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UNIVERSITY OF CRAIOVA
FACULTY OF AGRONOMY

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Particular focus of the conference:

"The importance of protecting the natural and cultural capital in accordance with climate change and modern methods of restoring the agricultural and forest landscape"

Topics:

- **Climate-resilient agriculture and silviculture; Ecological agriculture and silviculture systems;**
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- **Ecological reconstruction; Preservation of natural and cultural heritage;**
- **Biodiversity monitoring in current climate conditions;**
- **Methods of combating desertification and drought;**
- **Waste management and alternative energies in agriculture and silviculture; New agriculture plants and crops;**
- **Traditional food processing; Agro-products quality and bio-safety.**
- **Agrifood economy; Financial economic analysis; The economic efficiency of agricultural production;**
- **Rural Development; Agrotourism; Agrotouristic resource management;**
- **Touristic landscape planning;**
- **Environmental economics and bioeconomy.**

AGROECOSYSTEMS IN BULGARIA – DYNAMICS AND ECOLOGICAL ASPECTS

Elif ADEMOVA, Miroslava MIHAYLOVA, Adnan MEHMED
The coordinating teacher Prof. Dimcho ZAHARIEV, PhD
Konstantin Preslavsky University of Shumen, Faculty of Natural Sciences,
115 Universitetska Str., 9700 Shumen, Bulgaria
E-mails: 2420210010@shu.bg
2220120005@shu.bg
2422691043@shu.bg
d.zahariev@shu.bg
***Corresponding author**: 2420210010@shu.bg*

Abstract

The study traces the typology and dynamics of the development of agroecosystems in Bulgaria based on data from the Bulgarian Agricultural and Economic Survey over the years from its first implementation in 1998 to 2024. The reasons for the loss of agroecosystems are examined, which are mainly due to the abandonment of arable land and the change in the purpose of agricultural land for non-agricultural purposes. The impact of processes leading to soil damage and hence to disruption of the structure and functions of agroecosystems has been monitored: increased soil acidity, salinization, erosion, landslides. A list of endangered local plant varieties and breeds of farm animals important for Bulgarian agriculture is attached. A classification of ecosystem services provided by agroecosystems in Bulgaria is presented.

Key words: *agricultural land, soil damage, plant varieties, breeds of farm animals*

INTRODUCTION

Agroecosystems include lands used for the production of crops or agricultural products harvested by humans and used by humans or animals for food, production of fibers, oils, as a source of energy, etc. The functional part of these ecosystems includes the dynamic relationships between crops, pastures, livestock, flora and fauna, soils, waters, atmosphere, etc. An important role is played by the interactions between the three main structural components: 1. Agro-ecological niches (e.g. soil types, vegetation types, crops, forests, water sources, etc.), 2. Agricultural infrastructure (roads, wells, farms, etc.), and 3. Social units (various stakeholders, social groups, types of farmers, markets, etc.) (Yordanov et al., 2017). Although they have an artificial origin, agroecosystems fully meet the definition of an ecosystem (Maes et al., 2011).

The proposed classification of agroeco-systems (Table 1) in the Methodology for Assessment and Mapping of the State of Agricultural Ecosystems and Their Services in Bulgaria (Yordanov et al., 2017) corresponds to the ecosystem classification in Mapping and Assessment of Ecosystems and their Services (MAES, 2013), combined with the habitat classification types of the European Nature Information System (EUNIS). It is also related to some of the CORINE land cover classes (CLC). The MAES ecosystem typology distinguishes two levels, where MAES Level 2 corresponds to EUNIS Level 1.

Table 1. Classification of agroecosystems in Bulgaria(Source: Yordanov et al., 2017)

Level 1	Level 2	Level 3
Terrestrial	Agroeco-systems	Annual Crops (mainly cereals)
		Perennial Crops (orchards and vineyards)

		Perennial Crops (mainly forage crops)
		Mixed Agricultural Lands
		Livestock Farms for Large and Small Animals, Including Bees

MATERIAL AND METHODS

The aim of this study is to establish the dynamics of agricultural areas and the dynamics of agroecosystems in Bulgaria based on data from the Bulgarian Agricultural and Economic Survey during the years from its first implementation in 1998 to 2024 (27-year period), as well as to monitor some of the ecological aspects of this group of ecosystems.

Emphasis is placed on the impact of the Republic of Bulgaria's accession to the European Union in 2007.

The Bulgarian Agricultural and Economic Survey (BAES) is conducted annually and provides an opportunity to monitor changes in employment on the territory of Bulgaria. The information is available online in the "Statistics/Land Use" section of the website of the Ministry of Agriculture and Food of the Republic of Bulgaria (Statistical Survey of Employment and Land Use, 2025).

All graphs in the Results and Discussions section are original and were created using data from the Bulgarian Agricultural and Economic Survey for the period 1998-2024.The red dot marks accession of the Republic of Bulgaria to the EU in 2007.

RESULTS AND DISCUSSIONS

Agricultural areas on the territory of the Republic of Bulgaria occupy an area of 6,048,969.80 ha, which is 54.50% of the country's territory (Land use distribution of the Republic of Bulgaria, 2025).

This area can be divided into several categories according to the definitions adopted by the European Commission Decision No.89/651/EEC:

1. Agricultural Land Area.
2. Utilized Agricultural Area.
3. Arable Land.

The Agricultural Land Area is formed by arable land, permanent crops, permanent grassland areas with agricultural use (including high mountain pastures and grasslands with low productive potential), family gardens and agricultural land that has not been cultivated for more than five years.

The dynamics of this area in the period 1998-2024 shows a clear trend of decreasing area (Figure 1). Bulgaria's accession to the EU in 2007 did not affect the process of decreasing the area used for agricultural purposes in the next 7 years until 2014. After that, a relative preservation of the area was observed.

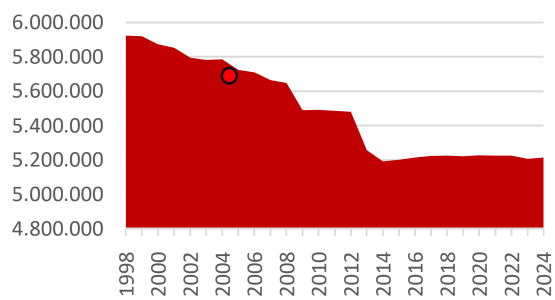

Figure 1. Dynamics of the Agricultural Land Area (in hectares)

The Utilized Agricultural Area is formed by arable land, permanent crops, nurseries, permanent grassland and family gardens. The dynamics of this area are presented in Figure 2.

The decreasing trend is similar to that observed for the area with agricultural purpose.

The minimum was reached again in 2014. The accession of the Republic of Bulgaria to the European Unionhad a positive impact and the pace of decline was greatly reduced and there is even an attempt to recover the lost areas.

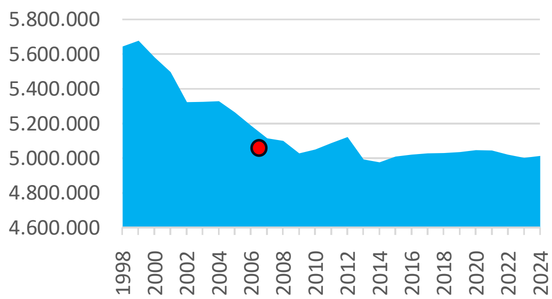

Figure 2. Dynamics of the Utilized Agricultural Area(in hectares)

The Arable Land includes areas where crop rotation is applied, temporary meadows with cereal and leguminous grasses, fallows and greenhouses. This land is only part of the two larger areas examined so far.

Like them, until accession of the Republic of Bulgaria to the European Union, there is a tendency to reduce the area (Figure 3). In contrast, however, after 2007 and a one-year retention of the value, a rapid increase follows with a maximum shortly after 2014.

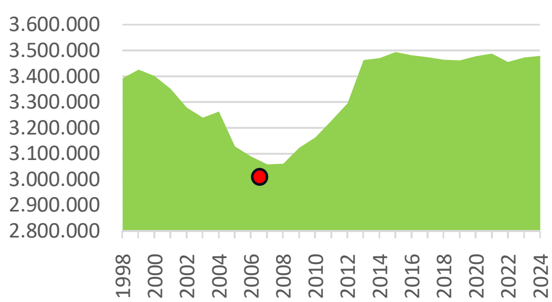

Figure 3. Dynamics of the Arable Land (in hectares)

The comparison of the dynamics of the three types of areas shows the aforementioned trends and the stabilization process after 2014 – a full 7 years after accession of the Republic of Bulgaria to the European Union.

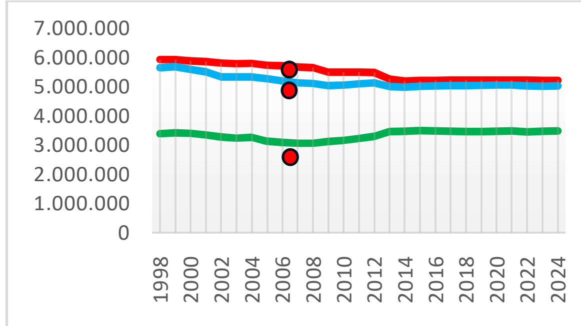

Figure 4. Comparison of the dynamics of the three types of areas (in hectares):
1. Red line – Agricultural Land Area;
2. Blue line – Utilized Agricultural Area;
3. Green line – Arable Land

The dynamics of the area of agroeco-systems shows a different course for each group. In the case of the**Annual Crops – cereals, vegetables, industrial crops, and oilseed crops**, there is a tendency for the area to decrease until accession of the Republic of Bulgaria to the European Union. After 2007, a rapid increase follows with a maximum in 2015 (Figure 5). The reason is the effect of European programs that stimulate farmers and the rapid return on investment from the crops grown in this group.

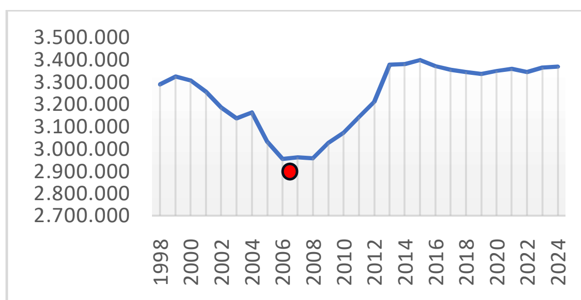

Figure 5. Dynamics in the area of the Annual Crops – cereals, vegetables, technical crops, and oilseed crops (in hectares)

In the case of two classes of **perennial crops**, the decrease in area continued until 2014. This was followed by a slight increase and relative stabilization of the area of these agroecosystems, both in the

Perennial Crops – orchards, vineyards, and nurseries (Figure 6), and in the Perennial Crops – forage crops, meadows, and pastures (Figure 7).

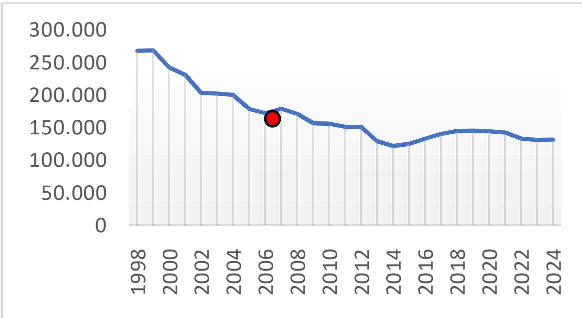

Figure 6. Dynamics in the area of the Perennial Crops – orchards, vineyards, and nurseries (in hectares)

It is interesting that in the area of agroecosystems Perennial crops - fodder crops, meadows and pastures, a trend towards stopping the reduction of the area and its increase was observed already in 2003. Unfortunately, this process lasted only three years and in 2006 the areas occupied by this group of ecosystems began to decrease again.

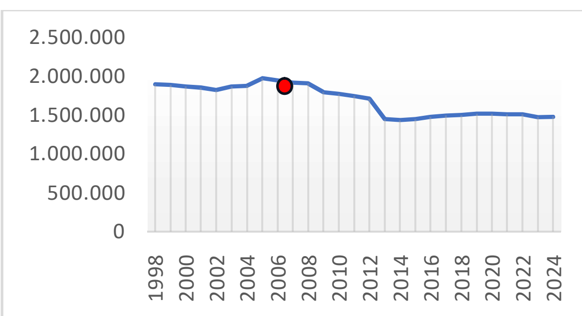

Figure 7. Dynamics in the area of the Perennial Crops – forage crops, meadows, and pastures (in hectares)

In the case of the **Mixed Agricultural Lands**, after Bulgaria's accession to the EU, the processes of area reduction, albeit more gradually, continue (Figure 8).

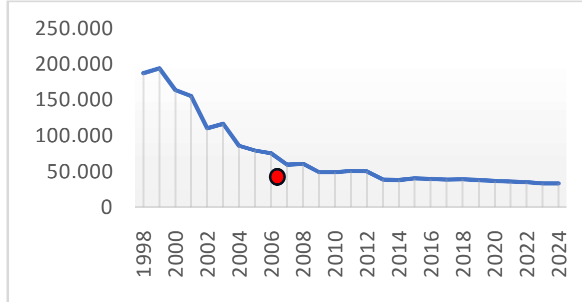

Figure 8. Dynamics in the area of the Mixed Agricultural Lands – family gardens, mixed perennial crops and meadow-orchards (in hectares)

The main reasons for the loss of agro-ecosystems are several: The largest share is the **abandonment of agricultural lands** (Figure 9). This process continued until accession of the Republic of Bulgaria to the European Union, after which a part of the abandoned lands was recovered approximately to the initial level.

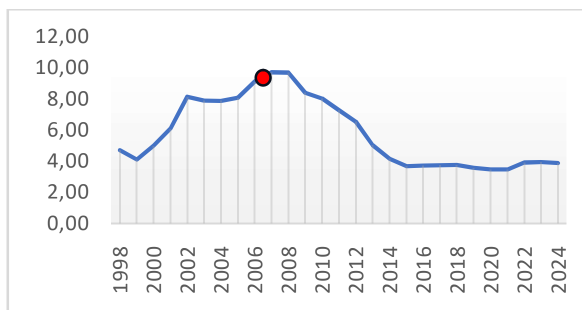

Figure 9. Dynamics of the area of uncultivated land (as a percentage of the area of land used for agricultural purposes)

The **change in the purpose of agricultural lands** is the second most important factor. What is unexpected here is that a large part of these lands has been transferred to the country's forest fund. The reason is the succession of abandoned lands, which led to the transformation of vegetation from grassland to forest. According to data from the Annual Agrarian Reports on the State and Development of Agriculture of the Ministry of Agriculture and Food of the Republic of Bulgaria for the period from 2004 to 2022, the percentage of agricultural land with a changed purpose ranges from 0 to 0.08% of the area of land with agricultural purpose (Figure 10). This relationship was broken in 2022, when this percentage sharply increased to 0.37%.

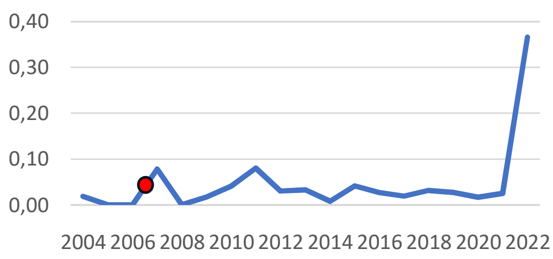

Figure 10. Dynamics of agricultural land with changed purpose (in percentage of the area of land with agricultural purpose)

The procedure for changing the purpose of agricultural land for non-agricultural needs under the Agricultural Land Protection Act of the Republic of Bulgaria is two-stage and includes: first stage - approval of a design site and second stage - change of the purpose of agricultural land. A mandatory document for the first stage is the presence of an effective decision or opinion issued under the procedure of Chapter Six of the Environmental Protection Act of the Republic of Bulgaria and under Art. 31 of the Biodiversity Act of the Republic of Bulgaria by the relevant Regional Inspectorate for Environment and Waters - a requirement of Art. 21, Para. 1 of the Agricultural Land Protection Act of the Republic of Bulgaria and Art. 30, Para. 1, Item 6 of the Regulations for the Implementation of the Agricultural Land Protection Act. The commissions under Art. 17, Para. 1 of the Agricultural Land Protection Act of the Republic of Bulgaria do not approve sites and do not change the purpose of agricultural land if there is an opinion issued by the Regional Inspectorate for Environment and Waters or the Ministry of Environment and Waters of the Republic of Bulgaria, which states that the construction of the site will have an adverse impact on species and habitats (Agricultural Report 2023).

The construction of wind parks and photovoltaic parks is a process that began after accession of the Republic of Bulgaria to the European Union and continues to this day. By 2050, it is planned to install photovoltaic power plants with a capacity of 11.8 GW, wind power plants with a capacity of 5 GW on land and 3.3 GW at sea in Bulgaria. This leads to the question "Where should these power plants be located?" (Kircheva, 2024). In most cases, these parks are built on land that is currently not used for agricultural purposes. In other cases, some of the parks are also located on the territory of agroecosystems. Such is the example of the largest wind park in Bulgaria near the town of Kavarna, Dobrich district, with a total capacity of 156 MW, completed in 2020 (Figure 11).

Figure 11. Part of the territory of the largest wind park in Bulgaria near the town of Kavarna (Photo: AES Bulgaria)

The practice in designing and building photovoltaic parks is similar. Most of these parks are built on land that is currently not used for agricultural purposes. In larger-scale projects, however, some of the parks are also built on agricultural land. An example of this is the largest photovoltaic park in Bulgaria near the village of Apriltsi, Pazardzhik district with a total capacity of 400 MW, completed in 2024. This is very clearly visible in the two photos before and after the construction of the park (Figure 12 and Figure 13).

