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MOUNTAIN AREA – ANALYSIS AND DEVELOPMENT PROSPECTS

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Abstract

Mountain areas play an important role in the agricultural and environmental sustainability of Romania, particularly through their extensive permanent grasslands and livestock production systems. The aim of this study was to analyze the development potential of mountain agriculture and forage resources using a SWOT (Strengths, Weaknesses, Opportunities, Threats) approach. The research was based on a bibliographic and documentary analysis, and strategic assessment of the factors influencing agricultural development in mountain regions. The results highlighted several strengths, including the high biodiversity of permanent grasslands, the availability of local forage resources, the ecological benefits of grassland ecosystems, and the potential for agritourism development. The study emphasizes the importance of sustainable grassland management, support for mountain farming systems, and the implementation of rural development measures aimed at preserving biodiversity and improving the economic viability of mountain communities.

Keywords: *biodiversity, mountains, fodder crops, SWOT analysis*

INTRODUCTION

Mountainous areas are distinguished by specific natural conditions, which directly influence the production of fodder and the organization of livestock farming systems (PĂCURAR and GHETE, 2025). The rugged relief, the more severe climate, the soil types and the characteristic biodiversity determine distinct particularities compared to the plain regions (POSEA, 2005). The steep slopes and the fragmentation of the relief make it difficult to mechanize agricultural work and favor the practice of traditional methods of land use (ROTAR AND CARLIER,

2010, VÎNTU et al., 2011). Also, agricultural lands are dispersed and difficult to access, an aspect that influences both the harvesting and the conservation of fodder. Under these conditions, natural meadows and hayfields constitute the main fodder resources for animals (WORLD BANK and MADR, 2023).

Forage crops are the basis for the development of mountain animal husbandry, providing the necessary resources for raising cattle, sheep and goats. In conditions where natural grasslands do not fully cover the nutritional

needs, forage crops complement the animal diet and stabilize production.

Grazing-based feeding systems, especially those in mountain and sub-mountain areas, are associated with obtaining animal products with superior nutritional characteristics. Green fodder from natural grasslands is rich in polyunsaturated fatty acids and their precursors, which leads to an increase in the content of omega-3 fatty acids and conjugated linoleic acid (CLA) in milk and meat, as well as an improvement in the ratio of omega-6 to omega-3 fatty acids (ALOTHMAN *et al.*, 2019). These changes are considered beneficial for consumer health, being associated with cardioprotective and anti-inflammatory effects (ALOTHMAN *et al.*, 2019). In the case of mountain grasslands, the high floristic diversity and the presence of species rich in

MATERIAL AND METHOD

The methods used in this paper are: bibliographic and documentary analysis and SWOT analysis (table 1).

Bibliographic and documentary analysis was used to consult and interpret specialized literature, rural development strategies and official documents on mountain agriculture and permanent grassland management.

KOTLER and KELLER (2012) consider SWOT analysis one of the most widely used methods of

secondary metabolites further contribute to improving the quality of dairy products. Milk from animals fed on alpine pastures presents a more favorable lipid profile, an increased content of bioactive compounds and sensory properties appreciated by consumers, being often associated with traditional products with high added value (LOPEZ *et al.*, 2022; 2023).

The aim of this study was to assess the development potential of mountain agriculture and forage resources through a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. The research focused on identifying the main internal and external factors influencing the sustainable management of permanent grasslands and livestock production systems in mountain areas.

strategic analysis in project management and organizational development.

The internal factors of SWOT analysis, namely strengths and weaknesses, are determined by elements specific to the organization or system being analyzed, such as available resources, level of organization, human resources, managerial capacity, existing infrastructure or the way resources are used.

Table 1

Description of the methodology used

Method used	Description	Role in the research
Bibliographic and documentary analysis	Method used for consulting and interpreting specialized literature, rural development strategies and official documents regarding mountain agriculture and permanent grassland management.	Ensures the theoretical and scientific substantiation of the research and supports the interpretation of the information analyzed in the work (CHELCEA, 2007, YIN, 2014).
SWOT analysis	Strategic analysis tools are used to identify strengths, weaknesses, opportunities and threats specific to mountain agriculture.	Contributes to the evaluation of the local agricultural system and the formulation of proposals for management and sustainable development (KOTLER and KELLER, 2012).

RESULTS AND DISCUSSIONS

Strengths:

An important strength of the mountain area is the extensive area of permanent grasslands and natural meadows, which provide favorable conditions for livestock breeding and fodder production (HOPKINS and HOLZ, 2006). The area has a diversified vegetation cover, consisting of valuable species of grasses and spontaneous legumes, which contributes to obtaining fodder of good nutritional quality (PEETERS, 2004). The mountain and hilly meadows of Transylvania are recognized for their high biodiversity and important pastoral value (MARUȘCA, 2018, FAO, 2015, PĂCURAR and ROTAR, 2014, TASSER and TAPPEINER, 2002).

Natural fertilization through spontaneous legumes is an ecological method of improving soil

fertility, based on the ability of these plants to fix atmospheric nitrogen through symbiotic bacteria of the genus *Rhizobium*, present in the nodules on the roots (PEETERS, 2004, CARLSSON and HUSS-DANELL, 2003, FRAME, 2005).

Perennial legumes (*Trifolium pratense*, *Trifolium repens*) and forage grasses (*Dactylis glomerata*, *Lolium perenne*, *Festuca rubra*) contribute to increasing biomass production and improving the nutritional value of forage. Legumes are of particular importance due to their capacity for biological nitrogen fixation, reducing the need for chemical fertilizers and improving soil fertility (WHITEHEAD, 2000). Nitrogen fixation can reach significant values in forage agroecosystems, contributing to increasing productivity and

reducing production costs (POP, 2010).

From an economic point of view, permanent grasslands are the fodder base of mountain livestock, supporting animal husbandry and the production of traditional products such as milk, meat and cheeses specific to mountain regions. At the same time, they contribute to the maintenance of local economic activities and the development of rural communities. Reducing livestock activities or abandoning the traditional use of grasslands can lead to their degradation and the loss of characteristic biodiversity (WORLD BANK and MADR, 2023).

The use of local fodder resources reduces dependence on concentrated fodder and reduces production costs. In mountainous areas, where access is difficult and transport costs are high, fodder autonomy becomes a major economic advantage (FAO, 2015).

The grassland protects the soil against erosion on the slopes, stabilizes the land and contributes to water infiltration. Mountain meadows are important reservoirs of biodiversity and contribute to carbon sequestration (PIMENTEL and KOUNANG, 1998; CONANT *et al.*, 2001)

Natural grazing allows for the production of dairy products and meat with superior organoleptic characteristics, appreciated on the market and associated with mountain identity.

Another advantage is the potential for the development of agritourism and ecotourism (PIMENTEL and KOUNANG, 1998). Natural landscapes, rural traditions and local agri-food products can be important factors for the economic development of the commune (OECD, 2020, PLIENINGER *et al.*, 2015). Regional development strategies highlight the importance of capitalizing on the tourism and rural resources of the North-West Region (TOURISM SECTOR STRATEGY 2021-2027 for the North-West Development Region -January 2026 version).

Last but not least, the commune preserves an important cultural and traditional heritage, specific to the Transylvanian village. Local customs, rural architecture and traditional agricultural practices represent important elements for the local identity and for the sustainable development of the community (COUNCIL OF EUROPE, 2000, EEA, 2020).

Weaknesses

Development in mountain areas is influenced by several constraints: fragmentation of agricultural land, poorly developed agricultural infrastructure, low mechanization, difficult accessibility, aging of the rural population, depopulation of mountain villages, and low productivity of some grasslands

(EUROPEAN COMMISSION, 2021; OECD, 2020).

One of the main weaknesses is the fragmentation of agricultural land, a phenomenon frequently encountered in rural areas of Transylvania. Farms are small and dispersed, which makes it difficult to mechanize agricultural work and apply modern, efficient technologies. This situation leads to high exploitation costs and low productivity of grasslands. Land fragmentation has been identified as an important obstacle to agricultural competitiveness and sustainable rural development in many European mountain regions (VERBURG *et al.*, 2010; OECD, 2020).

Climate change represents another important challenge for mountain agriculture, influencing fodder production, species composition, water availability and ecosystem stability. Mountain grasslands are particularly sensitive to changes in temperature and precipitation patterns, which may affect both forage yield and biodiversity conservation (IPCC, 2023; FAO, 2015).

Another negative aspect is the degradation of grasslands through excessive grazing and inadequate maintenance. In many pastoral areas, the phenomenon of soil compaction occurs, together with the reduction of valuable forage species and the expansion of unproductive or invasive vegetation. Overgrazing can significantly

reduce the ecological and productive value of permanent grasslands and negatively affect soil quality (MARUȘCA, 2018; FAO, 2015).

The lack of maintenance work, such as organic fertilization, weed control or over-seeding, favors the decrease in the pastoral value of the vegetation cover and may accelerate grassland degradation processes (MARUȘCA, 2018; OSPA Cluj, 2022, CIREBEA *et al.*, 2020).

Population aging and the migration of young people to urban areas or abroad reduce the availability of labor and limit the capacity for innovation and investment in mountain agriculture. These demographic trends contribute to the gradual abandonment of agricultural land and threaten the long-term viability of rural communities (EUROPEAN COMMISSION, 2021; OECD, 2020).

Opportunities

In the context of European policies on sustainable development and environmental protection, mountain agriculture can benefit from various financial support programs aimed at the conservation of permanent grasslands, the development of livestock farms, support for young farmers, adaptation to climate change, and the modernization of agricultural activities. The European Union's Common Agricultural Policy promotes environmentally friendly

farming practices and supports the sustainable development of rural and mountain areas (EUROPEAN COMMISSION, 2021; 2023).

By efficiently using local resources and implementing sustainable agricultural projects, the mountain area has the potential to develop a competitive and sustainable agricultural system. Sustainable management of grasslands and livestock systems can contribute to increased economic resilience while maintaining ecosystem services and biodiversity (FAO, 2015; OECD, 2020, TILMAN *et al.*, 2002).

The natural landscapes, local traditions, and the specific characteristics of mountain agriculture can attract tourists interested in rural tourism, traditional gastronomy, and recreational activities. Rural tourism is increasingly recognized as an important tool for diversifying local economies and enhancing the value of natural and cultural heritage in mountain regions (EUROPEAN COMMISSION, 2021; OECD, 2020).

Another important opportunity is the growing demand for traditional, local, and mountain-certified food products. Consumers increasingly value products associated with high environmental quality, traditional production methods, and territorial identity, creating new market opportunities for mountain farmers (BELLETTI and MARESCOTTI, 2011;

EUROPEAN COMMISSION, 2021).

Last but not least, the development of road and digital infrastructure in Cluj County can facilitate local farmers' access to larger markets and new economic opportunities. Investments in transport, digitalization, and rural connectivity are considered essential factors for improving competitiveness and supporting economic development in rural areas (EUROPEAN COMMISSION, 2021; OECD, 2020).

Threats

One of the most important threats to agriculture and pastoral ecosystems in the mountain area is represented by climate change. Increasing temperatures, changes in precipitation patterns, and the higher frequency of extreme weather events can affect forage production, biodiversity, water availability, and the stability of mountain ecosystems. Grassland productivity and species composition are particularly vulnerable to climatic variability, which may compromise the sustainability of livestock systems (IPCC, 2023; FAO, 2015).

A major threat to the mountain area is represented by the migration of the young population to cities or to other European countries. The reduction of the active population in rural areas leads to the abandonment of agricultural land and the decline of

traditional livestock breeding activities. The depopulation of mountain villages affects the continuity of agro-pastoral practices and reduces the community's capacity to capitalize on local agricultural resources. In many rural areas of Transylvania and other European mountain regions, the aging of the agricultural population and the shortage of skilled labor negatively influence agricultural development and the maintenance of permanent grasslands (EUROPEAN COMMISSION, 2021; OECD, 2020, MACDONALD *et al.*, 2000).

In the context of reduced agricultural activities and insufficient maintenance of grasslands, many areas are affected by the invasion of woody vegetation and species with low forage value. The expansion of shrubs and invasive species reduces the area effectively available for grazing and contributes to the decline of valuable grassland habitats. This phenomenon is frequently encountered in abandoned or extensively managed mountain and

CONCLUSIONS

The importance of this work is determined by the need to develop sustainable agricultural systems in mountain areas, based on the efficient use of fodder resources and the application of modern agricultural management measures.

In the context of climate change, grassland degradation and depopulation of mountain areas,

hilly regions, where traditional management practices have been reduced or discontinued (TASSER *et al.*, 2007; KEENLEYSIDE *et al.*, 2014). In the absence of maintenance measures such as shrub removal, controlled grazing, fertilization, or over-seeding, grassland degradation tends to accelerate over time, resulting in reduced pastoral value, lower productivity, and biodiversity loss (MARUȘCA, 2018; FAO, 2015).

The SWOT analysis highlighted the multifunctional role of mountain agriculture in maintaining biodiversity, supporting livestock production and preserving rural heritage. Similar findings have been reported in previous studies emphasizing the importance of permanent grasslands for ecosystem services and sustainable rural development (FAO, 2015; Marușca, 2018; OECD, 2020). However, demographic decline, land fragmentation and climate change remain significant constraints that require targeted policy interventions and improved grassland management practices.

efficient management of agricultural holdings and the implementation of rural development projects are essential elements for maintaining agricultural activities and preserving the ecological balance of mountain ecosystems.

However, local agriculture is affected by structural problems such as land fragmentation, low

mechanization and underdeveloped infrastructure. Access to European funds and the development of organic farming can represent important opportunities for the modernization of agricultural

holdings and the diversification of the rural economy.

The results of the work can contribute to identifying sustainable development solutions for agricultural holdings in mountain areas.

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ASSESSING THE IMPACT OF AGRI-ENVIRONMENTAL PAYMENTS ON THE DYNAMICS OF PERMANENT GRASSLANDS IN HUNEDOARA COUNTY, ROMANIA

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Abstract

Permanent grasslands represent one of the most valuable components of agricultural landscapes in Romania, providing essential ecosystem services, supporting biodiversity conservation, and maintaining the ecological stability of rural areas. In recent decades, changes in agricultural policies and the implementation of agri-environmental payment schemes under the Common Agricultural Policy (CAP) have significantly influenced the management and conservation of these ecosystems. This study assesses the impact of agri-environmental payments on the dynamics of permanent grasslands in Hunedoara County, Romania, with particular emphasis on their spatial distribution, management patterns, and conservation status.

The research was based on the analysis of agricultural and environmental datasets, GIS mapping, and the evaluation of grassland areas included in different agri-environmental support schemes. The distribution of permanent grasslands was examined in relation to subsidy uptake, management intensity, and the occurrence of potential abandonment processes. The results indicate that areas benefiting from agri-environmental payments generally exhibit a higher degree of grassland preservation and a lower risk of abandonment compared to areas with limited participation in support schemes. Furthermore, the spatial analysis revealed significant differences in the distribution of grassland systems according to topographical conditions and the type of agri-environmental measures implemented.

The findings highlight the important role of agri-environmental payments in maintaining permanent grasslands and supporting sustainable land-use practices in Hunedoara County. Continued financial support, combined with effective monitoring and targeted management measures, is essential for preserving the ecological and socio-economic functions of these valuable grassland ecosystems.

Keywords: *ermanent grasslands, agri-environmental payments, Common Agricultural Policy, grassland dynamics, GIS analysis, grassland conservation, Hunedoara County.*

INTRODUCTION

Permanent grasslands are among the most valuable agricultural ecosystems in Europe, providing essential ecosystem services such as forage production, biodiversity conservation, carbon sequestration, soil protection, water regulation, and the maintenance of traditional cultural landscapes (Habel et al., 2013; Dengler et al., 2014; Rotar et al., 2020). Semi-natural grasslands are particularly important because they support a high diversity of plant and animal species and represent some of the most species-rich habitats in the European agricultural landscape (Pärtel & Zobel, 1999; Wilson et al., 2012; Vaida et al., 2021).

During the last century, however, semi-natural grasslands have experienced substantial declines in both area and ecological quality as a consequence of agricultural intensification, land-use change, and abandonment of traditional management practices (Stoate et al., 2001; Dahlström et al., 2006; Cousins et al., 2015). These processes have led to habitat fragmentation, biodiversity loss, shrub encroachment, and the degradation of ecosystem services associated with extensively managed grasslands (Pykälä, 2004; Öckinger et al., 2006; Păcurar et al., 2020). As a result, the conservation of permanent grasslands has become a major objective of European

environmental and agricultural policies.

To address these challenges, the European Union introduced agri-environmental schemes (AES) within the Common Agricultural Policy, aiming to encourage farming practices compatible with biodiversity conservation and sustainable land management (Kleijn & Sutherland, 2003; Batáry et al., 2015). These schemes provide financial support for maintaining grazing or mowing regimes, limiting agricultural intensification, and preserving habitats of high conservation value. Nevertheless, the effectiveness of agri-environmental measures remains a subject of scientific debate, as positive effects on biodiversity are not always consistent across regions, taxa, or management systems (Kleijn et al., 2001; Pe'er et al., 2014; Berg et al., 2019).

Romania hosts some of the largest remaining areas of semi-natural grasslands in Europe and is recognized as a stronghold for High Nature Value (HNV) farming systems (Babai & Molnár, 2014; Rotar et al., 2020; Vaida et al., 2021). These grasslands are characterized by high floristic diversity, extensive management practices, and important socio-economic functions for rural communities. Through the Rural Development Programme (RDP

2014–2020) and the National Strategic Plan (NSP 2023–2027), Romania has implemented several agri-environmental measures intended to support the conservation and sustainable management of permanent grasslands (PNDR, 2019; PNS, 2023).

