant capacity (442.5 mg TE/100g). In contrast, the cultivar 'Hu Ping' recorded the lowest values for these parameters. The highest sugar content was identified in the 'Jurilovca III 1' genotype (31.07%).

Table 2

Biochemical profile of jujube fruits

Genotype	Sugar content (%)	Total polyphenols (mg galic acid/100)	Antioxidant capacity (mg Trolox/100g)
Jurilovca I 1	26.4	690	375
Jurilovca I 2	19.04	750	382.5
Jurilovca III 1	31.07	780	405
Mahmudia 1	19.71	720	397.5
Mahmudia 2	22.49	1020	442.5
Ostrov	29.9	510	232.5
Bugeac	26.17	690	315
Taigu Ban	19.03	420	142.5
Hu Ping	15.91	390	120
Xuan Chen Jiang Zao	19.48	540	270
Jun Zao	16.35	480	202.5
Hongan	17.45	450	240

The content of macroelements and heavy metals is summarized in Table 3. Lead and Cadmium levels were highest in the 'Mahmudia 1' and 'Ostrov' genotypes but remained within the permissible legal limits. The local genotypes generally showed a superior content of Calcium and Potassium compared to the cultivated varieties. The highest Calcium content was measured in 'Jurilovca III 1' (47.95 mg/100g), while the highest value for Potassium was found in 'Mahmudia 1' (55.16 mg/100g).

Table 3

Mineral composition of jujube fruits

Genotype	Pb (µg/kg)	Cd (µg/kg)	K (mg/100g)	Ca (mg/100g)
Jurilovca I 1	7.88	<1	42.09	38.95
Jurilovca I 2	13.53	<1	51.99	37.51
Jurilovca III 1	16.8	<1	53.61	47.95
Mahmudia 1	49.86	3.87	55.16	34.66
Mahmudia 2	9.21	<1	51.06	36.3
Ostrov	45.43	3.66	52.54	14.44
Bugeac	8.9	<1	47.87	25.09
Taigu Ban	26.73	2.17	53.6	9.44
Hu Ping	17.68	1.89	49.43	6.29
Xuan Chen Jiang Zao	20.77	2.58	54.07	9.57
Jun Zao	17.37	2.3	51.88	8.33
Hongan	40	2.2	49.79	9.97

The integrative statistical analysis of the chemo-morphological and mineral data revealed several key findings.

A strong, statistically significant negative correlation was identified between the physical parameters of the fruits and the concentration of bioactive compounds. Specifically, fruit mass, fruit diameter, and pulp mass were inversely correlated with total polyphenol content (Table 4 and Figure 1) and antioxidant capacity (Table 5 and Figure 2). This is most evident when comparing the genotypes at the extremes: the 'Ostrov' genotype, which produces the largest fruits (average mass 4.73 g), shows a modest polyphenol content (510 mg gallic acid/100 g), whereas the 'Mahmudia 2' genotype, with some of the smallest fruits (average mass 1.47 g), has an exceptional polyphenol content (1020 mg gallic acid/100 g) and the highest antioxidant capacity (442.5 mg Trolox/100 g) of all genotypes studied.

Table 4

Pearson Correlation Matrix between fruit weight and total polyphenol content

		Fruit weight (g)	Total Polyphenols
Fruit weight (g)	Pearson Correlation	1	-.818**

	Sig. (2-tailed)		1
	N	12	12
**. Correlation is significant at the 0.01 level (2-tailed).			

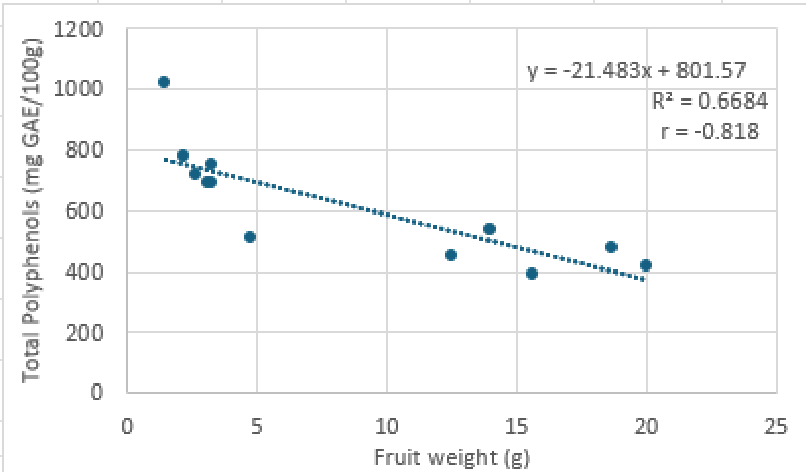

Fig. 1. Correlation between fruit weight and total polyphenol content

Table 5

Pearson Correlation Matrix between fruit weight and antioxidant capacity

		Fruit weight (g)	**Antioxidant Capacity**
Fruit weight (g)	Pearson Correlation	1	-.875**
	Sig. (2-tailed)		0
	N	12	12
**. Correlation is significant at the 0.01 level (2-tailed).			

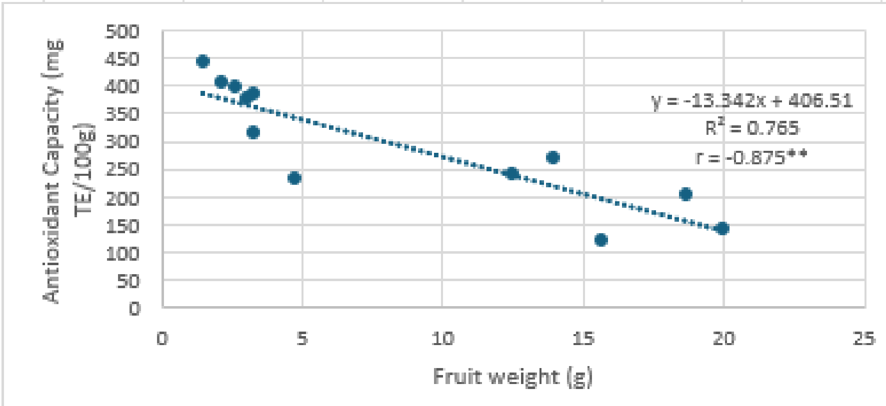

Fig. 2. Correlation between fruit weight and antioxidant capacity

The mineral analysis identified distinct geochemical patterns linked to geographical origin. The 'Mahmudia 1' (Pb: 49.86 µg/kg; Cd: 3.87 µg/kg) and 'Ostrov' (Pb: 45.43 µg/kg; Cd: 3.66 µg/kg) genotypes showed significantly higher concentrations of heavy metals, specifically lead (Pb) and cadmium (Cd), compared to other local genotypes. It is noted that all values are below the maximum limits permitted by European legislation. Furthermore, the analysis of essential minerals showed that the 'Jurilovca III 1' genotype contains the highest concentration of calcium (Ca) at 47.95 mg/100 g, while the 'Mahmudia 1' genotype has the highest level of potassium (K) at 55.16 mg/100 g.

The results of this study provide a deeper understanding of the relationships between the physical, chemical, and environmental traits of Romanian jujube genotypes, with significant implications for breeding and cultivation.

The inverse correlation between fruit size and bioactive content reflects a physiological principle known as the "dilution effect." The biosynthesis of secondary metabolites like polyphenols occurs early in fruit development [Sulusoglu, 2014]. As the fruit later expands by accumulating water and sugars, these pre-existing compounds are diluted, leading to lower concentrations in larger fruits [Wang *et. al*., 2024]. This finding highlights a critical trade-off for breeding programs: selecting for large fruit size, often desired for fresh consumption, may unintentionally reduce the nutraceutical value. Consequently, small-fruited but biochemically rich genotypes like 'Mahmudia 2' are identified as elite genetic resources, not for the fresh market, but for developing high-value ingredients for functional foods and nutraceuticals.

The distinct heavy metal profiles suggest possible environmental signatures (Figure 3). The higher Pb and Cd levels in the 'Mahmudia 1' and 'Ostrov' genotypes are likely linked to their collection sites near the Danube River. The river's floodplain and delta are known to accumulate sediments and associated pollutants from its basin, suggesting a higher bioavailability of these elements in the local soil

[Gati *et. al.*, 2016]. This underscores the importance of site selection for commercial orchards and suggests jujube genotypes could serve as bio-indicators of soil geochemistry.

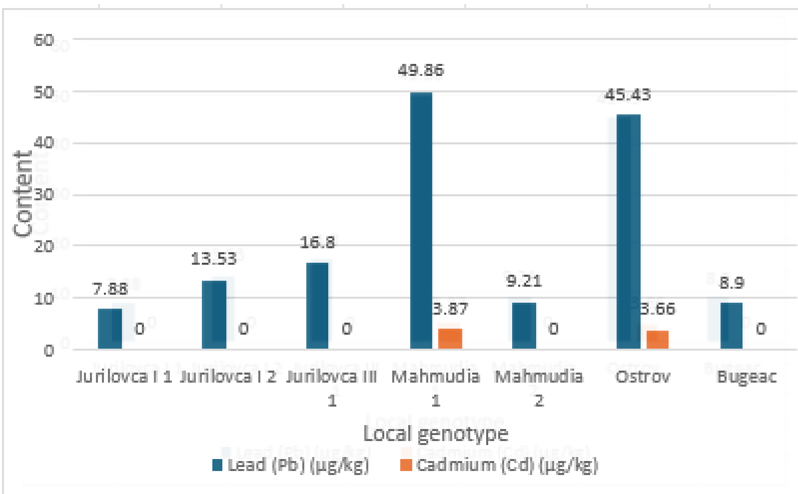

Fig. 3. Geographic variation in mineral and heavy metal levels

A significant finding regarding food safety is the non-detectable Cadmium level in the 'Mahmudia 2' genotype (Figure 4). This result is particularly noteworthy when contrasted with the 'Mahmudia 1' genotype which, despite growing in close proximity, showed quantifiable levels of this heavy metal. This stark difference suggests that 'Mahmudia 2' may possess a valuable genetic trait that limits its uptake or accumulation of Cadmium from the soil.

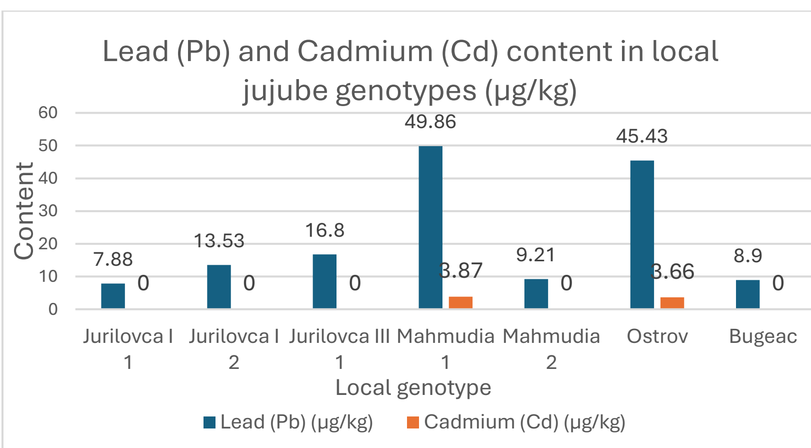

Fig. 4. Lead (Pb) and Cadmium (Cd) content in the fruits of local jujube genotypes (µg/kg)

Furthermore, the mineral content appears to influence fruit quality. The high calcium content in 'Jurilovca III 1' may contribute to improved fruit firmness and shelf-life, as Ca is essential for cell wall integrity [Roper, 2016]. Potassium's role in sugar transport suggests a link between its high levels and the fruit's soluble solids content.

These integrated findings allow for the definition of data-driven "rootstock ideotypes." A rootstock can significantly influence scion performance, including fruit quality. Based on this analysis, 'Jurilovca III 1' emerges as an ideotype for quality and productivity. Its high sugar and calcium content indicate a superior capacity for mineral uptake and assimilation, potential traits for enhancing fruit quality in the scion. 'Mahmudia 2' represents an ideotype for resilience and adaptability; its exceptionally high polyphenol and acidity levels indicate a robust defense metabolism, which could confer enhanced tolerance to biotic and abiotic stress upon the scion [Jayswal and Lal, 2020; Vijayalaxmi, 2023].

Finally, 'Bugeac', with its balanced profile, could serve as a general-purpose rootstock. This strategic approach, which moves beyond simple morphological selection, is supported by recent trials that have begun to test these local genotypes as rootstocks [Stoli *et. al*., 2022].

The Principal Component Analysis (PCA) of the 10 key variables revealed a clear separation between local genotypes and cultivated varieties (Table 6). The first principal component (PC1), explaining 58.6% of the total variance, separated genotypes primarily based on fruit size (to the right) and the content of bioactive compounds and key minerals (to the left). The second principal component (PC2), explaining 19.7% of the variance, further differentiated genotypes based on heavy metal content (upwards) (Figure 5.)

Table 6

Coordinates of the jujube genotypes on the first two principal components (PC1, PC2)

Genotype	Type	PC1	PC2
Jurilovca I 1	Local	-1.54	-0.32
Jurilovca I 2	Local	-1.74	-0.8
Jurilovca III 1	Local	-2.71	0.81
Mahmudia 1	Local	-0.81	2.5
Mahmudia 2	Local	-3.42	0.3
Ostrov	Local	-0.52	-2.31
Bugeac	Local	-1.45	-1.18
Taigu Ban	Cultivar	4.31	0.58
Hu Ping	Cultivar	2.56	-1.33
Xuan Chen Jiang Zao	Cultivar	1.83	0.69
Jun Zao	Cultivar	3.12	0.28
Hongan	Cultivar	2.4	0.77

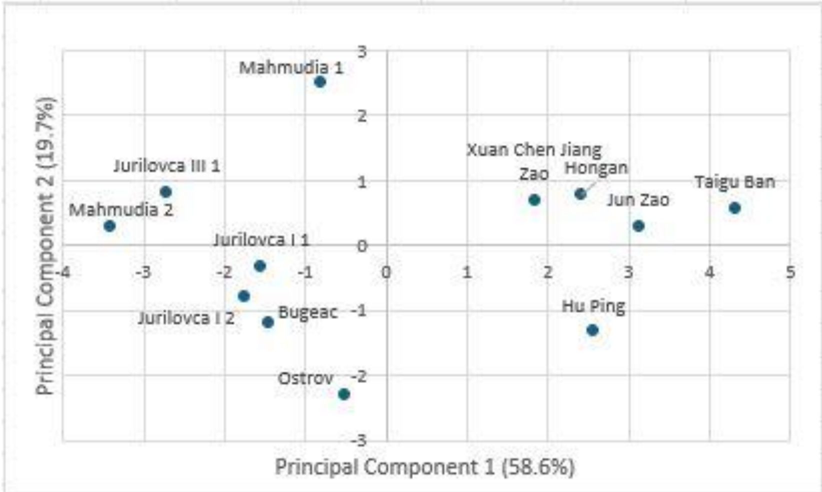

Fig. 5. Principal component analysis (PCA) score plot of jujube genotypes

CONCLUSIONS

This study performed the first integrative analysis of morphological, biochemical, and mineral data for a unique set of local jujube genotypes from Romania, generating new and valuable insights that surpass the conclusions of previous individual studies.

The main original contributions of this work are:

- Quantitative confirmation of the trade-off between size and nutraceutical value. A significant inverse correlation between fruit mass and the concentration of bioactive compounds, particularly polyphenols, was statistically demonstrated. The multivariate analysis (PCA) visually confirmed this distinction, revealing a clear separation between the small, nutritionally dense local genotypes and the large-fruited cultivars.

This discovery provides a solid scientific basis for strategically guiding breeding programs based on the final purpose (fresh consumption versus processing for functional products);

- Identification of environmental signatures in the mineral composition: A possible link between the geographical origin of the genotypes and their mineral profile was highlighted, especially the accumulation of heavy metals (Pb, Cd) in fruits from areas adjacent to the Danube.

This aspect opens a new research direction at the intersection of horticulture and environmental science, emphasizing the importance of local geochemical factors;

- Proposal of data-driven rootstock "ideotypes": The integrated analysis allowed for the definition of distinct chemo-morphological profiles for genotypes with rootstock potential.

Specific ideotypes were proposed for improving the fruit quality of the scion (based on 'Jurilovca III 1') and for increasing stress resilience (based on 'Mahmudia 2'), transforming a general hypothesis into a targeted breeding strategy.

These findings have direct practical implications. Breeders can use this analytical framework to select parental material more efficiently, balancing production traits with nutritional quality.

For the food industry, genotypes like 'Mahmudia 2' prove to be exceptional sources for developing high-value-added extracts for the functional food and nutraceutical market [Ding *et. al.*, 2016]. For growers, the study underscores the critical importance of site selection, demonstrating that soil and the surrounding environment can directly influence the chemical composition of the harvest.

To validate and extend the conclusions of this study, the following research directions are recommended:

- Soil analysis and geochemical hypothesis validation: It is essential to perform a detailed soil analysis at the exact GPS coordinates mentioned in the original study for the 'Mahmudia 1' and 'Ostrov' genotypes. This should include determining the total and bioavailable content of heavy metals (Pb, Cd) and the general mineral composition to directly confirm the link between soil and fruit composition;

- Establishment of experimental grafting plots: To directly test the hypotheses regarding rootstock ideotypes, establishing controlled experiments is recommended. These should use the proposed rootstocks ('Jurilovca III 1', 'Mahmudia 2', 'Bugeac') and a common scion (*e.g.*, 'Ostrov' or a valuable commercial cultivar). Measurements should target the rootstock's influence on the scion's growth, stress tolerance (*e.g.*, controlled water stress), and, most importantly, on the physical, biochemical, and mineral quality of the fruits produced by the scion. This approach would directly validate the potential identified in this analysis and continue the work already started in this field [Stoli *et. al.*, 2022].

- In-depth metabolomic analysis: The current study was based on total polyphenol content. A logical next step is to perform a metabolomic analysis (*e.g.*, via HPLC-MS) to identify and quantify specific phenolic compounds (*e.g.*, phenolic acids, flavonoids like rutin or quercetin) that contribute to the exceptional antioxidant capacity of genotypes like 'Mahmudia 2'. Identifying specific high-value compounds would exponentially increase the commercial and nutraceutical potential of these genotypes [Shao *et. al.*, 2024].

- Sensory evaluation: Correlating objective chemical data *(e.g.*, sugar/acid ratio, dry matter content) with consumer preferences through sensory evaluation panels would provide a complete picture of fruit quality and guide genotype selection not only based on composition but also on market acceptability.

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ASSESSMENT OF THE PHENOTYPIC DIVERSITY OF *PRUNUS CERASIFERA* EHRH IN NATURAL AND ANTHROPIZED ECOSYSTEMS

EVALUAREA DIVERSITĂȚII FENOTIPICE A SPECIEI *PRUNUS CERASIFERA* ÎN ECOSISTEME NATURALE ȘI ANTROPIZATE

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Abstract.
The study aims are to identify valuable species and genotypes tolerant to extreme environmental conditions, diseases, and pests. Wild biotypes of fruit tree species represent important genetic resources for improving adaptability and yield under low-input conditions. In Constanta and Arges counties, several cherry plum biotypes were identified and characterized in terms of plant habit, vigor, health status, and fruit quality. Most fruit samples exhibited high dry matter content, exceeding 15° Brix, and were classified as sweet or very sweet. The most promising rootstock selections will be grafted and included in the National Collections, serving as a gene reservoir for future breeding programs.
Key words: biotypes, myrobalan plum, evaluation, fruit

Rezumat.
Lucrarea are ca scop identificarea unor specii și genotipuri rezistente la factorii de mediu extremi, boli și dăunători. Pentru speciile pomicole cultivate, biotipurile din flora spontană pot fi resurse de gene valoroase în ceea ce privește adaptabilitatea la condițiile de mediu și sporirea producției cu inputuri reduse, în urma utilizării acestora în activitatea de ameliorare. În vederea identificării celor mai valoroase exemplare de corcoduș, în județele Constanța și în Argeș au fost localizate diferite exemplare care au fost descrise din punct de vedere al habitusului și vigorii plantei, al stării de sănătate și au fost recoltate probe de fructe; Majoritatea probelor au avut avut un conținut ridicat de substanță uscata, peste 15^0 Brix, fiind încadrate ca fiind dulci și foarte dulci. Selecțiile pe rădăcini proprii care s-au evidențiat urmează și fie altoite și plantate în Colecțiile Naționale pentru a fi folosite ca resursă de gene in programele de ameliorare.
Cuvinte cheie: biotipuri, mirobolan, evaluare, fructe

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INTRODUCTION

The cherry plum (*P. cerasifera* Ehrh. or *P. divaricata* Ledeb.) belongs to the *Rosaceae* family. Worldwide, there are germplasm collections for cherry plum or myrobalan plum and other *Prunus* species, aimed at conserving genetic diversity and supporting breeding programs for stone fruits. In Asia, China hosts a vast germplasm collection in Xiongyue, Liaoning Province, with over 600 *Prunus* varieties, including *P. cerasifera* [Liu *et al*., 2007]. This represents one of the largest *Prunus* genetic resources in Asia and includes both local cultivars and introduced hybrids, intended to broaden the genetic base and support breeding efforts. This collection reflects a long history of natural and artificial selection, adapted to different ecological conditions, making it an important resource for the development of the plum and cherry plum industry in China and worldwide.

In Romania, cherry plum grows spontaneously and is found as a tree or shrub almost everywhere, demonstrating high adaptability to various environmental conditions. It bears fruit regularly, shows significant variability, and is an entomophilous allogamous species [Botu *et al*., 2007]. It is used both as a rootstock for plum and apricot [Butac *et al*., 2011; Romanian's Pomology, 2018] and for its fruits, which can be processed into compote, alcoholic beverages or even yoghurt [Moga *et al*., 2024]. More recent studies indicate that the cherry plum provides multiple ecosystem services, including: reduce atmospheric CO_2 concentrations, pollutant filtering and biodiversity [Petrov *et al*., 2024].

The exact estimation of the number of cherry plum trees in Romania is difficult, as there is no census dedicated to this species, and official statistical sources do not provide detailed information about wild fruit tree species.

The cherry plum is a diploid species characterized by extensive phenotypic variability, which necessitates the selection and evaluation of the most promising genotypes.

MATERIAL AND METHOD

In order to identify the most valuable biotypes, several trees were recorded in Constanța County and described in terms of plant habit and vigour, plant health status, and fruit samples were collected. The fruits were analysed with respect to size and weight, average weight, fruit colour, pulp characteristics, aroma, stone, dry matter content, and harvest date of the samples. Each one was characterized according to the UPOV descriptors [TP 41/1 of 06.11.2003]. The fruit, 30 of each cultivar/variety were harvested at optimal maturity, the measurements being made with the support of the electronic calliper (mm). The fruit shape index was calculated as the ratio between fruit height and diameter. Fruit weight (g) was measured on 30 fruits per treatment using a technical balance (Kern 572-35, Kern & Sohn, GmbH, Balingen, Germany). The total soluble solids content of cherry plum juice was measured using a HI 96801 digital refractometer. Results were expressed as % Brix, in accordance with previous studies [Pereira *et al*., 2013; Panahirad *et al*., 2019; Adeboyejo *et al*., 2022; Barać *et al*., 2022].

In 2024, 28 cherry plum biotypes were analysed. Samples 1–4 and 11–28 represent biotypes on their own roots, while samples 5–10 are grafted cherry plum selections from the rootstock collection of the Research Station for Fruit Growing (RSFG) Constanța.

Also, 9 cherry plum biotypes from the rootstock collection of the Fruit Growing Research and Development Institute (RIGF) Pitesti-Maracineni were evaluated. The trees in the collection were established in the spring of 2009, at a spacing of 5×3 m, grafted onto Mirobolan C5 rootstock. In the spring of 2024, fruiting pruning was performed after a three-year interval, which promoted vegetative growth to the detriment of productivity. None of the biotypes exhibited visible symptoms of diseases or viral infections. Fruit evaluations were conducted on average samples of 30 fruits, in three replications. Stones were weighed after being washed and dried for several days.

RESULTS AND DISCUSSIONS

In Table 1, the geographic coordinates and the harvest dates of the cherry plum samples are presented. The samples were numbered in the order of collection.

Table 1

Identification of Cherry Plum Biotypes from Constanța County

Sample	Date of Collection	Location, Geographic coordinates	Sample condition*
1	16.07.2024	Valu lui Traian, 44.167634, 28.459381	1
2	17.07.2024	Constanța, 44.190054933224424, 28.644049186504635	1
3	18.07.2024	Valu lui Traian, 44.167813373338475, 28.491868810240085	1
4	20.07.2024	Constanța, 44°10'35.0"N 28°29'25.1"E	1
5	23.07.2024	SCDP Constanța, 44°10'35.0"N 28°29'25.1"E	5
6	24.07.2024	SCDP Constanța, 44°10'37.5"N 28°29'25.8"E	5
7	24.07.2024	SCDP Constanța, 44°10'35.0"N 28°29'25.1"E	5
8	25.07.2024	SCDP Constanța, 44°10'39.9"N 28°29'25.7"E	5
9	26.07.2024	SCDP Constanța, 44°10'39.9"N 28°29'25.7"E	5
10	26.07.2024	SCDP Constanța, 44°10'39.9"N 28°29'25.7"E	5
11	28.07.2024	SCDP Constanța, 44°10'42.1"N 28°29'27.6"E	1
12	28.07.2024	Valu lui Traian, 44.167450, 28.491787	1
13	29.07.2024	Ciocârlia de Sus, 44.1175660, 28.3342538	1
14	30.07.2024	Valu lui Traian, 44.1642817, 28.4630766	1
15	30.07.2024	Nicolae Bălcescu, 44°23'00.7"N 28°22'16.3"E	1

Sample	Date of Collection	Location, Geographic coordinates	Sample condition*
16	30.07.2024	Valu lui Traian, 44.165299, 28.489595	1
17	31.07.2024	Constanța, 44.1459743,28.63125	1
18	31.07 2024	Constanța, 44.1459743,28.63126	1
19	06.08.2024	Agigea, 44.089186, 28.610134	1
20	06.08.2024	Agigea, 44°10'42.1"N 28°29'27.6"E	1
21	08.08.2024	Agigea, 44.087743, 28.609226	1
22	08.08.2024	Agigea, 44.087995, 28.609022	1
23	09.08.2024	Agigea, 44.087578, 28.608901	1
24	09.08.2024	Valu lui Traian, 44.168897, 28.490733	2
25	09.08.2024	Valu lui Traian, 44.168862, 28.490471	2
26	10.08.2024	Valu lui Traian, 44.168160, 28.488703	2
27	10.08.2024	Valu lui Traian, 44.167785, 28.488611	2
28	12.08.2024	Ciocârlia de Sus, 44.118986, 28.334599	1

*Sample condition: 1- wild species; 2- traditional/heritage varieties;3- improved/modern varieties;4- clonal selections; 5- clonal rootstocks.

The majority of the samples are yellow in color (12), followed by shades of golden yellow (5), while darker colors such as red, purple, or black appear less frequently (1–3 samples each). Regarding aroma, most samples either have no aroma (8) or are aromatic (5), whereas the variants “slightly aromatic,” “sweet taste,” and “very aromatic” are less common.

Table 2

Characteristics of the Fruits from the Studied Biotypes, 2024

Sam-ple	Fruit shape index	Color of the skin	Skin thickness*	Skin adhesion**	Stone adherence***
1	0.92	yellow	2	NA	NA
2	0.96	yellow	3	A	NA
3	0.96	orange-yellow	2	NA	NA
4	0.92	yellow	2	NA	NA
5	0.97	black	2	NA	NA
6	1.12	yellow	3	A	A
7	1	yellow	3	A	NA
8	0.84	yellow	3	NA	NA
9	0.99	pink	2	A	A
10	1.04	coral-red	2	NA	SA
11	1.09	golden-yellow	2	NA	NA
12	0.99	yellow	2	A	NA
13	0.91	golden-yellow	3	A	A
14	1.02	yellow	4	A	A
15	1.08	red purple	2	NA	A
16	0.94	yellow	3	NA	A
17	0.94	golden-yellow	4	A	SA

Sam-ple	Fruit shape index	Color of the skin	Skin thickness*	Skin adhesion**	Stone adherence***
18	1.02	purple-black	1	NA	SA
19	1.08	orange-yellow	2	NA	A
20	0.94	pink	2	NA	A
21	1.2	ruby red	2	NA	A
22	1.03	black	1	NA	NA
23	1	dark red	2	A	A
24	0.93	yellow	2	NA	NA
25	1.04	black	2	NA	NA
26	1.02	dark purple	2	NA	NA
27	1.18	dark purple	2	NA	NA
28	0.88	yellow	3	A	NA

*1- very thin; 2- thin; 3- thick; 4- very thick
** A- adherent; NA- non-adherent
***A- adherent; SA- semi-adherent; NA- non-adherent

Table 3

Morphological and chemical parameters of the analyzed samples

Sample	Height (mm)	Diameter (mm)	Average weight (g)	SSC (Brix^0)
1	19.67	21.3	10.2	19.7
2	21.6	22.53	12.8	18.2
3	21.6	22.53	6	16.5
4	19.67	21.3	10.2	19.7
5	22.34	23.15	7	15.9
6	26.65	23.87	20.1	15.5
7	23.55	23.46	6.5	14.5
8	23.29	27.69	12.2	17.9
9	23.99	24.2	7.9	17.9
10	24.55	23.53	7.4	17.9
11	23.27	21.42	7.25	17.9
12	24.27	24.42	9.35	16.8
13	32.36	35.46	24.6	17.9
14	30.79	30.33	16.9	18.1
15	21.6	20.05	5.9	17.7
16	27.91	29.82	14.7	17.6
17	24.85	26.53	21	14.6
18	27.69	27.06	12.4	18.4
19	28.29	26.14	18	16.4
20	23.45	24.96	8.2	18.4
21	23.78	19.88	5.3	23.3
22	24.57	23.74	5.5	18.9
23	28.67	28.69	12.6	14.7
24	22.72	24.5	8.9	16.5
25	27.82	26.71	11.2	16.2
26	23.38	22.95	8.5	18.6
27	22.71	19.19	5.5	16.6
28	24.75	28	8.5	17.5

Pearson coefficient: average weight vs. height: moderate positive (~0.55), average weight vs. width: strong positive (~0.65), average weight vs. dry matter: weak, slightly negative (~0.15), height vs. width: moderate (~0.55). Interpretation: Weight is strongly associated with dimensions (particularly width), but shows little dependence on dry matter, which remains fairly constant.

At RIFG Pitești Maracineni, fruit ripening was monitored according to genotype over a two-month period, July and August. Four of the genotypes produced yellow fruits, while the others displayed shades of red. The number of pits per kilogram ranged from 1.602,98 in genotype CPC-V to 2.614,11 in genotype C11, table 4.

Table 4

Plant and fruit traits studied in nine genotypes of myrobalan plum from the rootstock collection (RIFG Pitești Maracineni)

Genotype	Tree vigor	Ripening time	Fruit skin color	Average weight (g)	Average stone weight (g)	Stones/ kg (pcs)	Stones / kg (pcs)
C1	high	15-25.08	yellow	7.86	0.47	127.18	2132.29
C4	high	10-20.07	dark red	9.94	0.44	100.67	2256.39
C11	high	10-20.07	yellow	8.07	0.38	123.88	2614.11
C18	medium	10-20.07	red-purple	9.60	0.53	104.18	1902.61
HC 82-C	low	10-20.07	yellow	7.75	0.51	129.00	1961.99
Hațeg Breazova	high	1-10.07	red	8.14	0.43	122.85	2349.41
Geoagiu Tileș 4	low	15-25.07	dark red	5.88	0.49	170.01	2063.65
CPC-V	high	25.07-05.08	pink	9.49	0.62	105.52	1602.98
Corcodus Merei	medium	25.07-05.08	yellow	8.80	0.58	113.68	1728.34

CONCLUSIONS

Under the current climatic conditions, the large number of existing cherry-plum biotypes makes it necessary to identify valuable specimens in terms of longevity, productivity, fruit quality, rooting ability, and resistance to biotic and abiotic factors.

Cherry-plum is widely distributed in the Constanța and Arges regions, occurring spontaneously in most areas. The analyzed samples exhibit biodiversity, resilience to prolonged drought, and resistance to specific diseases, with most biotypes bearing thorns. Fruit shapes ranged from spherical and flattened-spherical to elongated-ovoid, with average weights between 5.2 g and 24.6 g. Most samples had high dry matter content (>15 °Brix), classifying them as sweet to very sweet

[Sonea, 1957]. Outstanding selections on their own roots were either grafted or planted in the National Collections to serve as a genetic resource for breeding programs.

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STUDY REGARDING QUALITY TRAITS OF FRUITS IN CHERRY CULTIVARS (*PRUNUS AVIUM* L.) UNDER THE CONDITIONS OF THE NE AREA OF ROMANIA

STUDIUL ÎNSUŞIRILOR DE CALITATE A FRUCTELOR LA UNELE SOIURI DE CIREŞ (*PRUNUS AVIUM* L.) ÎN CONDIŢIILE ZONEI DE NE A ROMÂNIEI

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Abstract.
The paper introduces the valuable traits of the fruits in local and international cherry cultivars under the conditions of 2021 – 2024, cultivars suitable for both fresh consumption and for processing. Considering the fruit weight (g) and its equatorial diameter (mm) as averaged across four years of study, cultivars Ludovan (9.76 g and 27.25 mm), Cociuvaş (9.70 g and 27.11 mm), Andreiaş (9.20 g and 25.87 mm), Miris (7.92 g and 25.01 mm) and Van (7.90 g and 25.05 mm) stood out statistically, showing significantly higher differences. In terms of stone size, the cultivars recorded a weight between 0,26 g (Miris) and 0,35 g (Andreiaş). The dry substance content was between 14.7 °Brix (Scorospelka) and 19.86 °Brix (Margonia), while the values for the total content of polyphenols were between 299.17 mg GAE 100 mL^{-1} (Scorospelka) and 482.35 mg GAE 100 mL^{-1} (Cociuvaş). As for the resistance of the fruits to cracking, all the studied cultivars showed good resistance, with recorded values under 19%, except for cultivar Van (43.9%).
Keywords: cultivars, cherries, traits, qualities, fruit

Rezumat.
Lucrarea prezintă caracterele valoroase a fructelor la unele soiuri de cireş autohtone şi cosmopolite, în condiţiile anilor 2021 – 2024, soiuri pretabile atât pentru consum în stare proaspătă cât şi pentru procesare. Apreciind greutatea fructului (g) şi diametrul ecuatorial (mm) al acestuia, prin prisma mediei celor patru ani de studiu, s-au remarcat din punct de vedere statistic cu diferenţe semnificative mai mari soiurile Ludovan (9.76 g şi 27.25 mm), Cociuvaş (9.70 g şi 27.11 mm), Andreiaş (9.20 g cu 25.87 mm), Miris (7.92 g cu 25.01 mm) şi Van (7.90 g cu 25.05 mm). Ca

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mărime a sâmburelui, soiurile au înregistrat o greutate cuprinsă între 0,26 g (Miris) şi 0,35 g (Andreiaş). Conţinutul în substanţă uscată a fost cuprins între 14.7 °Brix (Scorospelka) şi 19.86 °Brix (Margonia), iar la conţinutul total de polifenoli valorile au fost cuprinse între 299.17 mg GAE 100 mL^{-1} (Scorospelka) şi 482.35 mg GAE 100 mL^{-1} (Cociuvaş). Referitor la rezistenţa fructelor la crăpare, toate soiurile luate în studiu au manifestat o rezistenţă bună, valorile înregistrate fiind sub 19%, excepţie făcând soiul Van (43.9%).

Cuvinte cheie: soiuri, cireşe, însuşiri, caracteristici, fruct.

INTRODUCTION

The cherry tree is a fruit-growing tree species of significant economic importance, due to its nutritional, technological and commercial traits of its fruits, that finds optimal conditions for expressing its agrobiological potential in Romania, except for certain years when natural calamities have occurred [Grădinariu and Istrate, 2003]. Cherries are the first fruits that reach maturity (2nd part of May until mid-June) during a time when other fruits are missing in the market [Ghena and Branişte, 2003]. These fruits surpass almost all other fruit-growing species in terms of total sugar average content, tanoide substances, crude proteins, mineral substances and vitamin C.

On the fresh fruits market, cultivars with “bigarreau” type fruits, bright red in colour, resistance to cracking, transportation and temporary storage and a weight higher than 7g are preferred [Budan and Grădinariu, 2000].

As the cultivar approaches commercial maturity, the fruit’s size and its soluble substance content increase [Rudi, 1992], while the fruit colour parameter determines the optimal harvest time [Webster and Looney, 1996; Tudela *et al*., 2005].

The paper introduces the valuable traits of the fruits in local and international cherry cultivars, under the conditions of 2021 – 2024, cultivars suitable both for fresh consumption and processing.

MATERIAL AND METHOD

The research was conducted between 2021-2024, using seven cherry cultivars as research material: five Romanian cultivars (Andreiaş, Ludovan, Cociuvaş, Miris, Margonia) and two international cultivars (Van, Scorospelka). Out of the seven cultivars, Scorospelka is an early cultivar, Margonia is a late cultivar and the rest show medium maturity.

The trees are planted at a distance of 5 x 4 m and pruned to form a free flattened palmette crown without support and irrigation systems.

The land plot on which the plantation was established is located in the Jijia-Bahlui depression, where the multiannual average temperature is 10.2 °C, oscillating during the research period between 10.1 °C in 2021 and 12.5 °C in 2024.

To describe the fruits, descriptors used for the *Prunus avium* L. genus were used, according to the UPOV TG/35/7, ^{xxx}, 2006 questionnaire.