Soil degradation processes are also a cause of loss of agroecosystems and their structure or functions. Observations of acidification processes at the monitoring network points show a trend towards a decrease in the degree of harmful acidification in 2022 (National Report on the State and Protection of the Environment in the Republic of Bulgaria, 2024). The percentage distribution of data from soil acidification measurements in the 0-20 cm soil layer in 2022 is presented in Figure 14.

Figure 12. The territory of the future largest photovoltaic park in Bulgaria near the village of Apriltsi (Photo from Google Earth in 2013)

Figure 13. The territory of the already built largest photovoltaic park in Bulgaria near the village of Apriltsi (Photo from Google Earth in 2024)

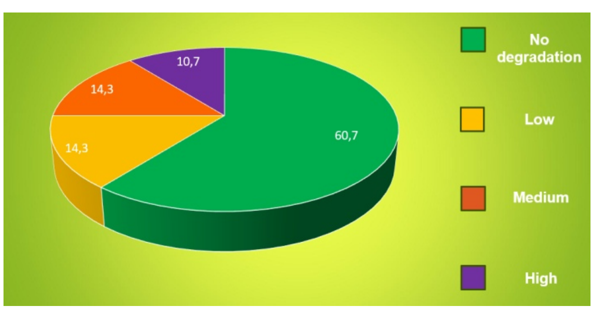

Figure 14. Percentage distribution of data from soil acidification measurements in the 0-20 cm soil layer in 2022

In the same year, 12 points from the monitoring network were surveyed to assess **soil salinity**. The points are representative of saline soils (National Report on the State and Protection of the Environment in the Republic of Bulgaria, 2024). The results show a decrease in salinity in most places. It remains the strongest in the lands of the town of Straldzha, the village of Trustikovo and the village of Belozem (Figure 15).

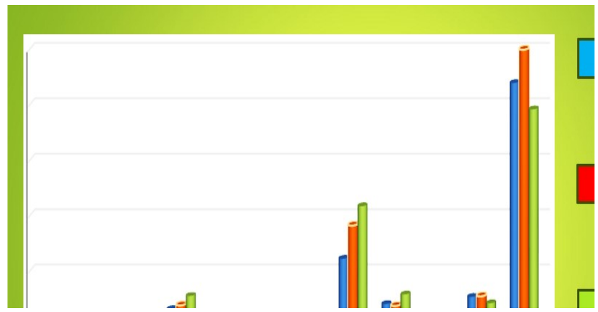

Figure 15. Distribution of soil salinity measurements at 12 points in 2022:
4 – Straldzha town (Yambol Province),
8 – Trastikovo village (Varna Province),
12 – Belozem village (Plovdiv Province)

In the period 2015-2022, the areas affected by **flat-water erosion of soil** and soil losses are increasing (National Report on the State and Protection of the Environment in the Republic of Bulgaria, 2024). The highest erosion risk is on arable land in the catchment areas of the Black Sea, the Rusenski Lom River and the lower reaches of the Maritsa River (Figure 16).

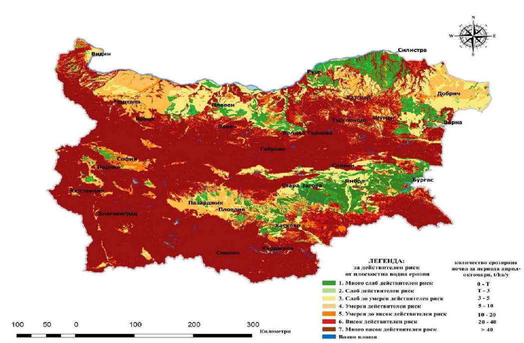

Figure 16. Map of the risk of flat-water erosion of soil in 2022

Unlike flat-water erosion, which is characteristic of mountainous and hilly conditions, **wind erosionof soil** occurs mainly on large and open plains. In the period 2015-2022, the areas affected by wind erosion remained relatively constant (National Report on the State and Protection of the Environment in the Republic of Bulgaria, 2024). The risk of wind erosion of soil in 2022 is presented in Figure 17.

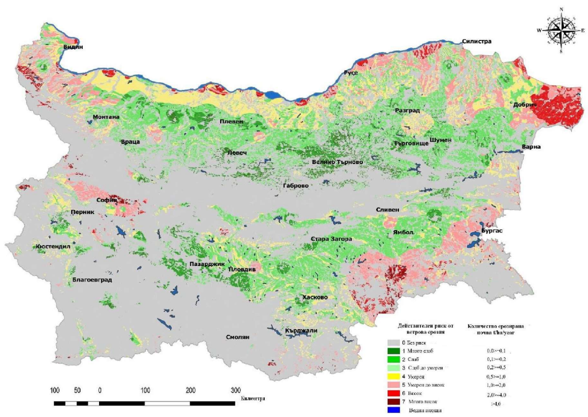

Figure 17. Map of the actual risk of wind erosion of soil for 2022

The change in species diversity and the diversity of plant varieties and animal breeds is also an important problem for agroecosystems. With the introduction of highly productive foreign plant varieties and animal breeds, local varieties and breeds are being abandoned and gradually disappearing. This leads to the loss of biological and genetic diversity.

The conservation of endangered local plant varieties important for agriculture has one particularly important reason: they are well adapted to regional conditions and are more resistant to diseases. They are also a specific part of the agroecosystems in Bulgaria, which distinguishes them from all other parts of the world. Endangered local plant varieties are an important cultural value that characterizes rural areas and is part of their specificity. The implementation of a separate activity in measure 10. Agro-ecology and Climate of the RDP 2014-2020 has a beneficial impact by encouraging farmers to grow local plant varieties. By increasing the areas on which such varieties are grown, the aim is also to increase the varietal diversity on the market, which is required by the economically more profitable plant varieties, the production of which is more profitable (Conservation of endange-red local plant varieties important for agriculture, 2025).

A list of endangered local varieties important for agriculture (2023) is included in Appendix 1. The varieties are divided into crop groups and, for the sake of brevity, the specific names of the varieties are not given. We include only one field crop among the endangered local varieties. Vegetable crops have the largest number of endangered varieties.

The conservation of endangered indigenous breeds of animals important for agriculture is related to similar reasons as for endangered indigenous varieties. A list of endangered indigenous breeds of animals important for agriculture (2023) is included in Annex 2.

As artificially created ecosystems, agro-ecosystems definitely exist due to the benefits that are derived from them. They are the main reason for their existence, which distinguishes them from all other groups of ecosystems.

The ecosystem services provided by agroecosystems can be divided into 4 groups:

Material services – these are all the goods that ecosystems provide us.

Regulating services – e.g. water purification, waste mineralization.

Cultural services – intangible benefits that people derive from ecosystems in the form of enjoyment of beautiful nature.

Supporting services – e.g. nutrient cycling, water cycling, soil formation.

A list of ecosystem services provided by agroecosystems is included in Appendices 3 and 4. The proposed list is based on data from the Methodology for Assessment and Mapping of the State of Agricultural Ecosystems and Their Services in Bulgaria (Yordanov et al., 2017). Each ecosystem service is accompanied by its code, according to the Common International Classification of Ecosystem Services (CICES). Annex 3 presents a list of ecosystem services of agroecosystems, according to the older CICES classification, Version 4.3, as used in the Methodology for Assessment and Mapping of the State of Agricultural Ecosystems and Their Services in Bulgaria (Yordanov et al., 2017). Annex 4 includes a list of ecosystem services of agroecosystems, using the latest CICES classification, Version 5.2.

CONCLUSIONS

Agroecosystems are also subject to negative impacts, just like other ecosystems.

Taking measures to minimize the effects of these impacts is part of good management practices for this group of ecosystems. Their future rests on a good balance between sustainable management and obtaining revenues from the ecosystem services they provide.

ACKNOWLEDGEMENTS

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Annex 1. List of endangered local plant varieties important for the agriculture of the Republic of Bulgaria

Crop	**Latin name**	**Number of varieties**
Arable Crops		
Potatoes	*Solanum tuberosum* L.	2
Vegetable Crops		
Tomatoes	*Solanum lycopersicum* L.	10
Pepper	*Capsicum annuum* L.	23
Cucumbers	*Cucumis sativus* L.	12
Melon	*Cucumis melo* L.	4
Watermelon	*Citrullus lanatus* (Thunb.) Matsum. et Nakai	4
Zucchini	*Cucurbita pepo* L.	3
Pumpkin	*Cucurbita maxima* Duchesne	1
Butternut squash	*Cucurbita moschata* Duch.	1
Common bean	*Phaseolus vulgaris* L.	7
Pea	*Pisum sativum* L.	10
Onion	*Allium cepa* L.	7
Leek	*Allium porrum* L.	1
Garlic	*Allium sativum* L.	1
White cabbage	*Brassica oleracea* L. var. *capitata* L.	4
Red headed cabbage	*Brassica oleracea* L. var. *capitata* L.	2
Fava beans	*Vicia faba* L.	2
Loofah	*Luffa cylindrica* M.J. Roem.	1
Gourds	*Lagenaria siceraria* (Molina) Standl.	1
Medicinal and Aromatic Crops		
Oil-bearing rose	*Rosa × damascena* Mill.	1
Lavender	*Lavandula* sp. diversa	4
Marigold	*Calendula officinalis* L.	1
Snowflake	*Leucojum aestivum* L.	1
Peppermint	*Mentha piperita* L.	1
Crop	*Latin name*	Number of varieties
Fruit Cultures		
Apple	*Malus domestica* Borkh.	18
Pear	*Pyrus communis* L.	4
Plum	*Prunus domestica* L.	12

sloe	*Prunus cerasifera* Ehrh.	2
Cherry	*Prunus avium* (L.) L.	12
Apricot	*Prunus armeniaca* L.	14
Peach	*Prunus persica* (L.) Batsch	6
Quince	*Cydonia oblonga* Mill.	1
Almond	*Prunus dulcis (Mill.) D. A. Webb*	7
Fig	*Ficus carica L.*	2
Raspberry	*Rubus idaeus L.*	2
Strawberry	*Fragaria × ananassa Duch.*	3
Grapevine	*Vitis vinifera L.*	27

Annex 2. List of endangered animal breeds important for the agriculture of the Republic of Bulgaria

Species	**Latin name**	**Breed count**
Cattle	*Bos primigenius* Bojanus, 1827	7
Buffalo	*Bubalus bubalis* Linnaeus, 1758	1
Sheep	*Ovis aries* Linnaeus, 1758	25
Goat	*Capra aegagrus* Linnaeus, 1758 subsp. *hircus*	4
Swine	*Sus scrofa* Erxleben, 1777 subsp. *domesticus*	2
Horse	*Equus ferus* Linnaeus, 1758 subsp. caballus	5

Annex 3. List of ecosystem services provided by agroecosystems in the Republic of Bulgaria, according to CICES, Version 4.3

No.	**Name**	**CICES Class code**
Provisioning Services		
P1	Cultivated crops (type, structure, percentage)	1111
P2	Reared animals and their products	1112
P3	Wild plants, algae, and their products	1113
P4	Wild animals and their products	1114
P5	Plants and algae from *in situ* aquaculture	1115
P6	Animals from *in situ* aquaculture	1116
P7	Surface water for drinking	1121
P8	Ground water for drinking	1122
P9	Surface water for drinking	1221
P10	Ground water for drinking	1222
P11	Fibres and other materials from plants, algae, and animals for direct use or processing	1211
P12	Materials from plants, algae, and animals for agricultural use	1212
P121	Materials from plants, algae, and animals for biochemicals and pharmaceuticals	-
P13	Genetic material from all flora and fauna	1213
P15	Surface water – non-potable	1221
P16	Groundwater – non-potable	1222
P17	Minerals extractable near or above the surface (e.g. Construction sand, lignite,	-

	gold, salts)	
P18	Plant-based energy resources	1311
P19	Animal-based energy resources	1321
P20	Abiotic energy sources used for conversion – solar	-
Regulating Services and Supporting Services		
R1	Filtration/sequestration/storage /accumulation by ecosystems	2112
R2	Dilution by atmospheric, freshwater, and marine ecosystems	2122
R3	Mediation of smells/noise/visual impacts	2123
R4	Mass stabilization and control of erosion rates	2211
R5	Buffering and attenuation of mass flows	2212
R6	Maintenance of the hydrological cycle and water flow	2221
R7	Flood protection	2222
R8	Storm protection	2231
R9	Ventilation and transpiration	2232
R10	Pollination and seed dispersal	2311
R11	Maintenance of nursery populations and habitats	2312
R12	Pest control	2321
R13	Disease control	2322
R14	Natural succession processes	2331
R15	Decomposition and nutrient fixation processes	2332
R16	Chemical condition of freshwater bodies	2341
R17	Regulation of global climate by reducing greenhouse gas concentrations	2351
R18	Regulation of micro- and regional climate	2352
Cultural Services		
C1	Experimental use of plants, animals, and landscapes/seascapes in different ecological settings	3111
C2	Physical use of landscapes/seascapes in different ecological settings	3112
C3	Scientific	3121
C4	Educational	3122
C5	Cultural heritage	3123
C6	Recreation	3124
C7	Aesthetic	3125
C8	Symbolic	3211
C9	Sacred and/or religious	3212
C10	Existence	3221
C11	Bequest	3222

Annex 4. List of ecosystem services provided by agroecosystems in the Republic of Bulgaria, according to CICES, Version 5.2

No.	Name	CICES Class code
Provisioning Services		
P1	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes	1111
P2	Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)	1112
P3	Cultivated plants (including fungi, algae) grown as a source of energy	1113
P4	Plants cultivated by in- situ aquaculture grown for nutritional purposes	1121
P5	Fibres and other materials from in-situ aquaculture for direct use or processing (excluding genetic materials)	1122
P6	Plants cultivated by in- situ aquaculture grown as an	1123

	energy source	
P7	Animals reared for nutritional purposes	1131
P8	Fibres and other materials from reared animals for direct use or processing (excluding genetic materials)	1132
P9	Animals reared to provide energy (including mechanical)	1133
P10	Animals reared by in-situ aquaculture for nutritional purposes	1141
P11	Fibres and other materials from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials)	1142
P12	Animals reared by in-situ aquaculture as an energy source	1143
P13	Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition	1151
P14	Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)	1152
P15	Wild animals (terrestrial and aquatic) used for nutritional purposes	1161
P16	Higher and lower plants (whole organisms) used to breed new strains or varieties	1212
P17	Individual genes extracted from higher and lower plants for the design and construction of new biological entities	1213
P18	Wild animals (whole organisms) used to breed new strains or varieties	1222
P19	Individual genes extracted from organisms for the design and construction of new biological entities	1223
P20	Surface water for drinking	4211
P21	Surface water used as a material (non-drinking purposes)	4212
P22	Ground (and subsurface) water for drinking	4221
P23	Ground water (and subsurface) used as a	4222

	material (non-drinking purposes)	
P24	Materials from plants, algae, and animals for biochemicals and pharmaceuticals	-
P25	Minerals extractable near or above the surface (e.g. Construction sand, lignite, gold, salts)	-
P26	Abiotic energy sources used for conversion – solar	-
Regulating Services and Supporting Services		
R1	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	2112
R2	Smell reduction	2121
R3	Noise attenuation	2122
R4	Visual screening	2123
R5	Control of erosion rates	2211
R6	Buffering and attenuation of mass movement	2212
R7	Hydrological cycle and water flow regulation (Including flood control, and coastal protection)	2213
R8	Wind protection	2214
R9	Pollination (or 'gamete' dispersal in a marine context)	2221
R10	Seed dispersal	2222
R11	Maintaining nursery populations and habitats (Including gene pool protection)	2223
R12	Pest control (including invasive species)	2231
R13	Disease control	2232
R14	Weathering processes and their effect on soil quality	2241
R15	Decomposition and fixing processes and their effect on soil quality	2242
R16	Regulation of the chemical condition of freshwaters by living processes	2251
R17	Regulation of chemical composition of atmosphere	2261

	and oceans	
R18	Regulation of temperature and humidity, including ventilation and transpiration	2262
R19	Dilution by freshwater and marine ecosystems	5111
R20	Dilution by atmosphere	5112
Cultural Services		
C1	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	3111
C2	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions	3112
C3	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge	3121
C4	Characteristics of living systems that enable education and training	3122
C5	Characteristics of living systems that are resonant in terms of culture or heritage	3123
C6	Elements of living systems used for entertainment or representation	3213
C7	Characteristics of living systems that enable aesthetic experiences	3124
C8	Elements of living systems that have symbolic meaning	3211
C9	Elements of living systems that have sacred or religious meaning	3212
C10	Characteristics or features of living systems that have an existence value	3221
C11	Characteristics or features of living systems that have an option or bequest value	3222

METAMITRON EFFECT ON FRUIT THINNING OF ’WILLIAMS’ PEAR

Slavica SPASOJEVIĆ[1], Čedo OPARNICA[1], Jasminka MILIVOJEVIĆ[1], Ksenija VUKIĆEVIĆ[2], Dragan RADIVOJEVIĆ[1]*

[1]University of Belgrade-Faculty of Agriculture, Nemanjina 6, 11080 Belgrade, Serbia

[2]Research and Development Institute Tamiš, Novoseljanski put 33, 26000 Pancevo, Serbia

***Corresponding author:** draganr@agrif.bg.ac.rs*

Abstract

Chemical fruit thinning is the preferred measure to apply in a pear orchard in order to ensure consistent yields and marketable fruit production. This study aimed to examine the thinning effect of the photosynthesis-inhibiting agent metamitron (MM), applied in two concentrations, on the yield and fruit quality of the ‘Williams’ pear cultivar. The experiment was conducted over two years (2023-2024) in a commercial pear orchard in Bogatić, Serbia, which was planted in 2019 at a distance of 3.5 m x 1 m on quince rootstock BA 29 and trained as a slender spindle. Metamitron was applied when central fruits in a cluster were 13-14 mm in diameter, using two concentrations: 250 mg/l (MM250) and 330 mg/l (MM330), with untreated trees serving as the control treatment. Metamitron applied at both concentrations reduced the number of the smallest fruit size category (diameter of <60 mm) by 34-57% in the MM250 treatment and 47-73% in the MM330 treatment compared to the control in both years studied. This effect was positively correlated with the applied concentration, leading to an increase in average fruit weight. In the first year investigated, the total yield was significantly lower in MM treatments compared to the control due to a reduction in total and smallest fruits number per tree. Conversely, in the following year, MM330 recorded the highest yield, along with an increase in the number of larger fruit size classes (65-70 mm and 70-75 mm). The number of fruits in the quality categories of 65-70 mm, 70-75 mm, and >75 mm did not differ significantly between the treatments. The treatments did not affect soluble solids, total acid content, or fruit firmness. The return bloom as an indicator of the following year's yield was higher in the MM treatments, but this difference was not statistically significant compared to the control treatment.