Despite the increasing financial resources allocated through agri-environmental payments, relatively few studies have evaluated their spatial distribution and potential contribution to grassland conservation at regional level in Romania. Understanding the relationship between agricultural support measures and permanent grassland dynamics is particularly important in mountainous and hilly regions, where both agricultural abandonment and management intensification can significantly influence ecosystem integrity and landscape structure.

Following the reform of the Common Agricultural Policy (CAP) for the 2023–2027 programming period, the support system for permanent grasslands in Romania has been substantially restructured through the integration of direct payments, eco-schemes, and agri-environment-climate interventions. Permanent grasslands cover approximately 4.8–4.9 million hectares nationally and represent a key component of both agricultural production systems and biodiversity conservation strategies. The current support framework combines the

Basic Income Support for Sustainability (BISS), the Complementary Redistributive Income Support for Sustainability (CRISS), support for young farmers (CIS-YF), voluntary eco-schemes, and rural development interventions targeting environmentally valuable grassland systems. All payments are linked to the fulfilment of conditionality requirements, including Good Agricultural and Environmental Conditions (GAEC) and Statutory Management Requirements (SMR), with particular emphasis on the protection of permanent grasslands located within Natura 2000 sites.

Among the available interventions, agri-environment-climate support for permanent grasslands (DR-01) plays a particularly important role in promoting sustainable management practices and conserving High Nature Value (HNV) grasslands. These measures provide compensation for income forgone and additional management costs associated with biodiversity-friendly practices, including restrictions on fertilizer and pesticide use, delayed mowing dates, maintenance of uncut strips, grazing intensity requirements, and habitat-specific conservation measures. Several packages specifically target species and habitats of European conservation concern, such as *Crex crex*, *Maculinea butterflies*, and *Aquila pomarina*. Through these interventions, agricultural support

policies aim not only to maintain agricultural activity but also to reduce land abandonment and preserve the ecological integrity of permanent grassland ecosystems.

Hunedoara County represents a relevant study area because of its extensive grassland resources, diverse environmental conditions, and significant participation in agri-environmental support schemes. Evaluating the distribution of permanent grasslands in relation to agri-environmental payments can provide valuable information regarding the effectiveness of current policy instruments and their contribution to sustainable grassland management.

MATERIALS AND METHODS

Study Area

The study was conducted in Hunedoara County, located in the western-central part of Romania. The county covers approximately 7,063 km² and is characterized by a complex relief structure comprising mountain, hill, and depression landscapes. Mountain areas occupy a significant proportion of the territory, creating favorable conditions for the development of extensive livestock farming systems and permanent grasslands.

Permanent grasslands represent an important component of the agricultural land fund of Hunedoara County, being distributed across both mountain and hilly regions. Due to their ecological importance and extensive

Therefore, the aim of this study was to assess the relationship between agri-environmental payments and the dynamics of permanent grasslands in Hunedoara County, Romania. The objectives were: (i) to analyze the spatial distribution of permanent grasslands; (ii) to evaluate the distribution of agri-environmental payment schemes; (iii) to identify areas potentially exposed to management changes or abandonment; and (iv) to assess the contribution of agri-environmental support measures to the conservation of permanent grasslands.

management, a considerable proportion of these grasslands are eligible for support through agri-environmental and climate interventions implemented under the Common Agricultural Policy (CAP).

Data Sources

The study was based on agricultural, administrative, and spatial datasets related to the implementation of support schemes for permanent grasslands.

Information regarding agricultural support measures was obtained from official documents of the Ministry of Agriculture and Rural Development (MADR), the Agency for Payments and Intervention in Agriculture (APIA), the National

Strategic Plan 2023–2027 (NSP), and the Rural Development framework applicable to permanent grasslands. Particular attention was given to interventions available for grassland management, including:

- Basic Income Support for Sustainability (BISS – PD-01);
- Complementary Redistributive Income Support for Sustainability (CRISS – PD-02);
- Support for Young Farmers (CIS-YF – PD-03);
- Eco-schemes applicable to grassland systems (PD-05);
- Agri-environment and climate intervention for permanent grasslands (DR-01).

Spatial information regarding the distribution of permanent grasslands was obtained from geospatial datasets used for agricultural land management and territorial analysis. Administrative boundaries, land-use layers, and thematic maps were integrated into a Geographic Information System (GIS) environment.

Classification of Grassland Support Systems

For the purpose of the study, the support instruments available for permanent grasslands were grouped into three major categories:

1. Direct income support schemes (BISS, CRISS and CIS-YF);

2. Eco-schemes promoting environmentally friendly management practices;
3. Agri-environment and climate interventions targeting High Nature Value (HNV) grasslands and habitats of conservation interest.

Special emphasis was placed on DR-01 interventions, as these measures are directly linked to biodiversity conservation objectives and include specific management requirements such as extensive grazing, delayed mowing, restrictions on chemical inputs, and habitat protection measures.

Evaluation of Agri-Environmental Support

The assessment of agri-environmental support was based on the analysis of eligibility conditions, management requirements, and environmental objectives associated with the main grassland interventions.

Particular attention was given to the DR-01 intervention, which supports High Nature Value grasslands and habitats associated with species of European conservation concern. The analysis considered management requirements related to grazing intensity, mowing dates, restrictions on fertilizer and pesticide use, maintenance of ecological structures, and long-term commitments undertaken by beneficiaries.

The role of these measures was evaluated in relation to their potential contribution to biodiversity conservation, sustainable grassland

management, and the prevention of land abandonment.

RESULTS AND DISCUSSION

Evolution of Land Use Categories and Permanent Grasslands in Hunedoara County

The analysis of land-use dynamics during the 2015–2023 period revealed significant structural changes in the agricultural landscape of Hunedoara County. Arable land (TA) increased steadily throughout the study period, indicating a gradual intensification of agricultural production and a more efficient utilization of available agricultural resources. This trend was accompanied by a continuous reduction in non-productive arable land (TAn), suggesting the conversion of previously underutilized areas into productive agricultural land.

Permanent grasslands (PP) remained the dominant land-use category across the entire study period, confirming their crucial role within the agricultural systems of Hunedoara County. However, after reaching a maximum in 2017, grassland areas exhibited a gradual decline, particularly after 2020 (Figure 1). The overall reduction in permanent grassland area may reflect increasing pressures associated with land-use change, reduced grazing activity, and

agricultural restructuring. Nevertheless, the relatively moderate decline observed over the study period indicates a certain degree of resilience of grassland systems.

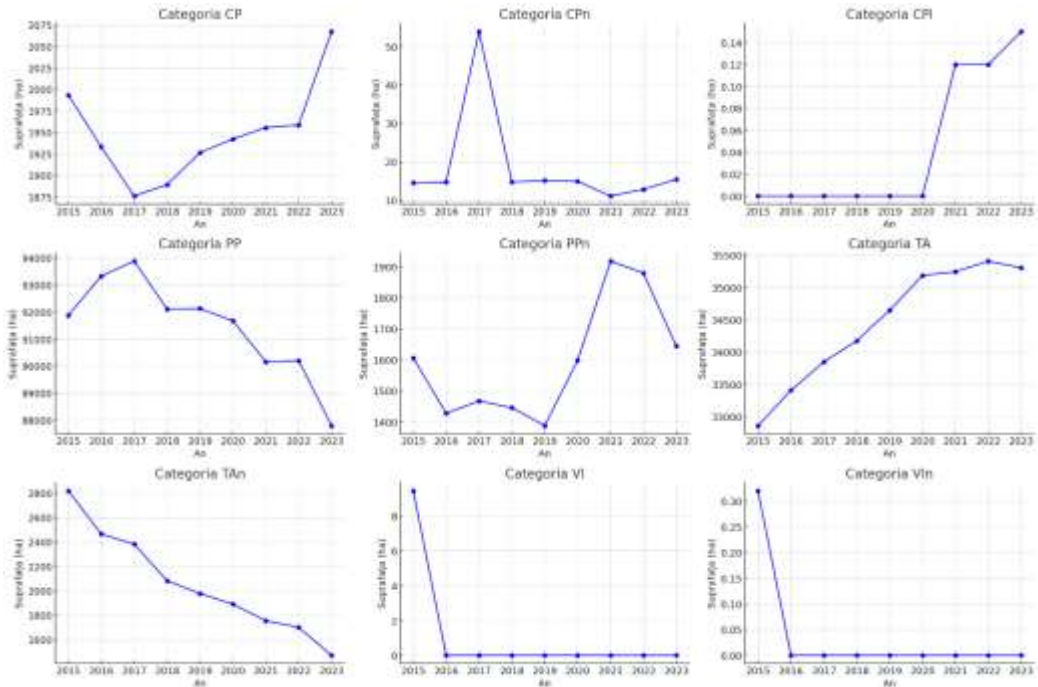
The dynamics of non-productive permanent grasslands (PPn) showed marked fluctuations, with a notable increase during 2020–2021, followed by a subsequent decline. This pattern may indicate temporary abandonment processes or changes in management intensity, influenced by economic conditions, agricultural policies, or climatic variability.

Permanent crops (CP) displayed a positive trend after 2018, suggesting renewed investments in orchards and other perennial production systems, while vineyards (VI) and non-productive vineyards (VIn) occupied only marginal areas and had a negligible influence on overall land-use dynamics.

Overall, the results indicate a gradual intensification of agricultural land use, characterized by the expansion of arable land and the reduction of non-productive surfaces. Despite these changes, permanent grasslands remained the predominant agricultural land-use

category in Hunedoara County, highlighting their continued ecological and economic importance. The persistence of extensive grassland systems throughout the study period suggests that agri-environmental

payments and CAP support measures may have contributed to limiting grassland conversion and maintaining the multifunctional role of these ecosystems in the regional landscape.



TA – arable land; TAn – non-productive arable land; PP – permanent grasslands; PPn – non-productive permanent grasslands; CP – permanent crops; CPn – non-productive permanent crops; CPi – irrigated permanent crops; VI – vineyards; VIn – non-productive vineyards.

Fig. 1 Evolution of agricultural land-use categories in Hunedoara County during the period 2015–2023

EVOLUTION OF PERMANENT GRASSLAND AREAS ENROLLED IN AGRI-ENVIRONMENTAL SUPPORT SCHEMES

The analysis of agri-environmental grassland management types revealed distinct temporal patterns between 2015 and 2019, reflecting both farmers' responses to support schemes and

the progressive implementation of CAP-related environmental measures.

A1 – Grazing Management

The evolution of grassland areas included under the A1 grazing

management category showed a sustained increase between 2015 and 2018, followed by a period of relative stabilization in 2019. This trend suggests an initial expansion of participation in grazing-related support schemes, likely associated with farmers' adaptation to agri-environmental requirements and increasing awareness of available financial incentives. The subsequent stabilization may indicate the attainment of a management

equilibrium, where most eligible grassland areas had already been incorporated into the support system. From an institutional perspective, the observed pattern reflects the gradual alignment of local farming systems with CAP objectives promoting sustainable grazing practices and grassland conservation.

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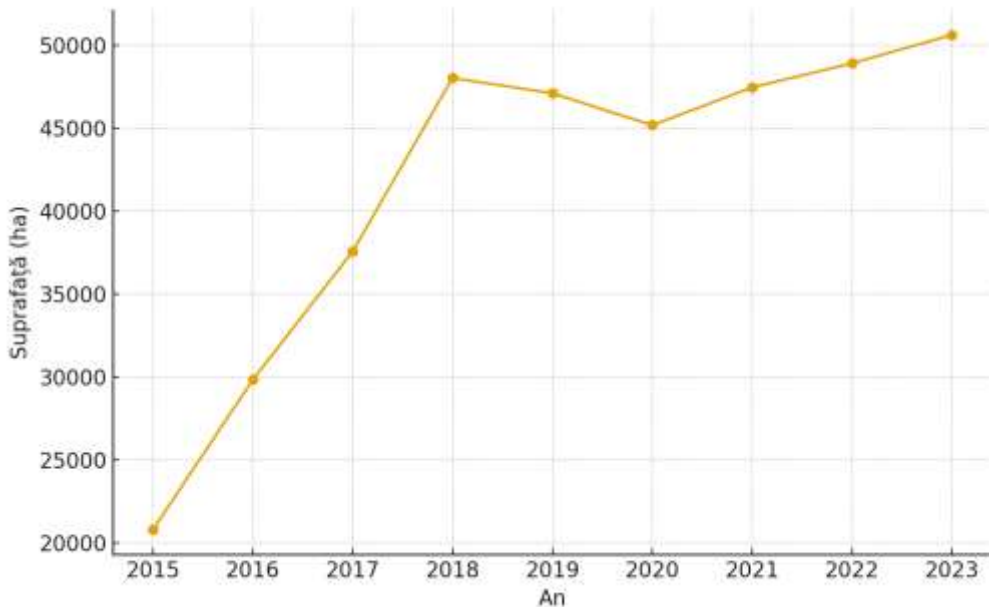


Fig. 2 Evolution of grassland areas under the A1 grazing management category during the period 2015–2019

A2 – Traditional Mowing Management

The A2 category, corresponding to manually mown grasslands, exhibited a continuous and nearly linear increase throughout the entire study period. This positive trend indicates a growing adoption of management practices compatible with

biodiversity conservation objectives. The acceleration observed after 2017 may be linked to increased participation in agri-environmental schemes and to adjustments introduced during the CAP transition period. From a socio-economic perspective, the results suggest that traditional mowing systems became increasingly

attractive for farmers, providing both environmental benefits and supplementary income through agri-environmental payments. The maintenance of manually managed

grasslands is particularly important for preserving floristic diversity and sustaining High Nature Value (HNV) farming systems.

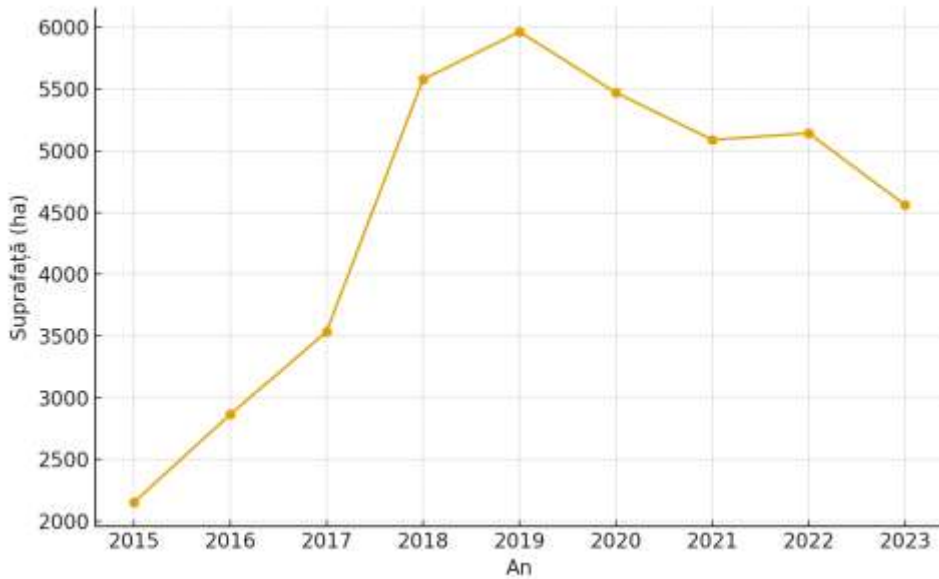


Fig. 3 Evolution of grassland areas under the A2 traditional mowing management category during the period 2015–2019

A3 – Mechanized Mowing Management

The A3 category showed the most pronounced increase among all analyzed management types. Grassland areas managed through mechanized mowing expanded rapidly between 2015 and 2019, displaying an almost exponential growth pattern. This substantial increase may reflect both the improved accessibility of grassland areas and the growing capacity of farmers to comply with management requirements while maintaining economic viability. The

observed expansion could also be associated with the implementation of targeted support measures encouraging the inclusion of previously underutilized grassland areas into formal agricultural management systems. The strong response of this category highlights the sensitivity of farmers to economic incentives and demonstrates the significant influence of agri-environmental payments on management decisions at farm level

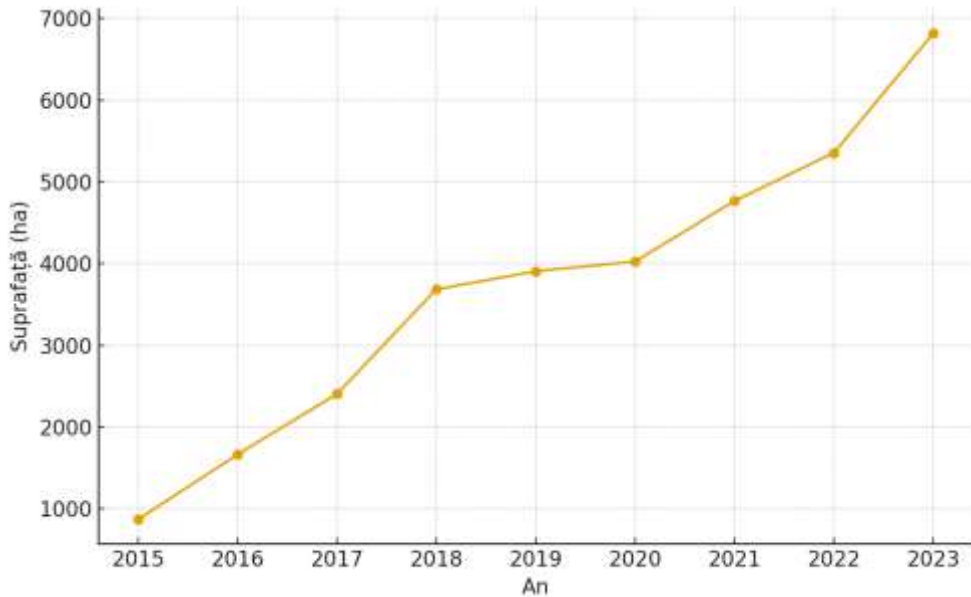


Fig. 3 Evolution of grassland areas under the A2 traditional mowing management category during the period 2015–2019

Overall, the evolution of the three agri-environmental management categories indicates a progressive increase in farmer participation in environmentally oriented grassland management systems. The positive trends observed across all categories

suggest that agri-environmental payments contributed to the maintenance and improved management of permanent grasslands, supporting both agricultural sustainability and biodiversity conservation objectives within Hunedoara County

CONCLUSIONS

The present study evaluated the dynamics of permanent grasslands and the evolution of agri-environmental support categories in Hunedoara County during the analyzed period.