To determine the average weight of the fruit, stone and peduncle (g), 50 fruits, 50 stones and 50 peduncles were weighted in three repetitions using the electronic precision scale 0.01G type Radwag; the equatorial diameter (D) of the fruit (mm) was determined using the digital callipers Luumytools for 50 fruits in three repetitions; pulp firmness, pulp adherence to stone and the intensity of the sweet taste of the fruits were evaluated using sensorial assessment (Table 3).

To determine the soluble dry substance content in the fruit, the portable digital Zeiss refratometer (° Brix) was used; the titratable acidity of the fruits was determined through the potentiometric method [Ghimicescu, 1977]; the total content in polyphenols was measured using the Folin-Ciocalteu method [Jayaprakasha *et al.*, 2001]; the resistance of fruits to cracking was determined using the Cristensen method, counting the cracked fruits after being immerset in distilled water at 20 °C for six hours [Webster and Looney, 1996].

The experimental data was statistically interpreted using the multiple comparisons method (Duncan test, with P 5%).

RESULTS AND DISCUSSIONS

Maglakelidze *et al.*, [2015], claim that the hereditary traits of the cherry, together with climatic and technological factors, act simultaneously on the biological processes.

Analysing the fruit's weight (g) and its equatorial diameter (mm) as averaged across the four years of study, cultivars Ludovan (9.76 g and 27.25 mm), Cociuvaş (9.70 g and 27.11 mm), Andreiaş (9.20 g and 25.87 mm), Miris (7.92 g and 25.01 mm) and Van (7.90 g and 25.05 mm) stood out statistically, showing significantly higher differences, followed by Margonia (6.72 g and 23.02 mm) and Scorospelka (5.75 g and 21.22 mm) that recorded significantly lower differences (Table 1).

Table 1

The fruit's physical characteristics in cherry cultivars
(RSFG Iaşi; average of 2021-2024; n=4)

Cultivars	Traits								
	Average weight of the fruit (g)[1]	Fruit's equatorial diameter (mm)	Stone's average weight (g)[2]	Fruit/stone ratio	Stone in the fruit's weight (%)	Peduncle average weight (g)	Total weight of the waste (g)	Ratio between pulp and waste (%)	
								Pulp	Waste
Andreiaş	9.20^{a}	25.87^{ab}	0.35^{a}	27.15^{ab}	3.89^{ab}	0.0913^{c}	0.4413^{a}	95.203	4.797
Ludovan	9.76^{a}	27.25^{a}	0.31^{ab}	32.38^{a}	3.27^{b}	0.1020^{ab}	0.4120^{a}	95.779	4.221
Cociuvaş	9.70^{a}	27.11^{a}	0.31^{ab}	31.53^{a}	3.25^{b}	0.1018^{b}	0.4118^{a}	95.755	4.245
Miris	7.92^{ab}	25.01^{b}	0.26^{b}	31.75^{a}	3.33^{b}	0.0728^{d}	0.3328^{b}	95.798	4.202
Van	7.90^{b}	25.05^{b}	0.30^{ab}	26.55^{b}	3.79^{b}	0.0880^{cd}	0.3880^{ab}	95.089	4.911
Margonia	6.72^{bc}	23.02^{bc}	0.34^{a}	19.17^{c}	5.11^{a}	0.0933^{bc}	0.4333^{a}	93.552	6.448
Scorospelka	5.75^{c}	21.22^{c}	0.27^{b}	20.78^{bc}	4.85^{a}	0.1155^{a}	0.3855^{b}	93.296	6.704

DS 5%	***0.30***	***0.47***	***0.017***	***2.32***	***0.26***	***0.0071***	***0.0206***		

[1]- different letters correspond with the significant statistical difference for P ≤ 5% Duncan test;
[2]- Stone weight: small = up to 0.26 g; medium = 0.27-0.40 g; high = 0.41 – 0,55 g; very high= more than 0.56 g (***, 2006).

In terms of stone weight, cultivars Miris (0.26 g) and Scorospelka (0.27 g) have a small stone, all the other genotypes having a medium size stone (0.30-0.35 g). Assessing the ratio (%) between pulp and waste (stone and peduncle) it was noticed that the pulp recorded values between 93.296 % (Scorospelka) and 95.798 % (Miris) (Table 1).

The dry substance content is extremely important in cherries as it directly influences the taste of the fruits [Kappel *et al*., 1996]. According to our results, this parameter was between 14.7 °Brix for the early cultivar Scorospelka and 19.86 °Brix for Margonia. The ratio between the soluble dry substance and titratable acidity is the parameter that reflects the balance between the sweet and sour taste of the fruits, influencing the quality of the taste [Vangdal, 1985].

From this point of view, the cherry cultivars recorded values between 18.00 (Scorospelka, early cultivar) and 45.53 (Andreiaş, medium-maturity cultivar), all being considered highly appreciated (including cultivar Scorospelka, early cultivar, despite its lower dry substance content).

All the cultivars stood out with a high content of polyphenols, with values between 299.17 mg GAE 100 mL^{-1} (Scorospelka) and 482.35 mg GAE 100 mL^{-1} (Cociuvaş), recording statistical differences (Table 2).

Table 2

Chemical composition of fruits in cherry cultivars (RSFG Iaşi; average of 2021-2024; n=4)

Cultivars	The soluble dry substance (°Brix)[1]	Titratable acidity (mg malic acid/100 mL^{-1})	SDS/TA[2]	Total content of polyphenols (mg GAE 100mL^{-1})
Andreiaş	18.67^{a}	0.41^{cd}	45.53^{a}	322.14^{c}
Ludovan	18.04^{a}	0.49^{c}	36.81^{ab}	380.66^{ab}
Cociuvaş	18.41^{a}	0.52^{c}	35.40^{b}	482.35^{a}
Miris	17.09^{b}	0.55^{bc}	31.07^{c}	349.15^{bc}
Van	17.19^{ab}	0.60^{ab}	28.65^{c}	377.25^{b}
Margonia	19.86^{a}	0.59^{b}	33.66^{bc}	301.55^{c}
Scorospelka	14.70^{b}	0.78^{a}	18.84^{cd}	299.17^{c}
DS 5%	***1.03***	***0.02***	***1.20***	***10.20***

[1]- different letters correspond with the significant statistical difference for P ≤ 5%, Duncan test;
[2]- SDS/TA= the ratio between the soluble dry substance and titratable acidity.

In terms of certain physical traits of the fruits in the seven cherry cultivars, the fruit's taste is sweet and the epidermis colour ranged between yellow (Margonia) and dark red (Andreiaş, Ludovan, Cociuvaş, Miris, Van, Scorospelka). In cultivars Andreiaş, Ludovan, Margonia and Scorospelka, the fruit shape was heart-shaped, in cultivars Cociuvaş and Miris, the shape is kidney-shaped and in cultivar Van, it is circular. In all the studied cultivars, the adherence of the pulp to the stone is absent and the pulp is firm, except for cultivar Scorospelka (early maturation cultivar), which has medium pulp firmness and shows adherence to the stone (Table 3). This parameter (pulp firmness) is an important quality trait, especially in fruits intended for fresh consumption [Kappel *et al*., 2000].

In terms of the presence of the cork layer between the peduncle and fruit, it is absent only in Scorospeka, while in the other cultivars it is present (table 3). The presence of the cork layer is a positive characteristic as suberin is a component of the cork and it helps seal the peduncular cavity when the peduncle detaches, preventing juice loss and oxidation [Lugli, 2003].

Regarding the fruits resistance to cracking, all the studied cultivars showed a good resistance with recorded values under 19%, except for cultivar Van (43.9%) (Table 3).

Resistance to the fruit cracking phenomenon is very important as it helps avoid a reduction in economic efficiency [Milatović, 2011].

Table 3

Physical, organoleptic and quality traits of the fruits in cherry cultivars (RSFG Iaşi; average of 2021-2024; n=4)

Cultivars	Epidermis Colour	Fruit' s shape	Pulp firmness	Pulp adherence to stone	Taste	Presence of the cork layer between peduncle and fruit[2]	Fruit' s resistance to cracking (%)[1]
Andreiaş	Dark red	Heart-shaped	Firm	non-adherent	Very sweet	present	8.3[b]
Ludovan	Dark red	Heart-shaped	Firm	non-adherent	Very sweet	present	3.5[bc]
Cociuvaş	Dark red	Kidney-shaped	Firm	non-adherent	Very sweet	present	2.9[c]
Miris	Dark red	Kidney-shaped	Firm	non-adherent	Very sweet	present	6.7[b]
Van	Dark red	Circular	Firm	non-adherent	Very sweet	present	43.9[a]
Margonia	Yellow	Heart-shaped	Firm	non-adherent	Sweet	present	2.1[c]
Scorospelka	Bright red	Heart-shaped	medium	adherent	Sweet	absent	18.9[ab]
DS 5%	-	-	-	-	-	-	***1.0***

[1]- different letters correspond with the significant statistical difference for P ≤ 5%, Duncan test;

All the traits of the studied fruits in this paper are very important for the marketing of cherries.

CONCLUSIONS

The analysis of the quality traits evaluated in the seven studied cherry cultivars showed statistical differences in all the determined parameters.

The cultivars stood out due to the exceptional quality of the fruits (size, sweet taste and fruit's colour, pulp firmness, it's non-adherence to the stone, the presence of the cork layer between the peduncle and fruit, high content in the most important chemical traits, representing a major source of antioxidant compounds) and a good resistance to the fruit's cracking phenomenon (Margonia, Cociuvaş, Ludovan, Miris, Andreiaş, Scorospelka).

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THE IMPACT OF THE PRODUCT PILARHANCE, SL ON INCREASING THE PRODUCTIVITY OF APPLE ORCHARDS

ACȚIUNEA PRODUSULUI PILARHANCE, SL ASUPRA SPORIRII PRODUCTIVITĂȚII PLANTAȚIILOR DE MĂR

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Abstract.
The investigations were carried out with Gala Buckeye apple trees variety grafted on the M9 rootstock. The planting distance was 3.5 x 0.8 m, with a vertical crown shape. The aim of the research was to study the effectiveness of Pilarhance, SL as a growth regulator in different treatment doses to stimulate fruit growth and development processes in apple orchards. To achieve the planned objective, the following variants were studied: 1. Control, without treatment; 2. Gibbera, SL, 0.5 l/ha; 3. Pilarhance, SL, 1.2 l/ha; 4. Pilarhance, SL, 1.3 l/ha. On the basis of the obtained results, it was established that the growth regulator Pilarhance, SL can be included in the technological scheme for apple cultivation at a dose of 1.3 l/ha, applied 3 times by foliar spraying. The first treatment has to be carried out after flowering, and the next 2 with an interval of 7-10 days between them.
Key words: growth regulator, fruit, production, firmness, quality.

Rezumat.
Investigațiile s-au efectuat cu pomi de măr din soiul Gala Buckeye, altoiți pe portaltoiul M9. Distanța de plantare 3,5 x 0,8 m, forma coroanei ax vertical. Scopul cercetărilor a fost de a studia eficacitatea produsului Pilarhance, SL ca regulator de creștere în diferite doze de tratare pentru a stimula procesele de creștere și de dezvoltare a fructelor în plantația de măr. Pentru atingerea obiectivului planificat, au fost studiate următoarele variante: 1. Martor, fără tratare; 2. Gibbera, SL, 0,5 l/ha; 3. Pilarhance, SL, 1,2 l/ha; 4. Pilarhance, SL, 1,3 l/ha. În baza rezultatelor obţinute, s-a stabilit că, regulatorul de creştere Pilarhance, SL poate fi inclus in schema tehnologică pentru cultivarea mărului in doza 1,3 l/ha, aplicat de 3 ori prin pulverizare foliară. Primul tratament de efectuat după înflorire, iar următoarele 2 cu un interval de 7-10 zile între ele.
Cuvinte cheie: regulator de creştere, fruct, producție, fermitate, calitate.

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INTRODUCTION

Plant growth regulators are physiologically active compounds of natural or synthetic origin that can cause, in small quantities, various changes in the process of plant growth and development [Babuc *et al.*, 2010; Babuc *et al.*, 2013; Cimpoieş, 2012; Peşteanu and Calestru, 2025].

Under the influence of active substances, changes directed towards intensive growth of green mass occur, cell regeneration processes are stimulated, vitamin metabolism improves, which over time are better absorbed by the plant [Babuc *et al.*, 2013; Balan *et al.*, 2025; Peşteanu and Calestru, 2025].

Stimulation of the plant's own immunity makes it possible to induce a complex non-specific resistance in plants to many diseases of fungal, bacterial and viral origin, as well as to other unfavorable environmental factors [Burzo *et al.,* 1999; Cimpoieş, 2012; Milică *et al.,* 1983; Neamțu and Irimie, 1991].

Today, the creation of effective plant growth regulators of chemical and biological origin belongs to the current modern direction of scientific research - nanotechnologies, since their use in small doses (mg, g per hectare) can be very effective for stimulating growth *processes* and protecting plants from abiotic stresses. To date, a wide range of growth regulators of different chemical natures have been synthesized, having a wide spectrum of effects on fruit plants [Burzo et al., 1999; Cimpoieş, 2012; Milică *et al.*, 1983; Neamțu and Irimie, 1991].

Growth regulators based on 24-epibrassinolide and gibberellic acid induce cell elongation and balanced development of crops, leaf expansion, fruit growth and reduce the fall of flowers and fruits from the crown of apple trees [Ahammed et.al., 2020; Mussig, 2005; Wei and Li, 2016].

MATERIAL AND METHOD

The research was carried out during the growing season of 2023 in the apple orchard of SRL "Vindex Agro", planted in the 2020 with "knip boom" type trees.

The object of the study was the Gala Buckeye apple variety, grafted onto a weak-growing M9 rootstock. Crown formation was carried out according to the vertical axis system. Planting distance 3.5 x 0.8 m.

According to the experimental scheme, in the control variant, trees were sprayed with water. In the second variant, they were treated with the growth regulator Gibbera, SL, 0.5 l/ha. The first treatment of the trees was carried out at the end of the flowering period (07.05.23), and the next 2 with an interval of 7-10 days between them (17.05.23; 26.05.23). In the third and fourth variants, 3 treatments were performed with the growth regulator Pilarhance, SL at a dose of 1.2 and 1.3 l/ha, respectively. The first treatment of the trees was performed after flowering (10.05.23) and the next 2 with an interval of 7-10 days between them (17.05.23; 26.05.23).

The studies were carried out in field and laboratory conditions according to the accepted methodology for conducting experiments with fruit crops with growth regulators.

Data were processed using the ANOVA test and STATGRAPHICS Centurion 18. The differences were considered statistically significant if the probability was greater than 95% (p-value < 0.05).

RESULTS AND DISCUSSIONS

Post-flowering treatments with the growth regulator Pilarhance, SL had a positive effect on the content of chlorophyll "a" and "b" and carotenoids in apple tree leaves. When apple trees were treated with the growth regulator Pilarhance, SL, 1.2 l/ha, the content of chlorophyll "a" in the leaves was 3.22 mg/dm² or increased by 12.6% compared to the control variant. In the variant treated with the growth regulator Pilarhance, SL, 1.3 l/ha, the chlorophyll "a" content increased by 14.0% compared to the control variant and by 5.2% compared to the Gibbera, SL, 0.5 l/ha variant. Thus, increasing the dose of treatment with the growth regulator Pilarhance, SL had a positive effect on the chlorophyll "a" content in apple tree leaves.

The above-mentioned law is also valid for the content of chlorophyll "b" and the sum of chlorophyll "a" + "b" in apple leaves.

Increasing the dose of treatment with the product Pilarhance, SL from 1.2 to 1.3 l/ha did not significantly affect the content of carotenoids in apple leaves.

The use of the growth regulator PilarHance, SL at a dose of 1.2 and 1.3 l/ha increased the leaf area compared to the control variant (Table 1). In the case of the Pilarhance, SL, 1.2 l/ha variant, the studied index was 8.89 thousand m²/ha, which is 0.43 thousand m²/ha lower than in the Gibbera, SL, 0.5 l/ha variant. In the variant where the trees were treated with the growth regulator Pilarhance, SL, 1.3 l/ha, the leaf area was 9.18 thousand m²/ha, or an increase in this indicator was recorded compared to the control variant of 1.04 thousand m²/ha, and compared to the Gibbera, SL dose 0.5 l/ha variant, this value decreased by 0.14 thousand m²/ha.

Table 1

The effect of the growth regulator PilarHance, SL on leaf area and annual growth in the crown of Gala Buckeye apple trees

Variants	Leaf surface		Length of annual increments	
	m²/tree	thousand m²/ha	cm	m/tree
Control	2.28	8.14	40.0	13.6
Gibbera, SL, 0.5 l/ha	2.61	9.32	47.2	16.0
Pilarhance, SL, 1.2 l/ha	2.49	8.89	45.3	15.4
Pilarhance, SL, 1.3 l/ha	2.57	9.18	46.0	15.6
LSD 0.05	0.13	0.45	1.94	0.75

These data indicate that there was a significant difference between the control variety and those varieties that were treated with the growth regulators Gibbera, SL and Pilarhance, SL.

Treatment of trees with growth regulators contributed to the improvement of biochemical processes in the plant and a more uniform development from the physiological point of view of plants.

The average length of annual growth was lower in the control variant (40.0 cm), and higher values in the variants treated with growth regulators Gibbera, SL and Pilarhance, SL. If the average length of annual growth in the Gibbera, SL, 0.5 l/ha variant was 47.2 cm, then in the Pilarhance, SL variants in the dose of 1.2 and 1.3 l/ha it was 45.3 and, respectively, 46.0 cm.

The total length of annual growth is in direct correlation with their average development length, which changed under the influence of treatments with the studied growth regulators.

Studying the effect of treatment doses with the growth regulator Pilarhance, SL, it was found that in the variant treated with a dose of 1.2 l/ha, the total length of annual growths was 15.4 m/pom, and when it grew at 1.3 l/ha, this index was 15.6 m/pom. Increasing the treatment dose of the growth regulator Pilarhance, SL, had a slight effect on the length of one-year growths, which is also confirmed by statistical processing of the obtained data.

The average weight of the fruits varied from 156.0 g in the control variant to 170.8 g in the variant treated with growth regulators Pilarhance, SL, 1.3 l/ha. The difference between the studied variants is also confirmed by statistical data (Table 2).

In the Gibbera, SL 0.5 l/ha variant and in the Pilarhance, SL, 1.2 l/ha variant, the average weight of apple fruits was 162.0 and, respectively, 167.3 g, meaning that there is no statistically significant difference between these two variants.

The lowest yield per tree (4.53 kg) and per unit area (16.18 t/ha) was recorded in the control variant. In the Gibbera, SL, 0.5 l/ha variant, fruit production was lower than in variants 3 and 4, but higher than in the control variant, constituting in this variant 4.70 kg/tree and 16.78 t/ha, respectively.

Table 2

The effect of growth regulator PilarHance, SL on fruit weight and productivity of apple orchard of Gala Buckeye variety

Variants	Average weight, g	Productivity		In % compared to control
		kg/tree	t/ha	
Control	156.0	4.53	16.18	100.0
Gibbera, SL, 0.5 l/ha	162.0	4.70	16.78	103.7
Pilarhance, SL, 1.2 l/ha	167.3	4.85	17.32	107.0
Pilarhance, SL, 1.3 l/ha	170.8	4.95	17.68	109.3
LSD 0.05	6.5	0.21	0.80	-

The difference between the fruit production obtained in the control variant and the variants treated with the growth regulator Pilarhance, SL at a dose of 1.2 and 1.3 l/ha was 7.1% and 9.3%, respectively.

The studies conducted (Table 3) demonstrate that the firmness of the pulp of apple fruits at the time of harvesting in the studied variants was 7.4-7.6 kg/cm². This proves that the studied index is optimal for harvesting fruits of the Gala Buckeye variety and their long-term storage.

The firmness of the fruits of apples of the Gala Buckeye variety changes under the influence of the growth regulators Gibbera, SL and Pilarhance, SL, i.e. the respective products slightly reduce the firmness of the fruit, as can be seen in Table 3. If, in the control variant, the firmness of the apples was 7.6 kg/cm², then in the variants treated with the growth regulators Gibbera, SL and Pilarhance, SL it decreased to 7.4-7.5 kg/cm². Comparing the variants treated with growth regulators studied, it can be observed that the lowest fruit firmness was obtained in the variants Gibbera, SL, 0.5 l/ha and Pilarhance, SL, 1.3 l/ha (7.4 kg/cm²). That is, a decrease in the parameters studied by 0.2 kg/cm2 compared to the control variant is observed. In the Pilarhance, SL variant, an average value (7.5 kg/cm²) was recorded compared to the other variants.

Table 3

The effect of the growth regulator PilarHance, SL on morphological indicators and ripening parameters of Gala Buckeye fruits

Variants	Pulp firmness, kg/cm²	Fruit parameters, mm		Soluble dry matter, %
		Hight	Diameter	
Control	7,6	60,7	70,4	13,1
St. Gibbera, SL, 0.5 l/ha	7,4	63,4	70,1	13,5
Pilarhance, SL, 1.2 l/ha	7,5	62,7	72,0	13,4
Pilarhance, SL, 1.3 l/ha	7,4	63,3	72,8	13,5

During fruit growth, the studied growth regulators had different effects on both fruit height and diameter.Higher fruit height values were recorded in the Gibbera, SL, 0.5 l/ha (63.4 mm) and Pilarhance, SL, 1.3 l/ha (63.3 mm) variants, compared to the control variant (60.7 mm). In the Pilarhance, SL, 1.2 l/ha variant, fruit height was lower compared to the previous variants (62.7 mm). Studying fruit diameter, higher values were noted in the variants treated with the growth regulator Pilarhance, SL dose 1.2 l/ha (72.0 mm) and 1.3 l/ha (72.8 mm). In the variant treated with the product Gibbera, SL, 0.5 l/ha, the fruit diameter was 70.1 mm, which was at the level of the control variant (70.4 mm).

The smallest amount of soluble substances was recorded in the control variant (13.1%). That is, the treatment with the studied growth regulators improves to some extent the ripening of the fruits and increases the content of soluble substances in the fruits by 0.3-0.4% compared to the control variant.

The sales income in the case of the control variant amounted to 105.17 thousand lei/ha, and in the treatment with the studied growth regulators, this figure amounted to 109.07 - 123.76 thousand lei/ha. The highest sales revenue was recorded in the Pilarhance, SL, 1.3 l/ha variant - 123.76 thousand lei/ha. In the variants treated with the growth regulators Gibbera, SL, 0.5 l/ha and Pilarhance, SL 1.2 l/ha, a decrease in sales revenue was recorded (Table 4). The lowest production cost was recorded in the control variant – 51.78 thousand lei/ha. In the variant treated with the product Gibbera, SL, 0.5 l/ha, the production cost was 52.87 thousand lei/ha. The treatment with the product Pilarhance, SL in a dose of 1.2 l/ha and 1.3 l/ha had a more significant contribution to the studied index (53.44 - 53.78 thousand lei/ha), including the costs for purchasing the product and harvesting additional fruits compared to the previous variants.

Table 4

Economic efficiency of apple fruit production from Gala Buckeye soil in the case of treatment with the growth regulator Pilarhance, SL

Variants	Sales revenue, thousand lei/ha	Production cost, thousand lei/ha	Profit, thousand lei/ha	Profitability level, %
Control	105,17	51,78	53,39	103,1
Gibbera, SL, 0.5 l/ha	109,07	52,87	56,20	106,2
PilarHance, SL, 1.2 l/ha	121,24	53,44	67,80	126,8
PilarHance, SL, 1.3 l/ha	123,76	53,78	69,98	130,1

Greater economic efficiency in the production of Gala Buckeye apples was recorded in the variant when the trees were treated with the product Pilarhance, SL at a dose of 1.3 l/ha.

CONCLUSIONS

Based on the experimental results obtained, we propose to include the growth regulator PilarHance, SL in the technological scheme for cultivating apple plantations at a dose of 1.3 l/ha, applied 3 times by spraying. The first treatment should be carried out after flowering, and the next 2 with an interval of 7-10 days between them.

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EFFECTIVENESS OF PRODUCTS THAT INHIBIT ETHYLENE SYNTHESIS IN THE APPLE FRUITS DURING THE POST HARVEST PERIOD

EFICACITATEA PRODUSELOR CE INHIBĂ SINTEZA ETILENEI ÎN FRUCTELE DE MĂR ÎN PERIOADA DE POST RECOLTARE

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Abstract.
To evaluate the effectiveness of treatment with the ethylene biosynthesis inhibitor 1-MCP during storage of the Gala Dark Baron variety, the following experimental scheme was developed: 1. Normal atmosphere (C), no treatment; 2. Fitomag, 0.44 g/m^3; 3. Grand Fresh, 60 g/m^3; 4. Grand Fresh, 68 g/m^3. The fruits of the control and treated variants were placed in room with a normal atmosphere (CO_2 - 0.03%; O_2 - 21%). Storage temperature 0...+1^{0}C and relative humidity 92-95%. The storage period was 150 days. Treating fruit with products whose active substance is 1-MCP before storage increases pulp firmness, DA-Meter index values, standard fruit yield, decreases ethylene emission, natural loss, fungal disease, and extends the "shelf life" of apples compared to the control variant.
Key words: 1-MCP, ethylene, firmness, ripening, DA-Meter

Rezumat.
Pentru a determina eficacitatea tratamentului cu inhibitorul de biosinteză a etilenei 1-MCP în perioada de depozitare la soiului Gala Dark Baron, a fost elaborată următoarea schemă experimentală: 1. Atmosferă normală (C), fără tratament; 2. Fitomag, 0,44 g/m^3; 3. Grand Fresh, 60 g/m^3; 4. Grand Fresh, 68 g/m3. Fructele din variantele martor și cele tratate au fost plasate în camere cu atmosferă normală (CO_2 - 0,03%; O_2 - 21%). Temperatura de depozitare a fost de 0...+1^{0}C, iar umiditatea relativă de 92-95%. Perioada de depozitare a fost de 150 de zile. Tratarea fructelor cu produse a căror substanţa activa este 1-MCP înainte de depozitare creste fermitatea pulpei, valorile indicelui DA-Meter, randamentul fructelor standard, scade pondera de etilenă emanată, pierderea naturala, afecțiunea de boli fungice, prelungește perioada de „raft” a merelor în comparație cu varianta martor.
Cuvinte cheie: 1-MCP, etilenă, fermitate, maturitate, DA-Meter

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INTRODUCTION

Apple culture is a species that is cultivated on the territory of our country on large areas [Babuc *et al.,* 2010; Babuc *et al.,* 2015; Peşteanu and Calestru, 2025], influencing particularly important in the lives of rural residents, where it constitutes a source of livelihood and income [Babuc *et al.*, 2010; Babuc *et al.*, 2013; Balan *et al.,* 2025].

Stable and quality harvests must be accompanied by the use of progressive methods of fruit preservation in the post-harvest period. This allows consumers to permanently use fresh products, rich in mineral elements and beneficial for the human body [Babuc *et al.,* 2013; Bujoreanu and Chirtoca, 2013].

At present, post-harvest storage technologies applied in the Republic of Moldova do not ensure the maintenance of high-quality fruits and their resistance to various disorders caused by fungal diseases [Babuc *et al.,* 2013; Bujoreanu and Chirtoca, 2013; Nicuță, 2023].

The disadvantages described above can be eliminated by implementing new methods of storing apples. Among these innovations is the use of growth regulators that inhibit the emission of ethylene from climacteric fruits, whose active substance is 1-MCP (1-methylcyclopropene) [Babuc *et al.,* 2013; Bujoreanu and Chirtoca, 2013; Nicuță, 2023; Гудковский *et al.,* 2013].

MATERIAL AND METHOD

The Gala Dark Baron apples were grown on trees grafted on M9 rootstock, with a vertical crown shape and a planting distance of 3.5 x 0.8 m.

To determine the effectiveness of treatment with ethylene biosynthesis inhibitors on the storage capacity of apples during the post-harvest period, the following experimental scheme was developed: 1. Normal atmosphere (NA), control; 2. Fitomag, 0.44 g/м^3; 3. Grand Fresh, 60 g/м^3; 4. Grand Fresh, 68 g/м^3. In variants 2-4, the fruits were stored in normal atmosphere and treated with growth regulators whose active substance is 1-MCP.

After harvesting, the apples were transported to the refrigerator, where they were subjected to cooling, gradually lowering the temperature from +20.5°C to +0.4°C. The cooled fruits were treated with growth regulators with the ability to inhibit ethylene biosynthesis (Fitomag, Grand Fresh) according to the methodology developed at the Miciurinsk Institute of Fruit Growing [Гудковский *et al.,* 2013].

The fruits were kept closed in a gaseous environment for 24 hours, followed by ventilation for a period of 15 minutes. The fruits of the control variants and those treated with an ethylene biosynthesis inhibitor were placed for storage in rooms with a normal atmosphere - NA (CO_2 - 0.03%; O_2 - 21%).

The storage temperature during the experiment for the Gala Dark Baron variety was maintained at the level of 0...+10C and humidity 92-95%. Control over the temperature regime and composition of the atmosphere - constant, automatic. The storage period was 150 days.

Data were processed using the ANOVA test and STATGRAPHICS Centurion 18. The differences were considered statistically significant if the probability was greater than 95% (p-value < 0.05).

RESULTS AND DISCUSSIONS

The firmness of the pulp of apple fruits of the Gala Dark Baron variety at the time of harvesting was 9.5 kg/cm^2, which is considered optimal for harvesting fruits and their placement for long-term storage and preservation.

The firmness of fruits changes under the influence of growth regulators intended to inhibit ethylene biosynthesis (Fitomag, Grand Fresh). If, in the control variant, the firmness of apples during the storage period decreased from 9.5 to 6.2 kg/cm^2, then in the variants treated with the ethylene biosynthesis inhibitor, the corresponding indicator was 7.2 kg/cm^2, that is, there was an increase in the firmness of the pulp by 1.0 kg/cm^2 (Table 1).

Table 1

The effect of treatment with ethylene biosynthesis inhibitors on changes in fruit pulp firmness dynamics during the post-harvest period, (kg/cm^2)

Variants	Determination period				
	02.10.21	**02.11.21**	**02.12.21**	**02.01.22**	**02.02.22**
Normal atmosphere (c)	8.9	8.4	7.7	7.0	6.2
Fitomag, 0.44 g/м^3	9.1	8.6	8.1	7.5	6.9
Grand Fresh, 60 mg/м^3	9.0	8.5	8.0	7.4	6.8
Grand Fresh, 68 mg/м^3	9.1	8.7	8.1	7.7	7.2
LSD 0.05	0.39	0.35	0.34	0.32	0.31

After five months of fruit storage, the firmness of apples in the control variant decreased by 34.8%, and in the variant treated with the Fitomag product, 0.44 g/m^3 by 27.4%. In the case of the variant treated with the growth regulator Grand Fresh, 60 mg/m^3, the index under study decreased by 28.4%, and in the Grand Fresh variant, 68 mg/m^3 by 24.2%.

During the storage period of apples, the maximum intensity of ethylene emanation was recorded in the control variant 3.4-13.7 ppm. Post-harvest treatment of fruits with the Fitomag and Grand Fresh products reduced the intensity of ethylene emanation. In the Fitomag variant at a dose of 0.44 g/m^3, the intensity of ethylene emanation from fruits during storage was 1.9-2.7 ppm (Table 2).

Table 2

The influence of growth regulators on the dynamics of the intensity of ethylene release (ppm) by apple fruits during storage, ppm

Variants	Determination period				
	02.10.21	**02.11.21**	**02.12.21**	**02.01.22**	**02.02.22**
Normal atmosphere (c)	3.4	5.0	7.2	9.6	13.7
Fitomag, 0.44 g/м^3	1.9	2.0	2.1	2.3	2,.
Grand Fresh, 60 mg/м^3	1.9	2.0	2.2	2.3	2,.
Grand Fresh, 68 mg/м^3	1.8	1.9	1.9	1.8	2,.
LDS 0.05	0.09	0.09	0.10	0.10	0.13

In the variant treated with the Grand Fresh product, 60 mg/m^3, the studied index was approximately at the same level as the Fitomag variant, 0.44 g/m^3. In the variant treated with Grand Fresh, 68 mg/m^3, the studied indicator decreased to the minimum values, ranging from 1.8 to 2.0 ppm.

Treatment of apple fruits with an ethylene biosynthesis inhibitor (Fitomag, Grand Fresh) contributed to preserving the firmness of the fruits and decreasing the intensity of ethylene release, both during storage and during the "shelf life" period.

After 5 months of storage + the "shelf life" period, the firmness of the fruits ranged from 5.2 to 7.0 kg/cm^2 according to the experimental variants. The minimum firmness of the fruits according to the studied variants was obtained in the control variant - 5.2 kg/cm^2. Fruit treatment with Fitomag, 0.44 g/m^3 and Grand Fresh, 60 mg/m^3 products influenced apple firmness (6.4 kg/cm^2), but not to the same extent as in the Grand Fresh, 68 mg/m^3 (7.0 kg/cm^2) variant (Table 3).

Table 3

The effect of treatment with ethylene biosynthesis inhibitors on fruit firmness and ethylene release intensity after 5 months of storage and during the “shelf life” period

Variants	Fruit firmness (кg/cm^2)		Ethylene emission intensity (ppm)	
	When storing	+7 days t+18–22^{0}C	When storing	+7 days t+18–22^{0}C
Normal atmosphere (c)	6.2	5.2	13.7	23.4
Fitomag, 0.44 g/м^3	6.9	6.4	2.7	3.7
Grand Fresh, 60 mg/м^3	6.8	6.4	2.7	3.8
Grand Fresh, 68 mg/м^3	7.2	7.0	2.0	2.4

The maximum intensity of ethylene emission was recorded in the control variant - 23.4 ppm, or an increase of 70.8% compared to the period of removing the fruits from storage. In the variant treated with the Fitomag product, 0.44 g/m^3, the studied index was 3.7 ppm, or an increase of 37.0%. In the case of the Grand Fresh variant, 60 mg/m^3, the amount of ethylene released from the fruits was approximately the same as the Fitomag variant, 0.44 g/m^3, registering 3.8 ppm. In the variant treated with Grand Fresh, 68 mg/m^3, the amount of ethylene released during the "shelf life" period of the apples was 2.4 ppm.

The DA-Meter index determines the ripening of the fruits based on the degradation of the chlorophyll content, which decreases with the intensification of the process of ethylene emission from the apple. The apple ripening index within a month from the moment of harvesting in the studied variants ranged from 0.44 to 0.54. So, the ripening index of apples changes under the influence of the growth regulators Fitomag and Grand Fresh, which are designed to inhibit ethylene biosynthesis (Table 4).

Table 4

The influence of growth regulators on the dynamics of ripening of apple fruits of the Gala Dark Baron variety during storage based on the DA-Meter index

Variants	Determination period				
	02.10.21	02.11.21	02.12.21	02.01.22	02.02.22

Normal atmosphere (c)	0.44	0.42	0.40	0.36	0.32
Fitomag, 0.44 g/м^3	0.49	0.48	0.45	0.43	0.40
Grand Fresh, 60 mg/м^3	0.50	0.48	0.45	0.44	0.40
Grand Fresh, 68 mg/м^3	0.54	0.53	0.51	0.49	0.47

If in the case of the control variant the apple ripening index was 0.44, then in the variants treated with Fitomag and Grand Fresh growth regulators, the corresponding indicator was 0.49-0.54.

After 5 months of apple storage, a high intensity of the degree of fruit ripening was observed in the control variant - 0.32, and in the variant treated with the growth regulator for inhibiting ethylene biosynthesis Grand Fresh at a dose of 68 mg/m^3, this indicator was 0.47, or was 46.8% higher compared to the previous variant.

Post-harvest treatment of fruits with the studied products after 5 months of storage increased the yield of standard fruits (Table 5). The optimal natural loss for apples during long-term storage in refrigerators with artificial cooling is 3-4%. The highest natural loss was observed after 5 months of storage in the control variant - 3.8%. Treatment of fruits with 1-MCP-based preparations (Fitomag and Grand Fresh) reduced the studied parameter, constituting 1.7-2.6%. The difference between the variants treated with the ethylene emanation inhibitor Grand Fresh, constituted 0.9%.

Table 5

The effect of treatment with ethylene biosynthesis inhibitors on standard fruit yield, natural loss and fungal infection damage after 5 months of storage, %

Variants	After 5 months of storage			+7 days T+18–22^{0}C
	Standard fruits, %	Natural losses, %	Botrytis cinerea,%	Botrytis cinerea,%
Normal atmosphere (c)	95.2	3.8	4.8	9.2
Fitomag, 0.44 g/м^3	98.8	2.4	1.2	1.6
Grand Fresh, 60 mg/м^3	98.4	2.6	1.4	1.7
Grand Fresh, 68 mg/м^3	100.0	1.7	-	-
LDS 0.05	1.1	0.21	-	-

The main losses during fruit storage are those recorded from fungal infections (fruit rot, gray mold, etc.). The highest share of fruit affected by fungal rot after 5 months of storage and during the "shelf life" period was noted in the control variant, where these values constituted 4.8 and 9.2%, respectively.

Fig. 1. Appearance of Gala Dark Baron apples after 5 months of storage in various variants treated with the growth regulator that inhibits ethylene synthesis

The share of fruits damaged by Botrytis cinerea during storage in the Fitomag variant at a dose of 0.44 g/m3 was 1.2%, and when using the tested growth regulator Grand Fresh, at a dose of 60 mg/m^3, it was 1.4%. Further maintenance of these apples for 7 days at room temperature (+18–22^{0}C) led to a slight increase in the proportion of fruits affected by fungal diseases, but not to the same extent as in the control variant.

CONCLUSIONS

Treating fruits with products based on the ethylene synthesis inhibitor 1-MCP before storage influenced the firmness of apple pulp, the share of ethylene emitted by the fruits and increased the DA-Meter index values after 5 months of storage, compared to the normal atmosphere variant, control.