Key words: *Pyrus communis, fruit chemical thinning, yield efficiency, fruit quality*

INTRODUCTION

Highly productive cultivars of European pear (*Pyrus communis* L.) often overyield, leading to unmarketable fruit production, increased harvest costs, and alternate bearing. To prevent this and obtain regular and high yields, careful management of crop load is needed. Winter pruning is the first management practice that is applied in order to regulate crop load by removing a certain number of flower buds (Radivojevic et al., 2023). Still, a large number of flowers can be developed, leading to an excessive number of fruits per tree in favourable pollination conditions. Therefore, crop load must be reduced, usually by applying chemical thinning as the most effective measure. Bloom and postbloom thinning is essential to provide a quality yield and fruit of the ’Williams’ pear (Elsysy et al., 2020), as highly yielding and one of the most commonly grown cultivars. Since this cultivar is highly sensitive to spring frost, producers more often wait for fruit formation to employ thinning (Radivojević et al., 2024). Several thinners, mostly plant bioregulators, can be applied in pears at postbloom, but their efficacy decreases with later fruitlet stages. Metamitron is a relatively new postbloom thinner for apples and pears that can be applied up to a fruit size of 20 mm or from 8 to 14 mm for maximal response (Green and Costa, 2013). It is a herbicide that acts through photosynthesis inhibition, blocking electron transport in photosystem II (Elsysy et al., 2020). Thus, it leads to negative carbohydrate balance, causing fruit abscission due to insufficient nutrients and greater competition between fruits. The thinning effect depends on many factors such as weather conditions, concentration of agent, timing, carbohydrate content, tree characteristics, etc. (Radivojevic et al., 2023; Gonzales Nieto et al., 2023). For effective thinning with metamitron, temperatures must be favorable during the treatment and for the subsequent 3 days, with maximum daily temperatures exceeding 20 °C and minimum night temperatures exceeding 10 °C (Radivojevic et al., 2020). According to Gonzales Nieto et al. (2023), meteorological factors can notably affect thinning 6 days after application, with temperatures and solar radiation being of particular importance. Numerous studies have confirmed metamitron's effectiveness in apple thinning, showing a positive response to concentration increase (Gonzalez et al., 2022; Gonzales Nieto et al., 2023), while efficacy in pears has been less investigated. This study aimed to examine the thinning effect of the metamitron (MM) applied in two concentrations on the yield and fruit quality of the 'Williams' pear cultivar.

MATERIALS AND METHODS

The experiment was conducted during 2023-2024 in the commercial orchard of 'Williams' pear, located in the Mačva District of western Serbia (municipality Bogatić; 44.84° N, 19.48° E, 84 m a.s.l.). The orchard was planted in 2019 with a spacing of 3.5 m between rows and 1 m within the row (2,857 trees per ha). Trees of the 'Williams' cultivar grafted onto BA 29 quince rootstock and trained as slender spindles were used. The experiment was set up as a randomized block design with four repetitions, each containing two trees. The trees were uniform, and flowering was abundant. The weather parameters collected from the closest meteorological station (Meteomanz, 2025) on the day of application (0) and 6 days after are presented in Table 1.

Table 1. Meteorological parameters during and 6 days after metamitron application in 2023 and 2024.

	Days after the application						
	0	**1**	**2**	**3**	**4**	**5**	**6**
2023							
Maximum temperature (°C)	20.1	23.4	24.5	26.4	18.2	17.8	19.6
Minimum temperature (°C)	11.6	7.8	10	10.3	9.5	4.5	7.5
Insolation (hours)	3.5	8.6	12.9	12	2.7	4.6	12
2024							
Maximum temperature (°C)	21	23.1	25	27	28.2	26.8	29
Minimum temperature (°C)	12.4	12	13.7	11.3	16.4	17	16.8
Insolation (hours)	12.2	9	9.8	11.5	9.8	10.8	5.9

Chemical thinning was performed when the central fruits in the cluster reached an average diameter of 13.4 mm in 2023 (May 4) and 14.1 mm in 2024 (May 15). Metamitron (Brevis) was applied at two concentrations: 250 mg l^{-1} (MM250) and 330 mg l^{-1} (MM330), and unthinned trees were kept as a control for comparison. Chemicals were applied foliarly with a hand sprayer at a volume rate of 1,000 l ha^{-1}. At harvest, all fruits were harvested at the same moment and classified according to their diameter into the following classes: <60 mm, 60-65 mm, 65-70 mm, 70-75 mm, and

>75 mm. The total yield and number of fruits, as well as those within each size class, were recorded. A sample of 10 fruits from each treatment and repetition was taken for laboratory analysis, including measurements of fruit weight (g), fruit height (mm), fruit diameter (mm), firmness (kg cm^{-2}), total soluble solids (TSS, %), titratable acidity (TA, %), and seed count. The return bloom, measured as the number of floral buds, was counted in the year following the application.
The obtained data were analysed using SPSS 17.0 Statistics and one-way analysis of variance. The significance of the differences between means was determined by the LSD post hoc test at $p \leq 0.05$.

RESULTS AND DISCUSSIONS

Yield parameters of the cultivar 'Williams' treated with metamitron are presented in Tables 2 and 3. The response to metamitron thinning varied by year. Concentrations similar to ours (200 to 300 ppm) have previously been shown to be effective in 'Williams' pear when applied from 10 to 13 mm, although with some variations between years (Elsysy et al., 2020). Another study confirmed metamitron's efficacy up to 18.5 mm, with a significant positive correlation to minimum temperatures and a negative correlation to maximum temperatures and solar radiation (Gonzales Nieto et al., 2023). Therefore, different metamitron responses between the studied years can be clarified by variation in meteorological data. The lower maximum temperatures and insolation (cloudy weather) after treatment in 2023 (Table 1) possibly increased plant stress and led to enhanced fruit drop. On the contrary, slightly higher maximum temperatures and increased insolation in the following year suppressed metamitron activity. In 2023, metamitron applied at both concentrations significantly reduced the total number of fruits per tree compared to the control (Table 2). This caused a notable decrease in total yield per tree, including yields from both size classes—fruits under and over 60 mm in diameter. Similarly, Fernandez (2018) observed reduced yields in 'Rocha' pear, especially with increased concentrations of metamitron. Contrary to earlier consistent findings with the same concentrations used (Radivojević et al., 2024), no differences were seen in fruit number or total yield per tree, nor yield of fruits over 60 mm in diameter during the second year of the experiment (Table 3). However, the yield of smaller fruits (<60 mm) was significantly reduced, with the reduction becoming more pronounced as the concentration of metamitron increased. Although not statistically significant, the yield of marketable fruits (>60 mm) tended to increase in MM treatments due to a decrease in small fruits and an increase in fruit weight. Consistent with Radivojević et al. (2024), fruit weight was significantly increased by metamitron applied at 330 mg l^{-1} in both seasons. The positive effect of metamitron on pear fruit weight was found to be related to yield reduction (Fernandez, 2018; Elsysy et al., 2020).
The return bloom was not significantly affected by MM treatments in 2023, although it was slightly increased in comparison to the control. Comparable to previous findings (Radivojević et al., 2024), lower MM concentration induced greater formation of generative buds.
There is often inconsistency found regarding the return bloom, even with satisfactory crop load reduction.
Thus, it can be even more reduced by chemical thinning agents than in unthinned trees (Fernandez, 2018). Data for the return bloom in the spring

following the application in 2024 were not presented due to frost effects.

Table 2. The effect of metamitron on the yield parameters of 'Williams' pear in 2023.

Treatment	Total fruit number per tree	Fruit weight (g)	Total yield (kg tree^{-1})	Yield of fruits <60 mm (kg tree^{-1})	Yield of fruits >60 mm (kg tree^{-1})	Return bloom
Control	104.88±6.41a	125.7+9.15b	13.5±0.74a	3.41±0.59a	10.09±0.83a	28.8±1.5
MM250	63.75±4.8b	141.49+3.14ab	8.98±0.7b	1.57±0.38b	7.41±0.52b	43.9±1.9
MM330	62±6.26b	147.4+2.52a	8.98±0.78b	0.97±0.24b	8.01±0.63b	34.6±2.6
Significance	***	*	***	**	*	ns

Means in the column followed by different letters indicate significant differences at $p \leq 0.05$. ns not significant; *, ** and *** indicate significance at 0.05, 0.01 and 0.001, respectively.

Contrary to earlier consistent findings with the same concentrations used (Radivojević et al., 2024), no differences were seen in fruit number or total yield per tree, nor yield of fruits over 60 mm in diameter during the second year of the experiment (Table 3). However, the yield of smaller fruits (<60 mm) was significantly reduced, with the reduction becoming more pronounced as the concentration of metamitron increased. Although not statistically significant, the yield of marketable fruits (>60 mm) tended to increase in MM treatments due to a decrease in small fruits and an increase in fruit weight. Consistent with Radivojević et al. (2024), fruit weight was significantly increased by metamitron applied at 330 mg l^{-1} in both seasons. The positive effect of metamitron on pear fruit weight was found to be related to yield reduction (Fernandez, 2018; Elsysy et al., 2020).
The return bloom was not significantly affected by MM treatments in 2023, although it was slightly increased in comparison to the control. Comparable to previous findings (Radivojević et al., 2024), lower MM concentration induced greater formation of generative buds. There is often inconsistency found regarding the return bloom, even with satisfactory crop load reduction. Thus, it can be even more reduced by chemical thinning agents than in unthinned trees (Fernandez, 2018). Data for the return bloom in the spring following the application in 2024 were not presented due to frost effects.
The distribution of fruits in size classes was improved by metamitron compared to the unthinned control (Figures 1 and 2). In both years, control recorded the greatest representation of the smallest fruits in the total fruit number (37 % and 34 %). At the same time, MM treatments reduced their presence in a dose-dependent manner by 57-73 % (2023) and 34-47 % (2024), consequently increasing the share of marketable fruits over 60 mm in diameter. Comparable to Fernandez's (2018) study, where metamitron resulted in 40 to 70 % fruits over 65 mm, we observed over 70% for MM250 and over 80 % for MM330 of marketable fruits in both studied years. As a consequence, the yield of fruits under 60 and from 60 to 65 mm was

significantly reduced by both MM250 and MM330 in comparison to the control in 2023. In the following year, treatments differed only regarding the smallest fruit size class, with MM330 statistically differing from the control (Figure 2b). For other size classes, there were no significant differences between treatments; however, an increased share of larger fruits in the total yield can be observed with metamitron treatments.

Table 3. The effect of metamitron on the yield parameters of 'Williams' pear in 2024.

Treatment	Total fruit number per tree	Fruit weight (g)	Total yield (kg tree^{-1})	Yield of fruits <60 mm (kg tree^{-1})	Yield of fruits >60 mm (kg tree^{-1})
Control	114.8±18.96	124.83±4.6b	14.47±2.76	3.5±0.27a	10.97±2.59
MM250	113.2±4.62	143.83±5.14a	15.34±0.69	2.5±0.38ab	12.84±0.74
MM330	127.4±10.13	146.71±7.62a	18.76±1.82	2.15±0.39b	16.61±2.06
Significance	ns	*	ns	*	ns

Means in the column followed by different letters indicate significant differences at p ≤ 0.05. ns not significant; *, ** and *** indicate significance at 0.05, 0.01 and 0.001, respectively.

The distribution of fruits in size classes was improved by metamitron compared to the unthinned control (Figures 1 and 2). In both years, control recorded the greatest representation of the smallest fruits in the total fruit number (37 % and 34 %). At the same time, MM treatments reduced their presence in a dose-dependent manner by 57-73 % (2023) and 34-47 % (2024), consequently increasing the share of marketable fruits over 60 mm in diameter. Comparable to Fernandez's (2018) study, where metamitron resulted in 40 to 70 % fruits over 65 mm, we observed over 70% for MM250 and over 80 % for MM330 of marketable fruits in both studied years. As a consequence, the yield of fruits under 60 and from 60 to 65 mm was significantly reduced by both MM250 and MM330 in comparison to the control in 2023. In the following year, treatments differed only regarding the smallest fruit size class, with MM330 statistically differing from the control (Figure 2b). For other size classes, there were no significant differences between treatments; however, an increased share of larger fruits in the total yield can be observed with metamitron treatments.

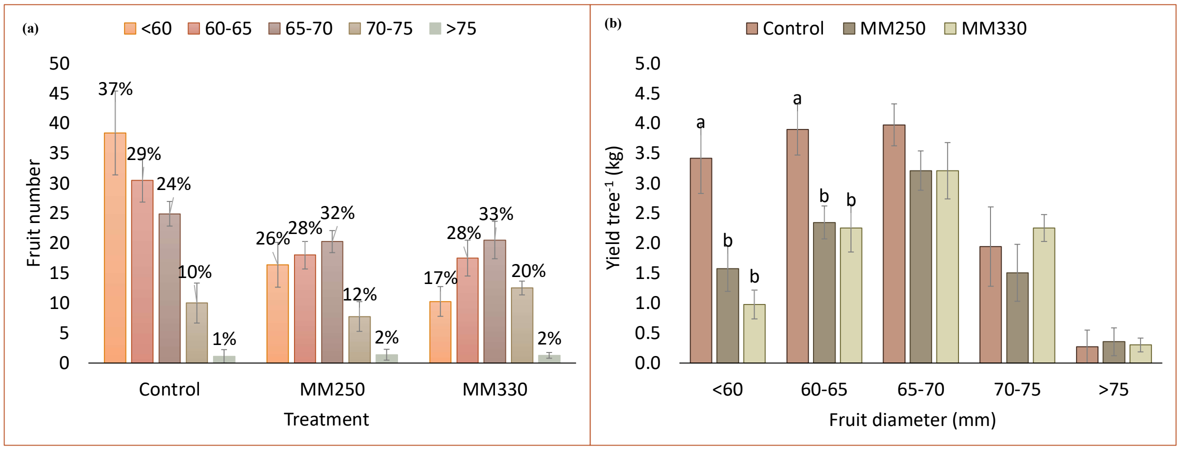

Figure 1. Distribution of fruit size classes represented as the number of fruits per tree (a) and the yield per tree (b) in 2023.

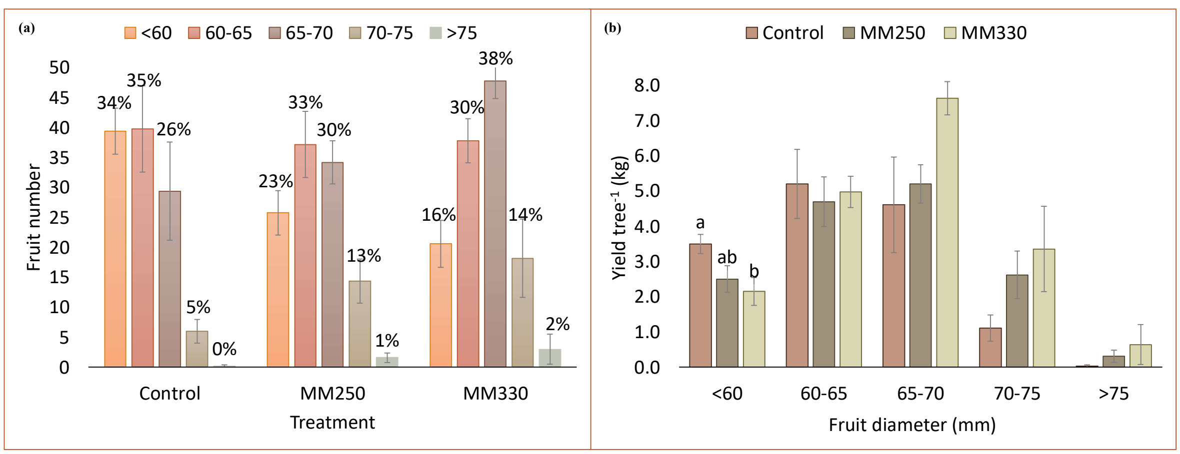

Figure 2. Distribution of fruit size classes represented as the number of fruits per tree (a) and the yield per tree (b) in 2024.

Metamitron treatment did not significantly affect fruit characteristics of 'Williams' pear except for fruit diameter, only in the second experimental season (Table 5). Related to greater fruit size, fruit diameter was increased by both MM250 and MM330.

Low and inconsistent influence on fruit quality was also stated by other research in apple and pear (Elsysy et al., 2020; Radivojevic et al., 2020; Radivojević et al., 2024). No consistent effect on Williams pear quality was found with the use of other chemical thinners as well (Dussi et al., 2008).