The results showed that permanent grasslands remained the dominant agricultural land-use category throughout the study period, emphasizing their continued importance within the agricultural

landscape of the county. However, a gradual decline in grassland area was observed after 2019, while arable land exhibited a continuous increase, indicating ongoing changes in land-use patterns.

The analysis of agri-environmental support categories revealed positive trends for all investigated management systems. Grassland areas included in the A1 (grazing), A2 (traditional mowing), and A3

(mechanized mowing) categories increased over time, reflecting a growing participation of farmers in agri-environmental support schemes.

The expansion of grassland areas managed under agri-environmental commitments suggests an increasing adoption of management practices compatible with the objectives of the Common Agricultural Policy. Although the total area of permanent grasslands showed a moderate decline, the growth of areas enrolled in agri-environmental schemes indicates a greater involvement of farmers in support measures designed to encourage sustainable grassland management.

Overall, the results suggest that agri-environmental support schemes may play an important role in maintaining agricultural activity on permanent grasslands and supporting environmentally friendly management practices. Continued monitoring of grassland dynamics and farmer participation in support schemes is necessary to better understand the long-term effects of these measures on the conservation and sustainable use of permanent grasslands in Hunedoara County.

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EVALUATION OF PLANT AND ANIMAL PRODUCTIVITY OF NATURA 2000 GRASSLAND HABITATS IN THE SECAȘELOR PLATEAU

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Abstract

The permanent grasslands of the Secașelor Plateau, a component of the Transylvanian Plateau, were studied from a geobotanical point of view. Based on these data, the productivity of 27 grassland associations and 4 Natura 2000 habitats (H) was evaluated, namely H 1530, H 6210, H6440 and H 6520. The highest pastoral value (PV) with an index of 78.7 was evaluated at H 6520 and the highest green fodder mass (GM) production of 15.55 t/ha at H 6440, which ensures an optimal load of 1.55-1.56 LU/ha in 154-155 days of the grazing season. The lowest plant productivity was evaluated at H 6210 invaded mainly by *Botriochloa ischaemum*, with a PV index of 8.1 and a GM of 1.24 t/ha, almost 10 times lower than H 6210 with normal vegetation. On average, the PV was 51.1 and the GM production was 9.72 t/ha, which allowed a load of 0.98 LU/ha, a grazing season of 152 days. The average consumption for 1 liter of cow's milk was 7 kg GM and for 1 kg of live weight gain in young bulls was 75 kg GM, resulting in 1573 L/ha of milk worth €785 or 145 kg/ha of weight gain worth €465. The best animal production results were achieved at H 6440 and H 6520 where an average of 2800 L/ha milk with €1400 or 250 kg/ha weight gain with €800 were evaluated. The lowest animal productions were evaluated at H 6210 with degraded vegetation, 136 L/ha milk or 13 kg/ha weight gain and H 1530 with 593 L/ha milk or 55 kg/ha weight gain, 3-12 times the average of the habitats or 5-19 times lower productions compared to the most valuable grassland habitats.

Keywords: Secașelor Plateau grasslands, plant productivity, animal productivity, milk and weight gain value

INTRODUCTION

To date, numerous geobotanical and typological research has been carried out on permanent grasslands (PUȘCARU-SOROCEANU et al., 1963; BĂRBULESCU, MOTCĂ, 1983).

Knowledge of the plant productivity of permanent grasslands, namely the amount of

green mass and its fodder value, are essential indicators for the preparation of pastoral arrangements and their subsequent optimal management (MARUȘCA et al. 2014).

Plant productivity directly influences animal performance expressed in milk, live weight gain,

wool, etc., which are finished products with economic value.

These indicators that ultimately define the yield of a permanent grassland are determined through experiments with laborious and expensive animals (MOTCĂ et al., 1994; MARUŞCA, 2022).

Productivity assessment based on floristic survey has simplified and substantially reduced

expenses, being sufficiently precise (MARUŞCA, 2019; MARUŞCA, 2026).

Through this new evaluation method, it was possible to establish the plant and animal production of numerous phytocoenoses and ultimately grassland habitats.

This work is a continuation of the productivity assessment of the Secaşelor Plateau.

MATERIAL AND METHOD

The study of grassland productivity is a continuation of the geobotanical research from the doctoral thesis "Flora and vegetation of the Secaşelor Plateau " prepared by biologist Vasile Cristea under the scientific guidance of Prof. doc. Ştefan Csürös from the

"Babeş- Bolyai" University of Cluj-Napoca, Faculty of Biology, Geography and Geology, defended in 1981.

The outline of the permanent grassland associations was as follows:

CI. MOLINIO - ARRHENATHERETEA R. Tx. 1937

Ord. ARRHENATHERETALIA Pawlowski 1928

Al. Arrhenatherion elatioris (Br.-Bl. 1925) W. Koch 1926

1. *As. Arrhenatheretum elatioris* (Br.-Bl.1919) Scherrer 1925
2. *As. Poëto- Festucetum pratensis* Soó 1949

Al. Cynosurion cristati R. Tx. 1947

3. *As. Anthoxantho- Agrostietum tenuis* Sillinger 1933, Jurko 1969
4. *As. Lolio - Cynosuretum*, Tx. 1940
5. *As. Trifolio repenti-Lolietum* Krippelova 1967, Resmeriţă et col. 1967

Ord. MOLINIETALIA Koch 1926

Al. Agrostion stoloniferae (Soó 1943) 1971

6. *As. Agrostietum stoloniferae* Ujvárosi 1941, Soó 1971

CI. FESTUCO-BROMETEA Br.-Bl.1931

Ord. FESTUCETALIA VALESIIACAE Br.-Bl. et Tx. 1943

Al. Festucion rupicolae Soó 1940

7. *As. Agrostio - Festucetum rupicolae* M. Csürös 1964
8. *As. Festuco rupicolae - Caricetum humilis praerossicum* Soó 1949
9. *As. Medicagini- Festucetum valesiaca* Wagner 1941
10. *As. Botriochloetum ischaemi* I. Pop 1977
11. *As. Chrysopogonetum grylli campinensis* Borza 1959
12. *As. Stipetum capillatae* (Hueck1931) Krausch. 1961

13. *As. Artemisietum pontico-serriceae* Soó (1927) 1942
Al. Danthonio-Stipion stenophyllae Ghişa 1947, Soó 1947
14. *As. Stipetum stenophyllae transsilvanicum* Soó 1946
Al. Cirsio-Brachypodion Hadac et Kilka 1944 em. Krausch. 1961
15. *As. Festuco rupicolae -Brachypodietum pinnati transsilvanicum* E. Schneider-Binder 1971
Al. Seslerio-Festucion pallentis Kilka 1934
16. *As. Seslerietum heufflerianae austro-transsilvanicum* Borza 1959
- Cl. PUCCINELLIO-SALICORNIETEA** Țopa 1939
Ord. THERO-SALICORNIETALIA Br.-Bl. (1931) Tx. 1950
Al. Thero-Salicornion Br.-Bl. (1930) 1933. em. Tx. 1950
17. *As. Salicornietum europaeae* Soó 1927, 1964, Wendelbg. 1943
Al. Puccinellion peisonis (Wendelbg. 1943), Soó 1957
18. *As. Puccinellietum distantis* Soó 1939, Knapp 1948
Al. Puccinellion limosae (Klika 1937), Wendelbg. 1943
19. *As. Puccinellietum limosae* (Rapaics 1927), Soó 1930
Al. Juncion gerardii Wendelbg. 1943
20. *As. Plantaginetum (cornuti)-Agrostietum stoloniferae* Soó et. Csűrös 1944, corr. 1973
21. *As. Astero (tripolio)-Triglochinietum* Țopa 1939
Ord. ARTEMISIO-FESTUCETALIA PSEUDOVINAE Soó 1933
Al. Festucion pseudovinae Soó 1933
22. *As. Artemisio-Festucetum pseudovinae* (Magyar 1928) Soó (1933) 1945
- Cl. PLANTAGINETEA MAJORIS** Tx. et Prsg. 1950
Ord. PLANTAGINETALIA MAJORIS Tx. (1947) 1950
Al. Polygonion avicularis Br.-Bl. 1931, em. Tx. 1950
23. *As. Polygonetum avicularis* Gams 1927
24. *As. Poëtum annuae* Gams 1927
25. *As. Lolio-Plantaginetum majoris* (Linkola 1921) Beger 1930
26. *As. Matricario-Lolietum* (Beger 1930) Tx. 1937
Al. Agropyro-Rumicion crispi Nordh. 1940
27. *As. Lolio-Potentilletum anserinae* (Rapaics 1927) Knapp 1946

Geobotanical research on grassland vegetation was carried out according to the Braun-Blanquet method of the Phytosociological School Zurich - Montpellier (CRISTEA et al., 2004).

The scores of the abundance-dominance (AD) rating scale were transformed into participation percentages in order to perform statistical calculations (Table 1).

Floristic surveys thus prepared, with the component species in percentages of participation in the grassland carpet, multiplied by quality and plant mass indices, made it possible to establish the pastoral value (PV) and green forage mass production (GM) indices according to a new method (MARUȘCA, 2019).

Table 1

Participation assessment (P%) from synthetic surveys, depending on the intervals abundance + dominance (AD) scale and average constancy (K%) for permanent grassland phytocoenoses (restored after Marușca 2019)

AD scale Br. – Bl.	AD based on K (%)				
	I (<20)	II (21 – 40)	III (41 – 60)	IV (61 – 80)	V (81 – 100)
5	8.8	26.3	43.8	61.3	87.5
4 - 5	7.5	22.5	37.5	52.5	75.0
3 - 5	6.3	18.8	31.3	43.8	62.5
2 - 5	5.3	15.8	26.3	36.8	52.5
1 - 5	4.6	13.9	23.2	32.4	46.3
+ - 5	4.4	13.2	22.0	30.8	44.0
4	6.3	18.8	31.3	43.8	62.5
3 - 4	5.0	15.0	25.0	35.0	50.0
2 - 4	4.0	12.0	20.0	28.0	40.0
1 - 4	3.4	10.1	16.9	23.7	33.8
+ - 4	3.2	9.5	15.8	22.1	31.5
3	3.8	11.3	18.9	26.3	37.5
2 - 3	2.8	8.3	13.8	19.3	27.5
1 - 3	2.1	6.4	10.7	14.9	21.3
+ - 3	1.9	5.7	9.5	13.3	19.0
2	1.8	5.3	8.8	12.3	17.5
1 - 2	1.1	3.4	5.7	7.9	11.3
+ - 2	0.9	2.7	4.5	6.3	9.0
1	0.5	1.5	2.5	3.5	5.0
+ - 1	0.3	0.8	1.4	2.0	2.8
+	0.1	0.2	0.3	0.4	0.5

Phytosociological alliances and associations were further included in Natura 2000 Habitats (DONIȚĂ et al. 2005, Gafta, MOUNTFORD 2008).

The duration of the grazing season was established according to

altitude and the duration of the interval with average daily temperatures between 10-20 ° Celsius (MARUȘCA 2001) according to the formula:

$$\mathbf{D.s.p. (100-500\ m\ alt.) = 100 \times 0.15 \times Alt.}$$

$$\mathbf{D.s.p. (500-2500\ m\ alt.) = 212 - 0.075 \times Alt.}$$

in which:

D.s.p. = duration of grazing season
(days)

Alt. = altitude (m)

The optimal loading and grazing capacity of a pasture is

determined by the following formula:

$$\text{GC (LU/ha)} = \text{GM Production (kg/ha)} / \text{D.s.p.} \times 65$$

in which:

GC = grazing capacity (animal load)

LU = large cattle unit

GM = green fodder mass

D.s.p. = grazing season duration

65 = amount of GM (kg) required for 1 LU/day (50 kg+30% annual and seasonal fluctuations of GM) (MARUȘCA, 2019)

Of particular importance are the conversion coefficients of green mass production into animal production, which are based on consumption indices for 1 liter of milk or 1 kg of live weight gain in cattle (MARUȘCA, 2025, 2026).

The green fodder consumption index for 1 liter (L) of milk was calculated using the formula:

$$\text{GM consumption (kg) for 1 L milk} = 9.5 - 0.05 \times \text{PV}$$

in which:

GM (kg) = green fodder mass

PV (ind.) = pastoral value

Cow milk production per hectare was calculated using the formula:

$$\text{Milk production (L/ha)} = \text{GM (kg/ha)} / \text{GM consumption (kg) for 1L}$$

The GM consumption index (kg) for 1 kg of live weight gain in

young bovine was calculated according to the formula:

$$\text{GM consumption (kg) for 1kg gain} = 100 - 0.5 \times \text{PV}$$

Similarly, the consumption of GM for 1 kg of live weight gain varies between 50 kg GM for the maximum PV index of 100 to 100 kg GM for the lowest PV index.

The production of growth (meat) in young bovine per hectare is calculated according to the formula:

$$\text{Gain production (kg/ha)} = \text{GM (kg/ha)} / \text{GM consumption (kg) for 1 kg gain}$$

The prices of animal products at EU level, namely cow's milk is 0.5 Euro/L and live meat is

3.2 Euro/kg higher. (MADR, Carcass Classification Commission, 2026).

The productivity of habitats mainly used as hayfields or mixed

in the Carpathians was calculated with the formula:

$$\text{Hay production (t/ha)} = \text{GM (t/ha)} \times 0.24$$

in which:

GM = green fodder mass

0.24 = transformation coefficient (PUIA et al., 1976)

By applying these formulas to the evaluation of plant and animal production during the grazing

season, the basic elements for the preparation of pastoral arrangements, optimal management and economic efficiency achieved on permanent grasslands are established.

RESULTS AND DISCUSSIONS

The 27 associations described in the Secaşelor Plateau located in South-West Transylvania

between 280-440 m altitude, belong to 14 phytosociological alliances (Table 2).

Table 2

General data on the resort and grassland vegetation

No. crt.	Associations	Altitude (m)	Exposition	Inclination (degrees)	Cormophyte (no.)	Covering (%)
<i>Arrhenatherion elatioris</i>						
1.	<i>Arrhenatheretum elatioris</i>	285	Plan (P)	-	61	100
2.	<i>Poëto- Festucetum pratensis</i>	320	NW, P	3	61	94
<i>Cynosurion cristati</i>						
3.	<i>Anthoxantho-Agrostietum tenuis</i>	380	N,NW,NE	8	95	96
4.	<i>Lolio - Cynosugetum</i>	400	N, NE, NW	2	54	90
5.	<i>Trifolio repenti-Lolietum</i>	310	M,N,F,W	4	55	89
<i>Agrostion stoloniferae</i>						
6.	<i>Agrostietum stoloniferae</i>	360	-	-	44	100
<i>Festucion rupicolae</i>						
7.	<i>Agrostio - Festucetum rupicolae</i>	370	NW,N,W,NE, E,P	12	188	96
8.	<i>Festuco rupicolae - Caricetum humilis praerossicum</i>	370	W,SW,NW	16	57	90

No. crt.	Associations	Altitude (m)	Exposition	Inclination (degrees)	Cormophyte (no.)	Covering (%)
9.	<i>Medicagini-Festucetum valesiaca</i>	350	S,E,SW,NE	17	83	83
10.	<i>Botriochloetum ischaemi</i>	340	S,SW,SE,W	23	127	82
11.	<i>Chrysopogonetum grylli campinensis</i>	440	S,SE	20	29	93
12.	<i>Stipetum capillatae</i>	400	S,P	15	28	93
13.	<i>Artemisietum pontico-serriceae</i>	340	SW,SE,S,W	27	26	49
<i>Danthonio-Stipion stenophyllae</i>						
14.	<i>Stipetum stenophyllae transsilvanicum</i>	340	NW,P	5	56	85
<i>Cirsio-Brachypodion</i>						
15.	<i>Festuco rupicolae - Brachypodietum pinnati transsilvanicum</i>	340	N,NW,SE,NE, SV,V,P	11	109	98
<i>Seslerio-Festucion pallentis</i>						
16.	<i>Seslerietum heufflerianae austro-transsilvanicum</i>	290	P,NW	-	14	75
<i>Thero-Salicornion</i>						
17.	<i>Salicornietum europaeae</i>	280	S,P	30	7	63
<i>Puccinellion peisonis</i>						
18.	<i>Puccinellietum distantis</i>	290	Plan (P)	-	20	96
<i>Puccinellion limosae</i>						
19.	<i>Puccinellietum limosae</i>	300	Plan (P)	-	17	87
<i>Juncion gerardii</i>						
20.	<i>Plantagineto (cornute)-Agrostietum stoloniferae</i>	290	Plan (P)	-	17	100
21.	<i>Astero (tripolio)-Triglochinietum</i>	295	Plan (P)	-	17	90
<i>Festucion pseudovinae</i>						
22.	<i>Artemisio-Festucetum pseudovinae</i>	315	Plan (P)	-	16	90
<i>Polygonion avicularis</i>						
23.	<i>Polygonetum avicularis</i>	360	Plan (P)	-	28	83

No. crt.	Associations	Altitude (m)	Exposition	Inclination (degrees)	Cormophyte (no.)	Covering (%)
24.	<i>Poëtum annuae</i>	360	-	-	28	93
25.	<i>Lolio-Plantaginetum majoris</i>	360	-	-	28	73
26.	<i>Matricario-Lolietum</i>	360	-	-	28	80
<i>Agropyro-Rumicion crispi</i>						
27.	<i>Lolio-Potentilletum anserinae</i>	360	-	-	23	85
AVERAGE		341	-	7	49	87

A total of 13 associations are located on flat land and 14 associations on sloping land with inclinations between 5-30 degrees.