Treating fruits with products based on the ethylene synthesis inhibitor 1-MCP before storage in a normal atmosphere regime increased the yield of standard fruits, decreased the degree of natural perishability, Botrytis cinerea diseases and extended the "shelf life" period of apples compared to the control variant.

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YIELD AND QUALITY OF ROUND PEPPER FRUITS - INFLUENCE OF CALCIUM NITRATE AND BIOSTIMULANTS

PRODUCȚIA ȘI CALITATEA FRUCTELOR DE ARDEI GOGOȘAR - INFLUENȚA NITRATULUI DE CALCIU ȘI A BIOSTIMULATORILOR

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Abstract.
The study aims to investigate the effect of using calcium nitrate, simple or combined with different biostimulants on the quantity and quality of round pepper fruits (Capsicum annuum L. var. grossum). The biological material used consisted of the cultivar "Asteroid 204". Three foliar treatments were applied, from fruit setting, with calcium nitrate alone or in combination with three seaweed-based biostimulants (Agrocean B, E-Dalgin and Kelpak), two based on microorganism inoculum (Triptolemus HV and Albit), and three mixed bistimulants (Sprintene, Kinactiv Fruit and Rerum). The mass of a fruit, the number of fruits per plant and the yield were determined, and for the assessment of quality - the firmness and thickness of the pulp, the total dry matter content, the total soluble solids, and the level of titratable acidity. The combined use of calcium nitrate with various biostimulants, such as Kelpak, Sprintene, Kinactiv Fruit or Rerum, increases production and improves some quality traits.
Key words: biostimulatori, calitatea fructelor, *Capsicum annuum*, producție

Rezumat.
Studiul are ca scop investigarea efectului utilizării azotatului de calciu, simplu sau combinat cu diferiți biostimulatori asupra cantității și calității fructelor de ardei gogoșar (Capsicum annuum L. var. grossum). Materialul biologic utilizat a constat în cultivarul "Asteroid 204". S-au aplicat trei tratamente foliare, de la formarea fructelor, cu nitrat de calciu singur și în combinație cu trei biostimulatori pe bază de alge marine (Agrocean B, E-Dalgin și Kelpak), doi pe bază de inocul de microorganisme (Triptolemus HV și Albit), și trei bistimulatori micști (Sprintene, Kinactiv Fruit și Rerum). Au fost determinate masa medie a unui fruct, numărul de fructe pe plantă și producția, iar pentru aprecierea calității - fermitatea și grosimea pulpei, conținutul de substanță uscată totală, totalul solidelor solubile, și nivelul acidității titrabile. Utilizarea

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combinată a nitratului de calciu cu diferiți biostimulatori, precum Kelpak, Sprintene, Kinactiv Fruit sau Rerum determină creșterea producției și îmbunătățirea unor caractere calitative.
Cuvinte cheie: biostimulants, *Capsicum annuum*, fruit quality, yield

INTRODUCTION

In recent years, a clear trend has been observed to reduce the application of mineral fertilizers in agriculture, especially those nutrients applied to the soil, such as nitrogen (N), phosphorus (P) and potassium (K) [Jin *et al*., 2022]. In parallel, foliar fertilization has become a method used to supplement macro- and micronutrients, as well as to administer plant hormones, stimulants and other beneficial substances to plants. Although foliar spraying cannot replace soil fertilization, it can be used as an additional strategy within sustainable agricultural practices [Kannan, 2010]. Foliar spray application is a crop management strategy, helping to maximize agricultural yields [Ciucu-Paraschiv and Hoza, 2022a; Ciucu-Paraschiv *et al*., 2023; Januszkiewicz *et al.,* 2025; Panayotov, 2004; Zong *et al.,* 2011], as well as increasing drought tolerance and improving the quality of agricultural crops [Botella *et al.,* 2017; Ciucu-Paraschiv and Hoza, 2021; Ciucu-Paraschiv and Hoza, 2022b; Fageria *et al.,* 2009; Stoica *et al.,* 2024]. The response of plants to foliar fertilization depends on the species cultivated, the form and concentration of the fertilizer, as well as the frequency and timing of application, depending on the stage of plant development. Kuepper [2003] and Lovatt [1999] have pointed out that foliar fertilization is becoming increasingly widespread in modern agriculture, due to its increased efficiency and ecological advantages compared to soil fertilization. Nutrient uptake through foliage can occur much more rapidly compared to soil nutrition [Fernández and Eichert, 2009; Kannan, 2010; Lester *et al.,* 2006; Weinbaum, 1988].

Round pepper (*Capsicum annuum* L.) is a very popular horticultural plant in Romania, due to its economic importance and the nutritional value of its fruits. Pepper is a valuable source of bioactive nutrients, including vitamin C, carotenoids (provitamin A) and phenolic compounds, which contribute to its nutritional profile and antioxidant activity [Abu-Zahra, 2011]. Production is carried out both in open fields and in greenhouses. Agricultural management practices play a fundamental role in the development of this crop. Recently, interest in foliar fertilization of peppers has increased, which is supported by several studies [Baloch *et al.,* 2008; López *et al.,* 2013; Maheswari and Haripriya, 2008; Rubio *et al.,* 2009]. Panayotov [2004] analyzed various doses of foliar fertilizer to evaluate the effects on vegetative growth and pepper production.

Calcium nitrate is an important source of calcium, which can be applied both by fertigation and foliar application to peppers, with a role in reducing the risk of fruits suffering from apical rot, a metabolic defect that can often occur in pepper fruits [Buczkowska *et al*., 2016; Marcelis and Ho, 1999].

Agriculture has increasingly turned to the use of inoculants of microorganisms and seaweed extracts for a sustainable and environmentally friendly approach. Biostimulants with beneficial microorganisms, such as *Trichoderma*, have an antimicrobial effect on diseases caused by bacteria and fungi [Drobek *et al.,* 2019]. These can be combined with fertilizers and contribute to pepper fruits growth and quality, promoting root development, nutrient absorption and resistance to abiotic and biotic factors [Duan *et al.,* 2023; Toader *et al.,* 2022]. Production can increase up to 30% after *Trichoderma* treatments [Benítez *et al.,* 2004]. Although they are mainly used for soil treatments, some studies indicate the potential for their use as foliar treatments on peppers [Saxena *et al.,* 2016].

Seaweed extracts, rich in nutrients, amino acids, vitamins and growth hormones, stimulate plant development and have been used in agriculture for a long time [Crouch and Van Staden, 1993]. They act as biofertilizers or biostimulants, due to their ability to fix carbon dioxide and nutrients [Piwowar and Harasym, 2020]. Brown macroalgae species, richer in essential elements for growth, are the most used [Pereira, 2021]. Studies indicate positive responses of pepper to seaweed treatments, with increases in fruit yield [Salazar-Salazar *et al.,* 2022]. However, research on the effects of seaweed on pepper is limited and requires further study.

Also, given the interest in increasing the nutritional value of foods, the purpose of this work was to examine the effect of calcium nitrate, administered with or without other nutrients, on the quality of pepper fruits and their yield.

MATERIAL AND METHOD

The present experience was carried out in 2025, within the Research and Development Institute for Vegetable and Flower Growing Vidra, between May and September 2025.

The biological material consisted of seedlings of round pepper, cultivar Asteroid 204. It is the variety with the highest demand for seed, among the varieties for which RDIVFG Vidra is the author and maintainer. It is a semi-early variety of bell pepper, with large fruits that have a round, flattened shape, with 3-4 lobes, of a glossy dark red color at physiological and technological maturity (which coincide with this variety of pepper). The seedling was produced in the greenhouses of the institute.

The seedling was planted on 23th May, on ground mulched with black polyethylene film, with a distance of 70 cm between rows and 25 cm between plants in a row. Irrigation was done by drip. Treatments applied for diseases and pests were done the same, regardless of the experimental variant. Weed control was done by two manual and three mechanized weedings.

Foliar treatments were applied to the vegetation, depending on the experimental variant studied. Foliar treatments were carried out with simple calcium nitrate or combined with biostimulants of different types. Products available on the market, from several categories of preparations, were used as biostimulant preparations. Three biostimulant products based on seaweed (Agrocean B, E-Dalgin and Kelpak), two based on microorganism inoculum (Triptolemus HV and Albit), and three mixed bistimulants (Sprintene, Kinactiv Fruit and Rerum) were used. Their chemical composition is presented in table form (Table 1).

Three foliar treatments were applied with the prepared solutions, starting with the moment when the first fruit reached the typical size of the variety (BBCH 71). The treatments were applied at 14-day intervals. The solutions and treatments applied on each variant were the following:

V1 = untreated control;
V2 = pepper treated with calcium nitrate (5 g/L);
V3 = pepper treated with calcium nitrate (5 g/L) and Agrocean B (2 ml/L);
V4 = pepper treated with calcium nitrate (5 g/L) and E-Dalgin (2 ml/L);
V5 = pepper treated with calcium nitrate (5 g/L) and Kelpak (2 ml/L);
V6 = pepper treated with calcium nitrate (5 g/L) and Triptolemus HV (2 ml/L);
V7 = pepper treated with calcium nitrate (5 g/L) and Albit (2 ml/L);
V8 = pepper treated with calcium nitrate (5 g/L) and Sprintene (2 ml/L);
V9 = pepper treated with calcium nitrate (5 g/L) and Kinactiv Fruit (2 ml/L);
V10 = pepper treated with calcium nitrate (5 g/L) and Rerum (2 ml/L).

Table 1

Products used for the preparation of treatment solutions and their chemical composition

Product	Chemical composition
Calcinit	Total nitrogen – 15.5% (from nitric nitrogen NO_2 - 14.4% and ammoniacal nitrogen NH4 1.1%); calcium oxide CaO 26.5%
Agrocean B	60% *Laminaria digitata* extract *Laminaria digitata* concentrate - 597.72 g/L; N – 6.0% (w/w), P_2O_5 – 5.0% (w/w), K_2O – 5.0% (w/w), B – 2.5% (w/w), MgO – 5.0% (w/w)
E-Dalgin	Pure extract of *Ascophyllum nodosum*
Kelpak	Pure extract of *Ecklonia maxima*
Triptolemus HV	Mycorrhiza content: 0.1%; Rhizosphere bacteria content: 1 x 10^5 CFU/g; *Trichoderma* spp. content: 1.2 x 10^8 CFU/g
Albit	Poly-beta-hydroxybutyric acid; natural biopolymer synthesized from soil bacteria: *Bacillus magaterium* and *Aureofaciens pseudomonas*, min. 0.62 %; N - min. 7.5 %; P - min. 6 %; K - min. 4.5 %; Mg - min. 0.6 %; S - min. 2.7 %
Sprintene	Mn 1%, Zn 1%, organic matter 80%
Kinactiv Fruit	Free amino acids 4% (w/w), P_2O_5 – 12,0% (w/w), K_2O – 16,0% (w/w), B – 0,5% (w/w), Mo –0,05% (w/w), Cu – 0,002% (w/w), Fe – 0,2% (w/w), Mn 0,01% (w/w), Zn 0,002% (w/w)
Rerum	N - 0,5%; P - 0,5%; K - 0,5%; Fe - 0,15%; Zn - 0,075%; Mn - 0,075%; Cu - 0,075%; B - 0,03%; Co - 0,015%; Mo - 0,015%; ASFAC BCO-4 - 20%; Amino acids - 20%; MgO - 0,15%

At round pepper, technological ripening coincides with physiological ripening. The fruits were harvested at their specific color, a glossy dark red. As they were harvested, the fruits were counted and weighed, and the following measurements were made: the average number of fruits per plant (pieces), the average weight of a fruit (g) and the production per hectare (t/ha).

To evaluate the quality of the fruits, a series of analyses were carried out aimed at determining some essential physicochemical properties, as follows: average fruit weight, fruit firmness, pH and titratable acidity, total dry matter (DW) and total soluble solids (TSS) content. Each parameter was determined in triplicate for each fertilization variant. The force required to pierce the pepper fruit was measured at three locations: near the stem end, the center, and the top of the fruit. The three firmness measurements were averaged to obtain a single firmness value for each fruit. Firmness was measured using a Force Gauge PCE-FM 200 with a 6.5 mm probe; values were expressed in Newtons (N). The total dry matter (DW) content was expressed as a percentage (%), determined by the gravimetric method by drying 10 g of fruit tissue at 105°C to constant weight, according to Krełowska-Kułas [1993]. For the determination of total soluble substances (TSS), a portable digital refractometer (Model: HI96800, Hanna Instruments, USA) was used, and the results were reported in % Brix according to PN-90/A-75101/02. The pH of each juice sample was measured with the EUTECH Cyberscan pH 11 electronic pH meter (Singapore), using a glass electrode. Statistical analysis of all data was performed using SPSS software, version 20.0 (SPSS Inc., Chicago, IL, USA). Results are presented as mean ± standard error (SE) and were discussed by one-way ANOVA. Statistically significant differences were considered at the $p < 0.05$ level.

RESULTS AND DISCUSSIONS

The cultivar Asteroid 204 recorded an average yield of 48.82 ± 1.69 t/ha (range 42.38–69.65 t/ha) and 5.50 ± 0.47 fruits/plant (minimum 4.20 and maximum 6.38 fruits/plant). The average fruit weight was 168.46 ± 20.68 g (range 130.66–219.12 g). The average BER was 7.50 ± 3.42% (range 2.99–14.22%). The coefficients of variation indicate high variability for BER (45.6%), whereas the average fruit weight showed the lowest variability (12.28%). From the ANOVA results, foliar treatments significantly influenced yield, the number of fruits per plant, and BER, with effect sizes of 52.6%, 60.4%, and 85.2%, respectively. By contrast, the average fruit weight (g) was not significantly affected by the foliar treatments (Table 2).

Table 2

Effect of the fertilization variant on productivity parameters (yield, fruits per plant, average fruit weight) of the round pepper cultivar Asteroid 204

Evaluated component		Yield (t/ha)	Fruits/plant	Fruit weight (g)	BER (%)
Fertilization technique	Sig.	* (p=0.044)	* (p=0.011)	n.s. (p=0.203)	*** (p=0.000)
	Effect size (%)	52.6	60.4	38.2	85.2

*Significance letters and symbols refer to treatment effects. n.s. = non-significant; * = significant (p ≤ 0.05); ** = highly significant (p ≤ 0.01); *** = very significant (p ≤ 0.001).

For all other quality characteristics, average values of the coefficients of variation were recorded mostly lower than those of the productivity parameters (from

5.16% to 14.42%). The ANOVA analysis revealed a very significant effect on the quality parameters: juice pH, TSS content (% Brix) and DW content (%) with effect size values of 79.50%, 30.10% (juice pH) and 21.8% (TSS content – % Brix). Pulp thickness (mm) was significantly influenced by the treatments applied; in this case, the effect size of the foliar treatments was only 8.30% (Tables 3 to 5).

Table 3

Effect of the fertilization variant on quality parameters (average weight, firmness, pH, TSS, DW and pulp thickness) of round pepper, cultivar Asteroid 204

Evaluated component		Firmness (N)	Juice pH	TSS content (% Brix	DW content (%)	Pulp thickness (mm)
Fertilization technique	Sig.	n.s. (p=0.086)	*** (p=0.000)	*** (p=0.000)	*** (p=0.000)	* (p=0.020)
	Effect size	12.7	30.1	21.8	79.5	8.30

Significance letters and symbols indicate the effects of treatments: n.s. = nonsignificant; * = p 0.05; ** = p ≤ 0.01; *** = p ≤ 0.001.

Table 4

Statistical descriptors (mean, median, standard deviation, coefficient of variation, minimum, and maximum) for the productivity parameters (yield, fruits per plant, average fruit weight)

Statistical descriptors	Yield (t/ha)	Fruits/ plant	Fruit weight (g)	BER (%)
Mean	52.46	5.22	168.46	7.50
Median	50.17	5.10	168.68	6.65
Std. deviation	7.85	0.66	20.68	3.42
Var. coeff.	14.96	12.64	12.28	45.6
Minimum	42.38	4.20	130.66	2.99
Maximum	69.65	6.38	219.12	14.22

Table 5

Statistical descriptors (mean, median, standard deviation, coefficient of variation, minimum, and maximum) for the quality parameters, firmness, juice pH, total soluble solids (TSS) content, dry weight (DW) content, and pulp thickness of the round pepper cultivar "Asteroid 204"

Statistical descriptors	Firmness (N)	Juice pH	TSS content (% Brix)	DW content (%)	Pulp thickness (mm)
Mean	25.45	5.04	7.35	7.65	6.85
Median	25.25	5.02	7.50	7.49	6.79
Std. deviation	1.95	0.26	1.06	0.84	0.95
Var. coeff.	7.66	5.16	14.42	10.98	13.87
Minimum	22.17	4.58	3,60	6.08	4.87
Maximum	32.09	6.91	9.20	9.15	9.89

The yield varied significantly following the treatments applied, with values ranging between a minimum of 44.86 t/ha and a maximum of 61.69 t/ha (Table 6). The highest yield was obtained in the case of the variant in which treatments with calcium nitrate + Sprintene product were used, with a value of 61.69 t/ha. The effect of this treatment was significantly higher both compared to the untreated variant (V1), and compared to some treated variants (V2 – treated with calcium nitrate; V3 – treated with calcium nitrate + Agrocean B; V7 – treated with calcium nitrate + Albit). Compared to the untreated variant, the increase was 37.52%.

With a yield that was not significantly lower than the best treatment, the combined treatment with calcium nitrate + Kelpak led to a significant increase compared to the variant in which no foliar treatments were used, with an increase of 33.33%, meaning an increase of 14.95 t/ha. This variant also differed significantly from the variant treated with calcium nitrate + Agrocean B. These results are consistent with some previous studies (Constantin et al., 2024), which indicate an increase in production determined by calcium nitrate + Kelpak treatments in round pepper.

Another variant that led to a significant increase in fruit yield was variant V10, in which treatments with calcium nitrate + Rerum were used. Compared to the untreated variant, this variant led to a 31.23% increase, meaning an increase of 14.01 t/ha.

Table 6

Influence of foliar treatments on fruit yield

Variant	Treatment	Yield (t/ha)	Fruits/ plant	Fruit weight (g)	BER (%)
V1	untreated	44.86±3.09^{c}	5.02±0.36^{bc}	150.04±21.53^{b}	12.95±0.74^{a}
V2	calcium nitrate (5 g/L)	48.82±1.69^{bc}	5.50±0.47^{abc}	149.04±15.92^{b}	7.17±2.93^{bcd}
V3	calcium nitrate (5 g/L) + Agrocean B (2 ml/L)	45.94±4.43^{c}	4.60±0.39^{c}	167.91±29.06^{ab}	9.07±1.02^{b}
V4	calcium nitrate (5 g/L) + E-Dalgin (2 ml/L	51.08±8.41^{abc}	5.20±0.64^{abc}	163.42±13.06^{ab}	4.51±1.35^{d}
V5	calcium nitrate (5 g/L) + Kelpak (2 ml/L)	59.81±11.75^{ab}	5.96±0.55^{ab}	166.27±19.94^{ab}	6.38±2.03^{bcd}
V6	calcium nitrate (5 g/L) + Triptolemus HV (2 ml/L)	50.89±4.83^{abc}	5.15±0.72^{abc}	166.35±23.79^{ab}	4.37±0.13^{d}
V7	calcium nitrate (5 g/L) + Albit (2 ml/L)	48.83±4.00^{bc}	4.56±0.33^{c}	179.09±18.56^{ab}	13.01±1.06^{a}
V8	calcium nitrate (5 g/L) + Sprintene (2 ml/L)	61.69±5.75^{a}	6.08±0.38^{a}	169.18±10.22^{ab}	4.53±1.65^{d}
V9	calcium nitrate (5 g/L) + Kinactiv Fruit (2 ml/L)	53.82±6.03^{abc}	4.69±0.18^{c}	191.85±24.93^{a}	5.25±1.48^{cd}
V10	calcium nitrate (5 g/L) + Rerum (2 ml/L)	58.87±8.57^{ab}	5.40±0.68^{abc}	181.47±7.93^{ab}	7.71±1.75^{bc}

*Duncan test: Significant differences ($p \leq 0.05$) are indicated by mean values in a column that do not share the same letter (a, b, c).

The amount of **fruit/plant** was also significantly influenced by the treatments applied.

The highest fruit/plant yields were obtained for the variants treated with calcium nitrate + Sprintene (6.08 fruits/plant) and calcium nitrate + Kelpak (5.96

fruits/plant). However, only the variant treated with calcium nitrate + Sprintene (V8) led to significant differences compared to the untreated variant (V1), which yielded an average of 5.02 fruits/plant.

The other treatment options did not determine significant differences compared to the untreated option, in terms of the number of fruits/plant.

Some treatment variants led to a decrease in the number of fruits/plant compared to the untreated variant, but without being significantly different. This is the case of variants V3 (calcium nitrate + Agrocean B), V7 (calcium nitrate + Albit) and V9 (calcium nitrate + Kinactiv Fruit).

The fruit weight was significantly influenced and varied between 149.04 g and 191.84 g. The largest fruits were obtained in the case of the calcium nitrate + Kinactiv Fruit treatment, this being the only variant that determined significant increases in fruit mass, compared to the variant in which no treatments were used. The fruits were larger by a percentage of 27.86%, meaning an average of 41.8 g more. This variant also led to a significant difference compared to the variant treated with calcium nitrate (V2).

The percentage of fruits affected by blossom end rot had an average value between 4.37 and 13.01%. Except for the treatments with calcium nitrate + Albit (V7), all experimental variants led to a decrease in the percentage of affected fruits. The lowest percentage of affected fruits was obtained in the case of using the treatments with calcium nitrate + Triptolemus (V6), followed by the variants to which foliar treatments with calcium nitrate + E-Dalgin (V4) and with calcium nitrate + Sprintene (V8) were applied. These values led to a decrease in the percentage from 12.95% to 4.37-4.53%.

The firmness. The consistency and texture of the pulp contribute to the stability of the products against external pressures. In the case of red bell pepper, these characteristics are influenced by both the stage of maturity and the cultivation conditions [Jovicich *et al.*, 2005; Pohrib and Petrache, 2011]. Research indicated that the water potential of the fruit at the time of harvest was greater in green peppers compared to red peppers, and that firmness diminished as the fruit changed color [Biles *et al.*, 1993]. The firmness of the fruits varied between a minimum of 24.04 N obtained in the case of variant V3 (calcium nitrate + Agrocean B) and 26.69 N, in the case of variant V8 (calcium nitrate + Sprintene) (Table 7).

The applied foliar treatments did not lead to significant differences compared to the variant in which no foliar treatments were applied. In contrast, the treatments with calcium nitrate + Sprintene (V8) led to significant differences compared to the variants in which treatments were applied with calcium nitrate + Agrocean B (V3 – 24.04 N), with calcium nitrate (V2 - 24.68 N), with calcium nitrate + E-Dalgin (V4 - 25.02 N), and, respectively, with calcium nitrate + Kelpak (V5 - 25.70 N). At the same time, the treatments with calcium nitrate + Kinactiv Fruit (V9) or Rerum (V10) significantly increased the firmness of round pepper fruits compared to the treatments used with calcium nitrate + Agrocean B.

Table 7

Influence of foliar treatments on fruit quality

Variant	Treatment	Firmness (N)	Juice pH	TSS content (% Brix)	DW content (%)	Pulp thickness (mm)
V1	untreated	25.25±2.60^{abc}	4.96±0.11^{bc}	7.31±0.78^{bc}	7.24±0.20^{cde}	6.95±0.96^{abc}
V2	calcium nitrate (5 g/L)	24.68±1.23^{bc}	5.18±0.10^{b}	7.40±0.90^{bc}	7.72±0.36^{bcd}	6.65±0.81^{c}
V3	calcium nitrate (5 g/L) + Agrocean B (2 ml/L)	24.04±1.30^{c}	4.97±0.17^{bc}	6.91±1.42^{cd}	7.02±0.26^{de}	6.60±0.99^{c}
V4	calcium nitrate (5 g/L) + E-Dalgin (2 ml/L	25.02±1.85^{bc}	5.16±0.09^{b}	6.28±1.42^{d}	6.41±0.41^{e}	6.86±0.56^{a}
V5	calcium nitrate (5 g/L) + Kelpak (2 ml/L)	25.70±1.86a^{bc}	4.96±0.16^{bc}	7.70±0.73^{ab}	8.24±0.29^{ab}	6.94±0.98^{bc}
V6	calcium nitrate (5 g/L) + Triptolemus HV (2 ml/L)	25.55±1.93^{abc}	4.97±0.07^{bc}	7.30±1.01^{bc}	7.24±0.22^{cde}	6.74±1.06^{c}
V7	calcium nitrate (5 g/L) + Albit (2 ml/L)	25.47±2.25^{abc}	5.16±0.09^{b}	7.24±0.86^{bc}	7.15±0.80^{de}	6.79±0.95^{abc}
V8	calcium nitrate (5 g/L) + Sprintene (2 ml/L)	26.69±1.88^{a}	4.99±0.09^{bc}	7.51±0.69^{bc}	8.03±0.68^{abc}	6.59±0.95^{c}
V9	calcium nitrate (5 g/L) + Kinactiv Fruit (2 ml/L)	26.12±1.81^{ab}	4.89±0.08^{c}	8.18±0.60^{a}	8.78±0.36^{a}	7.49±0.89^{abc}
V10	calcium nitrate (5 g/L) + Rerum (2 ml/L)	26.03±2.18^{ab}	5.41±0.65^{a}	7.63±0.81^{abc}	8.70±0.56^{a}	7.42±0.81^{ab}

*Duncan test: Significant differences ($p \le 0.05$) are indicated by mean values in a column that do not share the same letter (a, b, c).

The pH of the juice from red bell peppers can vary depending on several factors such as the stage of maturity, cultivation conditions, and treatment methods [Pohrib and Petrache, 2011]. Typically, the pH of red bell pepper juice ranges from approximately 4.5 to 5.5 [Jovicich *et al*., 2005]. In our study, the juice pH ranged from 4.89 (V9 – calcium nitrate + Kinactiv Fruit) to 5.41 (V10 – calcium nitrate + Rerum). The only treatment variant that resulted in significant differences compared to the untreated variant was V10, which used treatments with calcium nitrate + Rerum, increasing the pH value of the pepper juice by 9.07% (from 4.96 to 5.41). This treatment also led to significant increases in pH compared to all other foliar treatments. pH plays an important role in maintaining the texture of peppers. A significant loss ($P \le 0.05$) of firmness in red bell peppers was observed when the pH dropped below 3.4 [Papageorge *et al*., 2003].

The total soluble solids. Carbohydrates in vegetables and fruits are represented by monosaccharides (such as glucose, fructose, and sorbose), disaccharides (like sucrose), and polysaccharides (including cellulose, starch, and pectins). Sweet-tasting products contain significant amounts of monosaccharides. Soluble carbohydrates, along with acids and tannins, play a significant role in shaping the flavor of vegetables and fruits. Carbohydrates, along with organic acids, are the main source of energy for respiration [Gherghi, 1994]. The TSS content in round pepper fruits. varied significantly with values ranging from 6.28% Brix (in the case of variant V4 – calcium nitrate + E-Dalgin) to 8.18% Brix (in the case of V9 – calcium nitrate + Kinactiv Fruit). Compared to the variant in which no foliar treatments were applied (V1), variant V4 (calcium nitrate + E-Dalgin) determined a significant decrease in the TSS, from 7.31% Brix to 6.28% Brix. In oposite, variant V9 led to a significant increase from 7.31% Brix to 8.18% Brix. The other experimental variants did not determine significant differences compared to the non-foliar treated variant, even if a slight increase in TSS was observed in the case of treatments applied with calcium nitrate (V2) or in combination with Kelpak (V5), with Sprintene (V8) or with Rerum (V10). At the same time, variant V9 determined a significant increase in the TSS compared to the foliar treated variants V2 (calcium nitrate), V3 (calcium nitrate + Agrocean B), V4 (calcium nitrate + E-Dalgin), V6 (calcium nitrate + Triptolemus HV), V7 (calcium nitrate + Albit) and V8 (calcium nitrate + Sprintene).

The total dry matter content in peppers is an important parameter that reflects the overall quality and nutritional value of the fruit. Higher DW content is often associated with improved taste, texture, and processing qualities. Research has shown that factors such as variety, cultivation conditions, and maturity at harvest can significantly influence the DW of peppers [Kader, 1995]. Studies have reported that the DW content in bell peppers can range from 6% to 10%, depending on these factors [Sezen *et al*., 2006]. Additionally, higher dry matter levels have been correlated with better shelf life and increased resistance to post-harvest decay [Kader, 2002].

The DW varied significantly with values ranging from 6.41 (V4 – calcium nitrate + E-Dalgin) to 8.78% (V8 – calcium nitrate + Kinactiv Fruit). The highest values were obtained in the cases of variants treated with calcium nitrate + Kinactiv Fruit (V9), calcium nitrate + Rerum (V10), and calcium nitrate + Kelpak (V5). The rest of the experimental variants did not lead to significant changes in DW.

The pulp thickness ranged between 6.59 mm (calcium nitrate + Sprintene) and 7.49 mm (calcium nitrate + Kinactiv Fruit). Foliar treatments did not determine significant differences compared to the untreated variant, but there were differences between treatments. The treatments with calcium nitrate + Kinactiv Fruit (V9) determined significant increases in pulp thickness compared to variants V2 (calcium nitrate), V3 (calcium nitrate + Agrocean B), V6 (calcium nitrate + Triptolemus HV), V7 (calcium nitrate + Albit) and V8 (calcium nitrate + Sprintene). The conclusions of previous research [Tadesse *et al.*, 2002] show that the thickness of the bell pepper pericarp increases with the age of the fruit and is positively correlated with its firmness [Rahman *et al.*, 2014].

The strength of the correlations in Fig.1 indicates that the treatment variant was associated with a significant increase in yield ($r = 0.506$, $p < 0.01$). While this suggests a positive association, confirming the magnitude and practical significance of the effect would require additional testing to identify the optimal dose or conditions of the treatment. A positive correlation was found between the treatments applied and fruit firmness ($r = 0.270$, $p < 0.01$), as well as between the treatments and TSS ($r = 0.241$, $p < 0.01$) and DW ($r = 0.567$, $p < 0.01$), indicating a positive impact of the treatments on these properties. There is a positive association, of low intensity, between foliar treatments and fruit pulp thickness ($r = 0.158$, $p < 0.05$). This association is statistically significant, though modest in strength.

An inverse relationship was observed between the treatments and the occurrence of BER, but the strength of this correlation was not statistically significant ($p > 0.05$).

		Treatment	Yield (t/ha)	Fruit/ plant	BER (%)	Firmness (N)	TSS (% Brix)	DW (%)	Pulp thickness (mm)
Treatment	Pearson Correlation	1	0.506**	0.065	-0.310	0.270**	0.241**	0.567**	0.158*
	Sig. (2-tailed)		0.000	0.734	0.096	0.003	0.002	0.001	0.016
Yield (t/ha)	Pearson Correlation		1	0.639**	-0.445*	0.238	0.123	0.422*	0.285
	Sig. (2-tailed)			0.000	0.014	0.205	0.516	0.020	0.126
Fruit/plant	Pearson Correlation			1	-0.381*	0.350	0.027	0.142	0.128
	Sig. (2-tailed)				0.038	0.058	0.887	0.455	0.499
BER	Pearson Correlation				1	-0.102	0.097	-0.181	0.094
	Sig. (2-tailed)					0.591	0.610	0.340	0.620
Firmness (N)	Pearson Correlation					1	0.158	0.229	0.047
	Sig. (2-tailed)						0.087	0.223	0.613
TSS (% Brix)	Pearson Correlation						1	0.659**	0.184*
	Sig. (2-tailed)							0.000	0.023
DW (%)	Pearson Correlation							1	0.458*
	Sig. (2-tailed)								0.011
Pulp thickness (mm)	Pearson Correlation								1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Fig. 1. Correlation matrix between evaluated component

There is a significant positive correlation between total fruit production and the number of fruits per plant ($r = 0.639$, $p < 0.01$). The relationship between yield and the number of fruits per plant is strong. Both yield and the number of fruits per plant are significantly negatively correlated with the incidence of BER.

A very strong positive interdependent relationship was identified between TSS and DW ($r = 0.659$, $p < 0.01$). The thickness of the fruit pulp is inversely related to DW ($r = -0.458$, $p < 0.05$).

CONCLUSIONS

The synergy between calcium nitrate and biostimulants is associated with increased yield and improvement of certain qualitative traits of the crop.

The results support the hypothesis that blossom end rot is also a nutritional problem. The incidence of the phenomenon decreased following the application of calcium nitrate in combination with various biostimulants, with the exception of the combination of calcium nitrate with Albit.

In round pepper, among the tested biostimulants, Kelpak, Sprintene, Kinactiv Fruit, and Rerum are recommended both for increasing yield and for optimizing certain qualitative characteristics.

Favorable results were also observed for the combination of calcium nitrate with Triptolemus HV, though less evident.

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SORGHUM AND ITS ALLELOPATHIC POTENTIAL – PERSPECTIVES FOR WEED MANAGEMENT IN HORTICULTURE

SORGUL ȘI POTENȚIALUL SĂU ALELOPATIC – PERSPECTIVE PENTRU MANAGEMENTUL BURUIENILOR ÎN HORTICULTURĂ

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Abstract
Sorghum (Sorghum bicolor L.) is a xerophytic plant of the Poaceae family, known both for its adaptability to drought conditions and for its nutritional value. It has a deep root system and a metabolism that can generate bioactive compounds with allelopathic effects on other plants in the same environment. The main compound involved in this process is sorgoleone, a benzoquinone derived from root exudates and root hairs, which has herbicidal effects on weeds. Sorgoleone and its associated compounds are continuously released into the rhizosphere during the growing season, influencing the competitiveness of nearby plants and contributing to natural weed control. This allelopathic mechanism is mediated by the enzymatic biosynthesis of sorgoleone and the transport of bioactive compounds in the rhizosphere, offering opportunities for its application in sustainable horticultural systems and integrated weed management. The present study focuses on recognizing the allelopathic properties of sorghum, highlighting its potential as a natural resource for the development of innovative, efficient, and environmentally friendly agricultural practices.
Keywords: sorghum, sorgoleone, allelopathy, influence.

Rezumat
Sorgul (Sorghum bicolor L.) este o plantă xerofilă din familia Poaceae, recunoscută atât pentru adaptabilitatea sa la condiții de secetă cât și pentru valoarea sa nutritivă. Aceasta prezintă un sistem radicular profund și un metabolism ce poate genera compuși bioactivi cu efecte alelopatice asupra altor plante din același mediu. Principalul compus implicat în acest proces este sorgoleona, o benzochinonă derivată din exudatele rădăcinilor și perișorilor radiculari, ce prezintă efecte erbicide asupra buruienilor.
Sorgoleona și compuși asociați acesteia sunt eliberați continuu în rizosferă pe parcursul perioadei de creștere influențând competitivitatea

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plantelor din proximitate, contribuind la controlul natural al buruienilor. Acest mecanism alelopatic este mediat de biosinteza enzimatică a sorgoleonei și transportul compușilor bioactivi în rizosferă, oferind oportunități pentru aplicarea sa în sisteme horticole sustenabile și în managementul integrat al buruienilor. Studiul prezent se axează pe recunoașterea proprietăților alelopatice ale sorgului punând în evidență potențialul său ca resursă naturală pentru dezvoltarea practicilor agricole inovatoare, eficiente și ecologice.
Cuvinte cheie: sorg, sorgoleonă, alelopatie, influență.

INTRODUCTION

Sorghum *(Sorghum bicolor L.)* is a perennial herbaceous species at its base but behaves as an annual in our country. It belongs to the *Poaceae* family and can reach heights of up to 2.5 m, with an external morphology similar to that of corn. This species is the main source of grain in Africa and is also widely cultivated in southern Europe, Central America, and South Asia. The plant has a nodular stem, supported by a well-developed root system capable of penetrating deep into the soil. The leaves are alternate, broad, slightly pubescent, with sharp edges and an intense green color. The inflorescences are grouped in panicles, either sparse or slightly bent, up to 70 cm long. The fruit is an oval achene, red or pink in color [De Oliveira *et al.*, 2021; Gomes *et al.*, 2023; Istrate *et al.*, 2023].

Sorghum is mainly cultivated in areas with a high risk of drought due to its particular resistance to water deficiency, which is why it is also known as the "camel plant." Its root system is about twice as developed as that of corn, which allows it to efficiently utilize soil water resources. From a nutritional point of view, sorghum is an important source of energy, being rich in vitamins, fiber, and other bioactive compounds that are beneficial to human health.

The cultivation requirements of sorghum are similar to those of corn. Seed germination occurs at minimum temperatures of 10–12°C, and optimal development occurs at temperatures between 25–35°C. The plant adapts to a wide range of soils, tolerating a pH between 4.5 and 8.5. Being a heliophilous species, sorghum needs direct light, which promotes growth, development, and resistance to biotic and abiotic stress; in shady conditions, these processes are significantly affected [Macias *et al.*, 2019].

Beyond its agronomic and nutritional importance, sorghum is recognized for its ability to produce bioactive compounds with allelopathic roles. The plant synthesizes a series of secondary metabolites that can act either as inhibitors or stimulators of the growth of organisms and plants in the surrounding ecosystem. This allelopathic capacity is attributed in particular to lipid and protein substances that form a complex improperly called "sorgoleon". This is released naturally into the soil through the roots and trichomes, exerting an inhibitory effect on weeds [Liang and Niu, 2022; Hamburda *et al.*, 2013; Waligora *et al.*, 2023; Wang *et al.*, 2021; Zhao *et al.*, 2019].