Table 4. The effect of metamitron on the fruit characteristics of 'Williams' pear in 2023.

Treatment	Fruit height (mm)	Fruit diameter (mm)	Firmness (kg cm^{-2})	TSS (%)	TA (%)	Seed number
Control	78.01+2.16	62.06+1.41	8.72+0.25	13.53+0.28	0.31+0.02	3.79+0.56
MM250	79.03+1.06	63.07+0.42	8.63+0.19	14.03+0.31	0.31+0.01	3.96+1.03
MM330	78.47+0.71	65.13+0.61	8.41+0.27	13.78+0.19	0.28+0	3.42+0.44
Significance	ns	ns	ns	ns	ns	ns

Means in the column followed by different letters indicate significant differences at p ≤ 0.05. ns not significant.

Table 5. The effect of metamitron on the fruit characteristics of 'Williams' pear in 2024.

Treatment	Fruit height (mm)	Fruit diameter (mm)	Firmness (kg cm^{-2})	TSS (%)	TA (%)	Seed number
Control	76.33±0.98	60.26±0.64b	7.82±0.37	16.4±0.27	0.4±0.03	5.88±0.8
MM250	76.1±0.72	64.61±0.97a	7.2±0.3	15.9±0.16	0.35±0.02	5.44±0.53
MM330	79.04±1.77	63.9±1a	7.18±0.43	16.66±0.38	0.38±0.02	4.4±0.61
Significance	ns	**	ns	ns	ns	ns

Means in the column followed by different letters indicate significant differences at p ≤ 0.05. ns not significant; ** indicate significance at 0.01.

CONCLUSIONS

The obtained results suggest that metamitron can be used as a reliable thinner for crop load management in pears. The thinning effect can depend on weather conditions; thus, the moment of application should be carefully selected.

Metamitron showed consistency over two years, significantly reducing the share of small, unmarketable fruits in the total yield of 'Williams' pear. This consequently increased fruit size and improved the distribution of fruits in size classes in a positive correlation with the applied concentration. The return bloom was slightly increased by metamitron application, but without significant differences from the untreated control. Fruit quality parameters, except for fruit weight and diameter, which were related to crop load reduction, stayed unaffected.

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THE INFLUENCE OF FERTILISATION ON THE YIELD OF *ARUNDO DONAX* L. GROWN ON DIFFERENT SUBSTRATES

Nikola MILANOVIC[1], Aleksandar SIMIĆ[2], Snežana BRAJEVIĆ[1], Željko DŽELETOVIĆ[1]

[1]*University of Belgrade, Institute for Application of Nuclear Energy, Banatska 31, 11 080 Belgrade, Serbia*

[2]*University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11 080 Belgrade, Serbia*

Corresponding author: nikola.milanovic@inep.co.rs

Abstract

Arundo donax L. is considered one of the best options for low input bioenergy production. It is a second-generation perennial energy crop whose entire above-ground biomass can be utilised for energy production. Due to its adaptability to different agro-ecological conditions, Arundo donax is considered promising for cultivation on marginal and degraded soils.

In this study, we investigated the optimal fertiliser doses of NPK 16:16:16 on the biomass yield of Arundo donax grown on different substrates in two consecutive years. The study was conducted on fertile agricultural soil, flotation tailings and ash disposal sites. Three treatments were carried out: a control treatment without fertilisation (C), a fertilisation with 310 kg NPK ha^{-1} (T1) and 620 kg NPK ha^{-1} (T2) (corresponding to 50 and 100 kg of pure nitrogen, phosphorus and potassium per hectare), applied at the beginning of the growing season. Harvesting took place at the end of the growing season (February 2024 and 2025). The yield of dry biomass per hectare was calculated after drying the plant material in an oven at 80 °C until complete moisture loss.

Overall, significantly higher biomass yields were recorded in the second year than in the first year, which is consistent with the similar researches. The highest yield of dry biomass was obtained on agricultural soil under the T2 treatment (18.26 t ha^{-1}), while the lowest yield was recorded on flotation tailings under the control treatment (1.16 t ha^{-1}). On average across all three substrates, dry biomass yield increased with higher NPK doses: 4.95 t ha^{-1} (C), 6.09 t ha^{-1} (T1), and 6.83 t ha^{-1} (T2).

Key words: *fertilisation, yield, NPK, Arundo donax L.*

INTRODUCTION

The growth of the economy and population necessitates the constant search for new sources of energy. To improve energy security, one of the possible solutions is the use of renewable energy sources. The increased use of renewable energy sources is expected to help mitigate climate change and improve energy security (Taylor et al., 2019). The use of bioenergy has increased by an average of 7% per year between 2010 and 2021, and this trend is expected to continue (International Energy Agency Renewables, 2018). The problem is that most of the biomass currently used for bioenergy still comes from oil, sugar or starch crops destined for food, which has a direct negative impact on the food market. The first generation of biofuels requires large amounts of nitrogen fertilisation, which increases production costs (Lewandowski 2016) and has a direct negative impact on the food market due to the required use of agricultural land (Scarlat et al., 2015). One of the ways to improve the cultivation of biofuels is to grow non-food crops on marginal and polluted land. For this reason, second-generation perennial grass crops are increasingly taking centre stage in research. The cultivation of rhizomatous perennial grasses (*Arundo donax* L.) represents a sustainable alternative to the cultivation of food crops or typical annual crops, that can reduce competition for land use for food production as well as its negative impact on food production, greenhouse gas emissions and biodiversity loss (Blair et al., 2021; Clifton-Brown et al., 2023). In addition to the low input requirements, perennial grasses require no tillage except in the year of planting, so their cultivation is associated with a very low greenhouse effect while improving soil fertility and biodiversity.

Giant reed (*Arundo donax* L.) is considered one of the most promising plant species for the area of south-eastern Europe.

This plant is known for its high biomass production (15-30 t ha^{-1} dry biomass) (Corno et al., 2014), its low production costs and its versatile use. In addition to combustion (17 MJ kg^{-1} on average) (Taylor, 2008), the biomass is also used for the production of bioenergy, biofuels, chemicals, biopolymers, biocomposites or as an ecological building material (Dželetović and Glamočlija, 2011). It is estimated that 1 ha of giant reed can produce a net energy of about 637 GJ ha^{-1}, which could replace 14 t of oil or 20 t of coal per year of cultivation, and contribute to environmental protection through the use of renewable energy sources (Angelini et al., 2009). In addition to high biomass production, the plant is also known for its adaptability to many environmental stresses, such as pollution with potentially toxic elements (Milanovic et al., 2024), salinisation of the substrate (Nackley et al., 2015) and prolonged drought (Parenti et al., 2018), allowing it to survive in unfavourable agroecological conditions. In this study, we investigated the possibility of growing giant reed on different substrates, in particular on fertile arable land, flotation residues and ash landfills. Flotation residues, and ash disposal sites represent a specific substrate of anthropogenic origin called technosol. Landfills are extreme habitats, as they are characterised by a series of chronic and synergistic effects of stress factors (lack of water, unfavourable chemical and physical properties and high content of potentially toxic elements - PTE) (Gajić et al., 2013).

Flotation tailings, ash and slag resulting from coal combustion in thermal power plants are highly susceptible to aeolian and fluvial erosion, and can easily enter the surrounding natural ecosystems, where they represent a long-term source of PTE pollution (Simić et al., 2015).

In recent years, researchers' interest in the use of giant reed has increased, as the plant not only provides high-quality biomass but also has good phytostabilisation properties (Cristaldi et al., 2020).

MATERIALS AND METHODS

The experiment was carried out at three locations: on agricultural land in Simićevo near Žabar, on the ash and slag dump of the thermal power plant "Nikola Tesla B" in Obrenovac (TENT B) and on the flotation dump of the Pb, Zn and Cu mines on Rudnik Mount. At these sites, the effects of fertilisation with mineral fertiliser (NPK 16:16:16) in increasing doses, added at the beginning of each growing season, on biomass yield were investigated. Three treatments were used for this trial: a control treatment (C) without mineral fertilisation and two treatments with 310 kg NPK ha^{-1} (T1) and 620 kg NPK ha^{-1} (T2) (i.e. 50 and 100 kg of pure nitrogen, phosphorus and potassium per hectare). The trial was designed as a randomised block trial with three replicates and macropropagated plants from local production were used. The plants were grown without irrigation. The chemical properties of the substrates used are listed in Table 1.

Table 1. Chemical properties of substrates

Parameter/ Substrates	Content		
	Soil	Ash and slag dump	Tailings
pH in H_2O	7.11	7.37	6.85
pH in KCl	5.77	6.09	6.59
N (%)	0.29 ± 0.09	0.068 ± 0.02	0.005 ± 0.001
K_2O (mg/100g soil)	34.63 ± 0.82	26.35 ± 0.33	8.49 ± 0.04
P_2O_5 (mg/100g soil)	26.72 ± 0.79	16.39 ± 1.28	1.08 ± 0.006
Organic C (%)	2.86 ± 0.36	2.99 ± 0.11**	3.71 ± 0.25*

*It should be noted that the increased organic carbon content does not come from the humic substances but from the xanthates, organic compounds used to improve ore extraction (Shen et al., 2016).

**The increased organic carbon content does not come from humic substances, but from unburnt coal.

Sampling (harvesting and biomass measurement) took place at the end of the growing season (February 2024 and 2025). The yield of dry biomass per hectare was calculated after drying the plant material in an oven at 80°C until complete moisture loss. The dry biomass yield is given in Table 2 as the arithmetic mean ± standard deviation of triplicate experiments.Data were analysed using a two-way analysis of variance (ANOVA) in

Statistica 10 software. Two categorical variables were fertilisation and substrate.

RESULTS AND DISCUSSION

In our study, significantly higher biomass yields were achieved in the second year than in the first year, which is consistent with the results of other studies (Angelini et al., 2009; Danielli et al., 2021). The highest dry biomass yield of 620 kg ha^{-1} (T2) was obtained on agricultural land in the second year (18.26 t ha^{-1}), while the lowest yield was recorded on flotation tailings in the control treatment (C) in the first year (1.16 t ha^{-1}).

The plants treated with different doses of mineral fertiliser showed statistically significant differences in biomass yield (table 2). On average for all three substrates in both cultivation years, the biomass yield increased with increasing mineral fertiliser doses. The lowest yields were achieved in the control treatment (C) and the highest in treatment 2 (T2).

The substrate also had a statistically significant influence on the biomass yield (table 2). The highest yields were obtained on agricultural land (average 11.33), then on the ash and slag dump (average 3.89), while the lowest yields were measured on the flotation tailings (average 2.65).

Table 2. The influence of mineral fertilizer and substrate on the dry biomass yield of giant reed (*Arundo donax* L.)

Treatment (A) / Substrate (B)	C	T1	T2	Average (B)
	2024			
Soil	5.01 ± 0.77	5.80 ± 0.19	6.20 ± 0,19	5.68 ± 0.62
Ash and slag dump	1.79 ± 0.49	2.86 ± 0.55	3.20 ± 0,28	2.62 ± 0.73
Tailings	1.16 ± 0.16	1.79 ± 0.17	2.14 ± 0,08	1.69 ± 0.50
	2025			
Soil	15.66 ± 1.44	17.04 ± 1.14	18.26 ± 2,14	16.99 ± 1.30
Ash and slag dump	3.73 ± 0.53	5.24 ± 0.29	6.49 ± 0,62	5.15 ± 1.38
Tailings	2.33 ± 0.51	3.81 ± 0.66	4.64 ± 0,47	3.59 ± 1.17
Average (A)	4.95 ± 3.24	6.09 ± 3.69	6.83 ± 4.20	/
ANOVA				
A	**	**	**	
B	**	**	**	
A×B	NS	NS	NS	

Legend: NS - statistically not significant; *statistically significant; **statistically highly significant; C - Control (No fertilisation); T1 – Treatment 1 (fertilisation with 310 kg NPK ha^{-1}); T2 – Treatment 2 (fertilisation with 620 kg NPK ha^{-1})

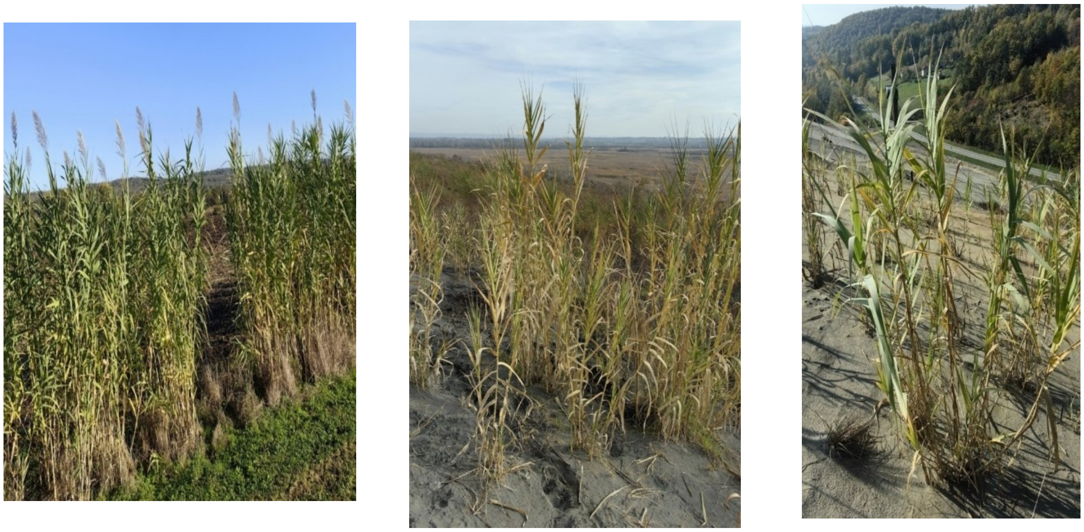

Figure 1. Giant reed (*Arundo donax* L.) on agricultural soil, ash and slag dump and flotation tailings

CONCLUSIONS

Giant reed (*Arundo donax* L.) is a perennial bioenergy plant that adapts very well to different agroecological conditions. The plant proved to be excellently suited for cultivation on technosols because, in addition to its ability to phytostabilise, the biomass obtained can be used for various technical purposes and it can also serve as an early pioneer in succession.

In the first year, relatively low yields were achieved, particularly on the ash and slag dump and the flotation tailings. In the second year, yields were many times higher. One of the reasons for the higher yields, in addition to the better overall development of the plants, is the higher plant density (larger number of plants per unit area). Fertilisation with mineral fertiliser had an overall yield-increasing effect, especially for plants grown on landfill sites. For plants grown on agricultural land, the difference between the control (C) and the treatments (T1 and T2) was drastically smaller than for plants grown on technosols. This raises the question of whether fertilisation on fertile arable land is economically viable, i.e. whether the yield differences achieved can outweigh the financial cost.

We believe that giant reed will gain popularity in the coming years, mainly because of the high yield of high quality biomass, but also because of the limitation of fossil fuels. Currently, the plant does not produce fertile seeds under the agroclimatic conditions of south-eastern Europe and is not considered an invasive species for the time being, but in view of climate change, attention should be paid to the introduction of this plant species into regular agricultural production.

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ASSESSMENT OF THE ECONOMIC QUALITIES AND RESISTANCE TO MAJOR DISEASES IN WHEAT VARIETIES GROWN IN THE AREA OF THE TOWN OF SUVOROVO, VARNA REGION, BULGARIA

Antoniya GANEVA, Stanislav IVANOV, Petar ZHELEZOV
The coordinating teacher Prof. Dimcho ZAHARIEV, PhD

Konstantin Preslavsky University of Shumen, Faculty of Natural Sciences,
Department of Plant Protection, Botany and Zoology,
115 Universitetska Str., 9700 Shumen, Bulgaria
E-mail: 2322291002@shu.bg
2220120008@shu.bg
2422691045@shu.bg
d.zahariev@shu.bg

Corresponding author: 2322291002@shu.bg

Abstract

The main tasks of the study are two: 1. Monitoring the productive capabilities of the studied varieties, as well as the main structural elements of grain yield. 2. Field study of the main weed vegetation and resistance to diseases during the growing season. The varieties Cosmic, Matthew, Sofru and Solindo were examined from the Demonstration Experimental Field of the Pesticide Ltd. Company in 2024. Pesticide Ltd. is one of the first companies in Bulgaria for complex services to agricultural producers.

The results show that the highest grain yield was obtained from the varieties Cosmic (810 kg/decare) and Matthew (749 kg/decare). Other important advantages of these two varieties over the others that participated in our study are follows: Hectoliter weight of the grain, Plant height, Length of the spikelet per plant, Number of spikelets per spike, Number of grains per spike, Weight of the grain per spike, Weight of 1000 seeds.

Regarding weeding, stronger weeding with annual broadleaf weeds and weaker weeding with perennial rhizome weeds was found. Very good resistance to economically important wheat diseases is possessed by the varieties Cosmic and Matthew, which makes them the most suitable wheat varieties among the studied varieties for the agro-ecological conditions of the area of the town of Suvorovo, Varna region.

Key words: monitoring, wheat varieties, resistance to diseases

INTRODUCTION

Wheat is the most widespread cereal crop in the world. Over the course of millennia, it has developed into a successful and sustainable cereal crop, which is why it is grown in a large number of countries today. In Bulgaria, 12 to 15 million decares of common wheat (*Triticum aestivum* L.) are grown annually, and the average yields range from 400 kg/da to over 1000 kg/da.

The constantly increasing requirements for the quantity and quality of wheat determine the need for the selection of highly productive varieties, possessing a complex of economic and biological qualities, resistant to abiotic and biotic stress factors and suitable for cultivation in a system of reduced production costs. In addition, in the conditions of climate change, it is important for new varieties to realize their productive potential under the changing environmental conditions in the regions for which they were created.