Under these stationary conditions, an average of 49 cormophytes per association were recorded, the most, 188 species, were found in the *Agrostio – Festucetum rupicolae* association and the fewest, only 7 species in *Salicornietum europaea*.

100% vegetation cover was reported only in *Arrhenatheretum*

elatioris, *Agrostietum stoloniferae*, *Plantaginetum (cornuti)- Agrostietum stoloniferae* associations.

The lowest vegetation covers were observed in *Artemisietum pontico-serriceae* (49%) and *Salicornietum europaea* (63 %).

The average participation in the grassy carpet of species with forage value is 64% and of harmful species 23% of the total 87% average vegetation cover (Table 3).

Table 3

Forage species participation, pastoral value, green mass production and animal loading

No. crt.	Associations	Species structure		Pastoral value (ind.)	GM output (t/ha)	Grazing season duration (days)	Loading with animals (LU/ha)
		Fodder	Harmful				
<i>Arrhenatherion elatioris</i>							
1	<i>Arrhenatheretum elatioris</i>	88	12	74.4	19.51	x	x
2	<i>Poëto- Festucetum pratensis</i>	92	2	81.9	16.66	x	x
<i>Cynosurion cristati</i>							
3	<i>Anthoxantho-Agrostietum tenuis</i>	94	2	71.8	12.59	157	1.23
4	<i>Lolio - Cynosuretum</i>	89	1	80.7	16.63	160	1.60
5	<i>Trifolio repenti-Lolietum</i>	88	1	83.6	17.09	147	1.85
<i>Agrostion stoloniferae</i>							
6	<i>Agrostietum stoloniferae</i>	92	8	71.6	15.55	154	1.55

No. crt.	Associations	Species structure		Pastoral value (ind.)	GM output (t/ha)	Grazing season duration (days)	Loading with animals (LU/ha)
		Fodder	Harmful				
<i>Festucion rupicolae</i>							
7	<i>Agrostio - Festucetum rupicolae</i>	92	4	68.4	13.04	156	1.29
8	<i>Festuco rupicolae - Caricetum humilis praerossicum</i>	73	17	39.9	7.78	156	0.77
9	<i>Medicagini-Festucetum valesiaca</i>	82	1	48.2	8.05	139	0.89
10	<i>Botriochloetum ischaemi</i>	19	63	11.0	1.73	151	0.18
11	<i>Chrysopogonetum grylli campinensis</i>	86	7	41.8	15.20	166	1.41
12	<i>Stipetum capillatae</i>	7	86	4.2	0.64	160	0.06
13	<i>Artemisietum pontico-serriceae</i>	3	46	1.6	0.23	151	0.02
<i>Danthonio-Stipion stenophyllae</i>							
14	<i>Stipetum stenophyllae transsilvanicum</i>	25	60	15.7	2.35	151	0.24
<i>Cirsio-Brachypodion</i>							
15	<i>Festuco rupicolae - Brachypodietum pinnati transsilvanicum</i>	93	5	52.5	16.50	151	1.68
<i>Seslerio-Festucion pallentis</i>							
16	<i>Seslerietum heufflerianae austro-transsilvanicum</i>	25	50	13.5	2.30	144	0.25
<i>Thero-Salicornion</i>							
17	<i>Salicornietum europaeae</i>	62	1	29.5	2.59	142	0.28
<i>Puccinellion peisonis</i>							
18	<i>Puccinellietum distantis</i>	83	13	55.3	5.89	144	0.63
<i>Puccinellion limosae</i>							
19	<i>Puccinellietum limosae</i>	85	2	65.9	5.85	145	0.62
<i>Juncion gerardii</i>							
20	<i>Plantagineto (cornuti)-Agrostietum stoloniferae</i>	83	17	56.9	2.93	144	0.31
21	<i>Astero (tripolio)-Triglochinietum</i>	12	78	9.2	0.64	144	0.07

No. crt.	Associations	Species structure		Pastoral value (ind.)	GM output (t/ha)	Grazing season duration (days)	Loading with animals (LU/ha)
		Fodder	Harmful				
<i>Festucion pseudovinae</i>							
22	<i>Artemisio-Festucetum pseudovinae</i>	85	5	47.8	5.90	147	0.62
<i>Polygonion avicularis</i>							
23	<i>Polygonetum avicularis</i>	82	1	45.6	5.50	154	0.55
24	<i>Poëtum annuae</i>	92	1	57.2	5.26	154	0.53
25	<i>Lolio-Plantaginetum majoris</i>	72	1	53.8	9.18	154	0.02
26	<i>Matricario-Lolietum</i>	11	69	10.0	1.31	154	0.13
<i>Agropyro-Rumicion crispi</i>							
27	<i>Lolio-Potentilletum anserinae</i>	18	67	16.5	2.41	154	0.24
AVERAGE		64	23	44.8	7.90	151	0.68

With participations of 90% and above, species with forage value were found in *Arrhenatherion elatioris*, *Cynosurion cristati*, *Cirsio-Brachypodion* and the association *Agrostio - Festucetum rupicolae*.

With the lowest participation of forage species in the grassy carpet of less than 20% were the *Artemisietum pontico-serriceae* (3 %), *Stipetum capillatae* (7 %), *Matricario-Lolietum* (11 %), *Lolio-Potentilletum anserinae* (18 %) and *Botriochloetum ischaemi* (19%) which are considered economically degraded, having a grazing capacity between 0.02-0.24 LU/ha in 151-160 days.

The highest animal load was assessed at the *Trifolio repenti-Lolietum* (1.85 LU/ha) și *Lolio - Cynosuretum* (1.60 LU/ha) associations in 147-160 days of grazing season, where 16.6-17 t/ha

GM was ensured with an index of 81-84 PV.

The average GM production of all phytosociological associations was 7.9 t/ha with a PV index of 44.8 which ensures an average load of 0.68 LU/ha in an optimal grazing period of 151 days.

The only alliance used almost exclusively in haymaking is *Arrhenatherion elatioris* where 18 t/ha GM (4.34 t/ha hay) is achieved with a very good average PV index of 78.

These data on plant productivity, together with the results of long-term experiences with dairy cows and young bovine on feed-animal product conversion, led to the final economic phase of evaluating milk production or live weight gain per hectare for grassland habitats in the study area.

The following grassland habitats (H) were highlighted:

➤ H 1530, Pannonian salt - steps and salt marshes with the following phytosociological alliances: *Puccinellion peisonis*, *P. limosae*, *Juncion gerardii* and *Festucion pseudovinae*;

➤ H 6210, Semi-natural dry grassland and scrubland facies on calcareous substrates (*Festuco-Brometea*) alliance *Festucion rupicolae* with normal vegetation of the associations: *Agrostio-Festucetum rupicolae*, *Festuco rupicolae-Caricetum humilis praerossicum*, *Medicagini-Festucetum valesiaca*, *Chrysopogonetum grylli campinensis* and *Cirsio-Brachypodion* alliance;

➤ H 6210 alliance *Festucion rupicolae* with degraded vegetation

forage of associations: *Botriochloetum ischaemi*, *Stipetum capillatae*, *Artemisietum pontico-serriceae* and *Danthonio-Stipion stenophyllae* alliance;

➤ H 6440, Alluvial grasslands of the river valley of the *Cnidion dubii* alliance with *Agrostion stoloniferae*;

➤ H 6520, Mountain grasslands with *Cynosurion cristate* alliance.

The highest pastoral value with an index of 78.7 was assessed at habitat (H) 6520 and the highest production of GM at H 6440 of 15.55 t/ha which ensures a load of 1.55-1.56 LU/ha in 154-155 days of grazing (Table 4).

Table 4

Vegetative productivity, grazing season length and optimal stocking with animals of the grasslands

Habitat	Status vegetation	Pastoral value (ind.)	Green table		Grazing season duration (days)	Loading with animals (LU/ha)
			t/ha	%		
1530	Normal	47.0	4.24	44	145	0.45
6210	Normal	50.2	12.11	125	154	1.21
	Degraded	8.1	1.24	13	153	0.12
6440	Normal	71.6	15.55	160	154	1.55
6520	Normal	78.7	15.44	159	155	1.56
AVERAGE	X	51.1	9.72	100	152	0.98

The lowest productivity was recorded in degraded H 6210, where the PV index was 8.1 and GM was 1.24 t/ha, almost 10 times lower than in H 6210 with normal vegetation.

On average, the PV was 51.5 and the GM production was 9.72 t/ha with a loading of 0.98 LU/ha in the 152-day optimal grazing season.

The main end products of a permanent grassland used by cattle

grazing are milk and live weight gain (Table 5).

Table 5
Feed-to-animal product conversion, production per hectare and economic value

Habitat	GM conversion feed-product		Animal production per hectare				Value (Euro)	
	1 L milk	1 kg gain	Milk		Gain		Cow milk	Weight gain
1530 N *	7.2	77	593	38	55	38	297	177
6210 N	7	75	1732	110	162	112	866	517
6210 D **	9.1	96	136	9	13	9	68	42
6440 N	5.9	64	2627	167	242	167	1313	775
6520 N	5.6	61	2774	176	255	176	1387	815
AVERAGE	7	75	1573	100	145	100	785	465

*) normal, **) degraded

The average consumption of GM for 1 liter of cow's milk was 7 kg with variations between 5.6 kg GM at H 6520 and 9.1 at H 6210 with degraded vegetation.

The average cow milk production per hectare was 1573 L/ha worth €785 with variations between 2774 L/ha on H 6520 and 136 L/ha on degraded H 6210, 20 times lower.

The average consumption of GM for 1 kg of live weight gain in young bulls was 75 kg with variations between 61 kg GM/kg gain in H 6520 and 96 kg GM in degraded H 6210 and the average

production was evaluated at 145 kg/ha/year worth €465/ha.

According to the PV quality index and GM production with its conversion, the highest growth production of 255 kg/ha was evaluated at H 6520 and the lowest of 13 kg/ha at H 6210 with degraded forage vegetation.

The average economic value of milk production per hectare, respectively profitability, is 69% higher than the live weight gain (785 ha compared to 465 €/ha), but the expenses for producing cow's milk are also higher than for maintaining young cattle on pasture.

CONCLUSIONS

The permanent grasslands of the Secaşelor Plateau with forage value have a high phytodiversity, belonging to 27 associations, 14

alliances, 6 orders and 4 vegetation classes.

Four Natura 2000 habitats were identified, namely H 1530, H 6210 (normal and degraded variant),

H 6520 and H 6440 with an average pastoral value (PV) of 51.1, green fodder production of 5.72 t/ha with a grazing capacity of 0.98 LU/ha in 152 days of optimal grazing season.

The average feed-animal production conversion was 7 kg GM/1 L milk or 75 kg GM/1 kg weight gain, achieving an average of 1573 L/ha milk worth €785 or 145 kg/ha live weight gain in young bovine worth €465/ha.

The highest plant productivity was evaluated at H 6440 (*Al. Agrostion stoloniferae*) and H 6520 (*Al. Cynosurion cristati*) with 71.6-78.7 PV, 15.44-

15.55 t/ha GM, loading 1.55-1.56 LU/ha in 154-155 days of grazing.

The highest animal productivity was evaluated at the same H 6440 and H 6520 with a feed-milk conversion of 5.6-5.9 kg GM/ 1L or feed-gain weight of 61-64 kg GM/ 1kg, resulting in 2627-2774 L/ha milk worth 1313-1387 € or 167-176 kg/ha gain worth 775-815 €/ha/year.

The lowest plant and animal productivity was recorded at H 1530 on saline soils and H 6210, the degraded variant on slopes exposed to aridification and overgrazing.

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ECONOMIC ASSESSMENT OF PRODUCTIVITY IN OAK (*QUERCUS ROBUR*) AGROSILVOPASTORAL SYSTEMS IN THE HOMOROADELOR PLATEAU

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Abstract

The oak (*Quercus robur*) agrosilvopastoral system (ASP) from Mercheașă–Homorod, covering approximately 1,000 ha, is one of the most representative systems of this type in southeastern Transylvania, providing shade for livestock during the grazing season. The herbaceous layer beneath the tree canopy, dominated by *Festuca rupicola*, *Lolium perenne*, and *Trifolium repens*, produced 14.42 t ha⁻¹ of green mass and achieved a pastoral value of 70.7, compared with 9.60 t ha⁻¹ and 56.6, respectively, on the treeless pasture. The tree stand consisted of 16 trees ha⁻¹, belonging to four species, with crowns covering an average of 2,980 m² ha⁻¹. Milk production reached 1,712 L ha⁻¹, representing a 19% increase over the treeless pasture. At a harvesting age of 120 years, the woody component provides annually 0.65 m³ ha⁻¹ of timber and 0.45 m³ ha⁻¹ of fuelwood, in addition to acorn production. The total economic value of the ASP was estimated at €1,441 ha⁻¹ year⁻¹, nearly double that of the treeless pasture.

Keywords: oak (*Quercus robur*) agrosilvopastoral system, cow milk production, forestry production, economic value.

INTRODUCTION

Climate change is particularly affecting permanent grasslands and grazing livestock in Romania, as well as in other countries with warmer and drier climates where agrosilvopastoral systems (ASP) are known under names such as “dehesa”, “montado”, and “agroforestry” (Scharrow and Flechter, 1994; Olea and San Miguel, 2006; Hartel et al., 2017). In Romania, grasslands with scattered trees are locally known as “rariște” and “dumbravă” and occur

on communal pastures, especially in Transylvania and Banat, where they provide shade for grazing animals (Mihăilă et al., 2010; Marușca, 2012).

Productivity studies of permanent grasslands based on floristic surveys have enabled the assessment of pastoral value (PV) and green mass (GM) production in open grasslands and beneath tree crowns, highlighting the importance of ASP systems for animal welfare during the grazing season (Marușca,

2019; Marușca et al., 2020, 2025). The development of zoopastoral indices for estimating milk production, together with the economic valuation of timber and tree products (acorns, beechnuts, wild pears, etc.), has made it possible to compare the economic performance of ASP systems with that of treeless grasslands

(Corlățeanu, 1984; Marușca, 2025, 2026; Nesterov et al., 2006).

This study provides a comprehensive economic assessment of milk, construction timber, firewood, and acorn production in an oak (*Quercus robur*) dominated agrosilvopastoral system located in Mercheașa–Homorod, Homoroadelor Plateau, Brașov County, Romania.

MATERIAL AND METHOD

The economic study of the oak agrosilvopastoral system (ASP) was conducted on the communal pasture of Mercheașa village, Homorod commune, Brașov county. The system covers an area of 1,000 hectares, located at an altitude of 530 m in the Homoroade Plateau.

The wooded pasture is surrounded by forest stands on almost all sides. The existing forest vegetation was analyzed within three experimental plots of 1 ha each, considered representative in terms of tree density and their vegetative state (Figure 1).

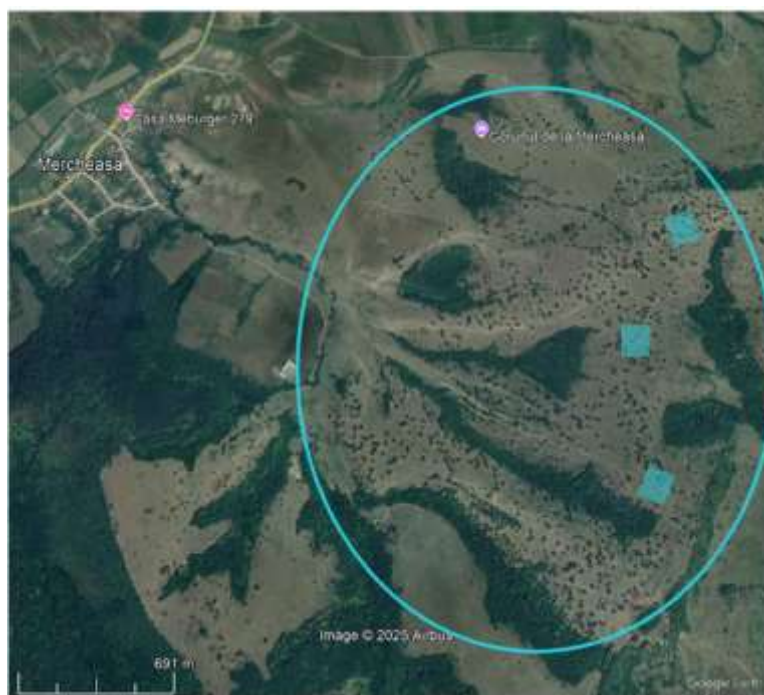


Fig. 1. Mercheașa Pasture and the location of the experimental plots, ■

From a pedological and floristic perspective, the soil characteristics, dominant species structure, and fodder quality indicators under both

conditions (open grassland vs. under trees' crowns) are summarized in Table 1.