Sorgoleone, the main active compound, is found in the hydrophobic exudates of the roots and has herbicidal effects on nearby plant species. Chemically, sorgoleone belongs to the benzoquinone class, with the molecular formula $C_{22}H_{30}O_4$ and consisting of 2-hydroxy-5-methoxy -1,4-benzoquinone, in which the hydrogen atom in position 3 is substituted by the (4Z,7Z)-pentadec-1,4,7-trien-15-yl group. Studies conducted by Pan ZhiQiang and colleagues [2018] have shown that the biosynthesis of sorgoleone is catalyzed by the enzyme CYP71AM1 and cytochrome P450 CYP71. Sorgoleone and its analogues, such as resorcinol and other related hydroquinones, are produced exclusively by living root hairs and are released as golden droplets into the rhizosphere. Secretion occurs throughout the growing season and remains active in the soil for an indefinite period [Uddin *et al.*, 2013]. Under stress conditions, the roots also release low molecular weight compounds, organic acids, phenolic compounds, and proteins, which contribute to the plant's adaptation. Root hairs are the main site of sorgoleone biosynthesis, where it is stored in the form of dense osmiophilic deposits, constituting up to 85% of the dry weight of the exudate [Uddin *et al.*, 2013; Massalha *et al.*, 2017; Murimwa *et al.*, 2022; Santos *et al.*, 2012].

Through these mechanisms, sorghum plays an important role not only as a source of food and fodder, but also as an active ecological factor with potential for use in natural weed control.

MATERIAL AND METHOD

The working material under study consists of specialized literature comprising over 300 papers on sorgoleone and related substances, 67 papers on the allelopathic effect of sorgoleone, and over 12,000 papers on sorghum, published to date by various authors and researchers in the field. For the present study, we selected the most detailed studies that best included the necessary details about the allelopathic effect of sorghum, its associated substances, and the possibility of its use as a bioherbicide in weed control.

The working method consists of deepening and understanding the results obtained so far by researchers in the field in order to understand exactly the mechanisms of sorghum allelopathy and its potential for beneficial use.

RESULTS AND DISCUSSIONS

After a thorough analysis of the studies conducted to date, from those selected bibliographically, we found that sorghum plants contain certain enzymes and substances that can have an allelopathic effect against weed growth but also against crop pests, without having negative effects on the crops themselves.

The selected studies focused largely on laboratory testing and on the exact identification of the substance with allelopathic properties present in the plant, named sorgoleone after the plant, which is based on a classic benzoquinone (2-hydroxy-5-methoxy-1,4-benzoquinone).

A study on the cytochrome P450CYP71 enzyme and the biosynthesis of sorgoleone in a laboratory setting showed that sorgoleone, a hydrophobic compound exuded from sorghum roots, is primarily responsible for the plant's allelopathic effect. Its biosynthesis is catalyzed by enzymes, including cytochrome P450 (CYP71AM1), which facilitates the formation of dihydro-sorgoleone, subsequently oxidized to its active form. Studies have shown that root exudate contains between 40-90% sorgoleone, a component that inhibits weed growth. The presence and function of the enzymes involved in this process have been confirmed by genetic analyses (BLASTIN, TBLASTIN), highlighting their essential role in suppressing competing species and the potential of sorghum as a natural bioherbicide [Pan *et. al*. 2018]

Uddin et al. in a paper on the effects of jasmonates on sorgoleone accumulation the effects of jasmonates on sorgoleone accumulation showed that jasmonic acid (Ja) and methyl jasmonate (MeJa) stimulate sorgoleone biosynthesis in sorghum roots, with the effect being dependent on concentration and exposure time. At 0.5 µM, sorgoleone levels increased significantly, but at higher concentrations, root production and development were inhibited. The expression of genes involved in biosynthesis (DES2, DES3, ARS1, ARS2, OMT3) reached maximum values 12–48 h after treatment. The results suggest an important regulatory role of jasmonates in root hair growth and allelopathic compound secretion, opening up possibilities for the use of these substances for biological weed control (Figure 1) [Uddin *et. al.*, 2012].

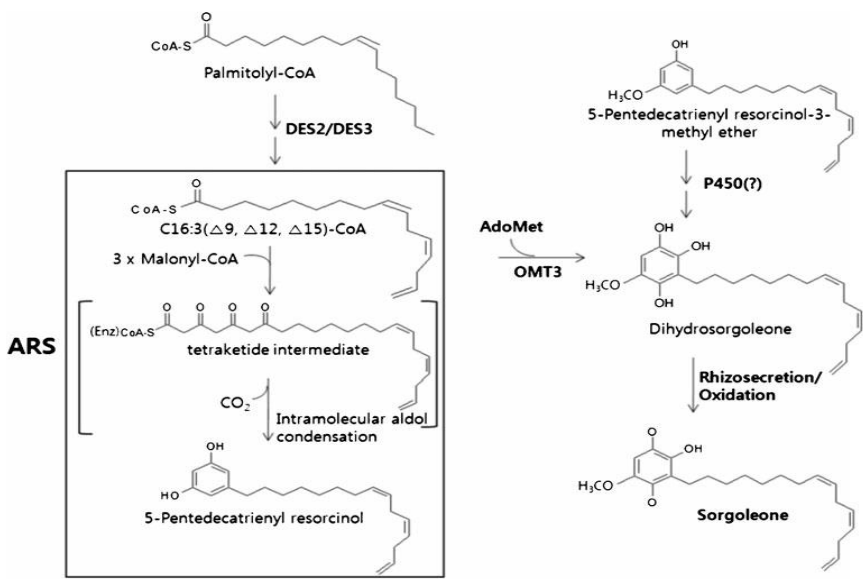

Fig. 1. The chemical formula of sorgoleone and its absorption by Baerson 2008 [Uddin *et. al.,* 2013]

The role of alkylresorcinols in sorgoleone biosynthesis was demonstrated by Cook and his colleagues [2010] in their paper, *Sorghum bicolor (L.)* plants produce sorgoleone, a benzoquinone compound with an inhibitory effect on monocots and dicots. Biosynthesis involves the ARS1 and ARS2 genes, which are predominantly expressed in root hairs, where resorcinol accumulation occurs. RT-PCR and GS-MS analyses confirmed the localization of these genes and their role in the synthesis of the compound. The process is based on the use of fatty acyl-CoA and leads to an increase in the concentration of allelochemicals in the rhizosphere, supporting the plant's potential as a natural weed control agent [Cook *et. al*. 2010].

Sorgoleone is a major allelochemical compound released by the root hairs of sorghum, playing a decisive role in the plant's phytotoxic activity. In a laboratory study conducted on four soil types sampled from two different regions (Denmark and the US), the mineralization of sorgoleona was analyzed until complete CO_2 degradation, in order to assess its potential as a biocide. The results showed that the mineralization process took place in all the soils tested, starting with the rapid degradation of the methoxyl group, followed by a slower mineralization of the rest of the molecule. Kinetics analysis also showed that microorganisms in American soils were able to use sorgoleone as an energy source, which has important implications for its persistence and applicability in integrated weed control strategies (Figure 2) [Gimsing *et. al*. 2009].

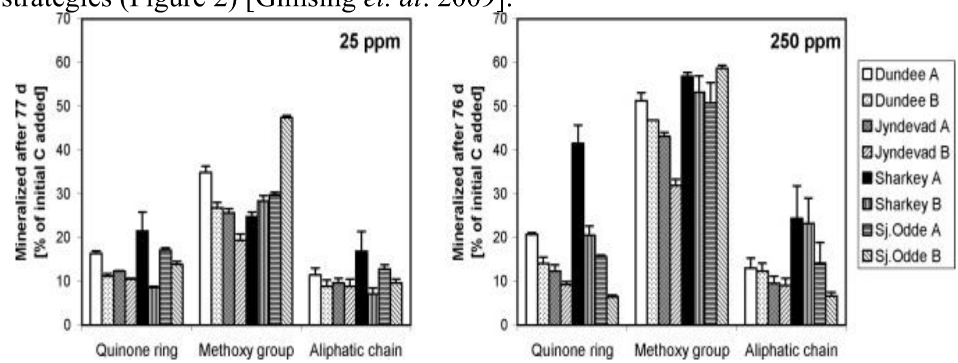

Fig. 2. Mineralization of the molecule after 76–77 days when applying the two concentrations obtained [Gimsing *et. al*. 2009]

The study conducted by Einhellig and his colleagues [1992] tested a benzoylhydroxide compound derived from sorgoleone, or predominantly from its main active ingredient, on rice, corn, and soybean crops. In the case of rice and corn crops, the results obtained were favorable, unlike those recorded for soybean crops, where the experiment did not show high safety, as the substance had negative effects not only on weeds but also on the crop plant. However, the compound degraded in the soil within a relatively short period of time, approximately 17–21 days after application, without negatively affecting the activity of soil microorganisms (Table 1) [Einhellig *et. al*. 1992].

Table 1

Effects of benzothiazine extracts on crop weed growth [Einhellig *et. al.* 1992].

Sorgoleone treatment (#M)				
	0	10	50	100
Setaria viridis				
Total plant wt (mg)	42.9 a	29.4 b	15.8 c	13.4 c
Shoot wt (mg)	32.8 a	22.0 b	11.8 c	10.5 c
Root wt (mg)	10.1 a	7.4 b	4.0 c	2.9 c
Shoot-root ratio	3.3 a	3.2 a	3.6 a	3.6 a
Digitaria sanguinalis				
Total plant wt (mg)	29.1 a	9.9 b	6.8 b	6.5 b
Shoot wt (mg)	24.3 a	7.9 b	5.7 b	4.8 b
Root wt (mg)	4.8 a	2.0 b	1.1 b	1.7 b
Shoot-root ratio	5.2 a	7.3 a	5.9 a	3.2 a
Echinochloa crus-galli				
Total plant wt (mg)	134.8 a	87.4 b	40.6 c	NT b
Shoot wt (mg)	105.0 a	65.7 b	29.9 b	NT
Root wt (mg)	29.8 a	21.7 a	10.7 b	NT
Shoot-root ratio	3.5 a	3.1 a	2.9 a	

The main weed species identified in the crops were *Setaria viridis, Eleusine indica, Digitaria sanguinalis, Amaranthus retroflexus, Echinochloa crus-galli and Solanum nigrum*. The bezothiazine derivative showed promising results in corn crops, suggesting that the development of a bioherbicide based on this compound could be a viable solution for weed management in the future [Einhellig *et. al.* 1992].

CONCLUSIONS

Analysis of the literature on the allelopathic potential of *Sorghum bicolor (L.)* highlights its remarkable ability to produce and release bioactive compounds with herbicidal properties, particularly sorgoleone. This compound, synthesised in root hairs and exuded into the rhizosphere, is the allelochemical agent responsible for inhibiting the germination and growth of competing weed species.

Biochemical and molecular studies confirm that sorgoleone biosynthesis is catalysed by specific enzymes, such as cytochrome P450 (CYP71AM1), and is regulated by signal molecules such as jasmonates, which stimulate the expression of key genes involved in this process (DES2, DES3, ARS1, ARS2, OMT3). These mechanisms highlight the existence of a complex regulatory network that contributes to the plant's allelopathic efficiency and ecological adaptability.

Experimental research also shows that sorghum degrades relatively quickly in the soil — generally within 17–21 days of application — without negatively affecting the activity of microorganisms. This supports its potential use in sustainable agricultural systems as a natural bioherbicide, reducing dependence on synthetic chemicals.

The positive results obtained in maize and rice crops treated with sorghum leonine derivatives, in contrast to the less favorable results observed in soybean crops, indicate that the allelopathic effects of these compounds are species-dependent. This highlights the need for targeted application and optimisation of conditions of use in an agronomic context.

Overall, the conclusions reinforce the role of *Sorghum bicolor (L.)* not only as a resistant and valuable plant from an agronomic and nutritional point of view, but also as a promising source of natural allelopathic compounds. Further studies on sorghum and its analogues could contribute to the development of effective and environmentally friendly bioherbicides that are compatible with the principles of sustainable agriculture.

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THE INFLUENCE OF THE APPLICATION OF ECO-SCHEMES REGARDING PERMANENT CROPS IN CHERRY PLANTATIONS ON BIODIVERSITY AND ENVIRONMENTAL IMPACT

INFLUENȚA APLICĂRII ECOSCHEMELOR PRIVIND CULTURILE PERMANENTE ÎN PLANTAȚIILE DE CIREȘ ASUPRA BIODIVERSITĂȚII ȘI IMPACTULUI ASUPRA MEDIULUI

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Abstract.
Observations were carried out during 2024–2025 in the experimental cherry lot of Research Station for Fruit Growing Iasi, located in Miroslava, with the objective of evaluating the impact of eco-schemes and technological variants in cherry plantations on biodiversity and reduction of external inputs. Four experimental variants (mechanical feeler, herbicide, repellent plants, biodegradable mulch) were compared in terms of the degree of attack by pathogens and pests. The results show that the variant with repellent plants had the best efficiency in reducing the pressure of pathogen and pest attack, a viable ecological alternative for integrated management of fruit plantations.
Key words: eco-schemes, cherry, repellent plants, biodiversity, biodegradable

Rezumat.
Observațiile au fost efectuate în perioada 2024–2025 în lotul experimental de cireș de pe teritoriul Stațiunii de Cercetare-Dezvoltare pentru Pomicultură Iași, localizată în Miroslava, având ca obiectiv evaluarea impactului ecoschemelor și a variantelor tehnologice aplicate în plantațiile de cireș asupra biodiversității și reducerii inputurilor externe. Patru variante experimentale (palpator mecanic, erbicidare, plante repelente, mulcire biodegradabilă) au fost comparate în ceea ce privește gradul de atac al agenților patogeni și al dăunătorilor. Rezultatele arată că varianta cu plante repelente (Allium sativum, Tagetes spp., Lavandula officinalis, Ocimum basilicum, Satureja hortensis) a avut cea mai bună eficiență în reducerea presiunii atacului agenților patogeni și a dăunătorilor, constituind o alternativă ecologică viabilă pentru managementul integrat al plantațiilor pomicole.
Cuvinte-cheie: ecoscheme, cireș, plante repelente, biodiversitate, mulcire biodegradabilă.

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[1] Research Station for Fruit Growing Iasi

INTRODUCTION

Creating a sustainable fruit ecosystem is a priority in the context of modern agriculture, where environmental pressure and climate change require the adoption of nature-friendly technologies [Altieri and Nicholls, 2017]. In recent years, traditional fruit systems have been criticized for their high resource consumption and intensive use of plant protection products, which has led to the need to integrate agroecological principles into orchard management [Wezel *et al*., 2020].

The present research aims to evaluate and introduce innovative agroecological practices in fruit plantations, such as the use of floral belts, repellent plants and conservative soil maintenance technologies, with the aim of increasing biodiversity and reducing dependence on external inputs [Simon *et al*., 2021; Garratt *et al*., 2019]. These practices contribute to maintaining ecological balance, increasing populations of pollinators and beneficial entomofauna, as well as improving soil health [Bàrberi *et al*., 2018].

The research objectives aimed to analyze natural resources and biodiversity of useful flora and fauna, assess the impact of soil maintenance works on ecosystem services, and disseminate the results among farmers and specialists in the field [Kremer and Peterson, 2022]. Thus, the study contributes to the development of an integrated vision sustainable fruit farming, adapted to current climate challenges.

MATERIAL AND METHOD

The biological material on which the studies related to the achievement of the objectives were undertaken is located in the cherry demonstration lot at SCDP Iaşi with a total area of 0.63 ha; the trees are in the 5th year after planting, are grafted on mahaleb, planted at a distance of 6 x 5 m and managed in the form of an improved pot, without a support system. As part of the experience in 2025, there were four experimental variants of soil maintenance.

In order to limit excessive mechanization, other types of tree row maintenance were practiced to the detriment of the black field, this type of maintenance strongly accentuating erosion processes. On the tree row, the soil is kept clean with the help of a feeler plow, and between the tree rows the soil is maintained as a grassy parterre.

As part of the experience for the establishment of the experimental variants, the following factors were used (Table 1) by implementing four experimental variants:

Table 1

Experimental variants

Species	Rootstock	Variants	Repetition
Cherry	mahaleb	**V1** – Trap plants used between trees	4 repetitions
		V2 – Use of herbicide on the tree row	4 repetitions
		V3 – Repellent plants	4 repetitions
		V4 – Mulching with biodegradable material	4 repetitions

In variant 1, the soil between the trees was maintained using a feeler disc, at regular intervals.

Variant 2 of the experiment was maintained using the herbicide, applied with a backpack spray pump.

In variant 3, repellent plants were planted or sown to limit the attack of pathogens and pests but also to maintain the soil between the trees cultivated with these sanitary-accompanying species.

Variant no. 4 of the experiment was maintained using biodegradable mulching foil, made of polyethylene or perforated agrotextile, which is distributed only in the direction of the row.

Each variant had four repetitions. Monitoring was carried out through phenological and phytosanitary observations, assessment of the degree of attack (GA%) of pathogens and pests, as well as analysis of climatic and edaphic conditions during the period September 2024 - August 2025.

As part of the experience, an integrated pathogen and pest control program was applied to limit the attack caused by them and maintain cultural hygiene.

Phytosanitary treatments were limited, namely 4 phytosanitary treatments (Table 2), in correlation with tree phenology (BBCH) and based on catches recorded on phytosanitary traps in order to carry out as few phytosanitary treatments as possible, in order to protect useful entomofauna.

Table 2

Cherry treatment program – SCDP Iași 2025

No.	Phenophase	Product	Dose ha/1000 L
T1 – BBCH 07-10	Bud burst – White bud stage	Bouille Bordelaise WDG	5 kg
		Decis Expert	0.1 L
		Polyactiv B	2 L
T2 – BBCH 65	Petal fall	Signum	0.5 kg
		Mospilan 20 SG	0.45 kg
		Polyactiv B	2 L
T3 – BBCH 74-80	Fruit coloring	Folicur Solo	0.75 L
		Energevo	3 kg
		Karate Zeon	0.25 L
T4 – BBCH 84	7 days before harvest	Signum	0.5 kg
		Karate Zeon	0.2 L

RESULTS AND DISCUSSIONS

Within the experiment, 3 determinations were made on the attack of pathogens (*Stigmina carpophilla* m.b. ellis., *Coccomyces hiemalis* HIGG) and pests (*Rhagoletis cerasi* L., *Sciaphobus squalidus*, leaf miners and *Myzus cerasi*).

The study followed the influence of four technological variants on the degree of attack (GA%) of pathogens on cherry, evaluated in three key phenological moments: May 20 (Figure 1), June 18 and August 4. The data highlight significant variations in the intensity of the attack depending on the treatment applied and the evaluation period (Figure 2).

Fig.1 Cherry orchard in full bloom

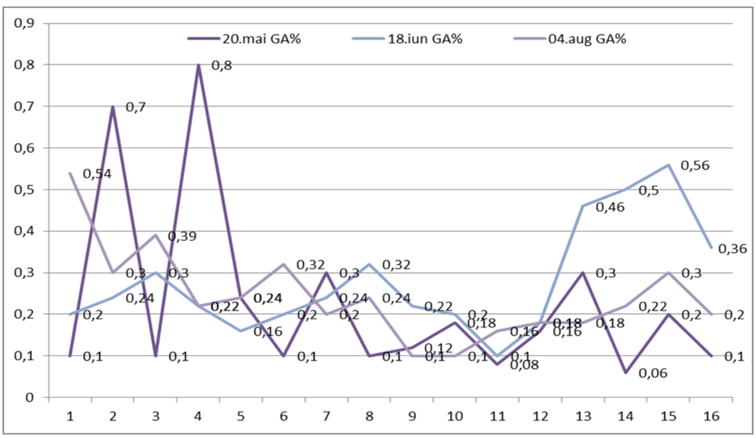

Fig 2. The degree of attack of pathogens encountered in the cherry orchard

V1 – Feeler used between trees

This variant presented the highest GA% values, with a peak of 0.8 %, recorded on May 20. Although a slight reduction in values is observed in June (0.22–0.3%), they increase again in August, reaching values up to 0.54%. The results indicate a low efficiency of this treatment in limiting the pathogenic pressure, possibly due to the fact that the use of the feeler does not sufficiently reduce the source of inoculum or does not directly influence the factors favoring the infection.

V2 – Use of herbicides in the tree row

Variant V2 generated average GA% values, relatively constant throughout the three evaluations. The values were in the range of 0.1–0.32%, suggesting a moderate efficiency of herbicides in reducing the incidence of diseases. It can be assumed that the elimination of adventitious vegetation in the row contributes partially to the reduction of excessive humidity and the infectious potential in the basal area of the trees.

V3 – Repellent plants (*Allium sativum spp., Tagetes spp., Lavandula officinalis, Ocimum basilicum, Satureja hortensis L.)*

This variant was distinguished by the lowest and most constant GA% values throughout the entire observation period, with values ranging between 0.08% and 0.22%. The high efficiency can be attributed to the action of phytoncides and volatile compounds emitted by repellent plants, which inhibit the development of pathogens or reduce the attractiveness of the environment for disease vectors.

V4 – Mulching with biodegradable material

Mulching generated oscillating results. Although in May the GA% values were reduced (0.06–0.3%), in June the highest values of the entire experiment were recorded (up to 0.56%). Subsequently, in August, the degree of attack decreased, but remained relatively high. These data suggest that mulching, although beneficial for water conservation and weed suppression, can create a humid and warm microclimate favorable to pathogen proliferation, especially under climatic conditions favorable to infection.

The comparative evaluation of the four treatment variants applied in the cherry orchard allowed highlighting their impact on the dynamics of pest attack during the vegetation period. The attack degree values (GA%), expressed as a function of the frequency (F%) and intensity (I%) of the attack, were recorded in three phenological stages: May 22, June 20 and August 1.

The data analysis indicates that each technological variant influenced the level of pest attack differently (Figure 3).

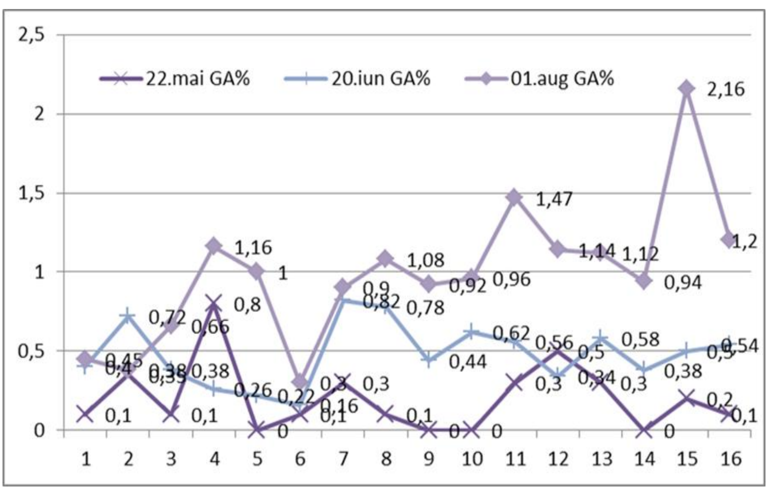

Fig 3. Degree of attack by cherry pests

V1 – Feeler used between trees (Figure 4)

This variant showed an upward evolution of the attack level, from low values in May (GA% = 0.1–0.8%) to high values in August (up to GA% = 1.16%). Although mechanical soil maintenance contributes to weed control, it does not have a direct effect on reducing pest populations, and the disturbance of the natural habitat can even stimulate the activity of some harmful species, in the absence of complementary measures.

Fig 4. Aspects from the experimental field

V2 – Use of herbicides on the tree row

Herbicide had a moderate initial efficiency (GA% ≤ 0.3% in May), but in the second half of the season a significant increase in attack was noted, culminating in values of over 1% in August. Possibly, the complete elimination of spontaneous vegetation contributed to the imbalance of the beneficial fauna, favoring the development of pests in the absence of natural predators or alternative hosts.

V3 – Repellent plants (*Allium sativum*, *Tagetes* spp, *Lavandula officinalis*, *Satureja hortensis*, *Ocimum basilicum*)

This variant recorded the lowest GA% values in May, some even zero, which indicates the initial efficiency of the volatile compounds emitted by the repellent plants in deterring pests. However, in the following months, the efficiency of these plants gradually decreased, with a significant attack being recorded in August (GA% of up to 1.47%). This can be attributed to the decrease in the concentration of active substances in plants under heat stress conditions or the development of pest resistance to these natural stimuli.

V4 – Mulching with biodegradable material; Although initially this method had moderate results (GA% ≤ 0.3% in May), during the summer an increase in attack was observed, reaching the highest values of all variants in August (with a maximum of 2.16%).

The mulching material probably contributed to the creation of a microclimate favorable to the development of some pests (high humidity, constant temperature, physical protection). Also, in the absence of additional interventions, this system allowed the uncontrolled multiplication of species developing on the ground or in the mulch layer.

CONCLUSIONS

Among the tested variants, V3 (repellent plants) demonstrated the best efficiency in reducing the degree of attack, constituting a viable ecological alternative in the integrated protection of cherry. On the other hand, V1 (Feeler used between trees) proved ineffective, requiring the completion with other phytosanitary measures. Variants V2 and V4 had variable efficiency, requiring optimization of the application regime or combination with other agrophytotechnical practices.

The interpretation of the data shows that, although the ecological treatment variants (repellent plants and mulching) may have initial benefits, their efficiency may decrease over time if they are not supported by complementary measures. Also, conventional methods (herbicides, mechanical works) may lead to ecological imbalances, favoring the development of harmful entomofauna in the absence of biological or integrated protection.

The climatic conditions during this period were favorable for the evolution of the attack of pathogens (*Stigmina carpophilla* m.b. ellis., *Coccomyces hiemalis* HIGG.) as well as the pests *Rhagoletis cerasi* L., *Sciaphobus squalidus*, leaf miners and *Myzus cerasi*.

In combating pathogens (*Stigmina carpophilla* m.b. ellis., *Coccomyces hiemalis* HIGG.)) the best results were obtained with the help of fungicides *Signum* and *Folicur Solo.*

Also, the insecticides *Decis 25, Exirel, Karate zeon* recorded high efficacy in combating pests.

As a general conclusion regarding the application of phytosanitary products accompanied by repellent plants - we can say that they have an important role and can be recommended in the cultivation technologies of the cherry species and encouraging farmers to also focus on products with reduced toxicity for humans and the environment.

The introduction of repellent plants into the crop gives us confidence that we can limit the number of treatments with their help, even if phytosanitary treatments were also used in the experience, a limitation of the attack by pests in the analyzed crop is observed, also the area in which the plantation is located greatly influences the evolution of pathogens and pests, these aspects must be taken into account when we want to establish a plantation regardless of the crop system.

ACKNOWLEGMENTS

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RESEARCH ON THE BIOLOGY OF THE SPECIES *LASPEYRESIA POMONELLA* L. IN THE NORTH-EAST AREA OF ROMANIA

CERCETĂRI PRIVIND BIOLOGIA SPECIEI *LASPEYRESIA POMONELLA* L. ÎN ZONA DE NORD EST A ROMÂNIEI

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Abstract.
The research was carried out at the Research Station for Fruit Growing Iași, during 2021–2022, with the objective of correlating climatic conditions with the biological dynamics of pests of the Laspeyresia Pomonella L. species in apple orchards. The year 2021 was characterized by an average annual temperature of 10.1°C (below the multiannual average of 11.0°C) and a precipitation amount of 563.6 mm, close to normal, but with an uneven distribution. In contrast, the year 2022 was more hostile, with an average temperature of 11.3°C, a maximum of 37.0°C and only 379.0 mm of precipitation, marking a deficit of -182.6 mm and causing severe water stress. Late spring frosts (down to -6.0°C in April 2022) affected the phenophases of apple and influenced the evolution of insect populations. Based on the accumulation of thermal degrees, two complete generations of pests were confirmed in both years. The first generation was triggered in April, with the emergence of adults, followed by egg laying and larval hatching in May (Σ≈200–270°C), pupation in June (Σ≈600–660°C) and adult maturation. The second generation took place in July–August (Σ≈1400–1500°C), and the mature larvae entered diapause in September–October (Σ≈1700°C). In conclusion, the data show that climatic variations (late frosts, droughts and excessively hot summers) influenced both the phenology of the trees and the synchronization of the biological stages of the pests, highlighting the need for ecological control strategies adapted to climate change.
Key words: fruit pests, phenology, biological stages, climate change, population dynamics.

Rezumat.
Cercetările au fost realizate la Stațiunea de Cercetare-Dezvoltare pentru Pomicultură Iași, în perioada 2021–2022, având ca obiectiv corelarea condițiilor climatice cu dinamica biologică a dăunătorilor speciei

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Laspeyresia Pomonella L. din livezile de măr. Anul 2021 s-a caracterizat printr-o temperatură medie anuală de 10,1°C (sub media multianuală de 11,0°C) și o cantitate de precipitații de 563,6 mm, apropiată de normal, dar cu distribuție neuniformă. În schimb, anul 2022 a fost mai ostil, cu o temperatură medie de 11,3°C, un maxim de 37,0°C și doar 379,0 mm precipitații, marcând un deficit de -182,6 mm și determinând stres hidric accentuat. Înghețurile târzii de primăvară (până la -6,0°C în aprilie 2022) au afectat fenofazele mărului și au influențat evoluția populațiilor de insecte. Pe baza acumulării gradelor termice, în ambii ani s-au confirmat două generații complete de dăunători. Prima generație s-a declanșat în aprilie, cu apariția adulților, urmată de depunerea ouălor și ecloziunea larvelor în mai (Σ≈200–270°C), puparea în iunie (Σ≈600–660°C) și maturizarea adulților. A doua generație s-a desfășurat în iulie–august (Σ≈1400–1500°C), iar larvele mature au intrat în diapauză în septembrie–octombrie (Σ≈1700°C).În concluzie, datele arată că variațiile climatice (înghețuri târzii, secete și veri excesiv de calde) au influențat atât fenologia pomilor, cât și sincronizarea stadiilor biologice ale dăunătorilor, evidențiind necesitatea unor strategii de combatere ecologică adaptate schimbărilor climatice.

Cuvinte cheie: dăunători pomicoli, fenologie, stadii biologice, schimbări climatice, dinamică populațională.

INTRODUCTION

The flight period of adults usually begins at the end of May and extends until September, and determining the biofix moment is essential for the application of phytosanitary treatments [Turcu *et al*., 2021].

The biological cycle of the species includes one to three generations per year, depending on the average temperature and the rainfall regime specific [Ungureanu *et all*, 2005]to the region of Moldova.

The distribution of the *Laspeyresia pomonella* L. species is high in the northeastern area of Romania, where climatic conditions favor the development of populations in apple and pear orchards [Emil *et al*., 2010, Mihaela Sumedrea et all.,2015].

Recent climate changes, characterized by higher temperatures and dry periods, have favored the expansion of the third generation [Grant *et al*.,2017; https://ipm.ucanr.edu/agriculture].

MATERIAL AND METHOD

In 2021, a moderate thermal deficit (−0.9°C compared to the multiannual average) and a normal amount of precipitation (563.6 mm) were recorded (Figure 1), with an uneven distribution and late cold episodes that negatively affected the phenology of fruit species.

By contrast, 2022 was warmer (+0.3°C compared to the multiannual average) and pronouncedly drier (379.0 mm, deficit of −182.6 mm), being marked by extreme climatic phenomena – late frosts, prolonged drought and high thermal maxima – which amplified the physiological stress of the plantations. The comparison of the phenological stages highlights a temporal gap of 4–12 days between 2021 and 2022, determined by contrasting climatic conditions. In 2022, the vegetative dormancy (BBCH 01–03) and bud development (BBCH 03–09) phases began on March 20 and 24, compared to March 16 and 20 in 2021, marking a slightly delayed start. However, bud break and leaf development (BBCH 10–19) occurred 12 days earlier (March 28 compared to April 9), indicating an acceleration of the vegetative rhythm. Inflorescence emergence (BBCH 51–59) and flowering (BBCH 60–69) phases occurred almost simultaneously in the two years (April 25–27 in 2021 and April 28–May 1 in 2022, respectively). Fruit development (BBCH 71–79) occurred on May 11 in 2022, compared to May 10 in 2021, and fruit maturity (BBCH 81–89) was reached 6 days earlier (August 24 compared to August 30). Similarly, vegetative dormancy (BBCH 91–99) began on October 2, 2022, three days earlier than in 2021.

In conclusion, 2022 presented a general acceleration of phenophases and a shortening of the vegetative cycle by 5–10 days, correlated with higher average temperatures (+0.3°C compared to the multiannual average) and a pronounced rainfall deficit (−182.6 mm), while 2021 was distinguished by a more balanced phenological dynamics, in line with the more moderate thermal regime (−0.9°C compared to normal).

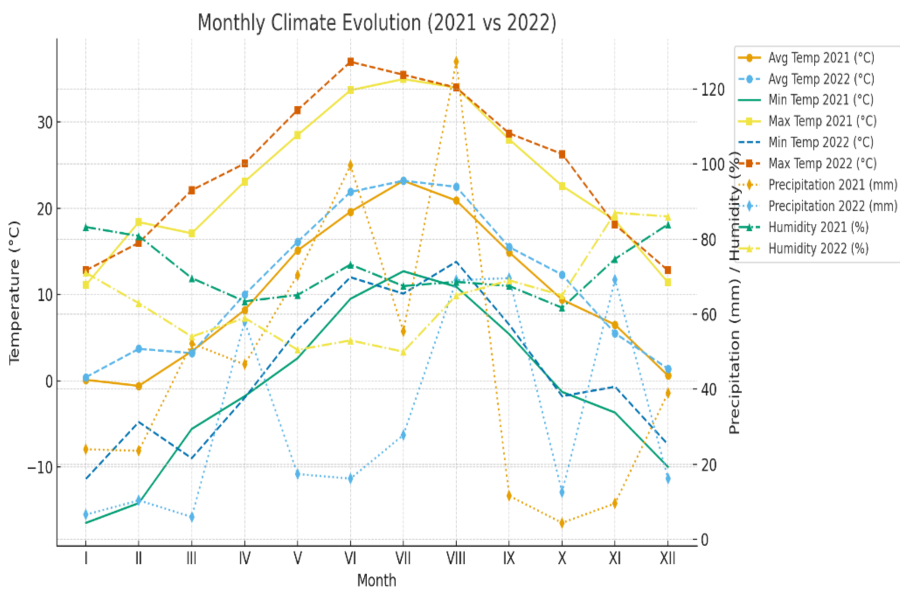

Fig. 1. The climatic situation of the area in 2021-2022

RESULTS AND DISCUSSIONS

Clear difference in the population development rate between 2021 and 2022, determined by seasonal thermal variations(figure 3) and the dynamics of degree-day accumulation ($\Sigma(t_n - t_0)$).

In both cases, the January–March period was characterized by larval diapause (L5 stage), without biological activity, because the average temperature was below the biological developmental threshold (9°C). Metabolic activity resumed in April, but with different intensities: in 2021 only 6°C were accumulated, compared to 36°C in 2022, which denotes an earlier and more intense start of activity in 2022, favored by a higher average monthly temperature (10.2°C compared to 8.2°C).

In May, thermal accumulations increased significantly, reaching 198.2°C in 2021 and 271.6°C in 2022, values that exceed the biological threshold of 80°C required for hatching of larvae from eggs. This difference of approximately 73°C determined an earlier hatching of the first generation larvae and an anticipated installation of the first active generation in 2022.

In June and July, cumulative values reached 956.3°C (2021) and 1097.8°C (2022), confirming the achievement of the 610°C threshold, corresponding to the emergence of adults (Figure 2) and the onset of flight II. Thus, in 2022, biological activity was accelerated by approximately 10–14 days, and the second generation cycle took place in a shorter interval.

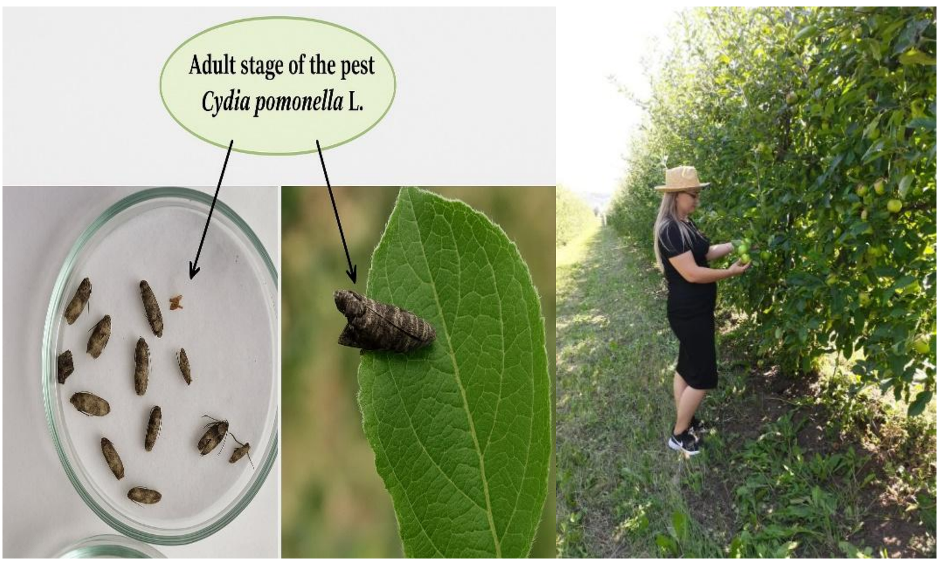

Fig. 2. Field aspects

In August, accumulations increased to 1326.2°C (2021) and 1516.3°C (2022), confirming an advancement of the second generation and a faster completion of the larval and pupal stages. In September, the biological threshold of ≈1.711°C, associated with the initiation of diapause, was reached only in 2022, while in 2021 it was reached only in October.

Finally, the cumulative values were 1506.6°C in 2021 and 1810.5°C in 2022, highlighting an annual thermal surplus of +304°C in favor of 2022. This surplus favored an intensification of biological activity, with the possibility of completing two complete biological generations and an earlier entry into larval diapause.