In terms of wheat quality, there are three groups of varieties created in Bulgaria. As a rule, the higher the quality of the grain, the lower the yield (Guide for integrated pest management in cereal crops (wheat, barley, oats, rye, corn), 2008). Wheat varieties from group A produce flour that absorbs relatively much water when kneading dough of normal consistency.

Such flour has a high air content. It produces high-quality bread. Such wheat varieties serve exclusively to improve the quality of bread when using flours of lower quality. These varieties yield grain up to 700 kg/da. Such varieties are the varieties created in Bulgaria: Yantra, Kristal, Todora, Milena, etc. and newer varieties include Lazarka, Aglika, Ahinora, Pchelina, etc. (Official variety list of varieties of agricultural and vegetable plant species accepted for certification and marketing on the territory of the Republic of Bulgaria, 2025).

Wheat varieties from group B have the same improver potential as wheat from group A. They produce high-quality bread without the need for the addition of improvers. This is the main group of wheat varieties grown in Bulgaria. Yields of 700 to 900 kg/da can be obtained from these varieties. This group includes the varieties Boryana, Bojana, Dunavia, Shibil, Venka 1, etc. (Official variety list of varieties of agricultural and vegetable plant species accepted for certification and marketing on the territory of the Republic of Bulgaria, 2025).

The lowest quality of the grain is from wheat varieties of group C. The flour from them absorbs a relatively small amount of water during bread production. At the end of the process, the dough is soft, slightly elastic and sticky. The bread is of poor quality. With these varieties, the yield can reach over 1000 kg/da. In practice, such types of wheat are referred to as fodder. Such varieties are Chudomira, Fani, Trakiyka, Tsveta, etc. (Official variety list of varieties of agricultural and vegetable plant species accepted for certification and marketing on the territory of the Republic of Bulgaria, 2025).

During the growing season, grain crops are attacked by a number of diseases and pests that have a direct impact on the harvest. Wheat diseases are one of the most important factors for grain production and if their control is not adequate, the risk of yield loss and deterioration of grain quality is very high (Bobev, 2009; Stancheva, 2006).

MATERIAL AND METHODS

The aim of this study is to determine the economic qualities and resistance to some major diseases of wheat varieties grown in the area of the town of Suvorovo, Varna region. The area of the town of Suvorovo, selected for the study, is located in Northeastern Bulgaria (Figure 1).

Figure 1. Geographical location of Suvorovo Municipality

To achieve the set goal, the following tasks were developed:

1. Identification of the main weed vegetation. Study of resistance to diseases that occurred during the growing season.
2. Monitoring the productive capabilities and main structural elements of the studied varieties.

The study included 4 wheat varieties: Matey, Solindo, Kosmik and Sofru (Figure 2). The study was conducted during the 2023-2024 marketing year in the Demonstration Experimental Field of Pesticide LTD. The area on which each of the varieties is grown is 15 decares. The experimental area included in the study is a total of 60 decares.

The determination of the species composition of weeds was carried out by the route method using plots with an area of 1 sq. m. Weed infestation was determined before the treatment of the areas with herbicides. The following scale was used for the degree of weed infestation:

+	light weeding	1-25%
++	medium weeding	26-50%
+++	strongly weeding	51-75%
++++	massively weeding	76-100%

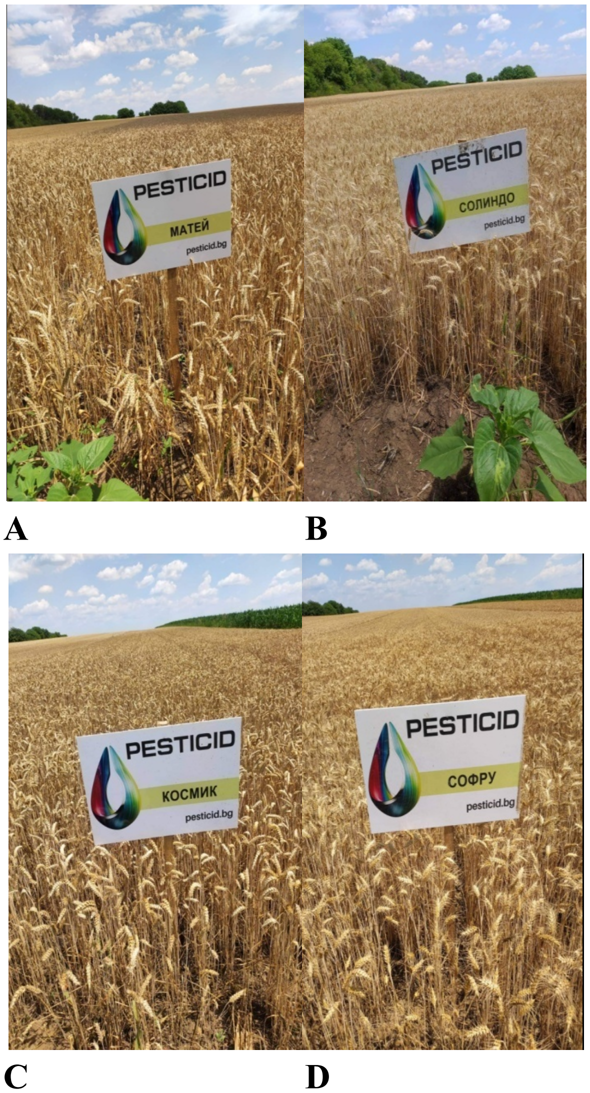

Figure 2. Wheat varieties included in the study: A. Matey, B. Solindo C. Kosmik, and D. Sofru

For diseases of the root system and bases (black root rot, fusarium root rot, base rot and parasitic lodging, etc.), the main stems and the tillers are included in the assessments. 10 plants are examined at 10 places located diagonally in the crop. The death of the sprouts and shoots from fusarium is determined in the tillering phase, and the death of the base of the plants - in the waxy maturity phase.

For leaf attacks (powdery mildew, brown and yellow rust, early and spring leaf blight, chaff spot, etc.), leaves of different ages are examined. For powdery mildew, the first powdery deposits are looked for in the fall on self-seeded crops, in the earliest crops, in the lower and wetter areas of the areas, and subsequent inspections must necessarily include dense, lush crops and those fertilized with nitrogen on one side. Initial inspections concern the brothers and sheaths, and later inspections - for the leaves and the ear. Observations continue in the spring to establish the number and size of the primary foci of infection. For brown leaf rust, sori are looked for in the fall and inspections continue in the spring. The earliest crops, monocultures, more sensitive varieties and wetter areas are examined first. A survey for yellow rust is carried out in the spring in a combination of cool weather, dense fog, heavy dew, frequent rainfall and northerly winds, using the methodology for brown rust. The attack of fusarium on the ears is recorded in the flowering, milky and full maturity phases. The assessment of the attack of oily and powdery mildew is carried out after harvesting the grain. If the degree of infection is above the permissible percentage, the seeds used for sowing must be treated with fungicides.

The degree of attack is an indicator that characterizes the intensity of the attack, which is directly related to the damage caused. It is determined by the percentage coverage of the plant organs with plaques, sori, spots, etc. For this purpose, keys (scales) are used. The degree (index) of attack is calculated using the McKinney formula: $I=E(n.k).100/(N.K)$, where: I is the attack index in %, E(n.k) - sum of the products of the number of attacked plants or organs (n) by the corresponding attack score (k), N - the total number of examined plants (organs), K - the highest degree in the corresponding scale (Guide for integrated production of cereals (wheat,

barley, rye, oats, corn) and sunflower, 2024).
The following scale was used to assess the extent of attack by economically important diseases:

0 absence of disease
+ weak attack from disease 1-25%
++ medium attack from disease 26-50%
+++ strongly attack from disease 51-75%
++++ massivelyattack from disease76-100%

RESULTS AND DISCUSSIONS
In our study, we found that the areas of all wheat varieties were weeded by a large number of weed plants. The results show that there is massive weeding with *Sinapis arvensis* from the annual broadleaf weeds and *Convolvulus arvensis* from the perennial weeds, as well as heavy weeding with *Galium tricorne* and *Amaranthus retroflexus* from the annual broadleaf weeds and *Cirsium arvense* from the perennial weeds (Table 1).

Table 1. Species composition of weed plants and their rate of weeding

Weed species	Degree of weeding
Annual broadleaf weeds	
Sinapis arvensis	++++
Amaranthus retroflexus	+++
Galium tricornutum	+++
Anthemis arvensis	++
Fallopia convolvulus	++
Solanum nigrum	++
Avena fatua	+
Chenopodium album	+
Consolida regalis	+
Papaver rhoeas	+
Xanthium strumarium	+
Perennial weeds	
Convolvulus arvensis	++++
Cirsium arvense	+++
Aristolochia clematitis	+
Sonchus arvensis	+

From the group of perennial weeds, the particularly dangerous species *Sorghum halepense* and *Cynodon dactylon* have not been found.
The most important diseases are those that damage the leaves and stems of cereal plants during the growing season. These are: powdery mildew, brown rust, yellow rust, septoria, and under certain conditions – fusarium in the class (Atanasova et al., 2015; Guide for integrated production of cereals (wheat, barley, rye, oats, corn) and sunflower, 2024). Yield losses can reach 25-30% for each disease separately and are mainly due to a decrease in the number of ears and seeds.
Table 2 shows the data from the reporting of attacks by economically important diseases in the studied wheat varieties.
The results obtained show that the varieties Kosmik and Matey show very good resistance to economically important diseases. A stronger attack in all varieties is found from the following diseases: powdery mildew caused by *Erysiphe graminis* (Figure 3), brown rust caused by *Puccinia recondita* (Figure 4) and septoria leaf spot caused by *Septoria tritici* (Figure 5).
The varieties Kosmik and Matey show the strongest resistance to diseases. In both

varieties, the degree of resistance is the same, with the exception of septoria leaf spot in the Kosmik variety and yellow rust in the Matey variety.
The weakest disease resistance was found in the Sofru variety.
The preliminary conclusion is that the studied varieties show relatively good disease resistance.

Table 2. Diseases identified in the tested wheat varieties: M – Matey, K – Kosmik, Sf – Sofru, and So – Solindo

Diseases	M	К	Sf	So
Powdery mildew (*Erysiphe graminis*)	+	+	++	++
Brown rust (*Puccinia recondita*)	+	+	++	++
Septoria leaf spot (*Septoria tritici*)	+	++	+++	++
Common bunt (*Tilletia tritici* and *T. levis*)	0	0	+	0
Black stem rust (*Puccinia graminis*)	0	0	0	0
Loose smut (*Ustilago tritici*)	0	0	+	0
Fusarium (*Fusarium* sp.)	0	0	+	0
Early leaf blight (*Zymoseptoria tritici*)	0	0	+	0
Yellow rust (*Blumeria graminis*)	+	0	++	+

Figure 3. Symptoms of powdery mildew attack

Figure 4. Symptoms of brown rust attack

Figure 5. Symptoms of Septoria attack

The results of the average grain yields obtained are different (Figure 6). The highest grain yield per hectare was obtained from the Kosmik variety (810 kg/da), followed by the Matey variety (749 kg/da).

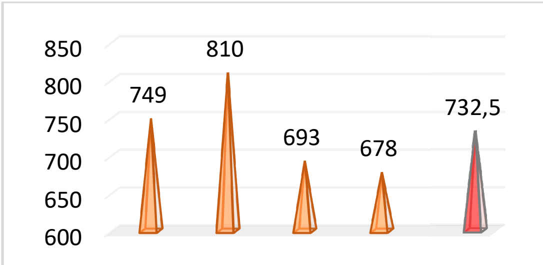

Figure 6. Average grain yield (in kg/da): M – Matey, K – Kosmik, Sf – Sofru, andSo – Solindo

Hectoliter weight is an indicator of the milling qualities of wheat. This indicator takes into account how much flour can be obtained from different batches of wheat. All varieties show relatively good indicators in terms of hectoliter weight of the grain with small differences between them (Figure 7).

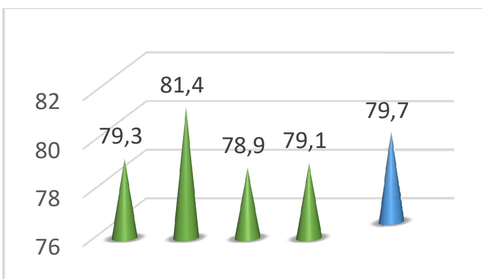

Figure 7. Hectoliter weight of grain (in kg):M – Matey, K – Kosmik, Sf – Sofru, andSo – Solindo

Some of the main indicators determining the yield structure are: plant height, spike length, number of spikelets, number of grains in one spike, weight of 1000 seeds.
Plant height is a varietal trait and a relatively constant value, but the cultivation technology and rainfall and temperature conditions influence the values of this indicator. The highest stem height was recorded for the Kosmik variety, followed by the Matey variety (Figure 8).

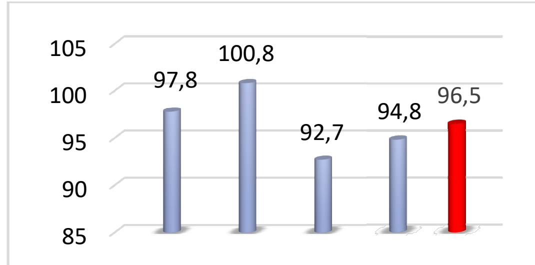

Figure 8. Plant height (in cm): M – Matey, K – Kosmik, Sf – Sofru, andSo – Solindo

The length of the spike as a genetically distinct trait is a constant value for each individual wheat variety, but the conditions of the year and the applied agricultural techniques have an impact on this indicator. The results of the study show that in terms of this indicator, the Kosmik variety forms the longest spike (Figure 9).

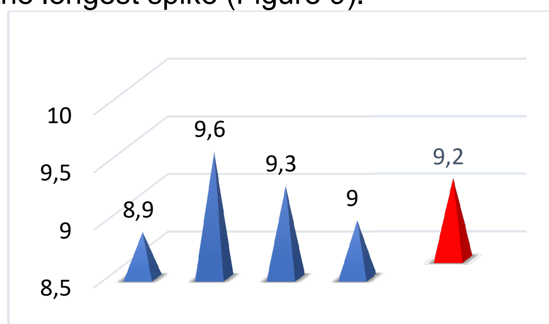

Figure 9. Length of spike of one plant (in cm):M – Matey, K – Kosmik, Sf – Sofru, andSo – Solindo

Variety Kosmik has the largest number of spikelets in one spike, followed by variety Matey (Figure 10).

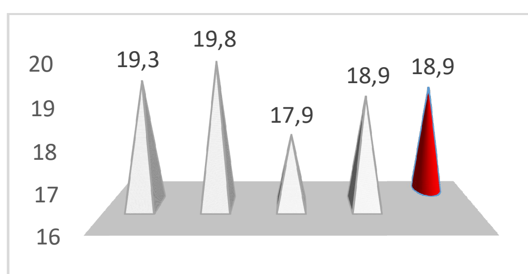

Figure 10. Number of spikelets in one spike:M – Matey, K – Kosmik, Sf – Sofru, andSo – Solindo

The number of grains in a single spike is one of the most important structural elements of yield in cereal crops. Its formation is greatly influenced by precipitation from the tillering phase to the end of the flowering phase. In the spring of the 2023-2024 crop year, climatic conditions were favorable for the flowering, pollination and fertilization phases of the spikelets, which led to the formation of a larger number of grains in them. Again, the Kosmik variety has the largestnumber of grains in a single spike. The Sofru and Matey varieties take second and third place (Figure 11).

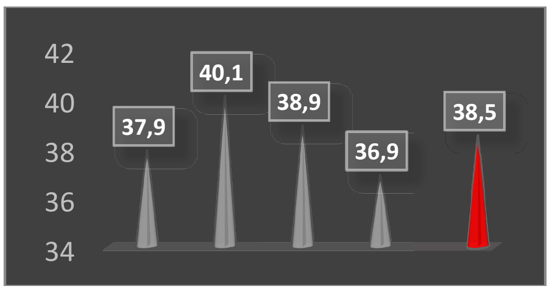

Figure 11. Number of grains in one spike: M – Matey, K – Kosmik, Sf – Sofru, and So – Solindo

The mass of 1000 seeds is a species and varietal trait, which is strongly influenced by agro-ecological conditions and cultivation technology. It is one of the indicators determining the suitability of the grain as a seed material. In soft wheat it is from 35 to 50 g, and in durum wheat it varies from 45 to 60 g.

The large grains are better seed material and they yield up to 15% higher yield.

The results of our study show that on average for the studied period the value for this indicator reaches 40.4 g (Figure 12). The highest value for this indicator is again for the Kosmik variety, followed by the Matey variety.

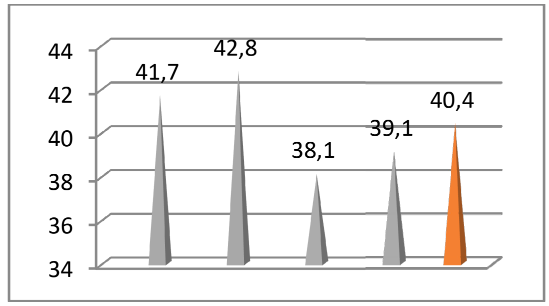

Figure 12. Mass of 1000 seeds (in g): M – Matey, K – Kosmik, Sf – Sofru, and So – Solindo

CONCLUSIONS

Weeding is relatively stronger with perennial rhizomatous weeds, and weeding with annual broadleaf weeds is weaker. The problematic weeds for wheat, *Sorghum halepense* and *Cynodon dactylon*, have not been identified.The studied wheat varieties show very good resistance to diseases. The varieties Kosmik and Matey have the best resistance to economically important diseases.