Table 1
General data on the oak (*Quercus robur*) agrosilvopastoral system (ASP) from Mercheaşa–Homorod, Braşov County (Maruşca et al., 2020)

Grassland condition	Soil		Dominant species	Forage			
	pH (index)	Humus (%)		CP	CF	OMD	
Open grassland without trees (sun)	5.20	7.01	<i>Festuca rupicola</i> <i>Agrostis capillaris</i> <i>Trifolium repens</i>	17.1	28.5	58.6	
Under tree crown (shade)	5.35	7.19	<i>Festuca rupicola</i> <i>Lolium perenne</i> <i>Trifolium repens</i>	19.7	27.3	65.9	
Difference	+, -	+ 0.15	+ 0.18	x	+ 2.6	- 1.2	+ 7.3
	%	103	103	x	115	96	113

Legend: CP = crude protein (N x 6.25); CF = crude fiber; OMD = organic matter digestibility

The evaluation of pasture productivity was carried out using the floristic relevé method (Maruşca, 2019, Maruşca et al., 2020). Having available data regarding the pastoral value (PV), the production of green forage mass (GM), and the duration of the optimal grazing season (days), formulas were applied to evaluate milk production (Maruşca, 2025, 2026):

Milk Yield (L/ha) = GM Yield (Kg/ha) / GM Consumption (kg) required for 1L of milk
GM Consumption (kg) required for 1L of milk = 9.5 – 0.05 x VP

Where:

GM = green forage mass production (kg/ha)

PV = pastoral value index

The baseline economic value for one liter of cow's milk at the EU level was set at 0.5 Euro (according to MADR, 2025).

To determine the stem volume, the standard general formula factoring in trunk diameter and height was utilized:

V=BA·h·f=0,7854·d²·h·f

Where:

V = stem volume (m³)

BA = basal area at a breast height of 1.3 m (m²)

d = tree diameter at breast height (DBH)

h = total tree height (m)

f = stem form factor

Due to the exceptionally wide crowns and relatively short trunks characteristic of isolated ancient trees on wood-pastures, the form factor (f) was estimated at relatively low values: 0.35 for oak and sessile oak with a diameter under 100 cm; 0.30 for oak and sessile oak with a diameter over 100 cm (as the form factor decreases as diameter increases in ancient trees); 0.34 for wild pear and wild apple.

To account for total tree biomass (firewood from large branches and secondary boughs), additional correction coefficients were applied relative to the stem volume: 70% (0.70) of the stem volume for oak species (oak, sessile oak) due to highly developed crowns and 80% (0.80) of the stem volume for wild apple and wild pear (where the trunk is shorter, the crown begins very low, and branching is robust)

Market prices and unified labor standards used for the economic evaluation were as follows:

- Medium-quality raw log (construction/furniture timber): 1,000 – 2,000 lei/m³.

- Processed firewood (cut to 30–50 cm and delivered to commercial centers): 700 – 1,000 lei/m³. In the calculations, a baseline average of 850 lei/m³ applied for low-quality stem wood, and 350 lei/m³ for

mixed firewood from branches and boughs.

- Acorn production: Estimates were based on the average yields of natural forest ecosystems (600 – 1,200 kg/ha in mast years), establishing a baseline average of 150 kg/ha/year for the ASP system. Harvesting labor costs were calculated according to the Unified Time and Production Standards for Forestry Operations (MAPPM_RNP, 1997) at 8–10 RON/kg. The final market value used in the model was 1.8 €/kg.

- Wild fruit (apples and pears): Annual yield was estimated at 25 – 50 kg/tree, assuming basic annual crown pruning. Harvesting labor was evaluated at 2.5 – 3.5 RON/kg.

RESULTS AND DISCUSSIONS

Within these three experimental plots, 49 trees scattered across the pasture were identified, with a higher count in one plot (25 trees) and lower counts in the others (14 and 10, respectively), corresponding to an average of 16 trees/ha. This value falls within the lower half of the density range for oak-dominated wood-pastures in countries with a long-standing tradition in wood-pasture development, such as Spain, Portugal, Italy, and Greece. In these regions, the number of trees per hectare varies from 10 to 40 in the case of the first two countries, and from 10 to 100 for the latter two (Eichorn et al., 2006).

The species found on the pasture are: oak, which is predominant, with 9 specimens per hectare; sessile oak and wild pear, each with 3 specimens per hectare; and wild apple, with 1 specimen per hectare. The species proportions in the composition of the pasture are 56% St (Oak), 19% Go (Sessile oak), 17% Pă (Wild pear), and 8% Mă (Wild apple), resulting in the composition formula: 6St 2Go 2Pă and scattered wild apple (Mă). The wild apple and wild pear are medium-sized trees that contribute to the diversification and aesthetic enhancement of wood-pastures. Shrubs such as hawthorn, wild rose, and juniper are also present.

The analysis of structural dendrometric parameters (Table 2) highlights the old-growth character of this ecosystem. Oak exhibits the largest diameter values, while sessile oak records the largest crown projection area. Both oak and sessile oak have similar heights. Pear and apple trees exhibit lower values of diameter, height, and crown projection area compared with the oak species; however, pear shows greater diameter and height than apple. The crown projection area is larger in the wild apple tree than in the wild pear tree (Table 2).

The canopy cover index of the forest vegetation (excluding shrubs) was calculated at $I_a = 0.30$ (a canopy density of 0.3), representing a medium-to-high consistency for wood-pastures. The

high crown ratio (78–83% of total tree height) indicates extensive crown development and substantial foliar biomass. The high coefficients of variation for diameter and crown area show a high structural variability, pointing to a slight non-homogeneity in the development of these ancient pasture trees.

Regarding tree health, approximately 45% of the trees display signs of degradation or stagnation, including dry or broken branches, trunk tumors, heavy lichen colonization, and cavities. Mistletoe is frequently present on the oaks. Without targeted conservation measures to protect natural regeneration (especially of oak species and, to a lesser extent, wild pear, which occurs in specific patches), much of it will disappear due to intense grazing pressure from cattle, goats, and sheep.

The main economic product of the oak-dominated agrosilvopastoral (ASP) system in Mercheaşa is cow's milk, which was evaluated based on the VP index, green mass (GM) production, and grazing season length under both open-field conditions and trees canopy cover (Table 3). The assessment of productivity indices over a 172-day grazing season indicates a clear superiority of shaded/tree-influenced areas compared with open-field areas (Table 3).

Table 2

Main dendrometric parameters of the trees on the Mercheaşa Wood-Pasture

Parameters	ST	GO	PĂ	MĂ	Total
Number of trees / 3 ha	27	9	8	4	48
Mean DBH (cm)	117	85	58	49	
Min	57	68	44	38	
Max	195	156	79	67	
Coefficient of variation (%)	32	32	18	27	
Mean H (m)	19	20,3	12,2	9,5	
Min	9	16,7	9,6	6,6	
Max	24	23,6	15,3	12,0	
Coefficient of variation (%)	19	13	19	25	
Mean crown H (m)	15,7	16,8	10,0	7,5	
Min	6,6	13,2	7,1	4,9	
Max	20,5	20,7	13,3	9,8	
Coefficient of variation (%)	21	17	25	29	
Crown ratio (%)	82	83	81	78	
Min	69	63	73	74	
Max	90	88	87	82	
Coefficient of variation (%)	7	9	7	5	
Mean crown projection area (m ²)	208	241	86	117	
Min	95	138	63	70	
Max	334	412	127	217	
Coefficient of variation (%)	31	36	27	58	
Σ S crown projection/ha (m ²)	1872	723	229	156	2980
Symbols: ST – <i>Quercus robur</i> , GO – <i>Quercus petraea</i> , PĂ - <i>Pyrus pyraster</i> , MĂ – <i>Malus sylvestris</i> , Mean DBH – Mean diameter at the breast height; Mean H – Mean height; Min – Minimum recorded value, Max – Maximum recorded value, Crown ratio (%) - ratio of crown length to total tree height, expressed as a percentage, Mean crown projection area (m ²) - mean area of the vertical crown projection onto the ground (m ²), Σ S crown projection / ha (m ²) - total area of vertical crown projections per hectare					

The increase in green mass (GM) production beneath tree crowns (+48%) is promoted by the concentration of nutrients derived from livestock manure beneath tree crowns, where animals seek shade and shelter. Changes in microclimatic conditions and soil properties (an increase of 0.15 pH units and a 0.18% higher humus

content) favor the dominance of the valuable species *Lolium perenne* over *Agrostis capillaris* (Table 1). This results in forage of higher quality, with increased crude protein content (+2.6%) and greater digestibility (+7.3%), thereby reducing the amount of herbage required per litre of milk produced (Table 1).

The VP index of 70.7 recorded in the agrosilvopastoral system is 25% higher than that of treeless pasture, while the green mass requirement of 6.0 kg L⁻¹ of milk is 10% lower than under open-field conditions without

trees (Table 3). The estimated milk production reaches 2,370 L ha⁻¹ beneath tree crowns, representing a 65% increase compared with open-field pasture.

Table 3

Evaluation of the main grassland productivity indicators in the ASP system with oak (*Quercus robur*) during a 172 day grazing season

Specification	Unit	Open grassland	Under trees	Difference	
				+, -	%
Green mass (GM) production	t/ha	9.60	14.22	+ 4.62	148
Optimal livestock load	LU/ha	0.86	1.27	+ 0.41	159
Pastoral value (PV)	Ind.	56.6	70.7	+ 14.1	125
GM Consumption for 1L of milk	Kg/L	6.7	6.0	- 0.7	90
Cow milk production	L/ha	1433	2370	+ 937	165

The total tree volume (main trunk and branches) is:

$V_{total} = V_{trunk} + V_{trunk} \times 0,60$.

The trunk volume for the three experimental plots is: 27.14 m³ for sessile oak, 127.97 m³ for pedunculate oak, 6.82 m³ for wild pear, and 2.17 m³ for wild apple.

The volume of thick branches, secondary branches, and the tree top per hectare is 9.05 m³ for sessile oak, 42.66 m³ for pedunculate oak, 2.41 m³ for wild pear, and 0.77 m³ for wild apple. Reported per hectare, the volumes structured by species and assortment categories are presented in Table 4.

Table 4

Timber volume and economic value estimation in the Mercheaşa ASP system

Analyzed Indicators / Economic Parameters	Species			
	Go	ST	PĂ	MĂ
V_trunk/ ha	12,92	60,94	2,84	0,91
Average price/m3	850	850	850	850
Average_price_V_trunk_processed_cut_delivered	10982	51799	2414	773,5
V_branches_boughs/ha	9,05	42,66	2,41	0,77
Average price /m3	350	350	350	350
Average_price_V_branches_boughs	3167,5	14931	843,5	269,5
Total price_ Total tree V	14150	66730	3258	1043

Although pedunculate and sessile oak wood is a hardwood, normally intended for construction or fine furniture, the quality of isolated trees in this pasture is medium to poor due to knots, sweeps (crooks), and rots. For this reason, the economic calculation was based on a mixed valuation or as firewood. Given the fundamental ecological and landscape role of these ancient trees, their total extraction is not economically or ecologically justified; the model serves only as an inventory of natural capital, recommending exclusively the harvesting of completely dried specimens.

In addition to wood, pedunculate and sessile oaks provide fruits (acorns), which are important for their nutrient content (proteins, lipids, carbohydrates, mineral salts, and vitamins) (Corlăţeanu, 1984, Nesterov et al., 2006). On pastures, where the oak has more light and space, it fructifies more frequently and abundantly, but the acorns may be smaller than those from forest oaks. It generally begins to bear fruit from 30–40 years of age for pedunculate oak and 40–50 years for sessile oak. It fructifies abundantly every 4–6 years for sessile oak and 5–8 years for pedunculate oak during "mast years" (heavy fruiting years), but produces acorns in smaller quantities almost every year. Heavy

fruiting depends on: climate (temperatures, drought), soil, and tree stress (dieback, pruning, diseases). As for the wild pear and wild apple, they have constant fructification, with a progressive production starting from the age of 8–10 years. The fruits are used as food for both wildlife and domestic animals. In the past, they were also used for preparing alcoholic beverages.

It is important to mention that sessile and pedunculate oak, as well as wild pear and wild apple, are highly valued species in terms of forest protection and landscape value on pastures. They can be harnessed for their ecosystem services, among which improving the microclimate and providing shelter for grazing animals prevail.

The synthesis of all quantifiable metrics (livestock yields, annualized silvicultural volumes, and non-timber forest products) reveals a doubled financial return for agrosilvopastoral systems over conventional open pasture monocultures (Table 5).

It is mentioned that the timber values were analyzed by reporting the total accumulated volume to an estimated average rotation age/harvest cycle of 120 years.

Table 5

Comparative annual economic value of ASP systems versus tree-less pastures (TLP)

Specification	Pasture system			Difference ASP-TLP	
	ASP	%	TLP	+, -	%
Cow milk production (L/ha/year)	1712		1433	+279	119
Value (x 0,5 €/Liter)	856.00	59	717.00	+ 139.00	119
Timber m ³ /ha at 120 year	77.61		-	-	x
Timber m ³ /year	0.65		-	-	x
Value (x 160 €/m ³)	110.50	8	-	-	x
Firewood m ³ /ha at 120 year	54.89		-	-	x
Firewood m ³ /year	0.45		-	-	x
Value (x 60 €/m ³)	33.30	2	-	-	x
Acorn kg/ha/year	150		-	-	x
Value (x 1.8 €/kg)	270.00	19	-	-	x
Additional Milk (20% crown shade effect)	342		-	-	x
Valoare (x 0.5 €/an)	171.00	12	-	-	x
Total annual value (€)	1440.80	100	717.00	+ 723.80	201
TLP = treeless pastures – open fields					

The total annual revenue generated within the ASP system reaches **1,441 €/ha/year**, compared to only **717 €/ha/year** for the tree-less pasture, representing a 101% increase. Within the ASP revenue structure, livestock products generate the dominant share at 71% (comprising 59% base milk and 12% additional milk gained through microclimatic buffering). The secondary products of the trees

represent the remaining 29% (19% the value of acorns, 8% construction timber, and 2% firewood). Beyond these tangible returns, the system offers unquantifiable ecosystem services: improved livestock health, stabilized atmospheric and soil moisture, and enhanced biodiversity (such as insectivorous birds that naturally suppress pasture canopy pests).

CONCLUSIONS

Pastures integrated into agrosilvopastoral (ASP) systems dominated by oak (*Quercus robur*) are twice as valuable economically compared to conventional treeless pastures.

The real and potential milk production within the oak ASP system achieves an optimal level of 1,712 L/ha/year compared to 1,443 L/ha/year in open pastures, representing a 19% increase driven

by higher forage quality and increased pastoral value under the tree canopies.

The consolidated annual economic value of the ASP system reaches 1,441 €/ha/year (at a calculated parity of 1 € = 5 RON), comprising 71% dairy products, 19% acorns, 8% construction

timber, and 2% firewood. In addition to direct financial benefits, the presence of scattered ancient trees provides major ecological returns by maintaining a pastoral landscape of high aesthetic value and supporting regional biodiversity conservation.

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THE INFLUENCE OF MORPHOLOGICAL PARAMETERS ON DRY MATTER YIELD IN MIXTURES OF GRASSES AND PERENNIAL LEGUMES IN THE CONTEXT OF CLIMATE CHANGE

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Abstract

The study evaluates the ability of multiple linear regression models to predict dry matter (DM) yield based on morphological indicators (plant height and shoot density) in the second year of vegetation at the Ezăreni farm (Iaşi). Climate change in northeastern Romania necessitates the development of rapid methods for estimating grassland productivity. The results obtained from the forty experimental plots have been processed in Microsoft Excel for two distinct mowings (spring and summer). For the first mowing, under optimal conditions, the model was highly significant ($R^2 = 0.48$), with plant height being the dominant indicator. The second mowing completely nullified these morphological correlations ($R^2 = 0.04$), as the plants entered a physiological stasis adapted to climatic conditions. The classical indicators included in the study lose their predictive utility during periods of water stress, making it necessary to integrate physiological stress indicators into future forecasting models.

Keywords: perennial mixtures, dry matter, morphological parameters, predictive power, height, shoots, yield, stability.

INTRODUCTION

In recent decades, the impact of climate change has become increasingly clear in agriculture. The main observable phenomena, which are becoming more frequent, include: early summer temperatures exceeding 35°C for periods longer than 7–10 days, periods without precipitation, and the uneven distribution of precipitation during the growing season. During the winter, snowfall is scarce, and the soil's water deficit can no longer be

replenished, with this deficit increasing year by year.

Because summers are becoming increasingly dry and heat and water stress set in early, a negative impact on the vegetation's ability to regenerate for the second cut is often seen immediately after the first cut.

In sown pastures, it is recommended to use simple or complex mixtures of perennial grasses and legumes, as growing them together yields a higher

production compared to using pure stands of only legumes or grasses.

In the study conducted by ZILONG et al. (2020), it was found that, in terms of plant morphology in sown pastures during periods of climatic stress, a reduction in root length was accompanied by a reduction in above-ground biomass, but no differences were observed in total root mass.

Plant adaptation to soil and climate conditions is necessary for their proper development, as the study by JING et al., 2026 demonstrated that plants responded better to drought if they were better adapted to growing conditions, regardless of the age of the grassland, so that plant age does not have such a noticeable effect on drought resistance, but the use of plants adapted to soil and climate conditions improves drought resistance and the plants' ability to regenerate.

Legumes can extract water from deeper soil layers due to their

taproot system, while grasses, due to their fibrous root system, make better use of spring precipitation.

However, it has been found that in species with taproots, the ability to move roots toward moister areas is lower, while in species with fibrous roots, they can preferentially distribute root mass to moister areas (FRY et al.; 2018).

Extreme drought events are likely to occur more frequently and last for longer periods, with negative effects on plant development. The root system is the primary part affected (ZHOU et al.; 2018), leading to a decrease in root length in grasses, while in legumes, a decrease in root diameter has been seen (SUN et al., 2024).