Month	Days	tn medium (°C)	Temperature (tn – 9, 0) × zile	Σ(tn-t0) cumulative	Estimated biological stage	Phenological observations	Month	Days	tn medium (°C)	Temperature (tn – 9, 0) × zile	Σ(tn-t0) cumulative	Estimated biological stage	Phenological observations
January-March	–	–	0	0	Diapause (L5) – larvae at rest	In the cocoon under the bark	January-March	–	–	0	0	Diapause (L5) – larvae at rest	In the cocoon under the bark
April	30	8.2	(0.2 × 30) = 6	6	Pre-pupation → pupa → adult emergence	At the end of the month; threshold for flight 1 confirmed	April	30	10.2	(1.2 × 30) = 36	36	Pre-pupation → pupa → adult emergence	At the end of the month; threshold for flight 1 confirmed
May	31	15.2	(6.2 × 31) = 192.2	198.2	Egg → hatching larva Gen I	Hatching after ~80 °C, now 198.2 °C → larvae in fruit	May	31	16.6	(7.6 × 31) = 235.6	271.6	Egg → hatching larva Gen I	Hatching after ~80 °C, now 198.2 °C → larvae in fruit
June	30	19.7	(10.7 × 30) = 321	519.2	Larva → pupa gen I	Mature larvae; adult emergence	June	30	21.9	(12.9 × 30) = 387	658.6	Larva → pupa gen I	Mature larvae; adult emergence
July	31	23.1	(14.1 × 31) = 437.1	956.3	Adult II → egg II → larva II	Intense activity; biofix stress II (~590 °C) has been reached	July	31	23.20	(14.2 × 31) = 439.2	1 097.8	Adult II → egg II → larva II	Intense activity; biofix stress II (~590 °C) has been reached
August	31	20.9	(11.9 × 31) = 369.9	1 326.2	Larva II → pupa II	Advanced Generation II approx. in 1400-1600 °C	August	31	22.5	(13.5 × 31) = 418.5	1 516.3	Larvă II → pupa II	Advanced Generation II approx. in 1400-1600 °C
September	30	14.6	(5.6 × 30) = 168	1 494.2	Mature II/III larva → seeking refuge	Mature larvae – approaching diapause (~1711 °C)	September	30	15.5	(6.5 × 30) = 195	1 711.3	Mature II/III larva → seeking refuge	Mature larvae – approaching diapause (~1711 °C)
October	31	9.4	(0.4 × 31) = 12.4	1 506.6	Larval diapause L5	Enters rest; threshold confirmed (>1711 °C)	October	31	12.2	(3.2 × 31) = 99.2	1 810.5	Larval diapause L5	Enters rest; threshold confirmed (>1711 °C)
November–December	–	–	0	1 506.6	Larval diapause L5	No biological activity until next spring	November–December	–	–	0	1 810.5	Larval diapause L5	No biological activity until next spring

Fig. 3. Development stages of the *Laspeyresia pomonella* L. species in 2021-2022

CONCLUSIONS

The species *Laspeyresia pomonella* L. shows high ecological plasticity, adapting quickly to climatic variations in the northeastern area of Romania. Its biological activity is influenced by temperature and humidity, factors that determine the number of annual generations.

Pheromonal monitoring is an essential method for integrated pest management, and the correct application of treatments, combined with biological control measures, can keep populations below the economic damage threshold.

The results support the need for the continuous application of the principles of integrated control and the adaptation of phenological models to the current climatic conditions in northeastern Romania.

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OBSERVATIONS ON THE STRUCTURE AND DYNAMICS OF ARTHROPOD SPECIES COLLECTED FROM PEA CROPS

OBSERVAȚII PRIVIND STRUCTURA ȘI DINAMICA SPECIILOR DE ARTROPODE COLECTATE DIN CULTURILE DE MAZĂRE

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Abstract.
The present study aimed to evaluate the community structure of arthropods in a pea crop (Pisum sativum) located in Răducăneni commune, Iași County, over two consecutive growing seasons (2023 and 2024). Biological material was collected using Barber pitfall traps, a passive and efficient technique for monitoring ground-dwelling fauna. Samples were collected at regular intervals of 12–16 days, and the captured material was subsequently preserved in 40% ethanol and taxonomically identified based on specialized literature and online resources. To characterize community diversity, the Shannon, Simpson, and Pielou's Evenness indices were calculated. The results revealed significant differences between the two years, reflecting the influence of climatic conditions on faunal dynamics. In 2023, the community was dominated by Coleoptera (1,048 individuals), followed by Hymenoptera and Orthoptera, indicating a diversified and relatively stable structure. In 2024, the total abundance of Coleoptera decreased significantly (702 individuals), while Diptera showed a marked increase (425 individuals), becoming the second most abundant group. This shift reflects the differential response of taxonomic groups to the warmer and drier conditions observed in 2024, which favored water-tolerant and generalist species. Analysis of diversity indices indicated a reduction in both diversity and evenness in 2024, associated with a more uneven distribution of abundances. The study highlights the sensitivity of ground-dwelling arthropod communities to interannual climatic variability and underscores the importance of continuous monitoring for understanding ecological dynamics in agroecosystems
Key words: pea crop, dwelling fauna, biodiversity indices.

Rezumat.
În lucrarea de față am avut ca scop evaluarea structurii comunității de artropode dintr-o cultură de mazăre (Pisum sativum) situată în comuna

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Răducăneni, județul Iași, pe parcursul a două sezoane consecutive de creștere (2023 și 2024). Materialul biologic a fost colectat folosind capcane Barber, o tehnică pasivă și eficientă pentru monitorizarea faunei terestre. Probele au fost colectate la intervale regulate de 12-16 zile, iar materialul capturat a fost ulterior conservat în etanol 40% și identificat taxonomic pe baza literaturii de specialitate și a resurselor online. Pentru a caracteriza diversitatea comunității, au fost calculați indicii de uniformitate Shannon, Simpson și Pielou. Rezultatele au relevat diferențe semnificative între cei doi ani, reflectând influența condițiilor climatice asupra dinamicii faunistice. În 2023, comunitatea a fost dominată de Coleoptera (1.048 de indivizi), urmate de Hymenoptera și Orthoptera, indicând o structură diversificată și relativ stabilă. În 2024, abundența totală de Coleoptera a scăzut semnificativ (702 indivizi), în timp ce Diptera a înregistrat o creștere marcantă (425 indivizi), devenind al doilea grup ca abundență. Această schimbare reflectă răspunsul diferențial al grupurilor taxonomice la condițiile mai calde și mai uscate observate în 2024, care au favorizat speciile tolerante la apă și generaliste. Analiza indicilor de diversitate a indicat o reducere atât a diversității, cât și a uniformității în 2024, asociată cu o distribuție mai inegală a abundențelor. Studiul evidențiază sensibilitatea comunităților de artropode terestre la variabilitatea climatică interanuală și subliniază importanța monitorizării continue pentru înțelegerea dinamicii ecologice în agroecosisteme.

Cuvinte cheie: cultura de mazăre, indici de biodiversitate, fauna terestră.

INTRODUCTION

Arthropods represent one of the most important and diverse groups of organisms in agroecosystems, being essential for maintaining biological balance and ensuring the optimal functioning of agricultural systems. In legume crops, such as pea (*Pisum sativum*), these communities include both entomophagous species — natural predators of pests or pollinators — and phytophagous species capable of causing significant yield losses. Therefore, the analysis of arthropod population structure and dynamics constitutes a fundamental tool for understanding ecological interactions in agroecosystems and for implementing integrated pest management strategies [Southwood and Henderson, 2000; Magurran, 2004].

Pea cultivation holds major agronomic importance in Romania, being used both for human consumption and as a fodder source. Due to its biological nitrogen-fixing capacity, pea contributes to the development of favorable soil structure and creates a suitable habitat for various arthropod groups associated with the soil and vegetation. *Coleoptera, Hemiptera, Diptera, Hymenoptera*, and other present orders provide valuable insights into the state of the agroecosystem and its resilience to climatic pressures [McGeoch, 1998].

Climate change, manifested through increased frequency of drought events, alternation of extreme temperature periods, and changes in precipitation patterns, profoundly affects the dynamics and distribution of arthropods in agricultural environments. Hygrophilous or mesophilous species may experience population declines during dry years, while thermophilous or opportunistic species tend to expand their activity and abundance [Wagner, 2000; Begon *et al*., 2006]. In this context, monitoring arthropod communities becomes crucial for assessing the adaptive capacity of agroecosystems.

The present study aims to analyze the diversity and abundance of arthropods in a pea crop located in Răducăneni commune (Iași) during the 2023 and 2024 growing seasons, characterized by contrasting climatic conditions. The use of Barber pitfall traps, an internationally recognized method for efficiently sampling ground-dwelling fauna [Greenslade, 1964; Andersen, 1995], allows the evaluation of population fluctuations and their interpretation in relation to temperature and humidity variations specific to each year. The obtained results contribute to a deeper understanding of the response of entomological communities to abiotic stress and provide a valuable data basis for the sustainable management of agricultural ecosystems.

MATERIAL AND METHOD

The study on the diversity of arthropods associated with pea (*Pisum sativum*) crops was conducted during the 2023–2024 period in Răducăneni commune, Iași County, which is characterized by a temperate-continental climate with significant annual variations in temperature and precipitation. These climatic fluctuations directly influence the phenology and population dynamics of arthropods, as widely documented in the literature [Krebs, 1999; Begon *et al*., 2006].

Arthropods were collected using Barber pitfall traps, a standardized method extensively used in ecological studies of ground-dwelling arthropods [Greenslade, 1964; Thiele, 1977]. These traps operate by passively intercepting walking individuals and are particularly effective for Carabidae, Staphylinidae, and other epigeic groups [Gâdei and Popescu, 2012].

The traps were constructed from cylindrical plastic containers (7–9 cm in diameter, 12 cm in depth) filled with a 2.5% sodium chloride (NaCl) solution used as a killing agent. This solution preserves the morphological integrity of the exoskeleton, allowing safe handling of specimens without structural damage [Gâdei and Dragomir, 2025].

Traps were arranged in uniform transects within the pea crop, spaced 10–15 meters apart to ensure adequate representation of microhabitats. Throughout the growing season, traps were continuously active and checked at 12–16 day intervals, according to standard population ecology protocols [Southwood and Henderson, 2000].

The date of each collection and the corresponding trap number were meticulously recorded to allow correlation of faunal data with climatic variables.

Collected specimens were transferred to labeled containers and preserved in 40% ethanol, a method suitable for maintaining morphological integrity and preventing degradation under variable temperature conditions [Gâdei and Dragomir, 2025].

The arthropods were identified in the laboratory using a stereomicroscope and recognized taxonomic keys for Romanian fauna, complemented by updated digital resources [Triplehorn and Johnson, 2005; Magurran, 2004]. Identification was performed to the species level whenever possible; in cases where specimen integrity was compromised, identification was limited to the genus level.

Data Processing — Ecological Indices

To assess the diversity of arthropod communities, three major ecological indices widely used in biodiversity studies were calculated [Magurran, 2004]: Shannon–Wiener index (H’), Simpson index (1–D), and Pielou’s Evenness (J’).

Shannon–Wiener Index (H’):

$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$$

This index quantifies overall diversity, combining species richness and evenness.

Simpson Index (1–D):

$$D = \frac{\sum n\ (n\ -1)}{N(N-1)}$$

D- represents the probability that two randomly selected individuals belong to different species.

Evenness (J’): J′=In(S)H′ - assesses the degree of uniformity in the distribution of abundances among species.

The calculation methodology follows standard recommendations in ecological literature [Krebs, 1999; Magurran, 2004].

RESULTS AND DISCUSSIONS

Comparison of arthropod species abundance collected in 2023 and 2024 reveals significant changes in the community structure of the pea crop, closely associated with notable climatic variations during this period [Table 1]. The year 2024 was characterized nationwide by record high temperatures and pronounced soil drought, directly affecting the availability of microhabitats and the dynamics of trophic resources. These climatic conditions led, in particular, to a marked reduction in species sensitive to dehydration and high temperatures, as reflected by sharp declines in their abundance.

A significant number of species present in 2023 recorded zero captures in 2024. Among these were: *Hippodamia variegata, Hippodamia variegeta, Opatrum sabulosum, Anthicus floralis, Anthicus humeralis, Anisodactylus binotatus, Aphthona euphorbiae*, and *Coccinella 11-punctata*. All these species are affected by changes in soil moisture and extreme temperatures, either through impacts on larval stages or by reducing the availability of food. Their temporary disappearance suggests a high sensitivity to abiotic stress, indicating that 2024 exerted strong pressure on these populations.

In addition to these disappearances, other groups exhibited moderate but significant declines. Species such as *Coccinella septempunctata*, *Dermestes* *laniarius*, ants, *Heteroptera, and Hymenoptera* showed lower abundances in 2024 compared to 2023. Although these are generalist species more resilient to temperature fluctuations, their reduction suggests a cumulative ecological pressure generated by prolonged drought and limited trophic resources. For coccinellids, the decline in aphid populations during periods of extreme heat may have been an important factor, while for *Hymenoptera* and ants, the degradation of soil microhabitats could have reduced colony efficiency.

Interestingly, certain groups showed significant increases in 2024, indicating a high tolerance to extreme climatic conditions. These included *Diptera* (52 → 425), *Crypticus quisquilius* (1 → 23), *Orthoptera* (111 → 136), as well as species such as *Chromatoiulus unilineatus, Pedinus femoralis, Podonta nigrita, Tipula sp., Syrphidae,* and *Otiorhynchus sulcatus*, which appeared in substantial numbers only in 2024. These increases can be explained by the ecological advantage of opportunistic species that benefit from dry microhabitats, reduced competition, and accelerated developmental cycles under high temperatures. Dipterans, for example, develop rapidly in environments with decomposing organic matter, and arid conditions may favor the accumulation of such resources.

Overall, the data indicate a clear reorganization of the arthropod community between the two study years. While mesophilous species experienced drastic declines and some disappeared entirely from the samples, thermophilous or opportunistic species showed significant increases, reflecting a differential response to climatic changes. These results suggest that drought and elevated temperatures in 2024 were the main factors shaping the arthropod community structure in the pea crop, leading both to losses among sensitive species and proliferation of those tolerant to abiotic stress.

Table 1

Structure, dynamics, and abundance of arthropod species collected in the pea (Pisum sativum) crop (Răducăneni, Iași, 2023–2024)

No.	Name of species/taxon	2023	2024	Total
1.	Acarieni	3	5	8
2.	*Acupalpus elegans*	1	1	2
3.	*Adalia bipunctata*	0	3	3
4.	Afide	0	2	2
5.	*Aleochara laevigata*	0	1	1
6.	*Aleochara moereus*	0	1	1
7.	*Amara aenea*	2	2	4
8.	*Amara apricaria*	2	0	2
9.	*Amara crenata*	1	0	1
10.	*Amara familiaris*	1	0	1
11.	*Anisodactylus binotatus*	6	0	6
12.	*Anisodactylus signatus*	2	0	2
13.	*Anthicus floralis*	19	0	19
14.	*Anthicus humeralis*	10	0	10
15.	*Aphodius granarius*	1	0	1

16.	*Aphthona euphorbiae*	7	0	7
17.	*Baris artemisiae*	1	0	1
18.	*Bothynoderes punctiventris*	14	3	17
19.	*Brachynus crepitans*	3	0	3
20.	*Bruchus pisorum*	2	1	3
21.	*Cantharis fusca*	1	0	1
22.	*Cantharis nigricans*	1	0	1
23.	*Carabus coriaceus*	1	0	1
24.	*Ceutorhynchus macula alba*	2	0	2
25.	*Chromatoiulus unilineatus*	0	7	7
26.	*Chrysomela menthastri*	0	1	1
27.	Cicade	0	1	1
28.	*Coccidula scutellata*	0	1	1
29.	*Coccinella 11-punctata*	12	0	12
30.	*Coccinella septempunctata*	225	201	426
31.	*Corymbites affinis*	0	2	2
32.	*Crypticus quisquilius*	1	23	24
33.	*Dermestes laniarius*	263	137	400
34.	Diptere	52	425	477
35.	*Elater elongatulus*	0	1	1
36.	*Elater nigerrimus*	3	0	3
37.	Furnici	260	131	391
38.	*Harpalus calceatus*	5	1	6
39.	*Harpalus distinguendus*	19	7	26
40.	*Harpalus tardus*	9	4	13
41.	Heteroptere	70	46	116
42.	Himenoptere	86	40	126
43.	*Hippodamia variegata*	68	0	68
44.	*Hippodamia variegeta*	20	0	20
45.	Lepidoptere	68	4	72
46.	*Lixus cardui*	1	0	1
47.	*Longitarsus anchusae*	2	0	2
48.	*Longitarsus suturalis*	1	0	1
49.	*Malachius bipustulatus*	1	0	1
50.	*Mecinus janthinus*	0	1	1
51.	*Meligethes aeneus*	1	0	1
52.	*Metabletus foveatus*	0	1	1
53.	*Metabletus truncatellus*	2	0	2
54.	Neuroptere	1	0	1
55.	*Notaris maerkeli*	1	0	1
56.	*Opatrum sabulosum*	57	0	57
57.	*Ophonus azureus*	3	0	3
58.	*Ophonus rupicola*	1	0	1
59.	Ortoptere	111	136	247
60.	*Otiorhynchus ovatus*	1	0	1
61.	*Otiorhynchus pinastri*	1	0	1

62.	*Otiorhynchus raucus*	5	0	5
63.	*Otiorhynchus sulcatus*	0	5	5
64.	*Oxythyrea funesta*	10	0	10
65.	*Pedinus femoralis*	0	26	26
66.	*Pentodon idiota*	0	3	3
67.	*Phyllobius piri*	5	0	5
68.	*Phyllobius pyri*	1	0	1
69.	*Pleurophorus caesus*	1	0	1
70.	*Podagrica malvae*	8	13	21
71.	*Podonta nigrita*	0	14	14
72.	*Polydrusus confluens*	0	1	1
73.	*Pterostichus vernalis*	1	0	1
74.	*Rhinomias forticornis*	1	0	1
75.	*Rhizophagus picipes*	1	0	1
76.	*Sitona lineatus*	19	25	44
77.	*Soronia punctatissima*	0	1	1
78.	*Tanymecus dilaticolis*	0	1	1
79.	*Valgus hemipterus*	1	0	1
80.	*Myzus persicae*	0	2	2
81.	*Tetranychus urticae*	0	2	2
82.	Syrphidae	0	8	8
83.	Liriomyza sp.	0	1	1
84.	*Tipula* sp.	0	5	5
	Total	1478	1296	2774

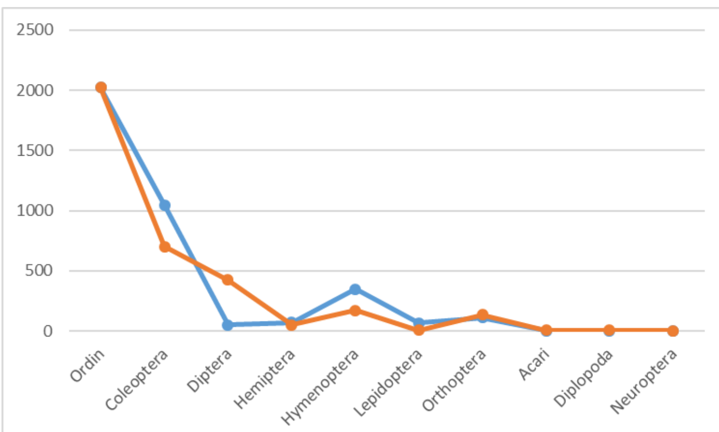

Fig. 1. Comparative abundance of arthropod orders in the pea (*Pisum sativum*) crop in 2023 (blue) and 2024 (orange), Răducăneni, Iași

The arthropod community structure showed marked differences [Fig. 1] between the two sampling seasons. In 2023, *Coleoptera* dominated the community (1,048 individuals), followed by Hymenoptera and *Orthoptera,* reflecting a complex structure and a relatively stable ecosystem. In 2024, Coleoptera abundance decreased substantially (702 individuals), while *Diptera* exhibited a sharp increase (425 individuals), becoming the second most abundant group in the total captures. This partial reversal of taxonomic dominance suggests a direct ecological response to the warmer and drier conditions in 2024, which favored generalist and water-tolerant groups (*Diptera*) at the expense of ground-dwelling *Coleoptera* sensitive to desiccation.

The analysis of species diversity, quantified using the Shannon, Simpson, and Evenness indices, reveals significant differences between the arthropod communities collected in 2023 and 2024. In 2023, the Shannon index (H' = 2.38) indicates a relatively diverse community, characterized by a more balanced distribution of abundance among species. This is further supported by the Simpson index (1–D = 0.87), reflecting a low probability that two randomly selected individuals belong to the same species, suggesting a complex community structure well-represented across different ecological niches. Additionally, the Evenness value (J' = 0.61) confirms a moderately uniform distribution of individuals among identified species, with a relatively low dominance of highly abundant species.

In contrast, 2024 exhibits a noticeable decline in diversity, with all three ecological indices decreasing. The Shannon index (H' = 2.11) and Simpson index (1–D = 0.82) indicate a reduction in both active species richness and abundance uniformity, suggesting a more unbalanced community dominated by a limited number of generalist species. Evenness (J' = 0.56) also reflects increased imbalance in community structure, with larger differences between dominant and rare species.

These interannual variations can be associated with the distinct climatic conditions of the two years. The year 2023 was characterized by favorable conditions for soil fauna and predatory insects, with well-distributed precipitation and moderate temperatures, supporting the maintenance of high diversity. In contrast, 2024 experienced high temperatures and prolonged periods of water deficit, leading to a decrease in abundance for several sensitive groups (e.g., *Carabidae, Staphylinidae*), while other tolerant–generalist groups (e.g., *Diptera*, *Coccinellidae*) became more dominant.

Overall, the decrease in diversity and evenness indices in 2024 reflects a simplification of the arthropod community and a clear ecological response to climatic stress, confirming the sensitivity of ground-dwelling fauna to temperature and moisture variations in agroecosystems.

CONCLUSIONS

The study of arthropod communities associated with pea (*Pisum sativum*) crops in Răducăneni (Iași), conducted over two agricultural years with contrasting climatic conditions (2023 and 2024), highlights significant structural changes in the composition and abundance of ground-dwelling fauna.

First, the comparison between the two seasons shows that 2023 was characterized by higher overall abundance, with warmer and drier conditions favoring species adapted to arid, pedestral environments and elevated temperatures, such *as Coleoptera* from the families *Dermestidae, Tenebrionidae, Carabidae,* and *Coccinellidae.* Species such as *Dermestes laniarius, Opatrum sabulosum, Coccinella septempunctata,* and *Hippodamia variegata* recorded notably higher abundances in 2023, confirming the general trend of thermophilous species developing more intensively under water-deficit conditions.

In contrast, 2024, characterized by more frequent precipitation and higher soil moisture, favored the increased abundance of groups dependent on moist microclimates, including *Diptera, Myriapoda, Opiliones*, and certain species of *Curculionidae* and *Staphylinidae.* Notable differences, such as the dramatic increase of Diptera from 52 individuals in 2023 to 425 in 2024, and the appearance of groups such as *Chromatoiulus unilineatus and Otiorhynchus sulcatus*, are consistent with literature reporting the direct relationship between soil moisture and the activity of detritivorous or saprophagous fauna.

At the community level, diversity (Shannon), dominance (Simpson), and evenness (Pielou's Evenness) indices indicate that community structure was strongly influenced by climatic dynamics. In 2023, a few abundant species dominated, whereas in 2024, although total abundance was lower, there was a more balanced distribution of individuals among taxonomic groups. This pattern reflects how abiotic stress (soil drought) can favor the proliferation of opportunistic species, thereby reducing community diversity and evenness.

The ecological roles of the identified arthropods are also relevant to agroecosystem functioning. Natural predators (*Coccinellidae, Carabidae*), detritivores (*Dermestidae,* saprophagous *Diptera*), pollinators, and phytophagous species can influence both the resilience of the pea crop and the overall stability of the soil. The simultaneous presence of these functional groups indicates a functioning agroecosystem that is nonetheless sensitive to climatic fluctuations.

In conclusion, the comparative analysis of the two years demonstrates that climatic factors are key determinants of arthropod community dynamics, influencing both abundance and taxonomic composition. These results emphasize the importance of continuous monitoring of fauna associated with agricultural crops, particularly under climate change, and can contribute to optimizing integrated pest management strategies adapted to local climatic conditions.

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OBSERVATIONS ON EPIGEIC ARTHROPOD SPECIES PRESENT IN CERTAIN ORCHARD AND FOREST PLANTATIONS

OBSERVAȚII PRIVIND SPECIILE DE ARTROPODE EPIGEE EXISTENTE ÎN UNELE PLANTAȚII POMICOLE ȘI SILVICE

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Abstract.
The observations were carried out over a single year, 2025, in an apple orchard and a forest plantation containing both coniferous and deciduous species.Several types of traps were used to collect arthropods: soil traps of the Barber type, Decis Traps, yellow sticky traps, etc. Direct observations of the trees were also performed. Collection of material and trap readings were conducted throughout the vegetation period at intervals generally ranging between 14–17 days. The exact dates of collection and readings were: 16.05.2025, 06.06.2025, 26.06.2025, 16.07.2025, 01.08.2025, 22.08.2025, 10.09.2025, and 24.09.2025. The species with the highest abundance and most frequently collected were: Pterostichus (Poecilus) cupreus, Silpha carinata, Gryllotalpa gryllotalpa, Armadillidium vulgare, Carabus coriaceus, Geotrupes vernalis, Necrophorus vespillo, Staphylinus caesareus, Agriotes ustulatus, Oiceoptoma thoracicum, Harpalus tardus, Aptinus bombarda, Dermestes laniarius, Carabus intricatus.
Key words: entomofauna, forest, apple.

Rezumat.
Observațiile au fost făcute pe durata unui singur an, 2025, într-o plantație pomicolă de măr și într-o plantație silvică cu specii de rășinoase și foioase. Pentru colectarea artropodelor au fost utilizate mai multe tipuri de capcane: capcane de sol tip Barber, capcane Decis Trap, capcane galbene lipicioase etc. De asemenea au fost făcute observații directe asupra pomilor și a arborilor. Colectarea materialului și citirile la capcane au fost făcute pe durata perioadei de vegetație la intervale cuprinse în general între 14-17 zile. Datele exacte ale colectarilor si citirilor au fost urmatoarele:16.05.2025, 06.06.2025, 26.06.2025, 16.07.2025, 01.08.2025, 22.08.2025, 10.09.2025, 24.09.2025.

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Speciile cu abundeța cea mai mare si cel mai frecvent colectate au fost: Ptreostichus (Poecelus) cupreus, Silpha carinata, Gryllotalpa gryllotalpa, Armadillidium vulgare, Carabus coriaceus, Geotrupes vernalis, Necrophorus vespillo, Staphylinus caesareus, Agriotes ustulatus, Oiceoptoma thoracicum, Harpalus tardus, Aptinus bombarda, Dermestes laniarius, Carabus intricatus
Cuvinte cheie: entomofauna, pădure, măr.

INTRODUCTION

Entomofauna represents a key component of both forest ecosystems and apple orchards, where it contributes fundamentally to insect population dynamics, pollination processes, trophic interactions, and overall plant health. Investigating the diversity and structure of arthropod communities in these habitats provides essential insights into ecological balance and the influence of agricultural practices on biodiversity [Bacal and Mihailov, 2020].

In natural forests, insect assemblages are shaped by factors such as tree species composition, microclimate conditions, humidity, temperature fluctuations, and the presence of invasive species. By contrast, apple orchards function as anthropogenically managed agroecosystems, where phytosanitary treatments, monoculture practices, and soil management can significantly modify entomofaunal structure and abundance [Petrescu, 2008].

The forest ecosystems of the studied region are organized into two major altitudinal layers: coniferous and broadleaf forests. The coniferous belt, situated between 1300 and 1700 m, is more extensively developed on northern slopes and is dominated by pure Norway spruce (*Picea abies*) stands. Toward river sources, the coniferous belt narrows into a thin band near the upper treeline, where silver fir (*Abies alba*) and, more rarely, Swiss pine (*Pinus cembra*) may occur.

The broadleaf forest belt includes mixed stands of beech, spruce, fir, and sessile oak. Mixed beech-conifer formations are typically found between 900 and 1400 m and are composed of European beech (*Fagus sylvatica*), Norway spruce (*Picea abies*), silver fir (*Abies alba*), mountain maple (*Acer pseudoplatanus*), mountain elm (*Ulmus glabra*), and rowan (*Sorbus aucuparia*). Beech forests largely surround the mountain ranges on the northern and western slopes, occupying areas between 500 and 1050 m, and locally extending up to 1500 m along valley systems. At the lower altitudinal limit, beech frequently occurs in association with sessile oak (*Quercus petraea*) [Bârdan, 2023].

Apple (*Malus domestica*) is among the most widely cultivated fruit species globally, valued for its high nutritional content—rich in vitamins, antioxidants, and fiber. Beyond its economic relevance for fruit production and the food industry, apple cultivation holds ecological importance by supporting pollinators and sustaing beneficial entomofauna within orchard ecosystems [Malschi, 2006].

MATERIAL AND METHOD

The study was conducted in two distinct ecosystems—a natural mixed forest and an intensive apple orchard—both located on the property of the Nechit Monastery in Neamț County, which ensured comparable climatic and soil conditions while allowing clear differentiation between the two habitats.

Epigeic arthropods were collected using Barber-type pitfall traps (Figure 1), following the method described by Andron [2019]. Each trap consisted of an 800 ml plastic container inserted flush with the soil surface to allow unrestricted access to ground-dwelling species. The traps were filled with a 2.5% NaCl solution, serving simultaneously as a preservative and a deterrent for scavengers. To prevent the entry of rainwater and debris, each trap was covered with a metal lid supported by two small stands, which ensured adequate protection without obstructing arthropod movement.

Between six and twelve traps were installed in each ecosystem, in accordance with the recommendations of Talmaciu [2019], who demonstrated that at least five traps are sufficient for capturing dominant and rare species, while installing more than twelve may significantly alter abundance ratios.

Fig. 1. Installation of traps in the experimental plots

The traps were arranged either linearly, at equal distances, or uniformly distributed across the study area, in order to account for habitat heterogeneity and to capture a representative sample of the epigeic fauna. Sampling took place at intervals of seven to ten days from April to September, corresponding to the main period of activity for most ground-dwelling arthropods.

During each sampling session, the trap contents were transferred into lidded plastic containers, gently cleaned of soil particles, and preserved in diluted medicinal alcohol. Each container was labeled with the date, trap number, and habitat type. In the laboratory, the samples were washed under a gentle water stream to remove plant debris and fine particles. Specimens were sorted under a stereomicroscope and subsequently identified to species level using standard entomological keys and specialized reference literature.

RESULTS AND DISCUSSIONS

The epigeic fauna collected in the Nechit station differs between the forest and the apple orchard, reflecting the characteristics of each ecosystem. In the forest, species diversity is greater, including beetles, millipedes, and other arthropods adapted to the forest environment. In contrast, the orchard is dominated by ants, spiders, and other invertebrates influenced by agricultural practices and soil structure. These differences highlight the impact of the habitat on the composition of the epigeic fauna.

Throughout the year 2024, from May to September, data collected from six sampling events of epigeic arthropod fauna in both the forest plot and the apple orchard provided the basis for determining the structure, dynamics, and ecological impact of the fauna.

In Table 1 are presents the ecological characteristics of each arthropod species recorded during the sampling period, including abundance, constancy, dominance, and ecological weight (W). A total of 412 individuals from 37 species were analyzed.

Table 1

The situation regarding the calculation of ecological factors for each species during the period in forest area from Nechit

No.	Name of species	No. of traps	Abun-dance	Constancy		Dominance		W	
				%	***	%	***	%	***
1.	*Geotrupes vernalis*	31	98	64,6	C3	23,8	D3	15,375	W5
2.	*Phalangium opilo*	32	96	66,7	C3	23,3	D5	15,541	W5
3.	*Armadilidium vulgare*	9	36	18,7	C1	8,7	D4	1,627	W3
4.	*Cychrus caraoides*	1	30	2,1	C1	7,3	D1	0,153	W2
5.	*Necrophorus vespillo*	10	30	20,8	C1	7,3	D4	1,518	W3
6.	*Panorpa comunnis*	9	16	18,7	C1	3,9	D3	0,729	W2
7.	*Chromatoulus unilineatus*	12	15	25,0	C1	3,6	D3	0,900	W2
8.	*Messor structor*	9	14	18,7	C1	3,4	D1	0,636	W2
9.	*Aptinus bombarda*	8	13	16,7	C1	3,1	D3	0,518	W2
10.	*Atomaria turgida*	1	9	2,1	C1	2,2	D3	0,046	W1
11.	*Staphilinus olens*	5	7	10,4	C1	1,7	D2	0,176	W2
12.	*Dolycoris baccarum*	5	7	10,4	C1	1,7	D2	0,176	W2
13.	*Carabus coriaceus*	4	6	8,3	C1	1,5	D2	0,124	W2
14.	*Dadobia immersa*	1	5	2,1	C1	1,2	D2	0,025	W1
15.	*Poecilus cupreus*	2	4	4,2	C1	1,0	D1	0,042	W1
16.	*Pterostichus niger*	4	4	8,3	C1	1,0	D1	0,083	W1
17.	*Carabus convexus*	1	3	2,1	C1	0,7	D1	0,015	W1
18.	*Ectobius lapponicus*	2	3	4,2	C1	0,7	D4	0,029	W1
19.	*Dociostaurus marocanus*	3	3	6,2	C1	0,7	D1	0,043	W1
20.	*Cychrus attenuatus*	3	3	6,2	C1	0,7	D1	0,043	W1
21.	*Quedius unicolor*	2	3	4,2	C1	0,7	D1	0,029	W1
22.	*Carabus hungaricus*	2	2	4,2	C1	0,5	D1	0,021	W1
23.	*Petrobius brevistylis*	2	2	4,2	C1	0,5	D1	0,021	W1
24.	*Oiceoptoma thoracica*	1	2	2,1	C1	0,5	D1	0,010	W1
25.	*Silpha carinata*	2	2	4,2	C1	0,5	D1	0,021	W1
26.	*Pterostichus vulgaris*	1	2	2,1	C1	0,5	D1	0,010	W1
27.	*Ceruchus chrysomelinus*	1	1	2,1	C1	0,2	D1	0,004	W1
28.	*Hister sinuatus*	1	1	2,1	C1	0,2	D5	0,004	W1

29.	*Poecilus cupreus*	1	1	2,1	C1	0,2	D1	0,004	W1
30.	*Brachynus crepitans*	1	1	2,1	C1	0,2	D1	0,004	W1
31.	*Cychrus semigranosus*	1	1	2,1	C1	0,2	D1	0,004	W1
32.	*Pterostichus cylindricus*	1	1	2,1	C1	0,2	D1	0,004	W1
33.	*Staphylinus caesareus*	1	1	2,1	C1	0,2	D1	0,004	W1
34.	*Meligethes aeneus*	1	1	2,1	C1	0,2	D1	0,004	W1
35.	*Psyllobora vigintiduopunctata*	1	1	2,1	C1	0,2	D1	0,004	W1
36.	*Carabus intricatus*	1	1	2,1	C1	0,2	D1	0,004	W1
37.	*Leistus rufomarginatus*	1	1	2,1	C1	0,2	D1	0,004	W1
Total 37 species		48	412						

The most abundant and ecologically significant species were *Geotrupes vernalis* and *Phalangium opilo*, both exhibiting high constancy (C3), high dominance (D3–D5), and the maximum ecological weight (W5), indicating their major role in the soil arthropod community. Species such as *Armadilidium vulgare* and *Necrophorus vespillo* were moderately abundant, with intermediate constancy (C1) and dominance values (D4), reflecting their secondary contribution to community structure.

The majority of species (e.g., *Carabus convexus, Leistus rufomarginatus, Meligethes aeneus*) were rare, with low abundance (<5 individuals), low constancy (C1), and low ecological weight (W1), suggesting sporadic or specialized occurrences within the habitat. Dominance values varied across species, reflecting their relative influence in the community, with only a few species achieving high dominance (D4–D5).

A total of 3,247 individuals representing 82 arthropod species were collected from soil traps in apple orchards in Nechit. The abundance and distribution of species were highly uneven, with a few taxa dominating the community (Table 2).

The ecological characteristics of arthropod species in apple orchards from Nechit were evaluated using abundance, constancy, dominance, and ecological weight (W). A total of 3,247 individuals from 82 species were analyzed (table 4).

The community was strongly dominated by *Armadilidium vulgare* (1,762 individuals, 84.4% constancy, D5 dominance, W5) and *Phalangium opilio* (520 individuals, 90.6% constancy, D5 dominance, W5), indicating their major ecological influence in the orchard habitat. *Pterostichus cupreus* (485 individuals, C3, D5, W4) was also highly abundant and contributed significantly to ecosystem processes. Several moderately abundant species, including Messor structor, *Lygaeus aequestris*, and *Onthophagus ovatus*, exhibited lower ecological weights (W1–W2), reflecting a secondary role in the community.

The majority of species (over 60%) were represented by only 1–2 individuals, with minimal constancy and dominance (C1, D1, W1), highlighting the presence of rare or sporadic taxa. These rare species contribute to overall biodiversity but have limited impact on ecological functions.

Overall, the data reveal a highly skewed community structure, with a few dominant species shaping the functional dynamics of the orchard soil ecosystem, while a long tail of rare species maintains species richness and potential ecological resilience.