The studied varieties have relatively good productivity. The highest grain yield per hectare was obtained from the varieties Kosmik (810 kg/da) and Matey (749 kg/da).

The varieties Kosmik and Matey have an advantage over the other studied varieties in terms of the following indicators: Hectoliter weight of grain, Plant height, Spike length of one plant, Number of spikelets in one spike, Number of grains in one spike, Grain weight in one spike, Mass of 1000 seeds. For the agro-ecological conditions of the area of the town of Suvorovo, Varna district, the cultivation of the wheat varieties Kosmik and Matey can be recommended.

ACKNOWLEDGEMENTS

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EFFECT OF AQUEOUS EXTRACT OF *SICYOS ANGULATUS* L. ON SEED GERMINATION AND SEEDLINGS OF *ZEA MAYS*

Cristia SĂVĂLAȘ, Paula IANCU
Faculty of Agronomy, University of Craiova, Romania
Corresponding author email: paula.iancu76@gmail.com

Abstract
This work investigates the effects of aqueous extract of Sicyos angulatus L., a plant with allelopathic potential, on seed germination and early development of maize (Zea mays) seedlings. Four concentrations of the extract were applied: 0% (control), 5%, 10% and 20%. The results showed that, with increasing concentration, the germination rate slightly decreased, while root length was negatively affected less than coleoptile in higher concentrations, indicating a dose-dependent inhibitory effect.

Key words: allelopathy, *Sicyos angulatus, Zea mays*, germination, aqueous extract

INTRODUCTION

Sicyos angulatus, also known by the popular name wild cucumber or bur cucumber, is an annual herbaceous climbing plant in the *Cucurbitaceae* family, native to eastern North America.

The species was introduced to Europe in the 18th century as an ornamental plant and naturalized in several countries, becoming an invasive species that is difficult to control, especially on riverbanks and wetlands (Niculescu, M. et al., 2021).

In Europe, it is present in countries such as Germany, Italy, France, Croatia, Czech Republic, Hungary, Moldova, Norway, Slovenia, Spain, Sweden, Turkey and the United Kingdom (https://gd.eppo.int/reporting/article-1613).

In Romania, it is found in meadow areas and alluvial forests, where it forms dense populations that negatively affect native vegetation (Niculescu, M. et al., 2021). In south-western Romania, such as the Danube Valley, this species has formed extensive populations with a negative impact on natural willow and poplar forest habitats (Niculescu, M. et al., 2024).

Sicyos angulatus is known as an aggressive invasive plant that can negatively affect agricultural crops by covering/pulling corn plants to the ground, making harvesting difficult. Extracts from this plant have also been studied for their inhibitory effects on the germination of other species, such as *Lactuca sativa* (lettuce), indicating its potential to inhibit germination (Lee, C.W., et al., 2015).

It is also known for its allelopathic potential. Allelopathy is the biochemical interaction between plants through compounds released into the environment, with effects that can be positive or negative.

The objective of the present study was to evaluate the effect of the aqueous extract of this plant on the germination and early development of maize (*Zea mays*) seedlings, an important agricultural crop worldwide.

MATERIALS AND METHODS

Materials: *Sicyos angulatus* fresh plant material (leaves and stems)

Corn (*Zea mays*) seeds; Distilled water; Petri dishes; Filter paper; Ruler (mm scale); Analytical balance.

Preparation of Extracts:

Fresh *Sicyos angulatus* tissue (leaves/stems) was ground and soaked in distilled water (1:10 w/v) for 24 hours. The mixture was filtered through muslin cloth and Whatman filter paper. The filtrate was considered the 100% extract. Extracts were diluted with distilled water to obtain 0% (control), 5%, 10%, and 20% concentrations.

Procedure:

10 corn seeds were placed in each Petri dish lined with filter paper (5 replicates per treatment). Each dish received 5 mL of the designated extract daily. Dishes were kept in a growth chamber at 25°C for 7 days. After 7 days, the following were recorded: Germination %; Mean root length (cm);
Mean coleoptile length (cm).
Germination percentage was calculated for each replication using the next formula:
G = (Germinated seed/Total seed) x 100.
After seven days, allelopathic effect was evaluated by measuring the root and coleoptile length (cm) of seedlings.
The collected data were analyzed statistically with ANOVA (Analysis of Variance).

RESULTS AND DISCUSSION

The variants germinated in the presence of *S. angulatus* typically develop shorter primary roots and also there is a root growth suppression. This is likely due to the allelopathic interference with hormone pathways that control root elongation.
Coleoptile length of maize was slightly reduced compared with root length under leaves extract of *Sicyos angulatus* extract (Table 1).

Table 1. ANOVA calculations for maize experienced characteristics

Extract concentration	Germination (%)	Root length (cm)	Coleoptile length (cm)
Ct.	98	7.2±0.4	4.5±0.3
5%	90	5.8±0.5	3.9±0.4
10%	76	4.3±0.6	2.8±0.3
20%	52	2.6±0.7	1.9±0.4

A dose-dependent decrease in the measured parameters was observed, indicating an inhibitory effect of the extract on germination and seedling growth.
The allelopathic effect of *Sicyos angulatus* extract is evident by the progressive decrease in root and coleoptile length in parallel with a slight decrease in germination rate. These results suggest that the bioactive substances present in the extract may interfere with hormonal and metabolic processes involved in germination and development. Compared to the control, even low concentrations had observable effects, which supports the idea of using *S. angulatus* in future studies on biological weed control.
All three parameters - germination, root length, and coleoptile length - were significantly affected by increasing concentrations of *Sicyos angulatus* extract (Table 2).

Table 2. ANOVA with effect of *Sicyos angulatus* upon analyzed characteristics

Extract concentration	SS	df	MS	F
Germination percentage (%)	6100	3	4066.67	2.89
Root length (cm)	58.64	3	977.29	2.51
Coleoptile length (cm)	20.04	3	1335.83	2.08

Germination (%) drops significantly as extract concentration increases. Root and coleoptile length both show strong dose-dependent reductions. A clear dose-dependent inhibition was observed across all parameters. The 20% extract significantly reduced germination, root elongation, and coleoptile growth (Figure 1).

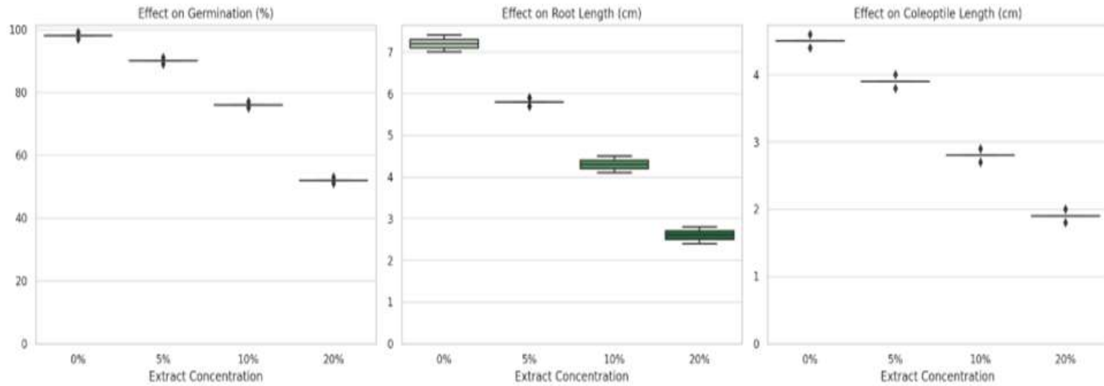

Figure 1. Effect of *Sicyos angulatus* upon analyzed characteristics

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These results suggest that the bioactive substances present in the extract may interfere with hormonal and metabolic processes involved in germination and development.

Compared to the control, even low concentrations had observable effects, which supports the idea of using *S. angulatus* in future studies on biological weed control.

Sicyos angulatus may have allelopathic effects on maize, but it is not the strongest type of interaction.

The main interaction with maize is not necessarily chemical, but competitive because this species climbs on maize stems and shades them, competing aggressively for light, water and nutrients. The results show that germination inhibition may occur to a small extent, but we consider that the effect on maize appears to be more physical and competitive, rather than directly chemical.

Figure 2. Invasive habit of bur cucumber

CONCLUSIONS

Sicyos angulatus aqueous extract negatively affects corn seed germination and seedling growth.

The inhibitory effect increases with higher extract concentration, indicating strong allelopathic potential.

These results may have implications for future research on the use of allelopathic compounds in organic agriculture.

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AGROBIOLOGICAL AND TECHNOLOGICAL CHARACTERISTICS OF CABERNET SAUVIGNON R5 CLONE GROWN IN OPLENAC SUBWINE REGION

Andreja PREKOVIĆ, Nebojša MARKOVIĆ, Slavica TODIĆ, Zoran PRŽIĆ

Faculty of Agriculture University of Belgrade, Serbia
Corresponding author email: *prekovicandreja@gmail.com*

Abstract

The aim of the research was to determine the agrobiological and technological characteristics of the Cabernet sauvignon R5 clone, grown under the agroecological conditions of the Šumadija wine region and the Oplenac wine subregion, Serbia. Grape and wine analysis was conducted in the Faculty of Agriculture University of Belgrade in the Department for viticulture laboratory. The study includes the observed phenological stages (bleeding, budburst, shoot growth, flowering, berry growth, veraison and harvest), fertility potential, the analysis of mechanical parameters of grapes and berries (mass of bunches, berries, skin and seeds, bunch structure) and chemical analysis of grape juice-must. Bleeding started on the 18th of March. Flowering occurred on the 16th of June and veraison on the 13th of August. Harvest was conducted on the 18th of September at full grape maturity. The period from bleeding to harvest lasted 185 days. The average number of inflorescences per vine was 11.00±0.99. The absolute fertility coefficient was 1.82 and the relative fertility coefficient was 1.70. The average bunch mass was 216.2 g, with the average berry mass of 204.8 g. Berry skin constituted 6.65% of total bunch mass and the average skin mass of 100 berries was 7.41 g. Grape juice-must analysis detected a sugar content of 24.02% and a total acid content of 9.15 g/L expressed as tartaric acid. Glycoacidometric index of the grape juice was 2.62 and the pH was 2.92. According to these results, the clone fulfills the requirements for the production of high-quality wines.

Key words: *Cabernet sauvignon, R5, phenology, fertility, mechanical composition, wine*

INTRODUCTION

Šumadija is a renowned wine-growing region in Serbia with a long tradition of viticulture and winemaking. It covers the hilly terrain from the Rudnik Mountains to the Velika Morava River. In 2012, Šumadija had 1119.79 ha of vineyards, with approximately 5000 winegrowers. In the Oplenac subregion, there are 1348 winegrowers cultivating 545.70 ha of vineyards (Ivanišević et al., 2015).

Cabernet Sauvignon is a late-ripening grape variety (III epoch) intended for the production of high-quality red wine. It is the descendant of Cabernet franc and Sauvignon blanc crossbreeding (Bowers and Meredith, 1997). In the Šumadija region, 9.36% of the vineyard area is planted with this variety (CEVVIN, 2025).

The R5 clone was selected and registered in 1969 in Sant Michele all'Adige, Italy. Other Italian Cabernet Sauvignon clones are VCR 7, VCR 8, VCR 11 and VCR 489 (Pržić and Marković, 2019). The vigour of the vine corresponds to the average for the variety. The clone has a lower yield and lower grape mass compared to the varietal average.

The wine has a broad sensory profile with pronounced fruity, spicy and floral (especially violet) notes and a characteristic herbaceous flavour. It has excellent colour intensity and good anthocyanin content as well as a better structure and higher acidity than other Cabernet Sauvignon wines and is suitable for medium to long ageing and blending (VCR, 2025).

Technological assessment in viticulture involves the analysis of mechanical and chemical grape characteristics to determine the optimal harvest time and to ensure quality grapes. The evaluation methods are rapid and inexpensive. Mechanical composition is characterised by the mass ratio of the morphological cluster parts. The ratio of these parts and their composition are of great oenological importance (Makuev et al., 2022). Chemical parameters (sugar concentration, titrable acidity and pH) are mainly connected with the technological maturity of grapes (Nogales-Bueno et al., 2014).

MATERIALS AND METHODS

The study was conducted in 2023, in a production vineyard in the Oplenac subwine region. The vineyard was planted in 2014 at an altitude of 250 m, with row spacing was 2.5 m with 0.8 m between plants in a row. The training system used was the Royat cordon and the vines were grafted onto Millardet 420A rootstock. For the purpose of the research, 20 vines were selected and pruned to four spurs per cordon with two buds each.

The phenological stages were determined according to the BBCH scale by Lorenz et al., (1995). The bleeding was registered by the appearance of sap on the cut shoots and the bud burst when the first buds opened. During flowering, the onset was recorded when 3-5 % of the flower caps were thrown off and the end when all caps were thrown off and the pistils darkened. Berry growth began with the appearance of the first berries. Veraison began when the first berries changed colour from green to reddish-purple.

Fertility was determined by counting the inflorescences. Based on this, the following fertility parameters were calculated: absolute fertility coefficient (inflorescences/fertile shoots), relative fertility coefficient (inflorescences/total shoots), potential fertility coefficient (inflorescences/buds obtained during pruning) and infertility coefficient of buds (dormant buds/fertile shoots) and shoots (infertile shoots/fertile shoots).

The laboratory analysis of grapes was carried out in the laboratory of the Department of Viticulture, Faculty of Agriculture University of Belgrade. The mechanical composition of grapes and berries was determined according to the method of Marković and Pržić (2020) on 10 representative bunches at full ripeness. Upon measuring the mass of bunches, berries and rachis were separated and each of their masses was determined. From the selected sample, 100 random berries were chosen for mass measurement. The mesocarp was then removed and the berry skins and seeds were dried at room temperature for 6 days, after which they were measured for mass and the seeds were counted.

The sugar content of the grape juice was determined using the Oechsle hydrometer and the values were calculated using the Dujardin-Salleron formula:

Sugar (%) = °Oe * 0.266 - 3

°Oe - value of the sugar content in the grape juice measured by Oechsle scale

The total acidity of the grape juice was determined using the titration method with 0.1 M NaOH. Phenolphthalein was used as a colour indicator.

The glycoacidometric index (GAI) is expressed as the ratio of sugar content (%) and total acidity (g/l). The pH value was determined using a pH meter.

RESULTS AND DISCUSSION

The Oplenac region is characterised by a temperate continental climate with hot summers and cold winters. The climatic conditions shown in this study refer to the period 2013-2022 and 2023 (Meteomanz, 2025). In the 2013-2022 period, the average annual temperature was 13.0°C and the average vegetation temperature (April-October) was 18.4°C. The average temperature in the 30 days prior to harvest was 1.66°C higher in 2023 compared to the 2013-2022 period. The average annual precipitation in the 2013-2022 period was 751.55 mm. These climatic values show the region is suitable for grapevine growth and fruiting. However, ripening accelerates under warmer conditions, resulting in the decoupling of sugar accumulation from the phenolic and aromatic composition (Previtali et al., 2022).

Phenological observations.

Understanding the phenology of a variety or clone, as well as the potential to assume it depending on the climate, allows for more efficient vineyard management (Petrie and Sadras, 2008; Caffarra and Eccel, 2010). Jovanović et al. (2011) report that the budburst of clone R5 in their study in the Župa subregion, Serbia began on 3 April, which is in accordance with our results (Table 1). The flowering and *veraison* dates are similar to those reported by Ramos et al. (2018). Cabernet sauvignon is generally characterised by late vegetation onset. The benefit from this is twofold - it reduces the risk of late spring frost damage (Mosedale et al., 2015; Bucur and Babes, 2015) and also delays further phenology stages.

Table 1. R5 clone phenology observations

Phenophase	Onset	End
Bleeding (Cod 00-03)	18 Mar	4 Apr
Budburst (Cod 05-08)	7 Apr	15 Apr
Shoot growth (Cod 11-19)	14 Apr	-
Flowering (Cod 60-69)	16 Jun	27 Jun
Berry growth (Cod 71-79)	24 Jun	-
Veraison (Cod 81-83)	13 Aug	-
Harvest (Cod 85-89)	18 Sep	
Bleeding to harvest = 185 days		

Earlier development of phenophases, mainly induced by high temperatures, has a negative impact on grape yield and quality (Hannah et al., 2013; Fraga et al., 2016). Cabernet sauvignon is traditionally harvested in early to mid-October (Jovanović et al., 2011; Zhao et al., 2019); however, due to the trend of increased temperatures during ripening, the harvest date has shifted towards mid-September (van Leeuwen, 2019). This is confirmed by our results (18 September) with the increased temperatures in the preharvest period. Mărăcinean et al. (2024) report an even earlier harvest date of Cabernet sauvignon (7 September) in their study.

Fertility. It is well established that inflorescence number is the main factor of grapevine yield that accounts for 60% of seasonal yield variation (Guilpart et al., 2014). In our research, on average there were 11.00±0.99 inflorescences, 6.05±0.55 fertile shoots and 0.40±0.16 infertile shoots per plant.

Table 2. Fertility coefficients of clone R5

Absolute fertility	1.82
Relative fertility	1.70
Potential fertility	1.10
Bud infertility	0.26
Shoot infertility	0.07

Research shows that clone R5 expressed high fertility. This was also reported by Cichi et al. (2024), who noted that clone R5 had the greatest relative fertility index among the examined Cabernet sauvignon clones (15 ENTAV, 338 ENTAV, ISV 105, ISV 117).

Mechanical composition. Mechanical components of grapes, especially the skin and mesocarp, are prime determinants of wine quality (Table 3).