The reduction in root system size during dry periods was also associated with an increase in soil nitrogen availability, although soil carbon availability was not directly affected (DE VRIES et al., 2016).

MATERIAL AND METHOD (TNR 11, B)

The research was conducted at the Ezăreni Educational Farm in the village of Miroslava, Iaşi County, a farm belonging to the "Ion Ionescu de la Brad" University of Life Sciences in Iaşi. The geographic coordinates of the site where the experiment was conducted are 47°07'28" north latitude and 27°30'25" east longitude.

The region under study has a temperate continental climate, characterized by hot summers and winters with low temperatures. However, in recent years, changes in temperature and precipitation conditions have been seen, including extreme summer temperatures exceeding 35°C, as well as an uneven distribution of

precipitation throughout the growing season.

The experiment was organized using the split-plot design with three replicates, with the primary aim of observing the yield and structural behavior of simple and complex mixtures of perennial forage grasses and legumes. The factors studied are as follows:

Factor A: 10 simple or complex mixtures of perennial grasses and legumes, as follows: a₁ – *Onobrychis viciifolia* Scop. (100%) (control); a₂ – *Onobrychis viciifolia* Scop. (75%) and *Bromus inermis* Leyss. (25%); a₃ – *Onobrychis viciifolia* Scop. (50%) and *Bromus inermis* Leyss. (50%); a₄ – *Onobrychis viciifolia* Scop. (25%) and *Bromus inermis* Leyss. (75%); a₅ – *Medicago sativa* L. (100%); a₆ – *Medicago sativa* L. (75%) and *Festuca pratensis* (25%); a₇ – *Medicago sativa* L. (50%) and *Festuca pratensis* (50%); a₈ – *Medicago sativa* L. (25%) and *Festuca pratensis* (75%); a₉ – *Medicago sativa* L. (20%), *Lotus corniculatus* L. (15%); *Festuca pratensis* (30%); *Lolium perenne* L. (10%) and *Dactylis glomerata* L. (25%) and a₁₀ – *Onobrychis viciifolia* Scop. (20%), *Lotus corniculatus* L. (15%); *Agropyron pectiniforme* L. (30%); *Bromus inermis* Leyss. (25%) and *Lolium perenne* L. (10%).

Factor B, represented by 4 fertilization levels: b₁—unfertilized (control); b₂ – N₅₀P₅₀K₅₀; b₃ – N₇₅P₇₅K₇₅; b₄ – N₁₀₀P₁₀₀K₁₀₀.

The morphological measurements taken in the field prior to each mowing focused on two indicators:

a) Plant height (X₁; cm): determined by repeated measurements at randomized points within each plot, using a graduated ruler, to establish the average height of each treatment.

b) Number of shoots (X₂; shoots/m²): determined by three repeated counts of shoots per 1 linear meter of each plot, then normalized to square meters.

Biomass harvesting was conducted during the budding and heading stages of the species comprising the mixtures. The specific calendar periods for these phenophase were late May for the first harvest, which coincided with heavy rains in April, and late July for the second harvest, which coincided with one of the driest periods in the study area. A cleanup harvest was conducted in September.

The dry matter content for each plot was determined by collecting green samples in vials, which were dried in an oven at 105°C until there were no longer any differences in weight, in accordance with standard SR ISO 6496/2001.

Statistical analysis using multiple linear regression was performed using Excel by running the Regression function from the Data menu.

The modeling procedure aimed to establish equations for predicting biomass (Y) based on the morphological indicators of height (X₁) and shoots (X₂), with model quality assessed through analysis of

variance (*Fisher's F-test*), the coefficient of determination (R²), and the *Student's t-test* for coefficient significance.

RESULTS AND DISCUSSIONS (TNR 11, B)

Following the entry and processing of experimental data from the second growing season using the Microsoft Excel analysis package, the relationship between grassland biomass—represented by the amount of dry matter per hectare, which served as the dependent variable (Y)— and the morphological factors represented by plant height (X₁) and the number of shoots per square meter (X₂).

KHAVSE, 2025 stated that in agriculture, multiple linear regression helps estimate how different variables collectively influence the results. Using multiple regression, we can more accurately represent certain agricultural phenomena that include two or more independent variables.

A general multiple regression equation (ORLOV, 1996; KHAVSE, 2025) can be written as follows:

$$Y = B_0 + B_1 * X_1 + B_2 * X_2 + \dots + B_n * X_n$$

Y = dependent variable (predicted by a regression model).
 X_i (i=1,2, ...n) = independent variable from total set of p variables.
 B_i (i=1,2, ...n) = coefficient corresponding to x_i.
 B₀ = intercept (or constant)

For a simpler yet direct comparison between the two harvest periods, the summary results on the overall quality of the models and the structural coefficients of the regression equations have been compiled in Table 1 and Table 2

Table 1

Overall statistical indicators of the multiple linear regression models for dry matter yield (Y)

Indicator	Mower I	Mower II
Number of observations (n)	40	40
Average yield (Y; kg/ha)	7056,36	2396,07
Standard deviation (SD)	2273,73	307,65
Multiple correlation coefficient (R)	0,6910	0,2017
Coefficient of determination (R ²)	0,48	0,04
Standard error of the estimate	1687,34	309,36
Calculated F-value (ANOVA)	16,91***	0,78 ^{ns}
Table F value (F _{0,05;2; 37})	3,25	3,25

*** - statistically highly significant at a 0.1% significance level; ns - not statistically significant.

For the first harvest, the analysis of variance (ANOVA) indicates that the model is highly statistically significant; the tabulated *F-test* value is 3.25, and the value obtained from running the program is 16.91.

The coefficient of determination $R^2 = 0.48$, which shows that 48% of the variability in dry matter yield from the first harvest is explained by the combined action of the two morphological factors (X_1 and X_2).

For the second mowing, a sharp decrease in the *F-test* value is observed, dropping to a completely insignificant level of 0.78 ($p=0.4638ns$), with the coefficient of determination being $R^2 = 0.04$, which shows that during the summer (June and July), the number of shoots and plant height account for only 4.00% of the variation in productivity of the studied plots.

Table 2 presents the final indicators that determined this behavior of the temporary grassland.

Table 2

Regression equation coefficients and the significance of the t-test (Student's t-test) for morphological indicators

Mower	Variable	Mean of the variable	Regression coefficient (B)	Standard error of the coefficient	Calculated t-value	Statistical significance
Mower I	Free term (B_0)	-	-1507,5822	1687,344	-0,89	ns
	Height (X_1 ; cm)	91,89	89,923	16,257	5,49	***
	Shoots (X_2 ; Shoots/m ²)	1423,97	0,253	0,589	0,43	Ns
Mower II	Free term (B_0)	-	1524,137	309,361	4,93	***
	Height (X_1 ; cm)	50,46	12,662	12,264	1,03	Ns
	Shoots (X_2 ; Shoots/m ²)	1160,57	0,201	0,167	1,20	Ns

t-critical=2.02 (for $\alpha=0.05$ and $df=37$; ***—statistically significant ($p<0.001$); ns—not statistically significant ($p\geq 0.05$))

Based on the coefficients obtained in Table 2, the two multiple linear regression equations were established as follows:

a) Equation for the first harvest:

$$Y = -1507.582 + 89.273 \cdot X_1 + 0.253 \cdot X_2.$$

b) Equation for the second harvest

$$Y = 1524.137 + 12.662 \cdot X_1 + 0.201 \cdot X_2.$$

For the first harvest, it can be observed that plant height is the

dominant indicator, with high statistical significance ($t = 5.49 > t_{critical} = 2.02$; $p < 0.001$).

The coefficient +89.273 indicates that for every additional centimeter in plant height, there is an average increase of 89.3 kg/ha DM. The number of shoots has an insignificant influence ($t=0.43$). This leads to the conclusion that plant height was positively influenced by the abundant rainfall during the spring.

At the second harvest, the situation changes radically, as both indicators become statistically insignificant, and the t -values of 1.03 for height and 1.20 for shoots are both below the critical threshold of 2.02. In this case, the lack of rainfall and high temperatures caused the plants to cease vegetative

growth at this point, resulting in a height of 50.46 cm at this mowing.

But surprisingly, the free term $B_0=1524.137$, with a t -value of 4.93, is highly significant. Thus, from a biological standpoint, the value of B_0 represents a minimum quantity that the mixtures managed to maintain as an adaptive survival mechanism, independent of their size at the time of harvest.

To accurately visualize the predictive capacity of the two mathematical equations in relation to the field data, the distribution of the actual dry matter yield values obtained in the 40 experimental plots was plotted alongside the theoretical values estimated by the regression models (Figure 1 and Figure 2).

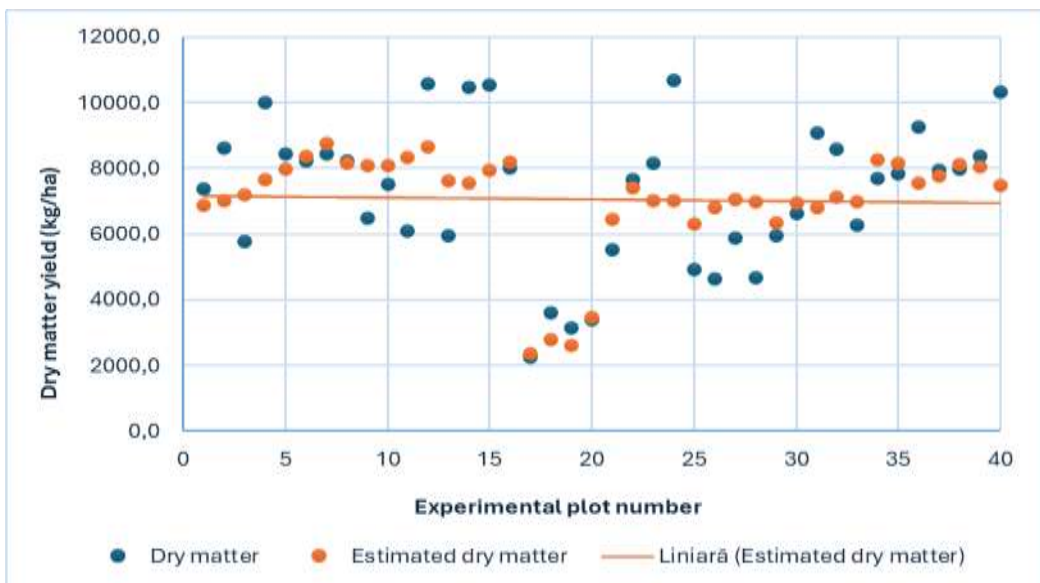


Fig. 1. The relationship between actual and estimated dry matter (DM) yields in the first cut.

Figure 1 confirms an optimal dynamic correlation between the actual data and the theoretical model ($R^2 = 0.48$). The estimated points (orange) closely follow the fluctuations in field production

(blue), a feature particularly visible in the range of plots 17–20, where the model instantly reduces its values in full agreement with the actual collapse in biomass.

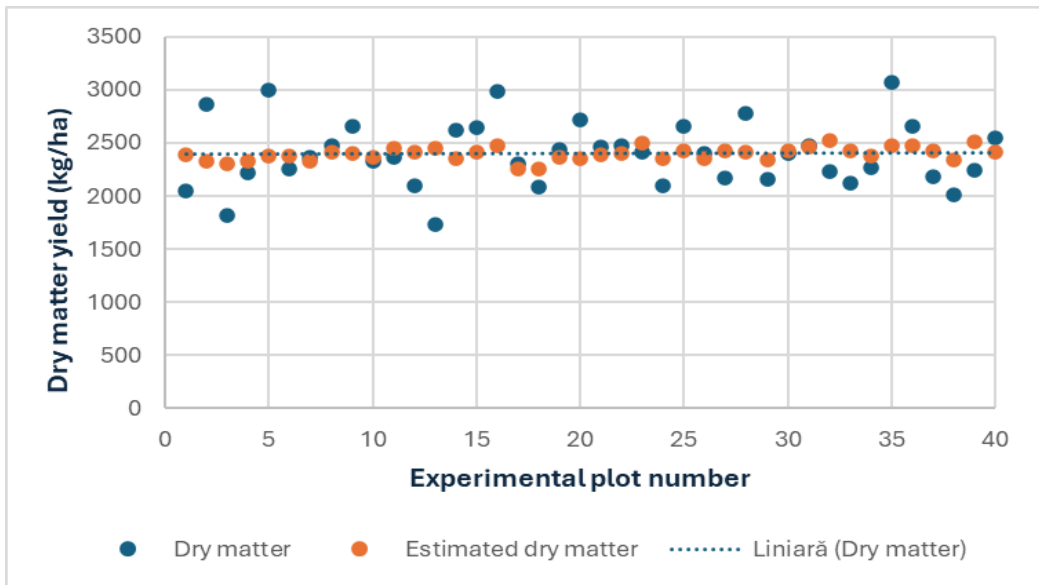


Figure 2 - Relationship between actual and estimated dry matter (DM) yields at the second cut.

In complete contrast, Figure 2 illustrates the model's complete decoupling under the impact of drought ($R^2 = 0.0407$). The estimated values (orange) no longer follow the variations in the field but align rigidly in the form of a

uniform horizontal band around the mean. The trend line (dotted) becomes a rigid plateau, visually demonstrating that the plant phenotype completely loses its predictive capacity under conditions of severe water stress.

CONCLUSIONS

The ability to predict biomass yield through simple measurements depends directly on climatic conditions. In the spring, the model performs with good accuracy ($R^2 = 48\%$), but in the summer it fails completely under the pressure of drought ($R^2 = 4\%$).

At the first cut, plant height is the decisive factor for yield (each centimeter yields an average increase of 89.3 kg/ha DM). In contrast, the number of shoots makes no real contribution to biomass estimation at any of the harvest times.

The statistical significance of the free term at the second mowing shows that, despite the drought, perennial mixtures managed to maintain a critical biomass threshold for survival (~1,524 kg/ha), as an adaptive survival response.

The results demonstrate that traditional estimation methods lose their usefulness during periods of water stress. For grasslands in eastern Romania, it becomes essential to integrate physiological stress indicators into future forecasting models.

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RESEARCH ON IMPROVING NITROGEN STOCK ON *DICHANTHIUM ISCHAEMUM* (L.) ROBERTY MEADOWS, THROUGH OVERSEEDING

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Abstract

Nitrogen stocks on grasslands are very important reservoirs with role in plant productivity, soil health and global carbon regulation. Improving nitrogen stocks on meadows by overseeding involves introducing atmospheric N-fixing legumes, such as sainfoin into existing plants cover. The purpose of the research conducted during the 2022-2025 agricultural period, at the Research and Development Station for Meadows Vaslui, was represented by the increasing amount of nitrogen fixed on a degraded *Dichanthium ischaemum* (L.) Roberty meadow by overseeding with the *Bromus inermis* Leyss. (smooth brome) and *Onobrychis viciifolia* Scop. (sainfoin) species. The results obtained have shown that in the second year of overseeding, 2025, from the production of plants has been obtained a quantity of nitrogen 2.5-3.5 times higher than the control variant, and from the production of roots a quantity of 0.5-0.8 times higher than the control variant. Compared to the soil nitrogen stock, the one obtained from plants production was on average 0.30-0.66 %, and the one obtained from the production of roots was on average 1.04-1.63 %, the average nitrogen stock of the *Dichanthium ischaemum* (L.) Roberty meadow being of 1.663 Mg·ha⁻¹ N and as a result the overseeding of the degraded permanent *Dichanthium ischaemum* (L.) Roberty meadow with the *Bromus inermis* Leyss. 50 % and *Onobrychis viciifolia* Scop. 50 % mixture to achieve the best results in terms of feed production and nitrogen stock, it can be recommended.

Keywords: plants production, roots production, soil nitrogen stock

INTRODUCTION

Nitrogen stocks on grasslands are very important reservoirs that drive plant productivity, sustain soil health, and regulate global carbon cycles. These stocks, which include organic nitrogen in the soil and above-

ground plant biomass, determine the resilience of the ecosystem. The dynamic flow of nitrogen allows grasslands to support livestock grazing, foster plant diversity, and act as significant carbon sinks (Guo L.B., et al, 2007; Ai Z.M. et al,

2017; Sariyildiz T. et al, 2017; Kizeková M. et al, 2024).

Efficient nitrogen retention within the soil-plant system is critical for preventing environmental pollution, such as nitrogen leaching or nitrous oxide emissions. Managing grasslands to maintain robust nitrogen stocks is fundamental for long-term sustainable agriculture, soil fertility, and climate change mitigation (Cong W.F. et al, 2014; Dlamini P. et al, 2014; Nyameasem J.K. et al, 2020).

Improving nitrogen stocks on grasslands involves combining targeted organ and nonorganic additions, biodiversity management, and controlled grazing to build soil organic matter and optimize nutrient cycling (Monaghan R.M. et al, 2005; Liu X. et al, 2020; Da Silva L.S. et al, 2022; Chen L. et al, 2023).

Improving nitrogen (N)

MATERIAL AND METHOD

The research was carried out in the 2023-2025 agricultural period at the Research and Development Station for Meadows (RDSM), Vaslui, Solești location.

The aim of the research was to increase the amount of nitrogen fixed on a degraded *Dichanthium ischaemum* (L.) Roberty meadow by overseeding with the *Bromus inermis* Leyss. and *Onobrychis viciifolia* Scop. species.

In order to achieve the

stocks on meadows by overseeding involves introducing atmospheric N-fixing legumes, such as sainfoin, clover or trefoil, into existing plants cover. These plants partner with *Rhizobium* bacteria to convert atmospheric nitrogen into plant-available N, improving soil fertility and forage quality without relying on synthetic fertilizers (De Deyen G.B. et al, 2009; Juarena M. et al, 2016).