Table 2

The situation regarding the calculation of ecological factors for each species during the period in apple orchards from Nechit

No.	Name of species	No. of traps	Abundance	Constancy		Dominance		W	
				%	***	%	***	%	***
1.	*Armadilidium vulgare*	81	1762	84,4	C4	54,3	D5	45,829	W5
2.	*Phalangium opilio*	87	520	90,6	C4	16,0	D5	14,496	W5
3.	*Pterostichus cupreus*	53	485	55,2	C3	14,9	D5	8,224	W4
4.	*Messor structor*	9	131	9,3	C1	4,0	D3	0,372	W2
5.	*Lygaeus aequestris*	12	57	12,5	C1	1,7	D2	0,212	W2
6.	*Onthophagus ovatus*	11	29	11,5	C1	0,9	D1	0,103	W2
7.	*Dermestes laniarius*	12	25	12,5	C1	0,8	D1	0,100	W1
8.	*Pyrrhocoris apterus*	15	20	15,6	C1	0,6	D1	0,094	W1
9.	*Agriotes ustulatus*	10	16	10,4	C1	0,5	D1	0,052	W1
10.	*Chromatiulus unilineatus*	14	15	14,6	C1	0,5	D1	0,073	W1
11.	*Staphylinus caesareus*	7	15	7,2	C1	0,5	D1	0,036	W1
12.	*Panorpa communis*	10	14	10,4	C1	0,4	D1	0,042	W1
13.	*Pseudophonus pubescens*	9	10	9,3	C1	0,3	D1	0,028	W1
14.	*Necrophorus vespillo*	7	9	7,2	C1	0,3	D1	0,022	W1
15.	*Acylophorus glaberimus*	5	8	5,2	C1	0,2	D1	0,010	W1
16.	*Agriotes aterrimus*	4	7	4,2	C1	0,2	D1	0,008	W1
17.	*Anisodactylus signatus*	2	7	2,1	C1	0,2	D1	0,004	W1
18.	*Silpha obscura*	5	7	5,2	C1	0,2	D1	0,010	W1
19.	*Amara aenea*	4	6	4,2	C1	0,2	D1	0,008	W1
20.	*Pterostichus lepidus*	3	6	3,1	C1	0,2	D1	0,006	W1
21.	*Staphylinus olens*	4	6	4,2	C1	0,2	D1	0,008	W1
22.	*Onthophagus vacca*	2	5	2,1	C1	0,1	D1	0,002	W1
23.	*Quedius cruentus*	2	5	2,1	C1	0,1	D1	0,002	W1
24.	*Brachinus crepitans*	3	4	3,1	C1	0,1	D1	0,003	W1
25.	*Aclypea alpicola*	3	3	3,1	C1	0,1	D1	0,003	W1
26.	*Hister neglectus*	2	3	2,1	C1	0,1	D1	0,002	W1
27.	*Quedius unicolor*	3	3	3,1	C1	0,1	D1	0,0003	W1
28.	*Anisodactylus binotatus*	2	2	2,1	C1	0,1	D1	0,002	W1
29.	*Athous haemorrhoidalis*	1	2	1,0	C1	0,1	D1	0,001	W1
30.	*Carabus coriaceus*	2	2	2,1	C1	0,1	D1	0,002	W1
31.	*Chrysomela geminata*	2	2	2,1	C1	0,1	D1	0,002	W1
32.	*Forficula auricularia*	3	2	3,1	C1	0,1	D1	0,003	W1
33.	*Galeruca pomonae*	2	2	2,1	C1	0,1	D1	0,002	W1
34.	*Gryllotalpa gryllotalpa*	1	2	1,0	C1	0,1	D1	0,001	W1
35.	*Harpalus calceatus*	1	2	1,0	C1	0,1	D1	0,001	W1
36.	*Harpalus tardus*	2	2	2,1	C1	0,1	D1	0,002	W1
37.	*Hister ruficornis*	1	2	1,0	C1	0,1	D1	0,001	W1
38.	*Nebria brevicollis*	1	2	1,0	C1	0,1	D1	0,001	W1
39.	*Pterostichus niger*	1	2	1,0	C1	0,1	D1	0,001	W1
40.	*Silpha carinata*	2	2	2,1	C1	0,1	D1	0,002	W1

41.	*Sitona lineatus*	2	2	2,1	C1	0,1	D1	0,002	W1
42.	*Absidia pilosa*	1	1	1,0	C1	0,03	D1	<0,001	W1
43.	*Acylophorus glaberrimus*	1	1	1,0	C1	0,03	D1	<0,001	W1
44.	*Agriotes lineatus*	1	1	1,0	C1	0,03	D1	<0,001	W1
45.	*Aleochara moerens*	1	1	1,0	C1	0,03	D1	<0,001	W1
46.	*Aphanisticus pusillus*	1	1	1,0	C1	0,03	D1	<0,001	W1
47.	*Aptinus bombarda*	1	1	1,0	C1	0,03	D1	<0,001	W1
48.	*Barynotus obscurus*	1	1	1,0	C1	0,03	D1	<0,001	W1
49.	*Bembidion varium*	1	1	1,0	C1	0,03	D1	<0,001	W1
50.	*Byrrhus pustulatus*	1	1	1,0	C1	0,03	D1	<0,001	W1
51.	*Calathus fuscipes*	1	1	1,0	C1	0,03	D1	<0,001	W1
52.	*Chrysomela rufa*	1	1	1,0	C1	0,03	D1	<0,001	W1
53.	*Cicindela campestris*	1	1	1,0	C1	0,03	D1	<0,001	W1
54.	*Cicindela germanica*	1	1	1,0	C1	0,03	D1	<0,001	W1
55.	*Cleonis punctiger*	1	1	1,0	C1	0,03	D1	<0,001	W1
56.	*Clivina fossor*	1	1	1,0	C1	0,03	D1	<0,001	W1
57.	*Clytra humeralis*	1	1	1,0	C1	0,03	D1	<0,001	W1
58.	*Coccinella septempunctata*	1	1	1,0	C1	0,03	D1	<0,001	W1
59.	*Drypta dentata*	1	1	1,0	C1	0,03	D1	<0,001	W1
60.	*Elater nigrinus*	1	1	1,0	C1	0,03	D1	<0,001	W1
61.	*Galeruca tanaceti*	1	1	1,0	C1	0,03	D1	<0,001	W1
62.	*Harpalus distinguendus*	1	1	1,0	C1	0,03	D1	<0,001	W1
63.	*Harpalus marginella*	1	1	1,0	C1	0,03	D1	<0,001	W1
64.	*Hister funestus*	1	1	1,0	C1	0,03	D1	<0,001	W1
65.	*Hister vernalis*	1	1	1,0	C1	0,03	D1	<0,001	W1
66.	*Hypera nigriostris*	1	1	1,0	C1	0,03	D1	<0,001	W1
67.	*Licinus granulatus*	1	1	1,0	C1	0,03	D1	<0,001	W1
68.	*Liophloeus tessulatus*	1	1	1,0	C1	0,03	D1	<0,001	W1
69.	*Lixus cardui*	1	1	1,0	C1	0,03	D1	<0,001	W1
70.	*Mordellistena parvula*	1	1	1,0	C1	0,03	D1	<0,001	W1
71.	*Notaris bimaculatus*	1	1	1,0	C1	0,03	D1	<0,001	W1
72.	*Oiceoptoma thoracium*	1	1	1,0	C1	0,03	D1	<0,001	W1
73.	*Dociostaurus maroccanus*	1	1	1,0	C1	0,03	D1	<0,001	W1
74.	*Philonthus coruscus*	1	1	1,0	C1	0,03	D1	<0,001	W1
75.	*Plagiodera versicolora*	1	1	1,0	C1	0,03	D1	<0,001	W1
76.	*Platynus glacialis*	1	1	1,0	C1	0,03	D1	<0,001	W1
77.	*Pseudophonus griseus*	1	1	1,0	C1	0,03	D1	<0,001	W1
78.	*Pterostichus nigrita*	1	1	1,0	C1	0,03	D1	<0,001	W1
79.	*Pterostichus vulgaris*	1	1	1,0	C1	0,03	D1	<0,001	W1
80.	*Sphenophorus piceus*	1	1	1,0	C1	0,03	D1	<0,001	W1
81.	*Tachinus elongatus*	1	1	1,0	C1	0,03	D1	<0,001	W1
82.	*Typocerus attenuatus*	1	1	1,0	C1	0,03	D1	<0,001	W1
	Total 82 specii		**3247**						

During the observation period, 14 arthropod species were common to both the forest and apple orchard ecosystems (Table 3). A total of 2,721 individuals were recorded across both habitats, with the vast majority (2,482 individuals) collected .

Among the shared species, *Armadilidium vulgare* was overwhelmingly dominant, accounting for 1,798 individuals (36 in the forest and 1,762 in the orchards), highlighting its strong adaptability and ecological importance as a detritivore (I). Other abundant shared species included *Phalangium opilio* (616 individuals) and *Messor structor* (145), both primarily predators (P). Several species, such as *Chromatiulus unilineatus* and *Panorpa communis*, were moderately abundant and functioned as fungivores (F) or predators (P).

Table 3

Centralization of common species collected in both ecosystems during the observation period

No.	Name of species	Forest area		Apple orchards		Total sam-ples	Type of food
		No. of traps	Abun-dance	No. of traps	Abundance		
1.	*Aptinus bombarda*	8	13	1	1	14	P
2.	*Armadilidium vulgare*	9	36	81	1762	1798	I
3.	*Brachinus crepitans*	1	1	4	5	6	P
4.	*Carabus coriaceus*	4	6	2	2	8	P
5.	*Chromatiulus unilineatus*	12	15	14	15	30	F
6.	*Messor structor*	9	14	9	131	145	P
7.	*Necrophorus vespillo*	10	30	7	9	39	I
8.	*Oiceoptoma thoracium*	1	2	1	1	3	I
9.	*Panorpa communis*	9	16	10	14	30	P
10.	*Phalangium opilio*	32	96	87	520	616	P
11.	*Pterostichus niger*	4	4	1	2	6	P
12.	*Quedius unicolor*	2	3	3	3	6	P
13.	*Silpha carinata*	2	2	2	2	4	P
14.	*Staphylinus caesareus*	1	1	7	15	16	P
Total			239		2482	2721	

The comparative analysis of the 14 arthropod species recorded simultaneously in the forest ecosystem and the apple orchards of Nechit reveals pronounced differences in population structure, largely driven by ecological and anthropogenic contrasts between the two habitats (Figure 2).

Overall, the data indicate that apple orchards support significantly higher population densities for most shared species, suggesting increased availability of trophic resources and favorable microhabitats. The most notable disparity occurs in *Armadilidium vulgare*, which reaches an abundance of 1762 individuals in orchards compared to only 36 in the forest, making it the dominant species in both habitats but with a clear preference for the agroecosystem. This pattern may be explained by the fragmented litter layer, moderate moisture levels, and enhanced detrital resources commonly associated with managed agricultural soils.

Similarly, *Phalangium opilio* exhibits markedly higher abundance in the orchards (520 individuals) than in the forest (96 individuals), indicating strong adaptability to open habitats and tolerance of anthropogenic influences typical of orchard environments (soil disturbance, abundant herbaceous vegetation, microclimatic fluctuations).

In contrast, species characteristic of more natural habitats—such as *Carabus coriaceus, Pterostichus niger*, and *Silpha carinata*—show low and relatively similar abundances across the two ecosystems. This suggests limited ecological plasticity and a preference for structurally complex forest environments.

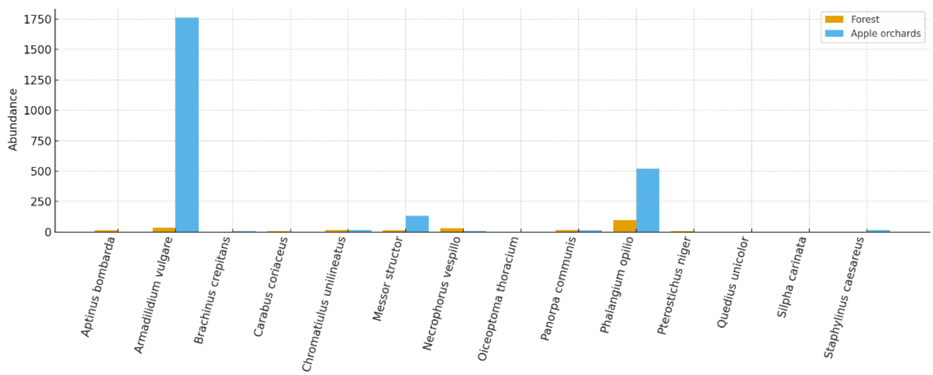

Fig. 2. Comparison of species abundance in forest vs. apple orchards

Overall, the composition and relative abundances suggest that the forest ecosystem supports more evenly distributed and balanced communities, whereas the orchard ecosystem promotes the numerical expansion of a few opportunistic species, resulting in a strongly skewed community structure. These differences highlight the potential of agroecosystems to favor detritivorous and omnivorous taxa, whereas forests maintain a more stable equilibrium among ecological strategies.

CONCLUSIONS

The comparative analysis of arthropod communities from the forest ecosystem and the apple orchards at Nechit highlights clear differences in species abundance and ecological structure. Although several species were shared between the two habitats, their population sizes varied markedly, reflecting differences in environmental conditions and resource availability.

Apple orchards supported substantially higher abundances for opportunistic and detritivorous species, such as *Armadilidium vulgare* and *Phalangium opilio.* This pattern suggests that agroecosystems provide favorable microhabitats—characterized by increased organic debris, soil disturbance, and open vegetation layers—that promote population growth in tolerant and generalist species.

Forest habitats maintained a more balanced and ecologically stable arthropod community, with less pronounced dominance by individual species. Species such as *Carabus coriaceus* or *Pterostichus niger* displayed low but consistent abundances, indicating a preference for structurally complex, less disturbed environments.

The differences between the two ecosystems indicate that habitat management strongly influences community composition. Agricultural practices in orchards create conditions that favor a limited number of highly adaptable species, whereas natural forest conditions support a more heterogeneous assemblage with multiple ecological strategies.

The presence of shared species across ecosystems demonstrates notable ecological plasticity, but their contrasting densities highlight the importance of microhabitat structure in shaping arthropod populations. These findings underscore the value of maintaining habitat heterogeneity to preserve biodiversity across landscape mosaics.

The study emphasizes the ecological significance of both environments: forests as reservoirs of stable biodiversity, and orchards as dynamic systems where species composition is strongly shaped by human management.

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RESEARCH ON THE ENTOMOFAUNA OF EPIGEAL COLEOPTERA COLLECTED FROM SOME VINEYARD PLANTATIONS

CERCETĂRI PRIVIND ENTOMOFAUNA DE COLEOPTERE EPIGEE COLECTATE DIN UNELE PLANTAȚII DE VIȚĂ DE VIE

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Abstract.
The material was collected using Barber-type soil traps in the vineyard plantations of the Odobesti vineyard. A 2,5% NaCl solution was placed inside the traps. The traps were placed in the plantation from June to August, in 2023, a total of 7 collections were made at intervals of 6 and 12 days. The material thus collected was brought to the laboratory, cleaned of plant debris, soil, etc., and only epigeal beetle species were then selected. In this research, two variants were used, the variant with chemical treatments and the variant without chemical treatments, each variant using 12 traps. In total, in the variant without treatments, 629 specimens of coleoptera belonging to 31 species were collected. In the variant with chemical treatments, a total of 95 specimens were collected, belonging to 22 species.
Key words: traps, treatments, variants

Rezumat.
Colectarea materialului s-a făcut cu ajutorul capcanelor de sol de tip Barber în plantațiile de viță de vie din podgoria Odobesti. În interiorul capcanelor a fost pusă o soluție de NaCl în concentratie de 2,5%. Capcanele au fost amplasate în plantație din luna iunie până în luna august, în anul 2023 facându-se un număr de 7 colectari la intervale cuprinse între 6 și 12 zile. Materialul astfel colectat a fost adus în laborator, curățat de resturile vegetale, pământ etc., fiind apoi selectate doar speciile de coleoptere epigee. În această cercetare au fost utilizate două variante, varianta cu tratamente chimice și varianta fără tratamente chimice la fiecare variantă utilizandu-se câte 12 capcane. În total, la varianta fără tratamente au fost colectate 629 exemplare de coleoptere aparținând la 31 de specii. La varianta cu tratamente chimice au fost colectate în total 95 de exemplare, care aparțin la un număr de 22 de specii.

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Cuvinte cheie: capcane, tratamente, variante

INTRODUCTION

Grapevines are among the most important agricultural crops worldwide, contributing significantly to the agricultural economy while also holding cultural and traditional value in many societies. However, grapevine cultivation faces numerous challenges, particularly from pests that threaten both the health and productivity of vineyards. These pests can cause direct damage by feeding on leaves and fruits and indirect damage by transmitting diseases, leading to considerable economic losses [Daane and Johnson, 2010].

Effective pest management is therefore essential to ensure high-quality yields and maintain the sustainability of vineyard ecosystems. Integrated Pest Management (IPM) strategies that combine chemical, biological, and cultural methods are widely recommended, as they reduce the reliance on chemical pesticides and help preserve ecological balance [Daane and Johnson, 2010]. Predatory arthropods play a crucial role in controlling pest populations naturally, contributing to environmentally friendly management approaches [Pătruică and Tănase, 2007].

Epigeic arthropods, particularly carabid beetles (Coleoptera: Carabidae), are key components of vineyard ecosystems, functioning both as predators and as bioindicators of environmental health. Studies on carabid fauna in vineyards have highlighted the diversity and ecological significance of these species, emphasizing their potential for pest suppression [Tălmaciu and Tălmaciu, 2005a; Tălmaciu *et al.*, 2005b]. Research has also demonstrated that vineyard management practices can influence carabid populations and their effectiveness in controlling pests [Tălmaciu *et al.*, 2020].

The present study aims to investigate the epigeic arthropod species associated with grapevine plantations, focusing on their identification, monitoring, and role in pest management. Understanding the interactions between pest species, grapevines, and the surrounding environment is critical for developing integrated, site-specific management strategies. By leveraging the natural predatory activity of epigeic arthropods, vineyards can reduce economic losses while minimizing environmental impact.

MATERIAL AND METHOD

In the studied biotope, a total of 12 pitfall traps were installed in two rows, arranged from the edge of the vineyard toward its interior. The distance between the rows was 10 meters, and the spacing between traps within each row was also 10 meters. Barber-type soil traps were used, consisting of plastic containers inserted into the ground and filled with a fixative solution, such as 4% formalin or a sodium chloride solution [Daane and Johnson, 2010; Pătruică and Tănase, 2007] (Figure 1).

Each trap consisted of a plastic container with a volume of 500 mL and a diameter of 10 cm, into which a 4% formalin solution was added as the fixative liquid.

Samples were collected periodically every 10–14 days during the study period from May to September 2023.

Fig. 1. Pitfall type Barber (original)

The experimental plot was established in a vineyard located on a slope in the Vrancea region. Two experimental variants were investigated:

Variant 1: A vineyard plantation on a hill where chemical treatments were applied for the control of pathogens and pests.

Variant 2: A vineyard plantation on a hill where no chemical treatments were applied for pathogen or pest control.

Material was collected from the traps on the following dates: 21 June, 30 June, 10 July, 16 July, 26 July, 2 August, and 14 August 2023. Collected specimens were subsequently cleaned of plant debris, preserved in 40% ethanol, and identified, focusing exclusively on epigeic arthropod species from the order Coleoptera [Tălmaciu and Tălmaciu, 2005; Tălmaciu *et al*., 2005; Tălmaciu *et al*., 2020].

RESULTS AND DISCUSSIONS

During the 2023 growing season, epigeic arthropods were monitored in both untreated and chemically treated vineyard variants. In the untreated variant (Table 1), arachnids were consistently the most abundant group, while beetle species including *Harpalus calceatus, Ontophagus ovatus, Rhizobius frontalis, Harpalus hirtipes, Pseudophonus pubescens,* and *Zabrus spinipes* were sporadically observed. Total arthropod abundance peaked during early to mid-summer, particularly in the 10 July sampling, with 16 individuals recorded, mainly arachnids. By mid-August, no arthropods were collected, indicating a natural seasonal decline in surface activity or the influence of environmental factors.

Table 1

The beetle species collected in 2023 from the untreated variant

No	Name of species	C1	C2	C3	C4	C5	C6	C7	Total
1st Harvest 21.06.2023									
1	Arahnids	-	2	-	-	1	1	-	4
2	*Harpalus calceatus*	-	-	-	1	-	-	-	1
Total		-	2	-	1	1	1	-	5
2nd Harvest 30.06.2023									
1	Arahnids	1	1	-	-	-	1	-	3
2	*Harpalus calceatus*	1	-	-	-	-	-	-	1
3	*Ontophagus ovatus*	-	1	-	-	-	1	1	3
4	*Rhizobius frontalis*	-	-	-	-	3	1	-	4
Total		2	2	-	-	3	3	1	11
3rd Harvest 10.07.2023									
1	Arahnids	-	-	2	1	6	3	4	16
Total		-	-	2	1	6	3	4	16
4th 16.07.2023									
1	Arahnids	1	-	-	-	-	1	-	2
2	*Harpalus hirtiptes*	-	-	-	-	1	-	-	1
3	*Pseudophonus pubescens*	-	-	-	-	-	1	-	1
Total		1	-	-	-	1	2	-	4
5th 26.07.2023									
1	Arahnids	-	1	-	-	-	-	-	1
2	*Ontophagus ovatus*	-	1	-	-	-	-	-	1
3	*Zabrus spinipes*	-	-	1	1	-	-	-	2
Total		-	2	1	1	-	-	-	4
1	Arahnids	-	2	-	-	-	-	3	5
2	Harpalus calceatus	-	-	-	-	2	-	-	
3									
4									
Total									
6th 14.08.2023									
At sampling 6, no arthropods were collected									

In contrast, the chemically treated variant exhibited lower overall arthropod abundance and diversity. The application of systemic fungicides (e.g., folpet, mancozeb) and insecticides (e.g., acetamiprid, spirotetramat) at various phenological stages (Table 2), as outlined in the vineyard chemical treatment program, appeared to reduce the activity of both beetles and arachnids. While these treatments effectively manage pests and disease, they also inadvertently suppressed populations of beneficial soil-dwelling predators, which are critical for natural pest regulation.

The treatment program emphasizes seasonal targeting and integration with vineyard phenology, aiming to minimize ecological impact. Dormant season copper and lime-sulfur applications reduced overwintering pathogen inoculum, while selective insecticides during bud break and early shoot growth provided control of sap-feeding pests with limited impact on non-target arthropods.

During flowering, fruit set, and veraison, reliance on biological control agents and targeted fungicide use further reduced disruption to epigeic arthropods. Pre-harvest and post-harvest measures focused on maintaining fruit quality and vineyard hygiene while minimizing chemical residues.

Table 2

Vineyard chemical treatment program in 2023

Growth Stage / Period	Objective	Fungicide / Chemical Treatment	Insecticide / Pest Control	Notes / Ecological Considerations
Dormant Season (Late Winter – Early Spring)	Control overwintering fungal pathogens and insect eggs	Copper-based fungicide (e.g., copper oxychloride), Lime-sulfur	Lime-sulfur for mites and scale insects	Apply before bud break
Bud Break – Early Shoot Growth (March – April)	Protect young shoots from fungal infections and early insect pests	Systemic fungicides (folpet, mancozeb)	Selective insecticides (acetamiprid, spirotetramat) for sap-feeding pests	Use reduced doses and spot treatments to minimize impact on beneficial arthropods
Flowering – Fruit Set (May – June)	Prevent botrytis bunch rot and control early grapevine pests	Botrytis-specific fungicides (fenhexamid) at pre-flowering and fruit set	Biological control (Bacillus thuringiensis for caterpillars)	Apply insecticides only if pest thresholds are exceeded
Berry Development – Veraison (July – August)	Prevent diseases affecting fruit quality, manage secondary pests	Systemic or contact fungicides for powdery mildew, downy mildew, botrytis	Targeted treatment for beetle pests if outbreak occurs	Avoid broad-spectrum insecticides to preserve predatory beetles and arachnids
Pre-Harvest (Late August – September)	Ensure fruit quality and minimize residues	Contact fungicides only if disease risk persists	Insecticides only if pest pressure exceeds threshold	Respect pre-harvest interval (PHI)
Post-Harvest (October)	Reduce overwintering inoculum and pest eggs	Optional fungicide if disease pressure high	None	Remove fallen leaves and debris

These observations underscore the dual effects of chemical treatments: they effectively control pest populations but can suppress beneficial arthropods that contribute to ecosystem services in vineyards. The data suggest that integrating chemical treatments with cultural practices and biological control may maintain higher arthropod diversity, enhance natural pest suppression, and promote ecological balance. Such an approach aligns with the principles of Integrated Pest Management (IPM), balancing productivity with environmental sustainability [Daane and Johnson, 2010; Pătruică and Tănase, 2007; Tălmaciu and Tălmaciu, 2005a].

CONCLUSIONS

The investigation of the epigeic arthropod fauna in the two vineyard variants—one subjected to chemical treatments and one left untreated—revealed clear differences in both species composition and population dynamics. The use of Barber-type pitfall traps proved to be an effective method for monitoring the activity and diversity of ground-dwelling arthropods in vineyard ecosystems.

In the untreated variant, a higher abundance and diversity of epigeic arthropods were recorded, particularly among predatory groups such as arachnids and carabid beetles. This indicates that the absence of chemical inputs allows for the development of a more balanced soil fauna community, which may contribute to natural pest regulation. Species such as *Harpalus calceatus, Ontophagus ovatus, Zabrus spinipes,* and *Pseudophonus pubescens* were consistently present, suggesting favorable ecological conditions for these beneficial groups.

Conversely, the chemically treated variant showed a reduction in both the number of individuals and the diversity of species ca

ptured. Although treatments effectively target key vineyard pests, they also appear to negatively affect non-target beneficial arthropods, potentially disrupting natural biological control processes.

The results highlight the importance of integrating ecological monitoring into vineyard management strategies. Understanding the composition of the epigeic arthropod community provides valuable insights into ecosystem functioning and supports the development of sustainable pest management programs. Reducing reliance on chemical treatments and promoting biodiversity-friendly practices can enhance the ecological resilience of vineyards and contribute to long-term agricultural sustainability.

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IMPROVING THE EFFICIENCY OF PEAS PROTECTION AND IMPROVING THE COMPETITIVENESS OF ITS PRODUCTION

ÎMBUNĂTĂȚIREA EFICIENȚEI PROTECȚIEI DE MAZĂRE ȘI ÎMBUNĂTĂȚIREA COMPETITIVITĂȚII PRODUCȚIEI ACESTEIA

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Abstract.
Annual leguminous crops, and peas in particular, are of great economic importance, used both as food for humans and for feed of farm animals. Pea crops are often damaged by various pests, the most dangerous of which are Acyrthosiphon pisum Harr., Kakothrips robustus Uzel, Sitona lineatus L., Sitona crinitus Hrbst., Bruchus pisorum L., Cydia nigricana Fabr., and Ceramica pisi L.
To more effectively utilize this crop, additional research is needed on cultivation technology, including the use of various chemical plant protection products. In the fight against the main pests of peas, the most effective is the insecticide with active substance cypermethrin with application rate of 0.15 l/ha, which provides a reduction in the number of green pea louse by 98.89–9.,91%, and pea beetle by 98.94–92.46%, within 7–12 days after treatment.
The authors analyzed, based on the income and expenditure budget, what the level of competitiveness is and how it can be optimized.
Key words: peas, pests control, biological efficacy, budget, cost.

Rezumat.
Culturile leguminoase anuale, și în special mazărea, au o mare importanță economică, fiind utilizate atât ca hrană pentru oameni, cât și pentru animale. Culturile de mazăre sunt adesea afectate de diverși dăunători, dintre care cei mai periculoși sunt Acyrthosiphon pisum Harr., Kakothrips robustus Uzel, Sitona lineatus L., Sitona crinitus Hrbst., Bruchus pisorum L., Cydia nigricana Fabr. și Ceramica pisi L.
Pentru a utiliza mai eficient această cultură, sunt necesare cercetări suplimentare privind tehnologia de cultivare, inclusiv utilizarea diferitelor produse chimice de protecție a plantelor. În lupta împotriva principalilor dăunători ai mazărei, cel mai eficient este insecticidul cu substanța activă cipermetrină, cu o doză de aplicare de 0.15 l/ha, care asigură o reducere a numărului de păduchi verzi ai mazărei cu 98.89–92.91% și a gândacului mazărei cu 98.94–92.46%, în decurs de 7–12 zile

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de la tratament. Autorii au analizat, pe baza bugetului de venituri și cheltuieli, care este nivelul de competitivitate și cum poate fi optimizat acesta.

Cuvinte cheie: mazăre, combaterea dăunătorilor, eficacitate biologică, buget, cost.

INTRODUCTION

As early as the early 19th century, it was believed that legumes absorbed nitrogen directly from the air through their leaves, enriching the soil. At the end of the same century, attention was drawn to the nodules located on the roots of legumes. It turned out that these are specialized root nodule bacteria that live on the roots and capture free nitrogen from the atmosphere. Root nodule growth begins at a temperature of 5 °C, and the assimilation of atmospheric nitrogen begins at temperatures above 10 °C (optimum 24-26 °C). To more effectively utilize this crop, additional research is needed on cultivation technology, including the use of various chemical plant protection products.

As already noted, annual leguminous crops, and peas in particular, are of great economic importance due to the high protein content of their grains, which is used both in human and livestock feed. Equally important are peas, which are intended for canning in their green form. However, this crop is often susceptible to attack by various pests, the most dangerous of which are the following species: *Acyrthosiphon pisum Harr., Kakothrips robustus Uzel, Sitona lineatus L., Sitona crinitus Hrbst., Bruchus pisorum L., Cydia nigricana Fabr., Ceramica pisi L.* [Panuţa S., Croitoru N., Bodescu C., Lăcătuşu O., 2018, Panuţa S., Croitoru N., Timuş A., 2010].

To successfully combat the main pea pests, a comprehensive set of integrated methods is used, with agronomic measures being the primary focus. Good results are achieved in controlling the pea armyworm by using the parasitic egg-eater *Trichogramma evanescens Westw* during the mass egg-laying period, releasing 50.000 exemplars per hectare twice, 6-8 days apart. Pheromone traps are also used to determine the level of pea moth population development and determine the optimal timing for chemical treatments.

Chemical control measures are applied only when the economic threshold (ET) of harmfulness is exceeded, which is 20-25 beetles per 1 m², and in dry years – 10-15 beetles per 1 m² for tuber weevils. The economic threshold of harmfulness for the pea weevil is 150-200 beetles per 100 sweeps of an entomological net.

The first chemical treatment is applied during the period of pea seedling emergence – against tuber weevils. To combat the pea weevil, three chemical treatments are recommended: the first – during the budding phase – the beginning of flowering; the second – after flowering and at the beginning of pod formation (if more than 20-25 eggs per 100 pods are detected); the third – 10-14 days after the second.

Initially, edge treatments are used, and when the economic threshold for damage is exceeded, continuous chemical treatments are carried out. Based on the above, the objective of this study was to evaluate the biological efficacy of the insecticide with active substance cypermethrin 500 g/L, in controlling the main pea pests.

MATERIAL AND METHOD

Research testing of the insecticide with active substance cypermethrin 500 g/l, for pea pest control was conducted in 2024 in the fields of the Moroz Alla agricultural firm in the village of Sarata Galbena, Hincesti District, in quadruplicate. The plots were 10 x 10 m in size, with each plot measuring 100 m². The plots were compactly arranged and randomized. The plots were square. 1 m of space was left between the plots as isolation strips. The total area of all experimental plots was 1,600 m², and the total area, including isolation strips, was 1,840 m². To extend the harvesting period, peas were sown at different times. This allowed us to select a plot with the highest pest infestation based on the time and stage of crop development. The seeding pattern was 15 x 8–10 cm, leaving two gaps 30–40 cm wide for equipment to pass through during the growing season [Croitoru, N., Magher, M., Panuța, S., Peșteanu, A., 2022; Croitoru N., Panuţa S., Magher M., 202].

Before establishing the field plot experiment, net sweeps were conducted to determine the general and phytosanitary condition of the fields and various sites and to select the most suitable site for the study.

The experiment included four treatment options: 1. Control without treatment; two doses (0,1 and 0,15 l/ha) of insecticide with cypermethrin 500 g/L. Insecticide with cypermethrin 250 g/:, at a rate of 0.3 L/ha, was proposed as the standard.

Throughout the study period, chemical treatments were applied manually using a portable knapsack sprayer. The amount of insecticide and the volume of water required for treatment of each plot and replicates of each treatment were calculated based on the application rates of the insecticides and water per hectare.

Counts to determine the phytosanitary condition were conducted by mowing with an entomological net. The number of tuber weevils was determined by counting adult individuals per square meter during seedling emergence. For this purpose, 0.25 x 0.25 m areas were marked with a ruler at 16 locations in each plot and the number of beetles was counted before, and on the 3rd, 7th, and 14th days after treatment. The numbers of green pea aphids, pea weevils, and pea moths were determined by sweeping with an entomological net, calculating the number of insects per 100 sweeps. The influence of abiotic factors on the development of entomological fauna during the growing season was studied by analyzing meteorological data from 2024.

RESULTS AND DISCUSSIONS

In the southern region of the Republic of Moldova, including at SRL „Moroz Alla”, Sarata Galbena village, Hincesti district, climatic conditions were relatively favorable for pea growth. Counts and observations conducted at the beginning of the emergence of pea shoots identified adult of *Sitona lineatus L., Sitona crinitus Hrbst.,* but their numbers were well below the economic threshold. Therefore, chemical treatment was not carried out against this group of pests.

In the second and third ten-day periods of May, of all the pests identified, the highest numbers were observed for pea aphids and pea beetle, whose populations exceeded the economic threshold. Therefore, a field trial was conducted against this group of pests. Chemical treatment was carried out on May 20, 2024. Counts were carried out before chemical treatment and on the 3rd, 7th and 14th day after treatment [Panuţa S., Croitoru N., Bodescu c., Lăcătuşu Oana., 201; Panuţa S., Croitoru N., Timuş Asea., 2010; Кроитору Н., Пануца С., Тимуш Ася., 2010; Пануца С., Кроитору Н., Тропоцел Д., 2014].

The results obtained are presented in table 1. Counts conducted before chemical treatment indicate that pea aphid populations in the experimental plot were quite high, ranging from 143.64 individuals/100 mowings with entomological net in the third treatment to 152.89 individuals/100 mowings with entomological net in the fourth treatment. This indicates a fairly balanced pest population.

Counts conducted on the third day after treatment revealed that complete pest suppression was not achieved in any of the treatments. The best results were obtained in the fourth treatment (1.86 individuals/100 mowings with entomological net) and the standard (2.03 individuals/100 mowings with entomological net). The third treatment yielded 12.54 specimens/100 specimens, which is 6.18 and 6.74 times higher than the standard and fourth treatments, respectively. However, comparing the results obtained in the third treatment with the control shows that this treatment significantly reduced pest numbers. Counts conducted on the 7th and 14th days after treatment indicate a decrease in the discrepancies between the third treatment and the standard and fourth treatments, but these differences remain significant.

Comparing the calculated aphid populations relative to the initial values, it is clear that the best results were achieved in variant 4 (1.21%) and the standard (1.37%), with insignificant differences between them. In Variant 3, this figure was 8.73%, significantly lower than the other experimental variants.

Comparing the results of the counts conducted seven days after treatment, it is clear that variant 4 does not differ significantly from the standard. In variant 3, this figure was 15.75%, which is 8.33 times lower than the control, but significantly higher than the standard and variant 3. The same pattern was observed in subsequent counts. The most convincing results are those calculated for aphid population reduction, compared to the control. The highest results were obtained in the fourth and standard treatments, where the pest population reduction was 98.89% and 98.74%, respectively, and the differences between them were insignificant. In the third treatment, aphid population reduction above 90,0% was achieved only during the first count (92.03%).

On the seventh day after treatment, population reductions above 90,0% were achieved only in the fourth treatment (92.91%) and the standard (92.59%). In these treatments and on the 14th day after treatment, biological effectiveness was quite high (87.08% and 86.41%), while in the third treatment, the aphid population reduction was 86.84%–75.67%.

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On the seventh day after treatment, population reductions above 90.0% were achieved only in the fourth treatment (92.91%) and the standard (92.59%). In these treatments and on the 14th day after treatment, biological effectiveness was quite high (87.08% and 86.41%), while in the third treatment, the aphid population reduction was 86.84%–75.67%.

Thus, it can be concluded that of all the tested options, the most effective insecticide with cypermethrin 500 g/L, applied at a rate of 0.15 L/ha. It provides effective reduction in pea aphid populations for 7-12 days after treatment and is comparable to the standard. The same product, applied at a rate of 0.1 l/ha, only reduces the pest population in the first few days after treatment.

Pre-blooming surveys revealed that, along with pea aphids, pea weevil beetles had appeared in the pea field, including the experimental plot. The numbers ranged from 17.55 to 19.43 adult individuals per 100 mowings with entomological net. Therefore, we conducted research on this pest. Counts were conducted by mowing with an entomological net, 10 sweeps per plot. The biological efficacy of insecticide with cypermethrin 500 g/L against pea beetle was calculated using the formula above. The results are presented in table 2. The table shows that the pea weevil population was fairly even, as evidenced by the surveys conducted before chemical treatment. It should be noted that pest numbers in all experimental treatments exceeded the economic threshold for damage. Counts conducted on the third day after treatment indicate a sharp reduction in beetle numbers in all treatments, while in the control treatment, the number of beetles increased to 21.25 individuals.

Comparing the experimental variants, it is clear that the best results were achieved in variant 4 and the standard, where the beetle counts were 0.25 and 0.32 specimens/10 mowings with entomological net, respectively. In Variant 3, the number of remaining live beetles was 1.92 specimens/10 sweeps, which is 6.00 times higher than in the standard and 7.68 times higher than in Variant 4. The same pattern was observed in the subsequent two counts.