Table 3. Clusters and berries mechanical composition

Cluster mass (g)	216.20
Berry mass (g)	204.80
Rachis mass (g)	11.40
Berries per cluster	194.00
Mass of 100 berries	103.00
Skin mass of 100 berries (g)	7.41
Seeds mass of 100 berries (g)	3.07
Mass of 100 seeds (g)	2.58
Seeds per 100 berries	118.00

The average cluster mass was 216.20 g, which is higher than that reported by Gatti et al. (2014) for clone R5 (134 g) in Piacenza, Italy. Pržić et al. (2022) report varying cluster masses for clones 169, 191 and 412, ranging from 88.8 to 259.0 g. Filho et al. (2019) report a smaller number of berries per cluster (51.9 - 94.0), but a greater mass of 100 berries (135.3 - 158.6 g) compared to our results. Wine composition varies with berry size, as wine made from smaller berries can show higher alcohol content and a deeper, more saturated colour (Chen et al., 2018). The cluster structure is shown in Figure 1.

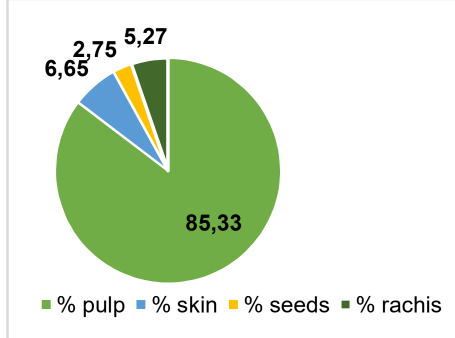

Figure 1. Structure of clone R5 cluster

Chemical composition. Grapes intended for wine production are harvested when they are most suitable for processing (technological maturity). This ripening stage for wine varieties often overlaps with full maturity, i.e., when sugar and acid accumulation in berries has ceased (Marković and Pržić, 2020). The results of the grape juice analysis are shown in Table 4.

Table 4. Clone R5 grape juice analysis.

Sugar content	°Oe	101.60
	%	24.02
Total acidity	NaOH (ml)	12.20
	g/l	9.15
Glycoacidometric index		2.62
pH		2.92

The determined sugar content is in accordance with the results of Cichi et al. (2024), who report R5 sugar level ranging from 23.4 to 24.3%. Jovanović et al. (2011) determined a lower sugar content (22.5%) for R5 in the Župa wine region. Pržić et al. (2022) report concentration of clones 169, 191 and 412 ranging from 21.8% to 27.3%. Sugar level directly influences the alcohol content in wine. Sufficient alcohol presence is important for microbiological stability of wine (Petrović, 2022) and for neutralisation of tannin astringency (Fontoin et al., 2008). The determined acidity content (9.15 g/l) can contribute to wine flavour, spoilage resistance and ageing potential (Li et al., 2023). Čoloveić et al. (2014) report higher acidity in R5 grape must (10.8 g/l), with sugar content of 23.3%. The tendency of R5 to accumulate higher acid content is especially important today due to global warming contributing to the lower total acidity of grapes (Plantevin et al., 2024).

CONCLUSIONS

The review of the climate conditions in the Šumadija region shows that they are adequate for grapevine growing. Temperature sums and rainfall amount and distribution throughout the year are satisfactory. Vegetation lasts well into autumn, which is mild so that even the varieties with the late grape ripening time can mature.

The clone has exhibited high fertility and the formation of large clusters (216.20 g). Smaller berries (103.00 g per 100 berries) can contribute to better wine quality. The measured sugar content (24.02%) and acid level (9.15 g/l) satisfy the standards for high-quality wine production. Therefore, R5 can be recommended for further planting in this region.

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GREEN MANAGEMENT FOR THE PROTECTION OF SPECIES DIVERSITY AND HABITAT IN THE MĂLNAȘ-BĂI QUARRY

Vladimir NATANTICU, Mariana NICULESCU

University of Craiova, Faculty of Agronomy, Craiova, vladimirnatanticu0@gmail.com
Corresponding author email: *mniculescum@yahoo.com*

Abstract

Quarrying activities are among the most impactful anthropogenic interventions on natural ecosystems, generating profound transformations of landforms, soils, hydrological regimes, and biological communities. Nevertheless, abandoned or rehabilitated quarry sites can acquire significant ecological value through natural colonization processes and the application of appropriate green management and ecological reconstruction measures. The Mălnaș-Băi Quarry, located in the Târgu Secuiesc Depression (Covasna County, Romania), is situated in an area of high ecological and landscape importance, characterized by calcareous geological substrates, mineral springs, and a mosaic of forest, grassland, shrubland, and rocky habitats.

The present study aimed to conduct a comprehensive assessment of species diversity, vegetation structure, and habitat types within and around the Mălnaș-Băi Quarry, with a particular focus on identifying rare, vulnerable, and protected taxa and Natura 2000 habitats. In addition, the study proposes and tests green management solutions through an experimental ecological rehabilitation action based on afforestation with native woody species.

Field investigations led to the identification of approximately 360 taxa and infraspecific taxa, including numerous species of conservation interest such as Lilium martagon, Gentiana asclepiadea, Orchis mascula, and Dactylorhiza maculata. More than ten phytocoenological associations and several habitats of community interest were recorded.

An experimental ecological rehabilitation plot covering approximately 100 m² was established on degraded quarry land using a mixed planting scheme with Pinus sylvestris, Fagus sylvatica, and Corylus avellana. The results demonstrate the high potential of integrated green management and nature-based solutions to reconcile extractive activities with biodiversity conservation and sustainable land use. The Mălnaș-Băi Quarry represents a relevant case study for the ecological reconstruction of quarry-derived landscapes in Central and Eastern Europe.

Key words: *quarry ecosystems, biodiversity conservation, ecological rehabilitation, Natura 2000 habitats, green management*

INTRODUCTION

Extractive industries, particularly open-pit quarrying, represent one of the most intense forms of anthropogenic pressure exerted on natural ecosystems.

Quarrying operations involve the removal of vegetation cover and soil horizons, exposure of bedrock, alteration of microclimatic conditions, and disruption of ecological processes. These disturbances often lead to habitat fragmentation, loss of biodiversity, and landscape degradation.

However, contemporary ecological research increasingly emphasizes that quarry sites, especially those partially abandoned or rehabilitated, can also function as important spaces for secondary ecological succession and biodiversity enhancement when appropriate management strategies are applied.

The Mălnaș-Băi Quarry is located in the Târgu Secuiesc Depression, within the Eastern Carpathians region, an area recognized for its mineral springs, calcareous substrata, and high natural diversity.

The calcareous geological foundation favors the development of specialized plant communities, including chasmophytic vegetation, calcareous grasslands, and forest ecosystems hosting numerous rare, endemic, or protected species.

Consequently, the quarry and its surrounding landscapes possess significant ecological value at both regional and national scales.

Understanding the floristic composition, vegetation structure, faunal presence, and habitat distribution in quarry landscapes is essential for designing effective conservation strategies and ecological rehabilitation programs.

Green management approaches, based on native species, natural succession processes, and ecosystem functionality, provide a viable pathway for restoring ecological balance while maintaining the socio-economic role of extractive sites.

The objectives of the present study were to: (i) inventory plant and animal species within and around the Mălnaș-Băi Quarry; (ii) identify plant communities and Natura 2000 habitats of conservation interest; (iii) assess the ecological value and conservation status of quarry-derived habitats; and (iv) propose and test an ecological rehabilitation model based on afforestation with native woody species.

MATERIALS AND METHODS

Study Area

The Mălnaș-Băi Quarry is situated in the Târgu Secuiesc Depression, Covasna County, Romania, within a mountainous and submontane landscape influenced by calcareous geological formations. The area is characterized by a temperate continental climate with montane influences, moderate precipitation, and relatively cool summers. The surrounding vegetation includes beech forests, mixed forests, mountain meadows, shrublands, and rocky habitats, many of which are included in the Natura 2000 network.

Floristic and Phytosociological Methods

Floristic surveys were conducted during the vegetation season using systematic transects and sample plots distributed across different habitat types, including forests, grasslands, shrublands, rocky outcrops, ruderal zones, and degraded quarry surfaces. Plant species were identified in the field and, when necessary, verified in the laboratory using specialized floras and taxonomic keys.

Phytosociological analyses were performed according to the Braun–Blanquet method, allowing the classification of vegetation into plant associations and higher syntaxonomic units. This approach facilitated the identification of phytocoenoses of scientific and conservation interest and the assessment of vegetation structure and dynamics.

Faunal observations focused on representative groups of vertebrates and invertebrates, including mammals, birds, amphibians, and insects.

Species presence was recorded through direct observations, traces, and opportunistic encounters, with particular attention paid to taxa of conservation concern listed under European environmental legislation.

Pedological analysis and rehabilitation design

Pedological observations were carried out on degraded quarry surfaces to evaluate soil depth, texture, structure, and fertility. These data informed the selection of species and the design of the ecological rehabilitation experiment. Based on the collected information, an experimental afforestation plot of approximately 100 m² was established, using native woody species adapted to calcareous, skeletal, and nutrient-poor substrates.

RESULTS AND DISCUSSIONS

Floristic Diversity and Vegetation Structure

The floristic inventory of the Mălnaș-Băi Quarry and its adjacent areas revealed approximately 360 taxa and infraspecific taxa, indicating a high level of species richness for a quarry-affected landscape. Among these, numerous rare and protected plant species were identified, including *Lilium martagon, Narcissus poeticus ssp. radiiflorus, Orchis mascula, Carlina acaulis, and Dactylorhiza maculata.*
The presence of these taxa highlights the conservation importance of the area.

Phytosociological investigations identified more than ten plant associations of particular scientific interest. Forest vegetation is dominated by beech (*Fagus sylvatica*) and spruce (*Picea abies*) stands developed on calcareous substrates, while shrublands and grasslands form transitional habitats that enhance landscape heterogeneity and ecological connectivity. Ruderal vegetation is primarily restricted to anthropized zones and does not currently constitute a major threat to native biodiversity.

Faunal Components

Faunal observations recorded the presence of large mammals such as wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), and brown bear (*Ursus arctos*), reflecting functional connectivity between quarry-derived habitats and surrounding forest ecosystems. Bird species characteristic of ecotones and open habitats were also observed, along with invertebrates of conservation interest such as *Lycaena dispar*. These findings demonstrate that quarry landscapes can function as complementary habitats for a wide range of fauna species.

Ecological Rehabilitation Experiment and Planting Scheme

An experimental ecological rehabilitation action was implemented on a degraded sector of the quarry through afforestation with native woody species.
The rehabilitation plot covered approximately 100 m² and employed a planting distance of 2 × 1 m, corresponding to an equivalent density of approximately 5,000 individuals per hectare.
The planting scheme (Figure 1) was designed to integrate species with complementary ecological roles, aiming to stabilize the substrate, improve soil conditions, and accelerate

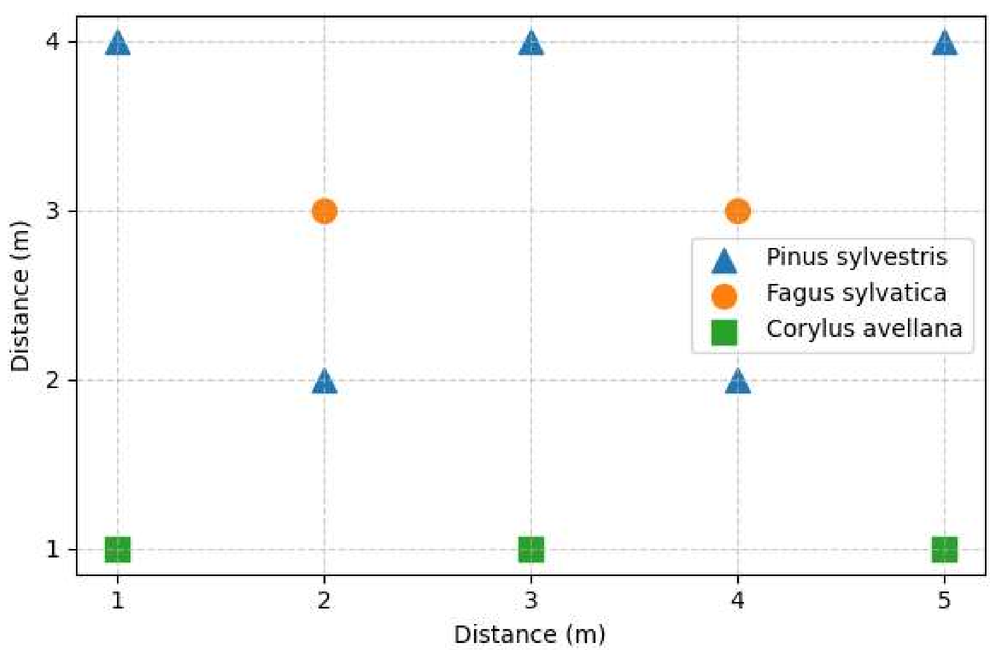
natural succession processes. Three native species were used:

Pinus sylvestris (Scots pine), a pioneer species tolerant of acidic, skeletal, and drought-prone soils, planted predominantly in upper and middle slope positions to ensure erosion control and early site stabilization.

Fagus sylvatica (European beech), the base or climax species of local forest ecosystems, introduced in more sheltered microhabitats with relatively higher soil moisture, ensuring long-term ecosystem stability and continuity with surrounding natural forests.

Corylus avellana (hazel), a shrub species planted in strips and clusters, contributing to understory development, soil improvement, and the provision of trophic resources and shelter for fauna.

Figure 1. Planting scheme used for the ecological rehabilitation experiment in the Mălnaș-Băi Quarry. The afforestation was carried out on an area of approximately 100 m², using a 2 × 1 m spacing. The scheme integrates Pinus sylvestris (▲), Fagus sylvatica (●), and Corylus avellana (■), aiming to enhance structural diversity and accelerate forest succession.



The mixed-species design enhances structural and functional diversity, increases ecosystem resilience, and reduces the risks associated with single-species plantations. The rehabilitation scheme represents a nature-based solution tailored to quarry-derived landscapes.

CONCLUSIONS

The Mălnaș-Băi Quarry and its surrounding areas host a high level of biodiversity, including rare and protected species and habitats of community interest within the Natura 2000 network. Despite the disturbances generated by extractive activities, the area retains significant ecological value and demonstrates strong potential for recovery through appropriate green management strategies.

The results of the experimental ecological rehabilitation action confirm that afforestation with native species, combined with an understanding of local eco-pedological conditions and natural succession processes, can effectively contribute to ecosystem restoration in quarry environments. Integrated green management approaches can reconcile economic activities with biodiversity conservation and landscape sustainability.

The Mălnaș-Băi Quarry can serve as a model for best practices in ecological reconstruction and sustainable management of extractive landscapes, with relevance for similar sites across Central and Eastern Europe.

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THE INFLUENCE OF CLIMATIC CONDITIONS ON SOME ROMANIAN ALFALAFA FODDER YIELD

Daniel Alexandru Mihăiță ILIE[1], Călin SĂLCEANU[1], Mirela PARASCHIVU[1], Alex Emanuel PRIVANTU[1]

[1]University of Craiova, Faculty of Agronomy, 19 Libertății Street, Craiova, Dolj county, Romania, Phone: +400251418475, Mobile: +40755038179; +40745577355; +40773818957
E-mails: mihaitailie34@gmail.com, calin.salceanu@yahoo.com, paraschivumirela@yahoo.com, alex_privantu@yahoo.com

Corresponding author: calin.salceanu@yahoo.com

Abstract

Alfalfa (Medicago sativa L.) is the most widely cultivated perennial forage legume globally, due to its high nutritional value and its broad capacity to adapt to varied agroecological conditions.The high biomass production and economic efficiency of this species are essential factors for the selection and dissemination of high-performing varieties to farmers.The objective of this study was to evaluate the variability of productivity and some morphological traits depending on genotype and environmental factors.Four Romanian alfalfa genotypes were tested during 2024 at the Caracal Agricultural Research and Development Station: the control variety Catinca and the synthetic lines F-2920-20, F2905-20, F2907-20.The alfalfa crop is in the 5th year of vegetation and the yield results included only the 1st mower. The following parameters were determined: total green mass yield, dry matter production (DM), production of 10 shoots with and without leaves, average stem length, number of internodes on the main stem.The production of yield ranged between 7.95 t/ha for the control Catinca and 9.05 t/ha for the synthetic variety F 2905-20. The dry matter of the F2905-20 variety exceeded the control by 16%, and the total weight of the 10 shoots with leaves varied between 11.3 g for the control variety and 14 g for the F2907-20 variety, exceeding the control by 23.8%.For the parameter height of the 10 shoots, the F 2920-20 variety had an average of 35.2 cm, exceeding the control variety by 3.5%.

Key words: *Medicago sativa*, yield, genetic variability, growth rate, genotype

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is widely recognized as one of the most productive and valuable perennial forage legumes due to its high biomass yield, superior protein content, and positive effects on soil fertility. It plays a critical role in sustainable livestock production systems and contributes significantly to global fodder supplies, particularly in temperate and semi-arid regions (Frame et al., 1998; Barnes et al., 2007; Sălceanu et al., 2023 a, b). The performance and persistence of alfalfa stands are strongly influenced by environmental conditions, among which climatic factors are of primary importance.

Climatic conditions such as temperature, precipitation, solar radiation, and their seasonal distribution directly affect alfalfa growth, development, and fodder yield.