The researches carried out in the 2023-2025 agricultural period, within the Solești location of the Research and Development Station for Meadows (RDSM), Vaslui, was represented by the increasing the amount of nitrogen fixed on a degraded *Dichanthium ischaemum* (L.) Roberty meadow by overseeding with the *Bromus inermis* Leyss. (smooth brome) and *Onobrychis viciifolia* Scop. (sainfoin) species.

proposed goal and objectives, in the experimental field (from the Solesti commune) of RDSM Vaslui was placed an experience, organized according to the method of randomized blocks, with 5 variants, in 3 replications.

The area of each variant was 100 m² (10 m × 10 m), and the harvestable area was 81 m² (9 m × 9 m). The total experience area was 1600 m² (50 m × 32 m).

Experimental factor was

applied management, with five graduations:

v₁ - abandonment;

v₂ - harvested by mowing (control variant);

v₃ - overseeded with *Bromus inermis* Leyss. 100%, harvested by mowing;

v₄ - overseeded with *Bromus inermis* Leyss. 75 % and *Onobrychis vicifolia* Scop. 25 %, harvested by mowing;

v₅ - overseeded with *Bromus inermis* Leyss. 50 % and *Onobrychis vicifolia* Scop. 50 %, harvested by mowing.

Biological material used for overseeding was represented by the *Bromus inermis* Leyss. Mihaela variety and *Onobrychis vicifolia* Scop. Anamaria variety, varieties created at RDSM, Vaslui, Romania. The species in the mixture are best adapted to the climatic conditions and soil in the study area. Overseeding was performed in March 2024.

In this paper are presented the results from the first year and the second year from the overseeding, respectively the years 2024 and 2025.

Initially, in the *Dichanthium ischaemum* (L.) Roberty meadow plants cover, 55 species were identified, 7 species have very good feed value, 3 species have good value, 15 species have medium value, 4 species have low value, 6 species have very low value, 13 species are without fodder value, 5 species are harmful (harming

products obtained from animals: 3 species depreciate the wool of animals, 1 species depreciates the quality of milk and 1 species that harm grassland vegetation), and two species are toxic.

In general, the agricultural year 2023-2024 was rainy, with high rainfall, only that the lack of rainfall in the periods from overseeding, to starting in vegetation, were small, led to a water stress, and during periods of high rainfall they had an uneven distribution. The same happened in the agricultural year 2024-2025, which was a rainy year, with precipitation in large quantities in some periods, but also with periods of water stress, the vegetation conditions being not ideal.

The nitrogen stock in the grassland was assessed by summing up the amount of nitrogen obtained by harvesting the production of dry matter, the amount of nitrogen obtained from the evaluation of the root system and the unharvested aerial part by mowing and the existing nitrogen stock in the soil.

The evaluation of the root quantity was made by harvesting, from each variant, monoliths with dimensions of 0.027 m³ (0.3 m × 0.3 m × 0.3 m), followed by root recovery through wetting, drying and weighing and analysis

The dry matter content (DM) was determined by SR ISO 6496/2001 standard.

Total nitrogen content from plant and root samples was

determined using the Vario MCRO Cube elemental analyzer - PT 162 by SR ISO 10694/1998 standard.

The nitrogen content from the soil was determined using the Kjeldahl method by STAS 7184/2-

RESULTS AND DISCUSSIONS

In the two years of research, the results obtained were different, because in 2024 the work of overseeding was realized, and the plants were poorly developed, their productive potential manifesting in 2025, which was year 2 of vegetation. Also, climatic conditions played a very important role in plant growth and development, in 2025 the conditions being more favorable.

In 2024, the average plants production was $0.501 \text{ Mg}\cdot\text{ha}^{-1} \text{ DM}$, ranging from $0.426 \text{ Mg}\cdot\text{ha}^{-1} \text{ DM}$ to the abandonment variant, to $0.565 \text{ Mg}\cdot\text{ha}^{-1} \text{ DM}$ to the overseeded with *Bromus inermis* Leyss. 50 % and *Onobrychis vicifolia* Scop. 50 %, harvested by mowing variant.

The total nitrogen content of plants varied between 0.95-0.99 %, being higher in the case of abandonment variant and to the overseeded with *Bromus inermis* Leyss. 100 %, harvested by mowing variant and there was no direct correlation with the applied management.

From the production of plants has been obtained a quantity of nitrogen that varied between $0.0040\text{-}0.0053 \text{ Mg}\cdot\text{ha}^{-1} \text{ N}$, the

85, PTL 09 standard.

Final results were statistically interpreted by analyzing the variance and calculating the least significant differences.

highest values being obtained at the variants where overseeded was made.

The average roots production was $3.571 \text{ Mg}\cdot\text{ha}^{-1} \text{ DM}$, ranging from $3.555 \text{ Mg}\cdot\text{ha}^{-1} \text{ DM}$ to the control variant (harvested by mowing), to $3.578 \text{ Mg}\cdot\text{ha}^{-1} \text{ DM}$ to the overseeded with *Bromus inermis* Leyss. 75 % and *Onobrychis vicifolia* Scop. 25 %, harvested by mowing variant.

The total nitrogen content of roots varied between 0.47-0.48 %.

From the production of roots has been obtained a quantity of nitrogen that varied between $0.0167\text{-}0.0172 \text{ Mg}\cdot\text{ha}^{-1} \text{ N}$, the highest values being obtained at the variants where overseeded was made.

Both in the case of plants, but also in the case of roots the N production increased due to the increase of the dry mass production and this increased due to the presence of the two species within the meadows vegetation coverage and they contribute with biomass to the formation of production.

Compared to the nitrogen stock in plants and roots, the soil stock is huge. The values were

between 1.557-1.652 Mg·ha⁻¹ N. The contribution of the two species with which the grassland was overseeded, even if it was a small one, it was statistically ensured, in the case of total nitrogen production, where, in the case of v₄ and v₅ variants the differences were very significant, most likely due to the presence of *Onobrychis vicifolia* Scop. species, is known to be a nitrogen-fixing one.

On average, in 2024, 98.66 % of nitrogen stock came from soil reserve, 1.04 % from root production and 0.60 % from plant production (table 1).

In 2025, the average plants production was 0.810 Mg·ha⁻¹ DM, ranging from 0.395 Mg·ha⁻¹ DM to the abandonment variant, to 1.188 Mg·ha⁻¹ DM to the overseeded with *Bromus inermis* Leyss. 50 % and *Onobrychis vicifolia* Scop. 50 %, harvested by mowing variant.

The total nitrogen content of plants varied between 0.85-1.54 %, being higher in the all overseeded variants and there was a direct correlation with the applied management. From the production of plants has been obtained a quantity of nitrogen that varied between 0.0034-0.0183 Mg·ha⁻¹ N, the highest values being obtained at the variants where overseeded was made (2.5-3.5 times higher than the control variant).

The average roots production was 5.537 Mg·ha⁻¹ DM, ranging from 3.492 Mg·ha⁻¹ DM to the

abandonment variant, to 7.651 Mg·ha⁻¹ DM to the overseeded with *Bromus inermis* Leyss. 50 % and *Onobrychis vicifolia* Scop. 50 %, harvested by mowing variant.

The total nitrogen content of roots varied between 0.47-0.41 %, and from the production of roots has been obtained a quantity of nitrogen that varied between 0.0164-0.0375 Mg·ha⁻¹ N, the highest values being obtained at the variants where overseeded was made.

Both in the case of plants, but also in the case of roots the N production increased due to the increase of the dry mass production and this increased due to the presence of the two species within the meadows vegetation coverage and they contribute with biomass to the formation of production.

The largest growths were in the case of roots, due to the fact that in the *Bromus inermis* Leyss. species the plants begin to develop stolons, and in the case of *Onobrychis vicifolia* Scop. species root thickens year after year, being a taproot system.

In the case of total nitrogen production, difference in production in the case of v₃ variant was significant, and in the case of v₄ and v₅ variants the differences were very significant, the contribution being of both species with which it was overseeded.

On average, in 2024, 97.71 % of nitrogen stock came from soil reserve, 1.63 % from root production and 0.66 % from plant production (table 2).

Table 1

The influence of the applied management on the nitrogen stock of the *Dichanthium ischaemum* (L.) Roberty meadow, in 2024

2024	Plants production		Roots production			Soil N production	Total N production	
Variant	Mg·ha ⁻¹ DM	N %	Mg·ha ⁻¹ N	Mg·ha ⁻¹ DM	N %	Mg·ha ⁻¹ N	Mg·ha ⁻¹ N	
v ₁	0.426	0.98	0.0042	3.588	0.47	0.0169	1.557	1.578 ^{ns}
v ₂ ^(C)	0.427	0.94	0.0040	3.555	0.47	0.0167	1.577	1.598 ^C
v ₃	0.525	0.99	0.0052	3.578	0.48	0.0172	1.593	1.615 ^{ns}
v ₄	0.560	0.95	0.0053	3.569	0.48	0.0171	1.649	1.671 ^{***}
v ₅	0.565	0.94	0.0053	3.566	0.48	0.0171	1.652	1.674 ^{***}
Average	0.501	0.96	0.0048	3.571	0.48	0.0170	1.606	1.627 [*]
%			0.30			1.04	98.66	100

^c - control variant; ^{ns} - not significant;

LSD 0.5 = 0.020 Mg·ha⁻¹ N; LSD 0.1 = 0.031 Mg·ha⁻¹ N; LSD 0.01 = 0.046 Mg·ha⁻¹ N.

Table 2

The influence of the applied management on the nitrogen stock of the *Dichanthium ischaemum* (L.) Roberty meadow, in 2025

2025	Plants production		Roots production			Soil N production	Total N production	
Variant	Mg·ha ⁻¹ DM	N %	Mg·ha ⁻¹ N	Mg·ha ⁻¹ DM	N %	Mg·ha ⁻¹ N	Mg·ha ⁻¹ N	
v ₁	0.395	0.85	0.0034	3.492	0.47	0.0164	1.576	1.596 ^{ns}
v ₂ ^(C)	0.511	1.05	0.0054	4.061	0.51	0.0207	1.596	1.622 ^C
v ₃	0.850	1.49	0.0127	6.080	0.48	0.0292	1.612	1.654 [*]
v ₄	1.104	1.39	0.0153	6.399	0.50	0.0320	1.668	1.716 ^{***}
v ₅	1.188	1.54	0.0183	7.651	0.49	0.0375	1.671	1.727 ^{***}
Average	0.810	1.26	0.0110	5.537	0.49	0.0272	1.625	1.663 ^{**}
%			0.66			1.63	97.71	100

^c - control variant; ^{ns} - not significant;

LSD 0.5 = 0.024 Mg·ha⁻¹ N; LSD 0.1 = 0.037 Mg·ha⁻¹ N; LSD 0.01 = 0.055 Mg·ha⁻¹ N.

Compared to the year 2024, in the year 2025, at each of the variants where it was overseeded, both plant production, but especially root production, contributed to the increase of nitrogen stock in the *Dichanthium ischaemum* (L.) Roberty meadow. If plant production, along with its nitrogen

stock, by being valued as feed, leaves the meadow, the roots remain and replenishes the soil's N stock year by year. Thus, it turns out that the overseeding of degraded permanent meadows with mixtures consisting of perennial grasses and legumes for feed will lead to an increase in nitrogen stock.

CONCLUSIONS

In the 2023-2025 agricultural period nitrogen stock of the *Dichanthium ischaemum* (L.) Roberty meadow grew as a result of the work of overseeding with the species *Bromus inermis* Leyss. and *Onobrychis vicifolia* Scop., in various proportions.

In the second year of overseeding, 2025, from the production of plants has been obtained a quantity of nitrogen 2.5-3.5 times higher than the control variant, and from the production of roots a quantity of 0.5-0.8 times higher than the control variant.

Compared to the soil nitrogen stock, the one obtained from plants

production was on average 0.30-0.66 %, and the one obtained from the production of roots was on average 1.04-1.63 %, the average nitrogen stock of the *Dichanthium ischaemum* (L.) Roberty meadow being of 1.663 Mg·ha⁻¹ N.

Following the results obtained, it can be recommended the overseeding of the degraded permanent *Dichanthium ischaemum* (L.) Roberty meadow with the *Bromus inermis* Leyss. 50 % and *Onobrychis vicifolia* Scop. 50 % mixture to achieve the best results in terms of feed production and nitrogen stock.

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THE PRODUCTIVITY AND NUTRITIVE VALUE OF FODDERS FROM THE TALL OATGRASS, *ARRHENATHERUM ELATIUS* (L.) BEAUV

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Abstract. *This article presents the results of a study on the productivity and nutritive value of fodder from a local ecotype of tall oatgrass (*Arrhenatherum elatius*) during the second and fourth growing seasons. The productivity of tall oatgrass at the first cut reached 3.46-4.47 kg/m² fresh mass or 0.84-1.01 kg/m² dry matter. The nutritive value of the harvested mass was 77-96 g/kg crude protein, 80-84 g/kg ash, 375-414 g/kg crude fibre, 399-436 g/kg ADF, 684-740 g/kg NDF, 35-40 g/kg ADL, 362-396 g/kg cellulose and 285-306 g/kg hemicellulose with 549-590 g/kg digestible dry matter, 10.96-11.48 MJ/kg digestible energy, 9.00-9.43 MJ/kg metabolizable energy and 5.02-5.67 MJ/kg net energy for lactation. The quality of ensiled mass were pH = 4.20-4.26, 24.20-29.6 g/kg organic acids, 88-109 g/kg CP, 368-405 g/kg CF, 100-102 g/kg ash, 388-420 g/kg ADF, 632-724 g/kg NDF, 26-30 g/kg ADL, 56-74 g/kg TSS, 358-394 g/kg Cel, 244-304 g/kg HC, with nutritive and energy value 56.5-58.7% DMD, 11.25-11.64 MJ/kg DE, 9.19-9.56 MJ/kg ME, 5.21-5.57 MJ/kg NEL. The hay prepared from tall oatgrass contained 77-100 g/kg CP, 393-414 g/kg CF, 80-94 g/kg ash, 418-436 g/kg ADF, 683-748 g/kg NDF, 38-40 g/kg ADL, 78-98 g/kg TSS, 380-396 g/kg Cel and 265-318 g/kg HC with nutritive and energy value 541-563 g/kg DDM, 10.97-11.21 MJ/kg DE, 9.00-9.20 MJ/kg ME and 5.02-5.23 MJ/kg NEL.*

Keywords: *Arrhenatherum elatius, biochemical composition, green mass, hay, nutritive value, productivity, silage*

INTRODUCTION

In the modern world affected by global climate change and limited natural resources, where the popularity of carbon-neutral farming is growing, forages play a key role in sustainable animal husbandry systems. Forage grasses constitute a highly diverse group of plants with a worldwide distribution, thriving in

both natural, undisturbed ecosystems and intensive grassland-based livestock farming systems. The use for breeding activity the grasses forage species ecotypes that are locally adapted to adverse conditions, such as drought, poor soil quality, and temperature fluctuations, can significantly enhance the productivity and

quality sustainability, and reducing reliance on external inputs of foreign grass cultivars (COȘMAN et al., 2023; TOD et al., 2023; 2025).

The Plant List recognizes 96 scientific names at the species rank within the genus *Arrhenatherum*, of which nine are accepted species with a Eurasian and North African distribution. In the spontaneous flora of the Republic of Moldova and Romania, a single species, *Arrhenatherum elatius* (L.) P. Beauv., commonly known as tall oat-grass, bulbous oat-grass, or false oat-grass, is present. *Arrhenatherum elatius* is a perennial, loosely caespitose plant, occasionally rhizomatous, with rhizomes reaching up to 3 mm thick. The erect culms may reach from 50 to 140 (180) cm in height, they are glabrous and unbranched, with 4-5 nodes. The basal internodes may be swollen or not, and the nodes are glabrous or occasionally puberulent to densely hairy. The young leaves are convolute; the sheaths split with overlapping margins; the ligules are membranous, 1-3 mm long, obtuse to truncate, usually ciliate. The leaf blades lack auricles, are long (up to 40 cm), widening from the base to about two-thirds of their length before tapering to an acuminate tip. The upper leaf surface is smooth and ribless, while the lower surface has a pronounced keel. The flag leaves are shorter, widest at the base, with a poorly developed keel.

The inflorescences are lax panicles, 20-30 cm long and 2-7 cm wide, initially green and shiny, later becoming stramineous and occasionally purple tinged. The inflorescence branches are 15-20 mm long, ascending to divergent, verticillate, usually bear spikelets at the base. The pedicels measure 1-10 mm. The spikelets are typically 2-flowered: the lower floret is male only and the upper one is hermaphroditic. Occasionally, a third, fourth, or even fifth floret may be present, which may be hermaphroditic or rudimentary; the lowest floret is also sometimes hermaphroditic.

The glumes are membranous and unequal, the lower glume being 1-nerved and shorter, and the upper glume 3-nerved and longer. The lower floret bears a long, twisted, geniculate awn inserted one-third from the base of the lemma; the upper floret is generally awnless, though when present, the awn is straight and inserted near the lemma tip. The flowering stage occurs from May to June, with cross-pollination and wind-pollination being specific to this plant. The fruits (caryopses) are 4-5 mm long, approximately 1.2 mm wide, ellipsoid, densely hairy and yellowish. The weight of 1,000 seeds ranges from 2.6 to 3.1 g. Chromosome counts are $2n = 14, 28, 42$. The species is propagated by sowing. *Arrhenatherum elatius* plants develop deep roots capable of accessing moisture and nutrients at greater depths than many other

grasses. The seeds germinate at temperatures as low as 3-4°C.