Comparing the percentage of detected live beetles with the initial counts, it is clear that Variant 4 and the standard again achieved the best results. Thus, on the third day after treatment, the number of live beetles was 1.28 and 1.72%, respectively, and the differences between them are not significant. In the third variant, during this period, the beetle population was 10.67%, which is 11.35 times lower than the control. However, the results obtained were significantly lower than both the standard and the fourth variant. The same trend was observed in the subsequent two counts.

Table 1

Biological efficacy of the insecticide cypermethrin 500 g/l, in the control of *Acyrthosiphon pisum* (2024)

Experimental variants	Application rate, L/ha	Aphid count per 100 sweeps of an entomological net				Aphid density in %, compared to initial, on…day after treatment			Reduction in aphid numbers, compared to control, in %, on …day		
		Before treatment	On ...day after treatment								
			3	7	14	3	7	14	3	7	14
V_1 – control	-	144.39	158.23	189.46	216.24	109.58	131.21	149.76	0.0	0,0	0,0
V_2 – standard, cypermethrin, 250 g/L	0.3	147.39	2.03	13.07	22.86	1.37	8.86	15.50	98.74	92.59	86.41
V_3 - cypermethrin, 500 g/L	0.1	143.64	12.54	22.63	39.89	8.73	15.75	27.77	92.03	86.84	75.67
V_4 - cypermethrin, 500 g/L	0.15	152.89	1.86	12.98	22.54	1.21	8.48	14.74	98.89	92.91	87.08
LCD, 95%, p-5%			3.15	4.57	5.89	3.25	4.63	5.88	3.54	4.75	5.63

Table 2

Biological efficacy of the insecticide cypermethrin 500 g/l, in the control of Bruchus pisorum (2024)

Experimental variants	Application rate L/ha	Number of beetles per 10 sweeps of an entomological net				Number of beetles in %%, compared to the initial, on…day after treatment			Reduction in the number of beetles, compared to control, in %%, on …day		
		Before treatment	On ...day after treatment								
			3	7	14	3	7	14	3	7	14
V_1 – control	-	17.55	21.25	23.63	27.88	121.08	134.64	158.86	0.0	0.0	0.0
V_2 – standard, cypermethrin, 250 g/L	0.3	18.59	0.32	1.71	2.88	1.72	9.19	15.49	98.58	91.73	86.87
V_3 - cypermethrin, 500 g/L	0.1	17.98	1.92	3.25	7.38	10.67	18.07	41.04	91.18	83.74	65.21
V_4 - cypermethrin, 500 g/L	0.15	19.43	0.25	1.63	2.75	1.28	8.38	14.15	98.94	92.46	88.00
LCD, 95%, p-5%			1.54	1.49	4.37	4.63	5.25	5.89	4.56	6.99	7.34

Calculations of beetle population reduction compared to the control indicate that on the 3rd day after treatment, this figure was 98.94% and 98.58%, respectively, in the 4.th and 98,58% variants, with insignificant differences, while in the 3rd variant, this figure reached 91.18%.

Counts conducted on the 7th day after treatment revealed that, in the 3rd variant, the beetle population reduction dropped sharply to 83.74%. In the 4th variant and 91.73% variant, this figure was significantly higher, reaching 92.46% and 91.73%, respectively.

Counts conducted on the 14th day after treatment revealed an overall decrease in the percentage of population reduction in all experimental variants, although even during this period, the 4th variant significantly outperformed the 3rd variant and remained at the same level as the standard.

Based on experimental data obtained in 2024, it can be considered established that the most effective insecticide for controlling pea weevil beetles is insecticide with cypermethrin 500 g/L at dose of 0.15 L/ha, providing a 98.94–92.46% reduction in pest numbers within 7–12 days after treatment, comparable to the standard. A lower application rate of this same product (0.1 l/ha) is significantly inferior to both the standard and the fourth option, and provides protection to pea plants only in the first few days after treatment.

It is known that when determining the biological efficacy of insecticides against pea weevil beetles, not only the degree of effect of the product on adult pests is considered, but also the extent of damage to grains by larvae. Therefore, in addition to pea weevil beetle counts, we also conducted counts to determine the degree of grain damage before harvesting peas. To do this, 300 grains were taken from each plot, the number of damaged and undamaged grains was counted, and the degree of grain damage was then calculated. The results of these counts are presented in table 3.

The table shows that the lowest grain damage was observed in variant 4 and the standard, where this figure was 0.88% and 0.75%, respectively. Regarding variant 3, it is clear that grain damage was 6.71%, which is significantly higher than the standard and variant 4, but 11.54 times lower than the control.

Thus, the grain damage analysis results revealed that the greatest reduction in grain damage was achieved in variant 4 and the standard, while variant 3 was significantly inferior to the above-mentioned variants.

Counts and observations of pea thrips development in the experimental plot revealed that, prior to chemical treatment, the population of this pest was represented by single individuals. Number of thrips were detected in any of the post-treatment counts, demonstrating the high efficacy of the studied chemicals against this group of pests.

Table 3

Effect of chemical treatment of peas with insecticide cypermethrin 500 g/L, on grain damage by *Bruchus pisorum*

Experimental variants	Application rate, L/ha	Number of grains (pcs.)			Damage to grains; in %%
		Taken for analysis	Of these		
			Damaged	Undamaged	
V_1 – control	-	300	232.25	67.75	77.42
V_2 – standard, cypermethrin, 250 g/L	0.3	300	2.25	297.75	0.75
V_3 – cypermethrin, 500 g/L	0.1	300	20.13	279.87	6.71
V_4 – cypermethrin, 500 g/L	0.15	300	2.63	297,37	0.88
LCD. 95%, p-5%					4.96

Table 4

Budget and cash flow analysis for peas cultivation per hectare

Specification	Amount euro/ha	Consumption structure, %	Cash flow for the months of the year, euro / ha											
			January	February	March	April	May	June	July	August	September	October	November	December
Initial cash flow	**X**	**X**	**0.0**	**0.0**	**0.0**	**0.0**	**-230.1**	**-550.1**	**372.7**	**370.8**	**368.8**	**350.9**	**301.0**	**139.5**
I. Net sales	**984.6**	**X**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**984.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
II. Cost of inputs	477.0	56.4%	0.0	0.0	0.0	183.1	284.7	1.9	1.8	1.8	1.8	1.8	0.0	0.0
III. Cost of machinery services	162.3	19.2%	0.0	0.0	0.0	31.2	20.0	50.2	0.0	0.0	15.3	45.7	0.0	0.0
IV. The cost of manual operations	6.1	0.7%	0.0	0.0	0.0	4.9	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
V. Other costs and fees	159.5	18.9%	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	153.8	0.0
VI. Unforeseen ((II+III+IV+V)*5%)	40.2	4.8%	0.0	0.0	0.0	11.0	15.2	2.9	0.1	0.1	0.9	2.4	7.7	0.0
VII. Fixed + variable cost (II+III+IV+V+VI)	**845.1**	**100.0%**	**0.0**	**0.0**	**0.0**	**230.1**	**320.0**	**61.8**	**1.9**	**1.9**	**18.0**	**49.9**	**161.5**	**0.0**
VIII: Gross margin (gross profit) (VIII-VII)	**139.5**	**X**	**0.0**	**0.0**	**0.0**	**-230.1**	**-320.0**	**922.8**	**-1.9**	**-1.9**	**-18.0**	**-49.9**	**-161.5**	**0.0**
IX: Gross margin percentage (I / VII*100%)	16.5%	X	X	X	X	X	X	X	X	X	X	X	X	X
X. Unit cost, euro/t	211.29	X	X	X	X	X	X	X	X	X	X	X	X	X
Cash flows final	**X**	**X**	**0.0**	**0.0**	**0.0**	**-230.1**	**-550.1**	**372.7**	**370.8**	**368.8**	**350.9**	**301.0**	**139.5**	**139.5**

Competition is extremely important for the sustainable development of agriculture (and not only), it requires farmers to invest and develop value chains aimed at increasing the competitiveness of peas and increasing adaptation to different resilience (especially climatic and economic).

Based on the research conducted for the peas crop and the calculated income and expenditure budget, it was possible to determine the economic efficiency, which profit is a minimum of 139.5 euros/ha, with a minimum economic profitability of 16.5% and a unit cost of 1 ton of peas of 211.29 euros/t, which requires the farmer to ensure impeccable agro-technological discipline to achieve these results.

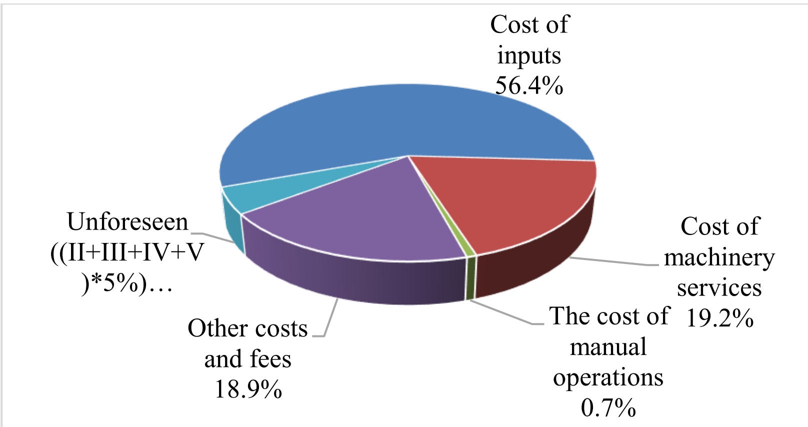

Figure 1. Structure of direct costs per hectare for peas cultivation by cost items, %
Source: Developed by the group of authors (Zbancă A., Panuța S., Morei V., Stratan A., Fală A., Litvin A., 2017).

The peas crop is characterized by low economic efficiency, due to high direct costs, namely: material resources 56.4%, the cost of mechanized services 19,2% and other costs (the main one is the rent payment) 18.9%, which is very risky in the current agricultural conditions and with the application of the conventional farming system.

CONCLUSIONS

1. Meteorological conditions, 2024 year, contributed to the high development of pea aphids and pea beetle.
2. In the fight against the main pea pests, the most effective is the insecticide with active substance cypermethrin 500 g/L, with a application rate of 0.15 l/ha, which provides a reduction in the number of pea aphids by 98.89 – 92.91%, and pea beetle by 98.94 – 92.46%, within 7 – 12 days after treatment.

3. The insecticide with active substance cypermethrin 500 g/L, with application rate of 0.1 L/ha provides effective protection of pea plants only in the first days after treatment, and in the following days its effectiveness drops sharply and is significantly inferior to both the 4th variant and the standard.

4. Based on the conducted researches and obtained results, the insecticide with active substance cypermethrin 500 g/L, is recommended as an insecticide against pea aphids, pea beetle and other pea pests, by performing 1-2 chemical treatments, with application rate of 0.15 L/ha.

5. Pea culture is excellent as a pre-emergent and especially for the cereal seeding sectors, as it allows the production of quality seeds;

6. Pea is a fully mechanized crop, but with a difficult harvesting process and low economic efficiency, which does not facilitate its mass cultivation.

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THE ROMANIAN VITIS DATABASE: AN INFORMATIVE, MULTIMEDIA WEB-BASED PLATFORM FOR MANAGING GRAPEVINE GENETIC RESOURCES IN ROMANIA

ROMANIAN VITIS DATABASE : UN INSTRUMENT UTIL PENTRU INVENTARIEREA, PROTEJAREA ȘI VALORIFICAREA RESURSELOR GENETICE ALE COLECȚIILOR DE VIȚA-DE-VIE DIN ROMANIA, CA PATRIMONIU PENTRU GENERAȚIILE VIITOARE

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Abstract. *Due to its geographic location and geological features, Romania has a rich history of grape cultivation and displays significant biodiversity, which is evident at both the ecosystem and species levels. Efficiently managing grapevine germplasm collections involves maintaining a database that records each country's viticultural heritage and complete descriptions based on relevant indicators. This strategy aims to effectively utilize biological material in breeding activities, ensure high-quality biological material for new vineyard plantations, and protect rare genotypes at risk of extinction. A complex characterization based on ampelographic, technological, and agrobiological descriptors, as well as SSR molecular marker genetic profiles, allows for the accurate fingerprinting of the cultivar and eliminates uncertainties caused by synonymy and homonymy. In this context, the Romanian Vitis Database will serve as a valuable source of information, accessible both nationally and internationally. It aims to effectively manage, protect, and utilize grapevine genetic resources in Romanian ampelographic collections as a legacy for future generations.*
Key words: *grapevine inventory, fingerprinting, online platform*

Rezumat. *Datorită poziției sale geografice și caracteristicilor geologice, România are o istorie bogată în cultivarea viței-de-vie și prezintă o biodiversitate semnificativă, vizibilă atât la nivel de ecosistem, cât și la nivel de*

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specie. Gestionarea eficientă a colecțiilor de germoplasmă de viță-de-vie implică menținerea unei baze de date care să înregistreze patrimoniul viticol al fiecărei țări și descrieri complete bazate pe indicatori relevanți. Această strategie are ca scop valorificarea eficientă a materialului biologic în activitățile de ameliorare, asigurarea unui material biologic de calitate superioară pentru noile plantații viticole și protejarea genotipurilor rare aflate în pericol de dispariție. O caracterizare complexă, bazată pe descriptori ampelografici, tehnologici și agrobiologici, precum și pe profile genetice determinate prin aplicarea de markeri moleculari SSR, permite identificarea precisă a soiului și eliminarea incertitudinilor cauzate de sinonimie și omonimie. În acest context, Romanian Vitis Database va reprezenta o sursă valoroasă de informații, accesibilă atât la nivel național, cât și internațional. Ea are ca obiectiv gestionarea eficientă, protejarea și valorificarea resurselor genetice ale viței-de-vie din colecțiile ampelografice românești, ca moștenire pentru generațiile viitoare.

Cuvinte cheie: *inventarierea vitei de vie, amprentare genetica, platforma online*

INTRODUCTION

In Romania, as in other viticultural regions, the practice of intensive grape cultivation has negatively impacted the genetic diversity of grapevine populations, resulting in the loss of local cultivars and intravarietal variability, a phenomenon known as genetic erosion. A key consequence of genetic erosion, apart from varietal uniformity, is the loss of genetic diversity within individual cultivars. More than 95% of vineyard plants produced in nurseries come from clonal selections chosen based on performance traits (quantitative or qualitative), while the original mother varieties, vital sources of genetic diversity, are facing extinction [Loureiro and Moreno Sanz, 2011; Gonçalves and Martins, 2022].

For these reasons, it has become necessary to preserve, within ampelographic collections, both old indigenous varieties, but also new autochthones genotypes, clonal selections, as well as foreign varieties introduced into the country through the international exchange of biological material. These collections, created and maintained in compliance with the specific internationally agreed norms, are located mainly in the research and development institutes, but also within the universities of agricultural sciences (Popescu *et al.*, 2018).

The use of SSR genetic profiling for both traditional local varieties and newly developed cultivars functions as a molecular passport, enabling the verification of varietal authenticity. This method is crucial for the precise documentation and long-term conservation of grapevine genetic resources, especially for heritage varieties that face the risk of misidentification or genetic erosion [Popescu and Crespan, 2018].

Molecular authentication also plays a critical role in breeding programs by ensuring the traceability of parental lines and maintaining the genetic integrity of newly created cultivars. Furthermore, it facilitates the management of germplasm collections and contributes to the implementation of strategies aimed at protecting plant breeders' rights and promoting sustainable viticultural development.

In recent years, Romania has seen several attempts, as part of research projects, to develop and maintain publicly accessible databases, online or on paper, in the fields of agriculture and horticulture (PN II PT PCCA 168/2014 GERMPLUM; Popescu *et al.,* 2018). These initiatives aimed to collect, organize, and share valuable information on plant species, cultivation practices, genetic resources, and agro-technical data. Despite their potential to support research, education, and sustainable development, many of these projects faced challenges such as limited funding, lack of long-term institutional support, and insufficient integration with international data systems.

Open access to existing *Vitis* databases has enhanced the global exchange of information. By linking microsatellite profiles with ampelographic, technological, and agrobiological descriptors, accurate varietal fingerprinting becomes possible, helping to resolve also some confusions caused by synonymy and homonymy (Maul *et al.*, 2015; Popescu *et al.*, 2017; Popescu and Crespan, 2018).

At European level, the inventory of grapevine varieties is carried out through some of the following databases:

- Vitis International Variety Catalogue (VIVC) - since 1983, the Institute for Grapevine Breeding Geilweilerhof (Germany) has been involved in the inventory of species, varieties, and other genotypes of Vitis found in grapevine collections worldwide. This effort led to the establishment of the Vitis International Variety Catalogue (VIVC) in 1984 [Alleweldt, 1988]. The database represents an inventory of Vitis species, varieties and clones maintained in Europe in germplasm collections, characterized in accordance with OIV Resolution no. 2/82 (Maul and Töpfer, 2015; https://www.vivc.de/);

- The European Vitis Database (http://www.eu-vitis.de/), was developed in 2007 by the Julius Kühn-Institut -Federal Research Centre for Cultivated Plants (JKI), Siebeldingen, Germany. This database was created within the European project Genres081, and completed within the European projects GrapeGen06 and COST Action FA1003.

- PlantGrape (https://plantgrape.plantnet-project.org/en/) originated as one of several case studies within the Pl@ntNet platform (plantnet.org), created in 2009 by the Agropolis Fondation to advance agronomic research and sustainable development. Dedicated to grapevine data, the project was initially led by UMT Géno-Vigne®, a Joint Technological Unit, bringing together the expertise of IFV (French Institute for Vine and Wine) and INRAE (National Research Institute for Agriculture, Food and Environment). PlantGrape's mission is to offer accessible, validated, and regularly updated information on grapevine varieties, rootstocks, and clones used in France, as well as throughout Europe and globally.

Several European countries have established national databases dedicated to the conservation and characterization of grapevine genetic resources. These systems are essential for safeguarding viticultural biodiversity, advancing grape breeding efforts, and promoting the long-term sustainability of wine production.

Bulgaria - The *Bulgarian Vitis Database (BVD)* is a web-based repository that compiles genotypic data on grapevine cultivars and accessions originating from Bulgaria. It is managed by the Institute of Viticulture and Enology in Pleven, while microsatellite profiling has been conducted at the AgroBioInstitute in Sofia. Developed within the framework of the INNOVINE project, the BVD supports sustainable viticulture by linking innovative vineyard management practices with the conservation of grapevine genetic diversity (BVD).

Czech Republic - The GRIN Czech database serves as the central system for managing plant genetic resources, including grapevine accessions. It provides detailed passport, characterization, and evaluation data. Maintained by the Crop Research Institute, the system facilitates the conservation and utilization of grapevine germplasm in national breeding and research programs (GRIN Czech).

France - France maintains one of Europe's most comprehensive grapevine germplasm collections, coordinated through a national network of over 50 field repositories. These collections contain extensive data on cultivar identity, sanitary status, and agronomic performance. The system is a cornerstone of French viticultural conservation, supporting both scientific research and practical viticulture (PNDB).

Spain - Spain has established germplasm banks, such as the one in Aragón, *Spanish Grape Germplasm Bank*, in order to explore and preserve the genetic diversity of grapevine cultivars. These banks play a crucial role in maintaining the country's viticultural heritage and supporting breeding programs [Ghrissi et al., 2022].

Italy - The Italian PlantA-Res database documents the collection, conservation, and utilization of plant genetic resources, including Vitis vinifera. It serves as the national inventory, integrating information from regional repositories and research institutions. The database underpins Italy's commitment to preserving agricultural biodiversity and supporting sustainable viticulture practices [Palombi et al., 2015].

Greece – The *Greek Vitis Database* (GVD) is an extensive web-based platform that integrates multimedia resources to aid in the conservation and study of grapevine genetic resources in Greece. Initially developed by the Laboratory of Plant Physiology and Biotechnology at the University of Crete, the GVD combines molecular, morphological, and ampelographic data to support both germplasm management and viticultural research. [Lefort et al., 2010]

These systems provide passport data, morphological descriptors, genetic profiles, and photographs, supporting breeding programs and biodiversity studies across borders.

In Romania, the absence of a current open access grapevine germplasm database highlights the need for the development of an online information system. Such a platform would serve as a key instrument for the conservation and sustainable use of biodiversity, offering continuous access to genetic resources and related data for researchers and growers.

MATERIALS AND METHODS

Plant material characterization

Ampelographic characterization was conducted in accordance with the standardized descriptor methodology detailed in the 3rd Edition of "OIV Descriptor list of grapevine varieties and Vitis species" (OIV, 2023). The methodology of ampelographic descriptors was developed by the OIV (International Office of Vine and Wine), UPOV (International Union for the Protection of Plant Varieties) and IPBGR (International Committee for Plant Genetic Resources), in order to harmonize the methodologies for describing varieties. Thus, since 1984 a standardized methodology has been in place for the ampelographic description of grapevine varieties, utilizing numerical codes to represent each trait. These descriptors are assigned by comparing traits to those of reference varieties.

To validate the accession's identification, nine *Vitis*-specific passport descriptors were utilized, including information related to varietal authenticity such as “variety name”, “synonyms”, “country of origin”, “variety pedigree”, “utilization”, “biological status” and “accession origin”.

For the characterization and evaluation of the accessions, a total of 54 descriptors were selected from the “OIV Descriptor list of grape vine varieties and Vitis species”, covering the following categories: young shoot (OIV 001–004), mature shoot (OIV 006–016), young leaf (OIV 051–053), mature leaf (OIV 067–094), flower (OIV 151), grape (OIV 202–209), berry (OIV 220–241), phenological descriptors (OIV 301–303), agrobiological descriptors (OIV 351), and technological descriptors (OIV 502–506).

Microsatellite profile

Molecular analyses were performed using a standardized protocol based on the recommendations of the OIV 2nd Edition (2009). A set of nine SSR loci was employed in order determine to the genetic profile: VVS2 [Thomas & Scott, 1993]; VVMD5 and VVMD7 [Bowers et al., 1996]; VVMD25, VVMD27, VVMD28, and VVMD32 [Bowers et al., 1999]; and VrZAG62 and VrZAG79 [Sefc et al., 1999].

Technical infrastructure

The *Romanian Vitis Database* was designed and implemented as a modern web-based platform, aimed at providing open access to structured and validated information on grapevine genetic resources. The system was developed using ASP.NET Core, a cross-platform, high-performance framework well-suited for building scalable web applications.

The relational database management system (RDBMS) selected for the project was MySQL, chosen for compatibility with ASP.NET environments. MySQL facilitated efficient management of structured datasets, including passport data, morphological descriptors, genetic profiles, and multimedia files such as images.

Front-end development leveraged HTML5, CSS3, and JavaScript to ensure a responsive, user-friendly interface, compatible with various devices and browsers (Figure 1).

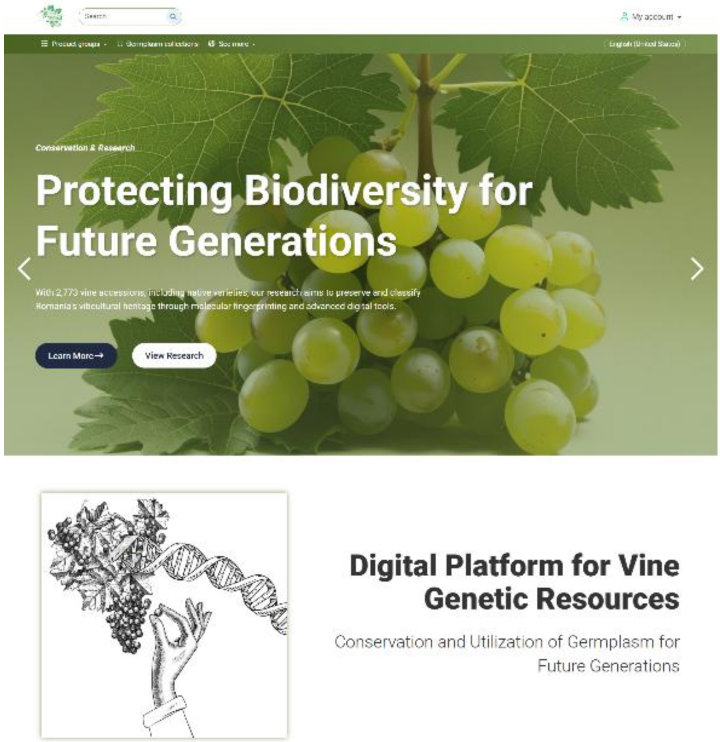

Figure 1. Aspects from *Romanian Vitis Database* front-end interface

Ajax (Asynchronous JavaScript and XML) was integrated to enable seamless, real-time data updates and dynamic page content without requiring full-page reloads, improving performance and user experience.

For server-side logic and data access, C# was used in conjunction with Entity Framework Core, enabling efficient communication between the application and the MySQL database

The architecture was also designed to support future integration with external germplasm databases (e.g., VIVC, EURISCO) and the adoption of standard descriptors as defined by OIV and FAO/IPGRI.

RESULTS AND DISCUSSIONS

A total of 2,773 grapevine accessions are currently documented in the *Romanian Vitis Database*, comprising cultivars, clones, and rootstocks. These entries were contributed by multiple research and academic institutions, including: Research and Development Institute for Viticulture and Enology Valea Călugărească, Research and Development Station for Viticulture and Enology Iasi, Research and Development Station for Viticulture and Enology Murfatlar, Research and Development Station for Viticulture and Enology Odobești, National Research and Development Institute for Biotechnology in Horticulture Stefanesti, University of Life Sciences *Ion Ionescu de la Brad* Iasi, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, University of Agricultural Sciences and Veterinary Medicine of Bucharest.

To date, 35 grapevine varieties from the total registered entries have been characterized but updates will be still made until the publicly release of the platform.

This effort represents an initial phase in the ongoing process of database enrichment, with the number of characterized varieties expected to increase on a yearly basis as part of a long-term strategy for comprehensive documentation and conservation.

A critical factor influencing the development of the database is the significant workload and financial resources required to sustain technical support and conduct molecular analyses. These efforts are often constrained by infrastructure-related challenges, such as limited access to high-throughput genotyping platforms, insufficient laboratory equipment, and the need for specialized personnel, all of which can hinder the pace and scalability of characterization activities.

CONCLUSIONS

The conservation and utilization of genetic diversity in viticulture, both for production and breeding, are matters of national interest, playing a crucial role in mitigating the loss of genetic variation within the *Vitis* genus and preventing the homogenization of viticultural heritage.

The existence of publicly accessible platforms that provide comprehensive datasets—including passport information, morphological descriptors, genetic profiles, and photographic records—is essential for advancing collaborative research and breeding efforts across national borders.

Romanian Vitis Database framework constitutes a robust, scalable, and interoperable platform, developed using industry-standard technologies to ensure the long-term preservation, accessibility, and efficient management of grapevine genetic resources.

ACKNOWLEDGEMENTS

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EVALUATION OF THE IMPACT OF MAJOR CLIMATIC FACTORS ON THE AGROBIOLOGICAL AND TECHNOLOGICAL POTENTIAL OF TABLE GRAPE VARIETIES CULTIVATED IN THE COPOU IAȘI VITICULTURAL CENTER

EVALUAREA INFLUENȚEI PRINCIPALILOR FACTORI CLIMATICI ASUPRA POTENȚIALULUI AGROBIOLOGIC ŞI TEHNOLOGIC AL SOIURILOR PENTRU STRUGURI DE MASĂ CULTIVATE ÎN CENTRUL VITICOL COPOU IAȘI

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Abstract.
The varied climatic conditions during the period 2015–2024 enabled the analysis of the performance of several table grape genotypes representative of the Iași vineyard, with regard to the cumulative effect of environmental stress factors on their agrobiological and technological traits. Under the influence of climatic factors whose levels have been altered by global warming, the studied varieties and clones (Gelu, Paula, Mara, Victoria, and Chasselas doré 20 Is) exhibited different responses, with their agrobiological and technological characteristics being affected both quantitatively and qualitatively. From the perspective of technological potential achieved in years with different climatic conditions (dry, normal, and rainy years), the results confirmed both the productive capacity and the climatic suitability of the Copou Iași viticultural center for the cultivation of table grape varieties.
Keywords: table grapes, variety, climatic suitability

Rezumat.
Condițiile climatice variate din perioada 2015 - 2024, au permis analiza modului de comportare a unor genotipuri pentru struguri de masă, reprezentative pentru podgoria Iași, cu privire la efectul cumulativ al factorilor de mediu stresanţi, asupra însuşirilor agrobiologice şi tehnologice a acestora. Sub acțiunea factorilor climatici a căror nivel s-a modificat datorită încălzirii globale, soiurile și clonele studiate (Gelu, Paula, Mara, Victoria și Chasselas dore 20 Is) au reacționat diferit, însușirile agrobiologice și tehnologice fiind influențate atât cantitativ cât și calitativ. Din punct de vedere al potențialului tehnologic realizat în anii cu condiții climatice diferite (ani secetoși, normali și ploioși), rezultatele obținute au confirmat capacitatea productivă și favorabilitatea climatică a centrului viticol Copou Iași pentru cultivarea soiurilor pentru struguri

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de masă.
Cuvinte cheie: struguri de masă, sortiment, favorabilitate climatică

INTRODUCTION

Table grape varieties have high requirements with respect to climatic factors, and their successful cultivation depends on identifying the most favorable ecological conditions capable of meeting their biological needs and highlighting their productive potential and economic efficiency [Olteanu *et. al*, 2002; Noa and Yishai, 2025].

In Romania, the effects of climate change have become increasingly evident over recent decades, through the growing incidence of late spring frosts and droughts, which exert a negative impact on vineyards by reducing both the qualitative and quantitative parameters of grape production. In this context, the continuous updating of knowledge regarding the climatic suitability of viticultural areas for table grape cultivation is essential [Damian *et al.*, 2022].

The cultivation of table grape varieties well adapted to the ecopedoclimatic conditions of a specific viticultural area represents a key factor in ensuring the sustainability of viticulture. The complex interactions between climatic factors and the genetic characteristics of the varieties determine grape quality [Bai *et al.*, 2022; Gashu *et al.*, 2020].

This study evaluates the influence of the main climatic factors recorded over the last ten years on the agrobiological and technological potential of representative table grape varieties cultivated in the Copou Iași viticultural center.

MATERIAL AND METHOD

The diverse climatic conditions recorded between 2015 and 2024 enabled the assessment of the performance of table grape genotypes (*Gelu*, *Paula*, *Mara*, *Victoria*, and *Chasselas doré* 20 Is), representative of the Iași vineyard, in relation to the cumulative effects of major climatic factors on their agrobiological and technological characteristics.

The ecological suitability of the Copou Iași Viticultural Center for table grape cultivation was determined using the evaluation system proposed by Irimia and Rotaru [2009], which considers the main ecological limiting factors for viticulture: mean annual temperature, mean July temperature, useful thermal balance, actual sunshine duration, total precipitation during the vegetation period, bioactive period duration, real heliothermal index, viticultural bioclimatic index, and oenoclimatic suitability index.

The study focused on assessing the agrobiological and technological potential through detailed observations and measurements of vegetation phenophases, fertility, productivity, growth vigor, and the quantitative and qualitative parameters of grape yield.

RESULTS AND DISCUSSIONS

The suitability classes of viticultural areas are determined based on the influence of climatic factors on the accumulation of sugars, anthocyanins, aromatic compounds, and organic acids in grapes.

The values of the thermal regime and synthetic climatic indices (IHr, Ibcv, IAOe) recorded during the period 2015–2024 classify the Copou Iași Viticultural Center as belonging to suitability class I (very suitable), indicating an abundance of these resources and confirming the potential for cultivating table grape varieties (Table 1).

Table 1

Favorability classes and rating scores for the representative ecoclimatic factors in the viticultural area of the Iași vineyard [according to Irimia and Rotaru, 2009]

Ecoclimatic Factors	Average years 2015 - 2024	Favorability class	Climate rating
Mean annual temperature (°C)	11.4	I	10
Mean temperature in July (°C)	22.9	I	10
Useful thermal sum (Σt°u)	1642.2	I	10
Σ sunshine during the vegetation period (h)	1476.4	II	8
Σ precipitation during the vegetation period (mm)	333.6	I	10
Duration of the bioactive period (days	171	III	5
Real heliothermal index (IHr)	2.4	I	10
Bioclimatic index (Ibcv)	9.1	I	10
Oenoclimatic suitability index (IAOe)	4707.0	I	10

Based on the amount of precipitation recorded during the vegetation period, the studied area was also assigned to suitability class I with moderate values (250 – 390 mm), which allow for normal physiological processes and the production of high-quality grapes. Suitability class II was determined by the total number of actual sunshine hours, while class III was defined by the mean values of the bioactive period. During the period 2015–2024, the average annual temperature was 11.4°C, with an amplitude of 2.5°C determined by the difference between the maximum value of 12.6°C recorded in 2024 and the minimum value of 10.1°C recorded in 2021 (Figure 1)

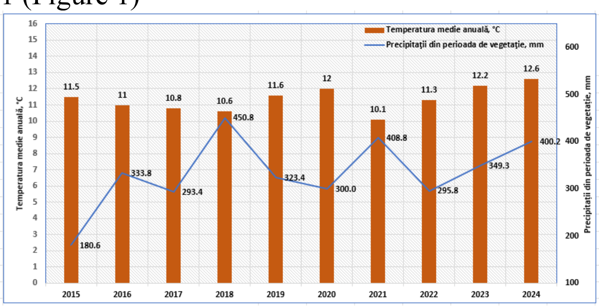

Fig. 1. Evolution of climatic factors recorded in the Copou Iași viticultural center

In the Copou Iași viticultural center, the multiannual average (1991 - 2020) of precipitation during the vegetation period (April - September) is 384.3 mm. In recent years, there has been a decline in precipitation levels and an increase in the frequency of drought years. The lowest amount of precipitation during the vegetation period was recorded in 2015, with only 180.6 mm.

The observations conducted regarding the progression of the vegetation phenophases exhibited by the studied genotypes, in direct relation to climatic factors, highlight that these were conditioned by both the level and the action of climatic variables, as well as by the hereditary specificity of the cultivars.

During the study period, budburst occurred starting from the first decade of April (Table 2). The onset of flowering in the analyzed cultivars took place between the last decade of May and the last decade of June. Furthermore, it was observed that within the same cultivar, the flowering period may last between 6 and 12 days.

Table 2

The progression of vegetation phenophases in the Iași vineyard (2015 – 2024)

Variety name	Budburst	Flowering	Veraison	Ripening
Gelu	03.IV – 29.IV	26.V – 22.VI	09.VII – 06.VIII	15.VIII – 14.IX
Paula	05.IV – 29.IV	24.V – 19.VI	04.VII – 31.VII	10.VIII – 08.IX
Mara	05.IV – 28.IV	23.V – 18.VI	03.VIII – 20.VIII	12.IX – 08.X
Chasselas doré 20 Is	08.IV – 29.IV	26.V – 21.VI	24.VII – 14.VIII	12.IX – 30.IX
Victoria	09.IV – 29.IV	26.V – 22.VI	12.VII – 05.VIII	03.IX – 23.IX
Average years 2015 - 2024	**03.IV – 29.IV**	**23.V – 22.VI**	**03.VII – 20.VIII**	**10.VIII – 08.X**

Grape veraison occurred between July 3 and August 20, lasting between 5 and 19 days, depending on the cultivar and the year. In dry years, veraison began earlier—during the first ten days of July—and proceeded over a shorter period, whereas in wetter years it began in the first ten days of August. Stage of consumer maturity coincided with the harvest date and occurred in August for cultivars belonging to epochs II and III, and in September for those belonging to epochs IV and V. First grapes to reach consumer maturity were those of *Paula* cultivar, beginning on August 10th, followed approximately one week later by *Gelu* cultivar.

In order to assess the fruiting capacity of the cultivars, observations and measurements were conducted for each genotype regarding the total number of shoots per vine, the number of fertile shoots per vine, the number of inflorescences per vine, fertility expressed as the percentage of fertile shoots, as well as the absolute and relative fertility coefficients (Table 3).

Table 3

Average values of fertility and productivity elements (2015–2024)

Variety name	No. total shoots/ vine	No. fertile shoots/ vine	Fertile shoots %	No. inflores-cences	Fertility coefficient		Productivity indeces	
					relative	absolut	relative	absolut
Gelu	31	18	61	23	0.78	1.26	232	371
Paula	35	24	68	28	0.80	1.16	258	377
Mara	30	28	95	43	1.45	1.53	296	313
Chasselas doré 20 Is	44	35	79	46	1.04	1.33	158	200
Victoria	35	23	67	27	0.78	1.20	350	535

The total number of shoots per vine varied among cultivars, reflecting both their inherent biological characteristics and growth vigor. The proportion of fertile shoots exceeded that of sterile ones, indicating that all analyzed cultivars assimilated the ecological conditions of the ecosystem favorably.

The average number of inflorescences per vine differed from one cultivar to another, influenced by their genetic traits and the fruiting load left after pruning. The Mara cultivar and the Chasselas doré 20 Is clone stand out through a high number of inflorescences, indicating a superior production potential, with an average of 43 and 46 inflorescences per vine, respectively. The values of the fertility indicators, namely the absolute and relative fertility coefficients, varied among genotypes and were largely influenced by pedoclimatic factors and the quality of the applied agrotechnical practices. In general, the values of the absolute fertility coefficient were greater than one for all genotypes, ranging from 1.16 in the cultivar *Paula* to 1.53 in the cultivar *Mara.* The absolute and relative productivity indices also showed variation among genotypes, generally exhibiting higher values in the *Victoria* cultivar, a result attributable to its greater bunch weight. The growth vigor of table grape cultivars, evaluated based on the quantity of wood removed during pruning and the elongation of shoots, was influenced by climatic conditions, the crop load retained after pruning, and the hereditary characteristics specific to each cultivar (Table 4).