Temperature regulates key physiological processes including germination, photosynthesis, respiration, and dormancy, while water availability determines stand establishment, regrowth capacity after cutting, and biomass accumulation (Lacefield et al., 2009; Pembleton et al., 2011). Variability in rainfall and the occurrence of drought or heat stress can substantially reduce yield and forage quality, particularly during critical growth stages. Moreover, projected climate change scenarios indicate increased frequency of extreme weather events, which may further challenge the stability and productivity of alfalfa-based systems (Hatfield et al., 2014, Velea et al., 2021).

In addition to its agronomic value, alfalfa plays a significant role in enhancing agricultural biodiversity. As a leguminous species capable of symbiotic nitrogen fixation, alfalfa supports diverse soil microbial communities, including *Rhizobium* species, which improve soil structure, nutrient cycling, and overall soil health (Crews & Peoples, 2004; Schipanski et al., 2010). These interactions contribute to increased belowground biodiversity and promote ecosystem resilience. Furthermore, alfalfa fields can serve as important habitats for pollinators, predatory insects, and other beneficial organisms, especially when managed under low-input or diversified cropping systems (Boutin et al., 2009).

Climatic conditions influence not only alfalfa growth and yield but also the composition and functioning of associated biological communities (Niculescu, 2020; Niculescu, 2023 a, b. Niculescu et al, 2024; Niculescu and Cojoacă, 2018; Niculescu and Nuță, 2018; Sărățeanu et al., 2022; Sărățeanu et al., 2023). Temperature and moisture regimes affect soil biological activity, nitrogen fixation efficiency, and the abundance and diversity of arthropods within alfalfa agroecosystems (Delgado et al., 2011). Consequently, climate-driven changes may alter ecosystem services such as pollination, pest regulation, and nutrient availability, with indirect effects on fodder productivity and sustainability (Florea et al. 2021).

Understanding the interactions between climatic factors, alfalfa fodder yield, and biodiversity is essential for developing adaptive management strategies under changing environmental conditions (Paraschivu et al., 2023). Therefore, the objective of this study is to evaluate the influence of selected climatic parameters on alfalfa fodder yield while considering their implications for agroecosystem biodiversity. The findings are expected to contribute to improved climate-resilient forage production and support sustainable agricultural practices that balance productivity with biodiversity conservation.In the context of global climate change, droughts have become increasingly frequent, seriously affecting agricultural production and putting pressure on available water resources from aquifers.

This research was made on the behaviour of some Romanian alfalfa genotypes under water stress conditions, aiming to identify the most drought-resistant varieties and evaluate their performance in the climatic conditions of the summer of 2024 year.

MATERIALS AND METHODS

The experience was organized within the Caracal Agricultural Research and Development Station, Olt County.

The Romanian genotypes were experimented under water stress conditions: Catinca alfalfa variety (Control, variety created by INCDA Fundulea in 1998) and three lines, respectively F 2920-20, F 2905-20 and F 2907-20. The research aimed to monitor green mass production in alfalfa in its fifth year of growth, as well as biometric determinations on 10 shoots/plot.

Two treatments were carried out with Zebra insecticide 2 ml/10 l water + Aminofed foliar fertilizer 20 g/10 l water on 06.03.2024. Two treatments were applied at an interval of 20 days between them.

Three waterings of 55 mm each were applied to the first mowing. The trail included three repetitions.

The plot length was 10 m and the plot width was 1m.

The herbicide work was carried out on 27.03.2024, the product used being Listego, which contains imazomax 40 g/l (fig.1). When applying the treatment, 40 g of herbicide diluted in 16 l of water were used and a single pump was administered to the 300 m2 corresponding to the experiment area (fig.2).

Figure 1. Listego herbicide solution

Figure 2. Applying herbicide treatment

The harvest was carried out in the budding phase, on 15.04.2024, a moment that coincided with obtaining a ratio between biomass production and a high nutritional value of the feed.The production obtained from each plot was weighed with an electronic scale.The mowing equipment used was a 1.5 kW power lawnmower, carried on the shoulder, with a fuel (gasoline) consumption of 0.7 l/hour.The green mass obtained from each plot was weighed using an electronic scale, and the productions were reported per hectare. The determination of dry matter production was carried out by standard methods, based on the harvested samples.

For biometric characterization, 10 shoots from each plot and repetition were analyzed, monitoring: leafy shoot weight, leafless shoot weight, leaf weight, leaf proportion (%), plant height and number of internodes.

The data obtained were statistically processed, and the results are presented comparatively, reported to the control variety Catinca, to highlight the differences between the studied genotypes.

RESULTS AND DISCUSSIONS

The climatic conditions of the 2023–2024 agricultural year, characterized byaverage monthly temperatures above multiannual averages and a pronounced deficit of precipitation, significantly influenced the development of the alfalfa crop.It can be appreciated that the studied area presents a moisture deficit during the calendar year 2024. According to the recorded monthly temperatures, the year 2024 exceeded the year 2023, considered the warmest year since climate records began (WMO Report, 2024).

This aspect can also be observed from the monthly average temperatures recorded during the experimental period, which, with the exception of September 2024 when they were recorded 1.6 ^{o} C less than the multiannual average, in all other months differences were recorded with temperature values ranging between +0.60 ^{o}C (May 2024) and +8.60 ^{o} C (February 2024), which was associated with a severe water deficit in the soil and a pronounced scorching, a fact also relevant to the low level of relative air humidity, reaching even 51% in August 2024 (table 1).

In 2024, it can be seen from the table below, a precipitation deficit of 100 mm compared to the multiannual monthly sum and a very uneven distribution of these precipitations. Practically from November 2023 to September 2024, with the exception of May (+ 6.9 mm) and June (+5.9 mm), in all other months there was a precipitation deficit compared to the multiannual monthly sum, which affected the proper development of the alfalfa crop.

Under the conditions at SCDA Caracal, in 2024, in the experience of the 5th year of vegetation, due to drought, only one harvest was harvested, which resulted in a production ranging between 7.95 t/ha of green mass for the control variety Catinca (Ct) and 9.05 t/ha for the new variety F 2905-20, a variety that exceeded the control by 13.8%, the variety F 2920-20 exceeded the variety mt. by 4.4% and the variety F 2907-20 by 3.1%. As for the average production of the four varieties taken in the study, it exceeded the variety Catinca by 5.3%.The Catinca control was not exceeded by any of the three lines F 2920-20 (86.9%), F 2905-20 (93.4%) and F 2907-20 (93.4%).

In the fifth year of vegetation, the proportion of leaves at the first mowing was very high and had values ranging between 59.3% for the control variety Catinca and 69.3% for the new line F 2907-20, the average of the experience being 65.3%.

The weight of the shoots, without leaves, was between 4.6 g for the Catinca variety (Ct.) and 4 g for F 2920-20. The Catinca control variety was not exceeded by any of the three lines F 2920-20 (86.9%), F 2905-20 (93.4%) and F 2907-20 (93.4%);

Regarding plant height, it ranged between 35.2 cm for line F 2920-20 and 33.7 cm for F 290720.

Compared to the Catinca control, one line had a smaller height, namely F 2907-20 recording a lower shoot height by 0.9%, and two lines were taller than the control, F 2920-20 (35.2 cm) exceeding the control by 3.5%, while line F2905-20 (34.7 cm) exceeded the control by 2%.

Regarding the number of internodes in the 10 shoots/plot/3 repetitions analyzed, it was found that it ranged between 7.1 internodes in the Catinca variety and 6.9 internodes in F 2907-20, and the lines F2909-20 and F2920-20 (7.2 internodes), Ct. Catinca being exceeded by 1.4% in terms of the number of internodes.

Specification													
	X	XI	XII	I	II	III	N	V	VI	VII	VIII	IX	Mediate
Temperature **Multiannual monthly average (T ° C)**	11.3	4.9	-0.5	-3.0	-0.6	4.8	11.2	16.6	20.5	22.7	21.9	17.6	+10.84
Monthly Average (T ° C)	16.0	8.1	3.9	1.0	8.0	8.9	15.0	17.2	25.9	27.2	26.8	16.0	+14.5
Difference ±	4.70	3.20	4.40	1.30	8.60	4.10	3.80	0.60	5.40	4.50	4.90	- 1.60	
rainfall **Multiannual monthly amount (mm)**	40.4	40.3	39.4	33.3	30.4	34.9	43.6	64.9	67.0	52.9	50.7	39.6	537.4
Monthly precipitation (mm)	21.4	124.2	21.4	26.8	11.6	22.4	26.0	71.8	31.6	58.8	6.0	15.4	437.3
Difference ±	- 19.0	83.9	-18	-6.5	- 18.8	- 12.5	- 17.6	6.9	- 35.4	5.9	- 44.7	- 24.2	100.1

Table 1.Evolution of climatic conditions 2023-2024

Regarding the determinations made, the following can be mentioned:the average weight of 10 shoots with leaves was between 11.3 g for the variety (Ct.)Catinca F 2920-20 - 12 g, F 2905-20 - 12.6 g and the line F 2907-20 - 14 g which exceeded the control by 23.8%. Of the 4 varieties taken in the study, all three lines had higher gains than the control, namely the varieties: F 2020-20 (6.1%), F 2905-20 (11.5%), F 2907-20 (23.8%). These results are consistent with data reported in the literature, which mention a higher sensitivity of green mass production to water deficit, compared to fundamental morphological parameters.

CONCLUSIONS

The climatic conditions in 2024, during the experiment, were favourable for the alfalfa crop only until the first decade of April. Subsequently, the average monthly precipitation recorded negative deviations of 100 mm from the multiannual average throughout the year. Also, the average monthly temperatures were 14.5°C, which exceeds the multiannual average of 10.8°C by 3.7°C.The average green mass production of the plots in the three repetitions at the first mowing was between 7.9 kg (7.9 t/ha) at Catinca (Control) and 9 kg (9 t/ha) at the F2905-20 line.The highest production was achieved by the F2905-20 line of 9 t/ha, with a green mass production increase of 13.8% compared to the Catinca variety, while the remaining two lines had an increase of 3.1% and 4.4% respectively compared to the control.The average SU production ranged between 1.9 t/ha for the control and 2.2 for the F2905-20 line, with a SU/ha increase of 16%.The average production of the 10 shoots with leaves ranged between 11.3 g for catincaand 14 g at line F 2907-20, Catinca having an average production of the 10 shoots with leaves of 11.3 g, lower by 23.8 g % compared to line F 2907-20 (14 g). In the case of the recorded percentage of leaves, the F 2907-20 line (69.3%) stands out as the most productive, registering a 15% increase comparedto the Catinca control (59.3%), the F 2920-20 line (66.7%) registering an increase of (11%), and the F 2905-20 line (65.9%) with a 10% increase compared to the control.In conclusion, of the 4 lines taken in the study, all three lines had higher yields than the control, namely lines F 2920-20 (6.1%), F 2905-20 (11.5 %) and F 2907-20 (23.8 %).

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STUDY ON THE ECOLOGICAL RECONSTRUCTION OF PHYTODIVERSITY IN THE SURROUNDINGS OF ROVINARI (GORJ COUNTY)

Vladimir NATANTICU, Alexandru DUICĂ, Mariana NICULESCU

University of Craiova, Faculty of Agronomy, Specialization Forestry, Craiova, Romania, *vladimirnatanticu0@gmail.com*

Corresponding author email: *mniculescum@yahoo.com*

Abstract

The territory surrounding the locality of Rovinari, situated in Gorj County, Romania, represents a unique landscape strongly influenced by anthropogenic activities, especially lignite mining and energy production. This area is an integral part of the protected site ROSCI 0045 – Jiu Corridor and hosts a remarkable diversity of plant species and habitats. The present study aims to analyze the phytodiversity, cormoflora, forest habitats, and woody and herbaceous vegetation in the Rovinari mining basin, while also proposing scientifically grounded solutions for ecological reconstruction. Field research identified more than 900 species of cormophytes, including rare, endangered, endemic, and Natura 2000 species. The area includes forest, grassland, tall grass, and freshwater habitats, many of which are affected by mining activities such as quarrying and the deposition of sterile material. Ecological reconstruction strategies focus on revegetation using native herbaceous and woody species adapted to local eco-pedological conditions. The study emphasizes the importance of phytocenological research in restoring ecological balance, improving soil quality, and ensuring sustainable land use in post-mining landscapes.

Key words: *phytodiversity, ecological reconstruction, mining impact, revegetation, Rovinari*

INTRODUCTION

The territory around Rovinari, located in the south-western part of Romania, represents a landscape of high ecological importance, but also one that is heavily affected by anthropogenic pressure. This area lies within the protected site ROSCI 0045 – Jiu Corridor and includes a wide variety of natural habitats that host a rich and diverse flora. Mining and energy production activities have significantly altered the natural environment, producing changes in land morphology, soil properties, hydrology, and vegetation structure.

The Rovinari mining basin occupies a central place among the lignite deposits between the Danube and the Olt River, with several active quarries such as Roșia de Jiu, Pinoasa, Tismana I and II,

Peșteana Nord and Sud, Rovinari Est, and Urdari.

Surface mining has resulted in large waste heaps and tailings ponds, causing habitat fragmentation and degradation. Despite these pressures, the surrounding areas still maintain a high level of phytodiversity, including numerous rare and protected species.

The aim of this study is to evaluate the phytodiversity of the Rovinari area and to identify viable solutions for ecological reconstruction based on native species and natural succession processes.

MATERIALS AND METHODS

The research was conducted in the surroundings of the locality of Rovinari, within the middle basin of the Jiu River, in Gorj County. Field investigations focused on the identification of plant species, plant communities, forest habitats, and degraded lands affected by mining activities. Observations were carried out in forested areas, grasslands, freshwater habitats, and tailings ponds.

Geomorphologically, the studied territory includes the Getic Plateau, the Jiu Piedmont, and the Getic Subcarpathians. Climatic conditions correspond to a moderate continental climate specific to hilly forested regions. Soil types vary depending on relief and vegetation, including podzolic, alluvial, and brown forest soils.

Floristic and phytocoenological analyses were used to assess species composition and habitat distribution.

Based on the results, ecological reconstruction strategies were formulated, focusing on revegetation with herbaceous and woody species adapted to the environmental conditions of sterile substrates and degraded soils.

RESULTS AND DISCUSSIONS

The flora of the Rovinari area includes over 900 species of cormophytes forming diverse herbaceous and woody vegetation types.

Meadows are characterized by a high diversity of Poaceae species, while forest habitats are dominated by genera such as *Quercus, Salix, Tilia,* and *Rubus*. Rare and protected plant species identified in the area include *Ruscus aculeatus, Galanthus nivalis, Orchis purpurea, and Platanthera bifolia, Spiranthes spiralis.*

Several Natura 2000 habitat types were identified, including:

91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior (Alno-Padion, Alnion incanae*, *Salicion albae*) (CLAS. PAL.: 44.3, 44.2 şi 44.13);

91M0 Pannonian-Balkan oak – Oak forest; CLAS. PAL.: 41.76;

9130 *Asperulo-Fagetum* beech forests; CLAS. PAL.: 41.13;

6240* Sub-pannonic steppic grasslands; CLAS. PAL.: 34.315

6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometea*) (* important orchid sites); CLAS. PAL.: 34.31 până la 34.34.

Mining activities have led to the formation of extensive waste heaps and tailings ponds, which initially represent abiotic substrates.

Natural colonization of these sterile lands begins with pioneer species such as *Tussilago farfara, Rumex scutatus, and Galeopsis angustifolia*.

Over time, herbaceous and woody species establish themselves depending on slope exposure, substrate composition, and microclimatic conditions.

Ecological reconstruction measures include agricultural and forestry recultivation, slope stabilization, and revegetation using native species with high ecological tolerance.

Thus, we have chosen an area of 100 m^2 in the area where the excavation ended where we have implemented a very well chosen reforestation scheme so that the experiment be a success. (Table No. 1). The planting distance was set at 2 x 1 m. We used as a basic species *Quercus petarea*, a genuine species forming a plant community right next to the wooded area.

In addition to this species we've also used mix species having the role to support the other ones. 50 seedlings were necessary compared to 4/1 meaning a number of 40 of Quercus petraea and 10 mixed species. Mixing species were: *Acer pseudoplatanus*, *Tilia argentea*, *Cerasus avium*.

For carrying out this experiment we took into account the type of native vegetation in the area, in order to avoid habitats fragmentation. Soil analyses were made and they indicate the fact that it has a good trophicity.

TABLE no. 1

1	2	3	4	5	6	7	8	9	10
Go	Go	Go	Go	Go	Go	Go	Go	Go	Go
Go	Go	Go	Go	Go	Go	Go	Go	Go	Go
Go	Go	Go	Go	Go	Go	X-Te	X-Ci	X-Te	Go
Go	Go	Go	Go	Go	Go	X-Ci	X-Te	X-Pa	Go
Go	Go	Go	Go	Go	X-Pa	X-Te	X-Pa	X-Pa	Go

Legend:
Go- *Quercus patraea*
1-10 no. of rows
X – mixed species
S=100 m^2
Pa – *Acer pseudoplatanus*
Ci – *Cerasus avium*
Te – *Tilia tomentosa*

CONCLUSIONS

The phytodiversity of the Rovinari area remains remarkably high despite intense anthropogenic pressure from mining and energy production.

The presence of numerous rare, endemic, and protected species highlights the ecological value of this territory.

Ecological reconstruction of degraded lands, especially waste heaps and tailings ponds, is essential for restoring ecological balance and landscape functionality.

Revegetation using native herbaceous and woody species adapted to local conditions represents a sustainable and effective approach to ecological reconstruction. *Phytocenological* studies provide a solid scientific basis for selecting appropriate species and ensuring long-term ecosystem stability.

The integration of ecological reconstruction measures with sustainable land management practices is crucial for the conservation of biodiversity in the Rovinari mining basin.

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