Table 4

The growth vigor of table grape cultivars grown in the Copou Iași viticultural center (average for the years 2015–2024)

Variety name	Total wood, kg/vine	Total wood, t/ha	Total shoot length per vine, m	Average shoot length per vine, cm
Gelu	0.665	2.517	37.7	128.1
Paula	0.608	2.303	43.3	124.4
Mara	0.408	1.546	29.9	100.6
Chasselas doré 20 Is	0.561	2.126	49.7	111.6
Victoria	0.645	2.441	44.0	120.4

Under identical ecoclimatic and agrotechnical conditions, the assessments indicated that the largest amounts of pruned wood were recorded in the highly vigorous cultivars *Gelu* (0.665 kg/vine) and *Victoria* (0.645 kg/vine), as well as in the moderately to highly vigorous cultivar *Paula* (0.608 kg/vine). The biometric measurements of the main shoots, taken at the onset of veraison when their intensive growth had ceased, confirmed the higher growth vigor of the *Gelu* variety, with an average main shoot length of 128.1 cm, followed by the *Paula* and *Victoria* varieties, with average lengths of 124.4 cm and 120.4 cm, respectively.

The assessment of technological characteristics indicated a good level of productivity in most of the genotypes examined, with yields reaching or exceeding their biological potential, depending on the climatic conditions of the viticultural year (Table 5). The average number of grape bunches per vine ranged from 15 bunches/vine for the *Victoria* cultivar to 29 bunches/vine for Mara. In terms of bunch size, *Victoria* ranked first, with bunch weights between 386 and 519 g, followed by *Paula* and *Gelu*, with average weights of 314 g and 294 g, respectively. Under unfavorable climatic conditions, particularly in 2015, 2017, and 2022, bunches were smaller, which was also reflected in lower total yields.

Table 5

The production potential of the studied table grape genotypes

Years	Gelu			Paula			Mara			Chasselas dore 20 Is			Victoria		
	NG (no)	ABW (g)	Y (kg/vine)	NG (no)	ABW (g)	Y (kg/vine)	NG (no)	ABW (g)	Y (kg/vine)	NG (no)	ABW (g)	Y (kg/vine)	NG (no)	ABW (g)	Y (kg/vine)
2015	16	298	4.77	9	298	2.68	23	148	3.4	20	134	2.68	10	421	4.21
2016	23	290	6.67	22	303	6.67	33	240	7.92	29	144	4.18	16	494	7.9
2017	16	319	5.1	20	316	6.32	26	125	3.25	31	134	4.15	15	451	6.77
2018	18	317	5.71	21	330	6.93	39	209	8.15	26	174	4.52	12	464	5.57
2019	22	330	7.26	19	328	6.23	21	244	5.12	25	152	3.8	14	478	6.69
2020	15	209	3.14	25	301	7.53	28	192	5.38	31	139	4.31	15	386	5.79
2021	26	323	8.4	21	345	7.25	34	256	8.7	26	174	4.52	18	412	7.42
2022	11	218	2.4	20	304	6.08	32	199	6.37	24	159	3.82	19	400	7.6
2023	24	323	7.75	21	297	6.24	29	205	5.95	30	161	4.83	18	463	8.33
2024	17	310	5.27	20	315	6.3	26	248	6.45	25	148	3.7	17	519	8.82
x̄	**19**	**294**	**5.65**	**20**	**314**	**6.22**	**29**	**207**	**6.07**	**27**	**152**	**4.05**	**15**	**449**	**6.91**

Note: NG (no) = number of grapes/vine;
ABW (g) = Average bunch weight;
Y (kg/vine) = yield, kg/vine

Regarding grape yield, the cultivars confirmed the productive potential observed during the pre-approval phase, achieving average yields ranging from 4.05 to 6.91 kg per vine.

CONCLUSIONS

The results obtained regarding the progression of veraison and grape ripening highlight the cultivars Paula and Gelu, which consistently retain their early ripening trait. This characteristic is important for completing and diversifying the varietal conveyor of table grape cultivars in the northeastern viticultural area of the country, a region that lacks a sufficient assortment to ensure fresh grape consumption over an extended period.

The specific climatic conditions during the 2015–2024 period positively influenced the physiological and metabolic processes, that determine fruiting capacity and shoot growth.

In terms of technological potential achieved under varying climatic conditions (drought, normal, and rainy years), the results confirmed both the productive capacity and the climatic suitability of the Copou Iași viticultural center for the cultivation of table grape varieties.

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ASPECTS REGARDING THE ECONOMIC EFFICIENCY OF DIFFERENT SOIL MAINTENANCE SYSTEMS IN VINEYARDS

ASPECTE PRIVIND EFICIENȚA ECONOMICĂ A DIFERITELOR SISTEME DE ÎNTREȚINERE A SOLULUI ÎN PLANTAȚIILE VITICOLE

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Abstract.
The vine-growing technologies in the vineyards of the country's north-eastern region are established differentially, according to ecopedoclimatic conditions, with specific technological practices applied depending on the area and the cultivated varieties. The implementation at SCDVV Iași of innovative technological practices aimed at reducing energy consumption, lowering pollutant emissions, and preserving soil structure for the promotion of sustainable agriculture involved testing four soil maintenance systems in the inter-row spaces. The analysis of manual and mechanical labor requirements, along with the inputs applied, allowed the assessment of the economic efficiency of different soil maintenance systems, highlighting their advantages and drawbacks under specific conditions. The results obtained highlight that the highest economic efficiency was recorded in variant V4, with a profitability rate of 44%, compared to only 8% in variant V1. Similar values were also achieved in variants V3 and V2, with profitability rates of 34% and 28%, respectively.
Key words: precipitation, vines, accessible moisture, soil

Rezumat.
Tehnologiile de cultură a viţei-de-vie din podgoriile din nord-estul ţării sunt stabilite diferenţiat, în funcţie de condiţiile ecopedoclimatice, intervenindu-se cu verigi tehnologice specifice zonei şi în funcţie de soiurile cultivate. Implementare la SCDVV Iași unor verigi tehnologice inovative pentru reducerea consumurilor energetice, a emisiilor poluante şi a conservării structurii solului în vederea promovării unei agriculturi durabile, a presupus experimentarea a patru sisteme de întreținere a solului pe intervalele dintre rânduri. Analiza consumurilor de forță de muncă manuală și mecanică, a input-urilor practicate, a permis stabilirea eficientei economice la diferite sisteme de întreținere a solului, cu plusurile și minusurile lor în anumite condiții. Rezultatele obținute evidențiază faptul că cea mai ridicată eficiență economică s-a înregistrat la varianta V4, cu o rată a rentabilității de 44 %, comparativ

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cu varianta V1 de numai 8 %. Valori apropiate s-au obținut și la variantele V3 și V2, cu 34% și respectiv 28 % rată a rentabilității.

Cuvinte cheie: precipitații, viță-de-vie, umiditate accesibilă, sol

INTRODUCTION

In viticulture, it is well established that the monocultural production system, combined with the intensive application of cultivation technologies, accelerates entropic processes that negatively affect various components of the ecosystem. Consequently, periodic reassessment and adaptation of vineyard management practices are essential to address the challenges posed by climate change. Developing viable, sustainable technological solutions is crucial for maintaining long-term ecological stability and enhancing the resilience of viticultural ecosystems [Ţârdea and Chivu, 1998].

Innovative technologies in viticulture must comply with a set of biological, ecological, technological, and economic criteria and requirements, ensuring both sustainability and efficiency across all stages of production. They aim to: mitigate the impact of viticultural ecosystems on the surrounding environment; eliminate, as far as possible, pollutant factors, reaching the threshold of a "biological product"; reduce mechanical soil maintenance operations through alternative grass-cover systems; promote organic fertilization as a foundation for conserving and enhancing the natural fertility of the soil, through the use of both organic and green fertilizers; generalize the application of biological methods for controlling diseases and pests; create optimal conditions for maximizing the capture of solar energy by the foliage through appropriate vine training forms and support systems; fully exploit the quantitative and qualitative production potential of grape varieties; reduce energy and labor consumption; and ensure the long-term economic utilization of vineyards.

For grapevine growers, the costs and labor requirements associated with different technological options, as well as with each individual operation, are of at least equal importance to understanding the technologies themselves and the optimal timing of their implementation. Economic efficiency represents the ratio between effort and effect, where effort is reflected by expenditures, and effect is determined by the level of income achieved [Alexandrescu *et. al.*,1998].

The analysis of manual and mechanical labor consumption holds significant theoretical and practical importance, as, on the one hand, these factors represent a substantial share of direct production costs, and, on the other hand, they constitute highly flexible cost components on which efficiency-oriented interventions can be more effectively applied [Zaldea, 1999a; Zaldea, 1999b].

The study undertaken aimed to assess the impact of different soil management systems on production costs, with particular emphasis on the consumption of manual and mechanical labor and materials, in relation to production quality and revenue generated, and ultimately on the economic efficiency and profitability level of each system.

MATERIAL AND METHOD

The research was conducted within an experimental plot with the Riesling de Rhin variety. The plantation was established in 2010, on a flat plot with a predominantly southern exposure, not exposed to risk climatic factors, and at full fruiting capacity (Figure 1).

Fig. 1. Aspects from the experimental lot: soil maintenance systems in the row spacing

Four soil maintenance systems were experimented on the inter-row intervals (Table 1).

Table 1

Experimental variant scheme

Variant experimental	Operations performed
V1 – conventional system: tilled soil (TS)	– autumn plowing; – spring plowing; – 5 mechanical weedings per interval; – 5 manual weedings per row; – fertilization with NPK according to soil nutrient status.
V2 – conservative system: partial interval mulching with grape marc (PMM)	– application of composted grape marc in a 10 cm thick layer; – 2 post-emergence herbicide treatments per vine row; – fertilization with NPK at minimum dose; – application of foliar fertilizers to reduce water stress.
V3 – conservative system: mulching with plant materials (MP)	– chopping of plant species from the interval and leaving them on the soil surface as mulch; – application of foliar fertilizers to reduce water stress.
V4 – conservative system: minimal and superficial soil operations (MO)	– autumn plowing; – one deep mechanical weeding in spring; – application of foliar fertilizers to reduce water stress; – scarification every 3–4 years.

RESULTS AND DISCUSSIONS

To determine economic efficiency within the different soil management systems, a detailed analysis was conducted on production costs, with particular emphasis on the consumption of manual and mechanical labor and materials (standard technological sheets for each variant). These were correlated with quantitative and qualitative production and the revenues obtained, and, ultimately, economic efficiency indicators and profitability levels were calculated, which represent the essential elements of any productive activity.

The volume of expenditures was expressed in person-days per hectare for manual operations and machine hours per hectare for mechanical operations, and in physical and monetary units for the consumption of fuels and materials (pesticides, fertilizers, etc.).

In all analyzed variants, manual labor accounted for a significant share of direct production costs, with the highest consumption in person-days per hectare, and consequently in monetary terms observed in V1 – tilled soil (195.09 person-days/ha, corresponding to 53847.68 lei/ha), and the lowest in V3 – mulching with plant materials (157.87 person-days/ha and 43239.98 lei/ha). It should be noted that in determining labor consumption, the entire technology was considered, including operations specific to the cultivation area under study. Differences between variants were recorded at harvest, which were determined by the quantity of production obtained (Table 2).

Table 2

Cost structure of experimental variants, RON per hectare

Specification	V1 (TS) mt	V2 (PMM)	V3 (MP)	V4 (MO)
Specification	53847.68	44658.49	43239.98	45203.63
Manual labor	1725.14	1543.06	1484.85	1613.95
Mechanical operations	55572.82	46201.55	44724.83	46817.58
Total wages	19450.49	16170.54	15653.69	16386.15
Contributions (social security, taxes, etc.)	75023.31	62372.09	60378.52	63203.73
Total remuneration	5213.90	5447.95	5483.35	5617.90
Materials (pesticides, diesel, etc.)	80237.21	67820.04	65861.87	68821.63
Total direct costs	12035.58	10173.00	9879.28	10323.24
TOTAL	**92272.79**	**77993.04**	**75741.15**	**79144.87**

Within the applied technology, mechanical operations targeted the following categories of activities: soil maintenance, pest and disease control, fertilization, and the transport of various materials. Consequently, the share of mechanical operations varied depending on the soil management system employed.

In the structure of production costs, material consumption accounted for a significant share, ranking second after manual labor. The materials considered included plant protection products, fertilizers, herbicides, and diesel, which contributed to the differences between variants. The value of materials ranged from 5213.90 lei/ha in variant V1 to 5617.90 lei/ha in variant V4.

To highlight the contribution of different cost components to production, such as labor consumption and its corresponding shares, as well as materials, these were quantified in monetary terms. In determining the value of these expenditures, the prices and rates used in 2025 were taken into account.

Economic efficiency was assessed using a series of indicators, including grape yield, sugar content, expenditures, production cost, delivery price, revenue, and profit per hectare. Production costs were calculated as the ratio between expenditures per hectare and the yield obtained (kg/ha).

The delivery price was determined based on the sugar content of the grapes (Table 3).

Table 3

Economic efficiency indicators

Specification	U.M.	V1 (TS) mt	V2 (PMM)	V3 (MP)	V4 (MO)
Grape yield	kg/ha	18068	16591	15644	17576
Sugar content	g/L	182	195	204	215
Expenditures per hectare	RON/ ha	92282.79	77993.04	75741.15	79144,87
Production cost	RON /kg	5.10	4.70	4,84	4.50
Delivery price	RON /kg	5.50	6.00	6.50	6.50
Revenue per hectare	RON /ha	99374.00	99546.00	101686.00	114244.00
Profit per hectare	RON /ha	7101.21	21552.96	25944.85	35099.13
Profitability rate	%	8	28	34	44

The revenues resulted as the product of the delivery price and the quantitative production, and the profit calculated by the difference between revenues and expenses per hectare ranged between 7101.21 lei/ha for variant V1 and 35099.13 lei/ha for variant V4.

The results obtained highlight that the highest economic efficiency was recorded in variant V4 – minimal soil operations – with the highest profitability rate of 44%, compared to variant V1 – tilled soil – which achieved only 8%. Similar economic efficiency values were observed in variants V3 and V2, with profitability rates of 34% and 28%, respectively.

In addition to the quantified aspects of economic efficiency, there are non-quantifiable economic effects, such as:

- ✓ improvement of the physical and chemical properties of the soil (maintaining soil structure, looseness, etc.);
- ✓ prevention of soil erosion by ensuring a minimum cover of perennial grasses;
- ✓ maintenance of optimal levels of organic matter in the soil and preservation of its biodiversity;
- ✓ ensuring a minimum level of soil maintenance by reducing the number of operations;
- ✓ reduction of soil, groundwater, and environmental pollution through minimal use of chemical fertilizers;
- ✓ improvement of both the quantitative and qualitative grape yield;
- ✓ possibility of marketing grapes at higher prices.

CONCLUSIONS

In all analyzed variants, manual labor accounted for a significant share of direct production costs, with the highest consumption in person-days per hectare observed in variant V1 – bare tilled soil, and the lowest in variant V3 – mulching with plant materials.

Regarding direct expenditures, the conventional system (tilled soil) proved to be the most costly, whereas the conservative system (composted grape marc mulching) incurred the lowest expenses. Within these costs, manual labor represented 34%, while materials accounted for 18%.

In the structure of material costs, plant protection products held the largest share, followed by diesel.

The lowest production costs were recorded in variant V4 (minimal and superficial soil operations), followed by variant V2 (grape marc mulch).

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RESEARCH ON THE GRAFTING AFFINITY OF VARIETY FOR TINCTORIAL RED WINES 'MĂGURA' ON ROOTSTOCKS WITH DROUGHT RESISTANCE

CERCETĂRI PRIVIND AFINITATEA DE ALTOIRE A SOIULUI PENTRU VINURI ROȘII TINCTORIALE 'MĂGURA' PE PORTALOI CU REZISTENTĂ LA SECETA

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Abstract. *The phenomen of global warming has considerably influenced the evolution of the thermal and water regime annually and during the growing season in the viticultural ecosystem of the Odobeşti vineyard, the atmospheric and pedological drought characterizing the last five years of viticulture. In this context, the use of drought-resistant rootstocks for grafting is one of the solutions to counteract this extreme phenomenon. The present paper presents preliminary results regarding the grafting affinity of the 'Măgura' grape variety for tinctorial red wines created at RDSVO Odobești, on three rootstocks with drought tolerance obtained in the Romanian viticultural research (Drăgășani 70). M.', 'Crăciunel 71 Bl.', 'Ruggeri 140 Vl.'). The rootstock 'Berlandieri x Riparia Sel.Oppenheim 4 –4 Bl.', was taken into the study as a control. The obtained results show a very good grafting affinity of the 'Măgura' variety on the 'Ruggeri 140 Vl.' rootstock.*

Key words: variant, rootstock, grafting affinity, drought

Rezumat. *Fenomenul de încălzire globală a influenţat considerabil evoluţia regimului termic şi hidric anual şi din timpul perioadei de vegetaţie în ecosistemul viticol al podgoriei Odobeşti, seceta atmosferică şi pedologică caracterizând ultimii cinci ani viticoli. În acest context, folosirea pentru altoire a portaltoilor rezistenti la secetă este una dintre soluțiile de contracarare a acestui fenomen extrem. Lucrarea de față prezintă rezultate preliminare privind afinitatea de altoire a soiului pentru vinurile roșii tinctoriale 'Măgura' creat la SCDVV Odobești, pe trei soiuri de portaltoi cu toleranță la secetă obținute în cercetarea viticolă românească (Drăgășani 70). M.', 'Crăciunel 71 Bl.', 'Ruggeri 140 Vl.'). Portaltoiul 'Berlandieri x Riparia Sel.Oppenheim 4 –4 Bl.', a fost luat în studiu ca martor. Rezultatele obţinute arată o afinitate de altoire foarte bună a soiului 'Măgura' pe portaltoiul 'Ruggeri 140 Vl.'.*

Cuvinte cheie: variantă, portaltoi, afinitate de altoire, secetă

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INTRODUCTION

Grafting affinity is an essential condition in the production of good quality viticultural planting material, while production affinity is the basic requirement for the establishment of new vine plantations with superior technological potential. Scientific research carried out over time has demonstrated once again that in the case of grapevine grafting there is a mutual influence of the grafted partners (Köse et al., 2014; Ungureanu et al., 2021). Thus, the rootstock exerts a strong influence on growth (Constantinescu et al., 1966), fertility, resistance to drought, at minimum temperatures, productivity (Țardea and Rotaru, 2003), as well as oenological potential. In the context of current climate changes that have led to the significant manifestation of the drought phenomenon in many wine-growing areas (Pușcalău et al., 2021), the use of rootstocks with drought resistance is increasingly necessary (Mărculescu et al., 2006). Establishing the most suitable rootstock varieties for grafting newly created vinifera varieties is one of the main objectives for the establishment of new vineyards, justifying current research on establishing the grafting affinity and production affinity of these varieties on different rootstock varieties.

MATERIAL AND METHOD

The research was carried out at RDSVO Odobești during 2023-2024, and the experimental device included four experimental variants, each with three repetitions. The cultivar for tinctorial red wines 'Măgura' was obtained at RDSVO Odobești from the crossing of the cultivars 'Băbească neagră' x ('Merlot' x 'Alicante Bouschet'), approved in 2014 (Fig. 1).

Fig. 1. ′Măgura′ cultivar - young shoot, grape and adult leaf (original)

The Măgura vine cultivar was grafted onto three rootstock clones with drought resistance obtained in Romania: 'Berlandieri x Riparia - Sel. Drăgășani 70 M.' provided by RDSVO Drăgășani, 'Teleki 8 B - Sel. Crăciunel 71 Bl.' provided by RDSVO Blaj and 'Ruggeri 140 – Sel. 59 Vl.' provided by RDIVO Valea Călugărească (Fig. 2). The rootstock ′Berlandieri x Riparia Sel.Oppenheim 4 –clone 4 Bl′, the most used for grafting in the Odobești wine growing area was used as a control.

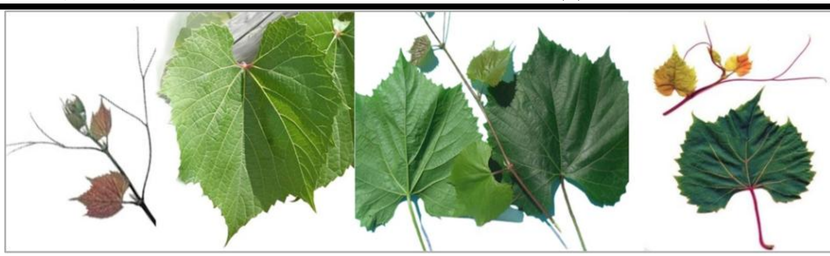

Fig. 2. Rootstock cultivars: a) 'Sel. Drăgășani 70 M'; b) 'Sel. Crăciunel 71 Bl.'; c) 'Ruggeri 140 – Sel. 59 Vl.'

The grafting was carried out mechanized in the "omega" system. The forcing of the grafted cuttings was done by the method with total stratification with sawdust and external heating. The planting of the cuttings in the vine nursery was done in linear soil beds made in the spring, on which a drip irrigation hose was placed. To determine the grafting affinity, after forcing and hardening the graft cuttings, the formation of circular callus at the grafting point, the growth of shoots from the grafts and the formation of roots at the base of the rootstock were observed in particular. After harvesting the vines from the nursery, the yield and quality of the seedlings were monitored for each variant of the experiment. The obtained data were statistically processed for analysis of variance using the statistical analysis program Data Analysis Single factor (Anova test).

RESULTS AND DISCUSSIONS

The analysis of the average values over the two years of experimentation obtained after forcing and hardening the grafted cuttings shows that the percentage of grafted cuttings with circular callus at the grafting point was higher in the case of grafting on the rootstocks ′Sel. Drăgășani 70 M.′ (94.2%) and ′Ruggeri 140 - Sel. 59 Vl.′ (91.0%), compared to the grafting variant on the rootstock Sel. Crăciunel 71 Bl. (83.7%) and the control rootstock - Sel.Opp. 4 – 4 Bl. (83.8%) (Table 1). Cuttings grafted onto the rootstock ′Sel. Crăciunel 71 Bl.′ presented a lower callus index (83.7%), a similar value to the control rootstock ′Berlandieri x Riparia Sel.Oppenheim 4 – 4 Bl.′ (83.8%). The highest values were obtained in the case of grafting onto the rootstock ′Sel. Drăgășani 70 M.′ (94.2%) and the rootstock ′Ruggeri 140 – Sel. 59 Vl.′ (91.0%).The average value obtained for the percentage of cuttings with shoots starting from the graft, after hardening before planting in the vineyard school, was higher when using the rootstock ′Ruggeri 140 – Sel. 59 Vl.′ (76.3%).

Table 1

Data obtained from forging and hardening grafted cuttings (%)

Variant / parameter		Cuttings with circular callus at grafting point	Cuttings with shoots from grafts	Cuttings with roots at the base
V1 - 'Măgura'/ Sel. Drăgășani 70 M.	2023	94.06	70.55	60.29
	2024	94.29	80.00	88.57
	average	**94.17**	**75.27**	**74.43**

V2 - 'Măgura'/ Sel. Crăciunel 71 Bl.	2023	81.45	64.72	41.41
	2024	85.93	84.44	15.56
	average	**83.69**	**74.58**	**28.49**
V3 - 'Măgura'/ Sel. Ruggeri 140 - 59 Vl	2023	91.16	70.71	64.71
	2024	90.91	81.82	90.91
	average	**91.03**	**76.26**	**77.81**
V4 - 'Măgura'/Sel.Opp. 4 – 4 Bl. (control)	2023	83.84	65.66	39.39
	2024	83.70	82.22	17.78
	average	**83.77**	**73.94**	**28.58**

Higher average values compared to the control rootstock were also obtained for the rootstocks ′Sel. Drăgășani 70 M.′ (75.3%) and ′Sel. Crăciunel 71 Bl.′ (74.6%). Regarding the formation of roots at the base of the grafted cuttings, the data obtained demonstrate that the type of rootstock influences both the duration of the rooting period and the number of rooted cuttings. (Fig. 3).

Fig. 3. Aspects of the planting material production process (grafted vines after forcing and hardening, vine school, harvesting and grading of grafted vines)

The percentage of grafted cuttings with roots at the base was much higher than the control in the case of the variants in which the rootstocks ′Ruggeri 140 – Sel 59 Vl.′ (77.8%) and ′Sel. Drăgășani 70 M.′ (74.4%) were used. Lower average values were obtained in the case of grafting on the rootstock ′Sel. Crăciunel 71 Bl.' (28.5%) and on the control rootstock 28.6%).

Statistical interpretation by analysis of variance (Anova test) of the experimental data obtained after forcing and hardening the graft cuttings shows very significant differences for the variants v1- ′Sel Drăgășani 70 M.′ and v3 - ′Ruggeri 140 – Sel. 59 Vl.′, compared to the control v4 - ′Sel. Oppenheim 4 – 4′ in terms of cuttings with circular callus at the grafting point, and cuttings with roots at the base of the rootstock, the value of the parameter P (5.42917E-06, respectively 0.001557922) being much lower than $p<0.05$ (Table 2).

Table 2

Statistical interpretation of experimental data obtained after forcing and hardening of grafted vines through analysis of variance (Anova test)

Source of Variation	SS	df	MS	F	P-value	F crit
cuttings with circular callus at the grafting point						
Between Groups	251.0071	3	83.66904	66.25458	5.43E-06	4.066181
Within Groups	10.10273	8	1.262842			

Total	261.1099	11				
cuttings with roots at the base of the rootstock						
Between Groups	6810.624	3	2270.208	13.85639	0.001558	4.066181
Within Groups	1310.707	8	163.8383			
Total	8121.331	11				

The basic criterion that determines the establishment of grafting affinity is the yield and quality of the grafted vine. The data presented in Table 3 confirm that in the combined scion/rootstock interaction the best results were obtained in the case of variant V3 - Măgura/′Ruggeri 140 – Sel. 59 Vl.′ (65.9%) followed by variant V1- Măgura/′Sel. Drăgășani 70 M.′ (42.1%). The lowest value was obtained in the case of variant V2 - Măgura/Sel. Crăciunel 71 Bl. (18.6%), lower than the control variant V4 - Măgura/′Sel. Opp. 4 – 4 Bl.′ (26.7%).

Table 3

Yield of grafted vines after removal from the vine school and grading (%)

Variant / Year	V1 - ′Sel. Drăgășani 70 M.′	V2 - ′Sel. Crăciunel 71 Bl.′	V3 - ′Ruggeri 140 – 59 Vl.′	V4 - ′Sel. Opp. 4 – 4′ (control)
2023	48.55	23.94	61.87	33.33
2024	35.56	13.33	70.00	20.00
Average	42.06	18.64	65.94	26.67

The statistical interpretation of the experimental data obtained from the classification of grafted vines by analysis of variance, shows very significant differences for variant v3 - Măgura/Ruggeri 140 - Sel. 59 Vl.′, and significant for variant V1 - Măgura/Sel. Drăgășani 70 M.′, the value of the parameter P (3.79672E-05) being much lower than P<0.05 (Table 4).

Table 4

Statistical interpretation of experimental data obtained after ranking grafted vines by analysis of variance (Anova test)

Source of Variation	SS	df	MS	F	P-value	F crit
cuttings with circular callus at the grafting point						
Between Groups	3899.63	3	1299.877	39.60789	3.8E-05	4.066181
Within Groups	262.5491	8	32.81863			
Total	4162.179	11				

CONCLUSIONS

1. Preliminary research on establishing the grafting affinity of the Măgura red wine variety in interaction with the three drought-resistant rootstocks demonstrated the existence of significant differences compared to the control.

2. The variants V3 - Măgura/′Ruggeri 140 – Sel. 59 Vl.′ and V1 - Măgura/′Ruggeri 140 – Sel. 59 Vl. demonstrated the best results regarding the percentage of grafted cuttings with circular callus at the grafting point (91.0%, respectively 94.2%) and the percentage of cuttings with roots at the base of the rootstock (77.8%, respectively 74.4%).

3. The variant V3 - Măgura/′Ruggeri 140 – Sel. 59 Vl. demonstrated the best grafting affinity, with an yield of grafted STAS vines by 65.9%, followed by variant V1 - Măgura/′Ruggeri 140 – Sel. 59 Vl. (42,1%).

4. Preliminary data for the two years of study show a good grafting affinity of the Măgura variety on the drought-resistant rootstock Ruggeri 140 – Sel. 59 Vl.

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PARTICULARITIES OF LAND RECLAMATION FACILITY MANAGEMENT

PARTICULARITĂŢI ALE MANAGEMENTULUI AMENAJĂRILOR DE ÎMBUNĂTĂŢIRI FUNCIARE

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Abstract.
The management of land reclamation facilities has special features determined by the complexity of the activities that are planned, organized and managed. Firstly, the special complexity of the activities results from the specificity of the elements that form the land reclamation facility: the agricultural land and the facilities built on it. Secondly, the complexity of the activities is determined by the need for these two elements to set up a consistent functional structure in order to fulfil the intended purpose, i.e. the sustainable increase of land productivity, by the effective exploitation not only of the natural resources, water and soil, but also of the genetic resources.
Key words: *management, land reclamation, agricultural holding, agricultural management, water regulation management.*

Rezumat.
Managementul amenajărilor de îmbunătăţiri funciare prezintă particularităţi deosebite determinate de complexitatea activităţilor care trebuie planificate, organizate şi gestionate. Complexitatea deosebită a activităţilor se datorează, în primul rând, specificităţii elementelor care formează o amenajare de îmbunătăţiri funciare: terenul amenajat cu folosinţă agricolă şi lucrările construite pe acest teren (Figura 1) În al doilea rând, complexitatea activităţilor este determinată de necesitatea ca aceste două elemente să formeze o structură funcţională unitară pentru a îndeplinit scopul propus, sporirea durabilă a productivităţii terenului, prin valorificarea optimă a resurselor naturale, apă şi sol, dar şi a resurselor genetice.
Cuvinte cheie: *management, îmbunătăţiri funciare, exploataţii agricole, managemet agricol, management hidroameliorativ.*

INTRODUCTION

Management defines leadership activities and ability and the organization, management and management of enterprises, according to dexonline.ro in order to

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achieve a certain purpose under conditions of time, resources and costs restrictions [Guvernul Romaniei, 1998].

The need to manage land reclamation works has occurred when the latter spread to large areas, according to the planning policy coordinated by the national authorities. The management of land reclamation works was originally aimed at the technical-engineering works themselves, without dealing with the reclaimed land.

Land management was provided by the agricultural holdings operating on the lands. When the authorities realized that the economic performance on the reclaimed land did not correspond to the designed indicators, they improved the relations of water regulation management with agricultural management by upgrading the institutional conditions existing in centralized economy.

In 1966 the Land Reclamation Department was established within the Ministry of Agriculture, to provide the management of the specialist activities and to coordinate the planning and execution of the specialist works, (Figure 1 a,b,c).


a. agricultural land

b. hydrotechnical scheme of the arranged


c. agricultural land arranged for irrigation and surface drainage

Fig.1. The components of land reclamation facilities (a, b, c)

MATERIAL AND METHOD

The transition to the market economy led to major changes in the management of land reclamation works. World trends in irrigation management dominated the structure of land reclamation works, which required the implementation of an institutional reform. The reform consisted in the transfer of irrigation management to users [***, 2009].

Government Order No. 292/1991 established the set-up of the Trading Company for the Operation of the Land Reclamation Works (S.C.E.L.I.F. S.A.) structured into county branches that coordinated water regulation systems, and companies for **maintaining** pumping stations and automation purposes (S.I.S.P.A).

Act No. 50/7 issued in 1994 established the set-up of the Autonomous Land Reclamation Agency (R.A.I.F.) subsequently renamed the National Land Reclamation Society Ltd (S.N.I.F.) by the Emergency Ordinance No. 23/27 issued in 2000, [***, 2006].

Government Emergency Ordinance No. 147/1999 established the set-up of the Associations of irrigation water users (AUAI) as legal entities. These associations were subsequently renamed Organizations of irrigation water users (OUAI). Act No. 138/2004 on Land Reclamation established the set-up of the National Land Reclamation Administration Ltd. aimed to operate, manage, maintain and repair the facilities belonging to the public/private state domain (Organization and operation regulations of the National Land Reclamation Agency on 23.07.2014, effective from 30.07.2014, [***, 2014].

The analysis of the practical realities regarding the management of the land reclamation facilities shows that the real global management of the facilities is not operational yet, as the relationship between water regulation and agriculture is still being limited to the service contracts between the specific organizational entities of the two sectors.

Therefore, we intend to analyze several solutions to increase the managerial effectiveness of the agricultural land supplied with land reclamation works.

RESULTS AND DISCUSSIONS

The analysis of the specific management of the agricultural land supplied with land reclamation works shows that this type of management should be differentiated according to the characteristics of the activities carried out for both the agricultural land and the design of the water regulation existing on the particular land. Each type of activity has specific planning, organization and management objectives. The objectives of agricultural management are to ensure that farm activities are carried out according to the agricultural trends, in order to modernize the production processes while using agricultural resources in a sustainable manner. In order to achieve these objectives, agricultural management must have a specific job and hierarchy structure through which it can ensure the concrete actions for continuous and effective work.

The most important three issues that are characteristic for agricultural management: the sustainable use of the agricultural land according to the internal land organization method and the morphological features of the territorial units; the choice of the crop plan and crop rotation based on the land evaluation notes and the agricultural suitability class of each field/plot of land and finally the establishment of the improvement culture technologies that bring out the full potential of the facilities (specific agro-technical works, irrigation system, organic and mineral fertilization system, phyto-sanitary treatments, pH correction, etc) [Vlad *et al.*, 2006].

In the case of large water regulation systems consisting of several agricultural units, the fusion of the units in an association would provide a more effective coordination between the two types of management, i.e. agricultural management and water regulation management.

The management of land reclamation facilities is based on the principles of general management and has particularities established by its specific activities. In the case of on-site land reclamation in different time intervals, three technical stages can be distinguished, each with distinct management: design, construction and operation.

The design phase has a limited time duration in time, during which it is necessary to elaborate the design variants, out of which, the best variant is selected through technical and economic approval. The evaluation criteria for the design variants include: the area that will be occupied by the facility elements, including protection areas, necessary resources, the specific investment/ return of investment, the net income/the income gain resulting from the effect of the facility on the land of the agricultural holdings, environmental impact. It should be noted that the net income/the income gain resulting from the land facility is the direct link between the two types of management, i.e. water regulation and agriculture. The additional income obtained by the agricultural holdings after land planning is the result of the combined effect of the facility and the specific agricultural technologies applied on the lands provided with land reclamation works.

The construction phase is limited in time and requires the organization of the activities by the Gantt chart. The project schedule ensures that the resources (physical resources, labour force, operation duration) are effectively used for the successful completion of the development and rehabilitation of the degraded lands, according to the project deadlines.

The operation phase begins with the handover to the agricultural beneficiary and has a long time interval, depending on the service life of the facility components. The main objective of water regulation management is the operation of the hydrotechnical scheme according to the design parameters, in order to ensure the production of the improving effects of the facility. A permanent functional connection between the agricultural activities and the water regulation system must be ensured from this moment on.

Water regulation management must ensure the following: recording the duration and intensity of land and crop degradation produced by the water excess, soil drought, critical rainfall, critical water levels in the water supply sources, etc., monitoring the hydrological scheme in the canals and the physical condition of their drain section, controlling the groundwater dynamics and quality, tracking the water supply in the soil for each crop and soil type and also writing maintenance documents for the elements of the hydrotechnical scheme.

Water regulation management is provided by operation and maintenance organizations that perform their activities according to the demands of the agricultural beneficiaries, as stipulated in service contracts available for a fee.

The tariffs collected for land reclamation services must provide support for their use (irrigation systems, drainage and dryness, flood defense works, soil erosion control works) so as to protect the interests of the beneficiaries. At the same time, they ensure efficient water use, excess water collection and discharge, soil erosion and pollution prevention, and environmental protection support [***, 2006]. Water regulation management must provide the beneficiaries of the facilities with recommendations for the application of specific water regulation works, according to the services contracted by the beneficiaries. The recommendations include time of watering onset and size of the watering rate, initiation of agro-technical works on the lands affected by excess water, etc.

The beneficiaries of the land reclamation facilities, together with those who benefit from their operation, must pay a fee for the management of the works [Postamentel et al., 2022].

CONCLUSIONS

The analysis of the issues presented in the present study results in the following conclusions:

1. Land reclamation facilities are the main means of production in modern agriculture.
2. Land reclamation facilities consist of agricultural lands and the water regulation works applied to these lands.
3. The increase in the production potential of the agricultural lands supplied with land reclamation works is supported by the application of specific land reclamation management.
4. The management of land reclamation facilities makes a clear distinction between agricultural land management and water regulation management.
5. The positive economic effects of land reclamation facilities reach the highest level when the two management types are correlated, even if they are carried out by different organizational entities, i.e. agricultural holdings and on-site operation organizations.
6. The correlation between the two management types is based on the service contract between the two organizational entities.

7. To improve the global management of land reclamation facilities, it is necessary to extend the collaboration between agriculture and water regulation through some measures such as the following:

- reorganizing the services of forecasting and watering application warning;
- monitoring the groundwater evolution (levels, quality);
- monitoring the efficiency of underground drainage;
- identifying the areas that require the secondary drainage measures, etc.

8. The improvement of the overall management of land reclamation facilities would lead to a sustainable exploitation of the water and soil resources, as well as of the genetic resources.
9. Law amendments would ensure watering control in agricultural holdings and this would prevent the side effects of irrigation (soil salting, swamp formation).
10. Watering control should be the responsibility of the facility operation and maintenance organizations.

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