The seedlings tolerate temperatures from -2°C to -4°C, while adult plants can grow slowly at -3°C to -4°C but suffer considerable damage at temperature as low as -6°C. During winter, the species can withstand very low temperatures, down to -23°C. The species grows on a wide range of soils with a pH between 5 and 8 and with medium salinity and prefers full sun to partial shade. It is mesophytic to xerophytic, occurring in open habitats such as dry grasslands, woodland edges, disturbed soils, successional fields, hayfields, pastures, thickets and roadsides, occasionally becoming a dominant grass. It can colonize and stabilize limestone scree, bare calcareous cliffs, maritime shingle and coastal dunes. The species *Arrhenatherum elatius* is cultivated as a forage grass due to its rapid recovery after mowing, though it does not tolerate overgrazing. It is often sown in mixtures with other species for grassland restoration (MEDVEDEV & SMETANNIKOVA, 1981; WILLS & BEGG 1994; HATCH, 2007; MACZEY, 2015; MACMILLAN & LEE, 2025). Also, tall oatgrass species has been evaluated for its potential as feedstock for renewable energy production and papermaking (MOUDRÝ et al., 2010; RACLAVSKÁ et al., 2011; EBELING et al., 2013; BOOB et al., 2019; DANIELEWICZ et al.,

2019; JEZERSKA et al., 2019; VON COSSEL et al., 2019; WALISZEWSKA et al., 2021). Considering the above, the main objective of this research was to evaluate the productivity and nutritive value of the fodder from tall oat-grass – *Arrhenatherum elatius*.

MATERIALS AND METHODS

The local ecotype of tall oatgrass (*Arrhenatherum elatius*), grown in monoculture on an experimental plot at the “Alexandru Ciubotaru” National Botanical Garden (Institute) of Moldova State University, Central Zone, Republic of Moldova, served as the subject of the present research. The experimental design was a randomized complete block design with four replications, the experimental plots measuring 10 m². The samples were collected during the second, third and fourth growing seasons, and the first cut was performed at the pre-flowering stage. The harvested plants were chopped into 1.5-2.0 cm pieces using a laboratory forage chopper. The dry matter content was determined by drying the samples to a constant weight at 105°C. The prepared hay was dried directly in the field. For ensiling, the chopped green mass was shredded and compressed into well-sealed glass containers, which were stored at ambient temperature (18-20°C). After 45 days, the containers were opened and the sensory and

chemical characteristics of the prepared silages were determined according to standard laboratory procedures and the Moldavian standard SM 108 for forage quality analysis.

For biochemical analyses, the straw samples were milled in a beater mill equipped with a 1 mm sieve. The key biochemical parameters, such as crude protein (CP), ash, acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin

(ADL), were assessed using near-infrared spectroscopy (NIRS) with a PERTEN DA 7200 near-infrared spectrometer at the Research and Development Institute for Grasslands in Braşov, Romania. The concentrations of hemicellulose (HC), cellulose (Cel), digestible dry matter (DDM), metabolizable energy (ME), net energy for lactation (NEL), and relative feed value (RFV) were calculated according to standard procedures.

RESULTS AND DISCUSSION

The local climatic conditions strongly influenced the growth and development of plants, as well as the productivity and quality indices of forage. Under the conditions of the Republic of Moldova, during the second year of growth, *Arrhenatherum elatius* plants resumed growth in mid-March. A more intensive growth and stem formation were observed in the second half of April. At the time of the first harvest, on May 18, plants had reached an average height of 87-93 cm. The studied species reached a green biomass yield of 3.46 kg/m² and a dry matter yield of 0.88 kg/m².

The third growing season was characterized by average temperatures above 0°C during January and February, which led to an earlier-than-usual resumption of growth. Thus, vegetative growth began in late February to early

March. Average daytime temperatures ranging from 9 to 18 °C accelerated plant growth and development, resulting in the onset of inflorescence formation 9-11 days earlier than usual. At the time of the first harvest, plants reached 105-111 cm in height, producing a green mass yield of 4.47 kg/m² and a dry matter yield of 1.01 kg/m².

In the fourth growing season, the plants emerged evenly on the soil surface between March 10 and 12, followed by stem formation in mid-April. At the time of the first harvest, on May 7, plants had reached a height of 77-83 cm. The productivity reached 3.61 kg/m² fresh mass and 0.84 kg/m² dry matter.

Various studies have reported differing results regarding the productivity of *Arrhenatherum elatius*. According to MEDVEDEV and SMETANNIKOVA (1981), tall oatgrass hay yield ranged from 4.4 to 7.2 t/ha. TOMIĆ et al. (2007)

reported that French ryegrass (*Arrhenatherum elatius*) was characterized by a plant height of 66 cm and a dry matter yield of 8.23-12.46 t/ha, English ryegrass (*Lolium perenne*) by 42.2 cm and 7.25 t/ha and Italian ryegrass (*Lolium multiflorum*) by 59.7-65.2 cm and 10.36-15.50 t/ha dry matter, respectively. NIVYOBIZI et al. (2005) noted that the first-cut dry matter yield of *Arrhenatherum elatius* reached 7.86 t/ha, *Lolium perenne* – 5.36 t/ha, *Alopecurus pratensis* – 4.05 t/ha and *Festuca rubra* – 6.13 t/ha.

SKLÁDANKA et al. (2009) found that the first-cut productivity of tall oatgrass, in early June, was 7.20 t/ha dry matter, while the second-cut yield, in late July, reached 2.49 t/ha. SVOBODOVÁ et al. (2009) reported that the average dry matter yield of the *Arrhenatherum elatius* sward was 4.3-5.0 t/ha in the third and fourth years, but in the fifth year, the total yield decreased by 48% as compared with previous years. GRYGIERZEC (2012) observed that *Arrhenatherum elatius* meadow produced 3.14-4.26 t/ha dry matter at the first cut and 1.78-2.31 t/ha at the second cut. HOLUB et al. (2012) reported that the biomass productivity of grass vegetation dominated by *Arrhenatherum elatius* ranged from 990 to 1,227 g/m².

USTAK et al. (2013) reported that the first-cut dry matter yield of tall oatgrass was 5.78 t/ha,

cocksfoot – 4.76 t/ha, meadow fescue – 3.74 t/ha and timothy grass – 5.47 t/ha. BOOB et al. (2019) noted that the dry biomass yield of a typical *Arrhenatherum elatius* community varied from 4.83 to 7.73 t/ha depending on fertilizer application. MARUȘCA (2022) reported that the productivity of main grassland habitats dominated by *Arrhenatherum elatius* in the Rarău Massif was 14.42 t/ha green mass. KONYK & IVANTSIV (2021) found that tall oatgrass meadows, under the conditions of Peredkarpattia, Ukraine, produced 35.0 t/ha green mass or 9.12 t/ha dry matter. MARUȘCA & VINTAN (2022) reported that *Arrhenatherum elatius* grasslands in the hydrographic basin of the Orăștie River yielded 23.29 t/ha green mass.

GEORGIEVA et al. (2023) found that during a nine-year experimental period, the highest yield was achieved by *Festuca rubra*, with 5.75 t/ha, followed by *Festuca arundinacea* – 5.54 t/ha and *Arrhenatherum elatius* – 5.43 t/ha. PITTARO et al. (2024) reported that the annual forage biomass accumulation of *Arrhenatherum elatius* plants was 7,863.26 kg/ha. MIRON & ȚÎȚEI (2025) found that the hay productivity of grasslands dominated by *Arrhenatherum* ranged from 4.13 to 5.63 t/ha.

The nutritional quality and diversity of forage are key factors influencing animal health, productivity and farm profitability.

The analysis of the biochemical composition of the collected fresh mass from *Arrhenatherum elatius* (Table 1) showed that the dry matter contained 77-96 g/kg crude protein (CP), 80-84 g/kg ash, 375-414 g/kg crude fibre (CF), 399-436 g/kg acid detergent fibre (ADF), 684-740 g/kg neutral detergent fibre (NDF), 35-40 g/kg acid detergent lignin (ADL), 362-396 g/kg cellulose (Cel) and 285-306 g/kg hemicellulose (HC), with 549-590 g/kg dry matter digestibility (DDM), 10.96-11.48 MJ/kg digestible energy (DE), 9.00-9.43 MJ/kg metabolizable energy (ME) and 5.02-5.67 MJ/kg net energy for lactation (NEL).

The concentrations of crude protein and total soluble sugars in the *Arrhenatherum elatius* fodder obtained during the third and fourth growing seasons were significantly higher than those found in the fodder from the second growing season. The mineral content in the fodder was the highest in the fourth growing season. The fresh fodder collected in the third growing season contained considerably lower amounts of structural carbohydrates and lignin. The concentrations of cellulose and hemicellulose in the fodder from the second and fourth growing seasons did not differ significantly. The tall oatgrass fodder obtained in the third growing season demonstrated the best values in terms of dry matter digestibility, metabolizable energy and net energy for lactation.

The specialized literature provides varying data on the green mass quality of *Arrhenatherum elatius* plants. According to D'OTTAVIO & ZILLOTTO (2003), the forage from grasslands dominated by *Arrhenatherum elatius* contained 5.08% CP, 1.54% EE, 6.09% ash, 35.66% CF, 61.34% NDF, 35.43% ADF, 6.09% ADL and 3.19 MJ/kg NEL at the first cut, while the second-cut forage contained 7.19% CP, 2.19% EE, 7.46% ash, 31.10% CF, 59.58% NDF, 31.35% ADF, 5.16-6.09% ADL and 4.60 MJ/kg NEL. NIVYOBIZI et al. (2005) reported that the dry matter of *Arrhenatherum elatius*, obtained at the first cut, contained 72 g/kg CP, 714 g/kg NDF, 599 g/kg OMD, 0.66 UFL/kg, 0.57 UFV/kg, 90 g/kg PDIE and 58 g/kg PDIN, while at the second cut, it contained 154 g/kg CP, 721 g/kg NDF, 645 g/kg OMD, 0.73 UFL/kg, 0.64 UFV/kg, 91 g/kg PDIE and 91 g/kg PDIN.

TOMIĆ et al. (2005) reported that *Arrhenatherum elatius* grown in pasture associations contained 6.28% CP, 30.07% CF and 8.11% ash. WYŁUPEK (2006) observed that *Arrhenatherum elatius* biomass from selected phytocenoses contained 11.37% CP, 1.22 g/kg P, 7.1 g/kg K, 2.04 g/kg Mg and 3.36 g/kg Ca.

SKLÁDANKA et al. (2008) reported that the forage dry matter from *Arrhenatherum elatius* contained 30.2% CF, 60.5% NDF, 35.9% ADF and 5.46 MJ/kg NEL,

while that from *Dactylis glomerata* contained 28.9% CF, 57.1% NDF, 35.1% ADF, 5.54 MJ/kg NEL and *Festulolium* – 26.9% CF, 58.9% NDF, 32.3% ADF, 5.84 MJ/kg NEL, respectively.

TOMIĆ et al. (2007) reported that French ryegrass (*Arrhenatherum elatius*) contained 13.24% CP and 31.8% CF, English ryegrass (*Lolium perenne*) 9.7-13.4% CP and 30.7% CF, and Italian ryegrass (*Lolium multiflorum*) 11.57-14.57% CP and 21.92-25.22% CF. COP et al. (2009) found that the forage dry matter from *Arrhenatherum elatius* grasslands contained 11.74-15.91% CP, 24.48-29.67% CF and 5.4-6.0 MJ/kg NEL.

AUFRÈRE et al. (2008) noted that the dry matter from *Arrhenatherum elatius* harvested for the first time in May contained 16.6% CP, 52.3% NDF, 25.4% ADF, 2.68% ADL and 786 g/kg OMD. SKLÁDANKA et al. (2010) compared the forage quality of green mass and reported that *Arrhenatherum elatius* contained 7.92-9.49% CP, 29.34-30.25% CF, 55.48-61.20% NDF and 71.80-78.0% OMD; *Dactylis glomerata* 9.00-9.17% CP, 27.52-30.33% CF, 56.59-57.79% NDF and 70.4-76.9% OMD; and *Festuca arundinacea* × *Lolium multiflorum* 7.11-7.54% CP, 25.36-29.79% CF, 56.10-61.25% NDF and 71.8-78.0% OMD, respectively. GOLÍŃSKI & GOLÍŃSKI (2013) reported that the biomass harvested from semi-

natural grasslands dominated by the *Arrhenatherion* alliance contained 308 g/kg dry matter, 10.35% CP, 6.36% ash, 50.98% NDF and 31.61% ADF.

HEJCMÁNOVÁ et al. (2015) reported that *Arrhenatherum elatius* forage contained 366 g/kg DM with 1.23% N, 6.45% ash, 65.4% NDF, 40.0% ADF, 0.13% P and 0.76% Ca, whereas *Dactylis glomerata* forage contained 284 g/kg DM with 1.26% N, 8.5% ash, 67.0% NDF, 40.4% ADF, 0.15% P and 1.06% Ca. LEE (2018) noted that *Arrhenatherum elatius* forage contained 8% CP, 61% NDF and 74% OMD. BOOB et al. (2019) reported that biomass dry matter from *Arrhenatherion* grasslands harvested before the flowering period contained 11.25% CP, 50.00% NDF, 5.37% ADL, 11.25% ash, 2.88 g/kg P, 24.9 g/kg K, 1.97 g/kg Mg, 10.00 g/kg Ca and 5.56 MJ/kg NEL. The biomass cut during the flowering period contained 7.88-8.62% CP, 52.86-55.77% NDF, 6.05-6.30% ADL, 8.92-9.50% ash, 2.88 g/kg P, 16.8-20.4 g/kg K, 1.64-1.87 g/kg Mg, 9.7-9.8 g/kg Ca and 4.52-5.22 MJ/kg NEL. VON COSSEL et al. (2019) found that first-cut biomass from *Arrhenatherion* grasslands contained 240-297 g/kg DM, 7.0-8.1% ash, 4.7-5.7% lignin, 29.3-31.9% Cel, 20.7-25.2% HC and 1.4-1.7% N.

REINÉ et al. (2020) studied the nutritional quality of meadow plant species and reported that

Arrhenatherum elatius contained 421 g/kg DM with 7.6% CP, 4.5% ash, 1.6% EE, 66.5% NDF, 35.2% ADF, 3.0% ADL, 61.5% DDM, 0.13% P and 0.50% Ca; *Lolium perenne* contained 371 g/kg DM with 6.8% CP, 5.8% ash, 1.6% EE, 63.6% NDF, 32.7% ADF, 2.8% ADL, 63.4% DDM, 0.11% P and 0.44% Ca; and *Dactylis glomerata* contained 405 g/kg DM with 8.3% CP, 4.7% ash, 2.2% EE, 69.0% NDF, 38.8% ADF, 5.0% ADL, 58.6% DDM, 0.13% P and 0.49% Ca. MESERSZMIT et al. (2021) noted that the herbage from *Arrhenatherum elatius* and *Dactylis glomerata* plant communities contained 8.00% CP, 3.17% EE, 57.30% NDF, 16.56% HC, 29.47% Cel, 11.24% lignin and 7.73% ash.

Hay is a key component of the diet of farm animals, primarily during the middle autumn to middle spring period, when there is a scarcity of fresh feed. However, it can also be fed to farm animals throughout the year, as a healthy feed containing essential nutrients, vitamins and minerals. It is particularly important for young breeding animals, pregnant females and reproductive males. Hay supports the motor functions of the rumen, including the muscular activity of the digestive system and rumination, which is indispensable for the proper utilization of feed. As a low-cost source of roughage, hay is vital for maintaining livestock health and productivity.

Table 1.

The biochemical composition and nutritional value of the *Arrhenatherum elatius* fresh mass

Indices	growing seasons		
	II	III	IV
Crude protein, g/kg DM	77.00	96.00	94.00
Minerals, g/kg DM	80.00	82.00	84.00
Crude fibre, g/kg DM	414.00	375.00	385.00
Acid detergent fibre, g/kg DM	436.00	399.00	428.00
Neutral detergent fibre, g/kg DM	740.00	684.00	734.00
Acid detergent lignin, g/kg DM	40.00	37.00	35.00
Total soluble sugars, g/kg DM	98.00	120.00	107.00
Cellulose, g/kg DM	396.00	362.00	393.00
Hemicellulose, g/kg DM	304.00	285.00	306.00
Digestible dry matter, g/kg DM	549.00	590.00	556.00
Relative feed value	68.00	77.00	70.00
Digestible energy, MJ/ kg	10.96	11.48	11.09
Metabolizable energy, MJ/ kg	9.00	9.43	9.10
Net energy for lactation, MJ/ kg	5.02	5.67	5.11

The hay prepared from tall oatgrass plants (Table 2) contained 77-100 g/kg CP, 393-414 g/kg CF, 80-94 g/kg ash, 418-436 g/kg ADF, 683-748 g/kg NDF, 38-40 g/kg ADL, 78-98 g/kg TSS, 380-396 g/kg Cel and 265-318 g/kg HC. The nutritive and energy values of the prepared hay were 549-563 g/kg DDM, 10.97-11.21 MJ/kg DE, 9.00-9.20 MJ/kg ME and 5.02-5.23 MJ/kg NEL.

The hay prepared in the third growing season was characterized by an optimal concentration of crude protein, acid detergent lignin and structural carbohydrates, which positively affected digestibility, nutritional value and energy supply. The lowest level of crude protein was observed in the hay produced in the second growing season, but the concentrations of structural carbohydrates and acid detergent lignin, as well as dry matter digestibility and energy content, did not differ significantly between hay from the second and fourth growing seasons. Several studies have evaluated the potential of *Arrhenatherum elatius* for hay production. According to MEDVEDEV & SMETANNIKOVA (1981), tall oatgrass hay contained 7.6-12.7% CP, 1.6-3.4% EE, 23.2-32.0% CF, 36.0-50.0% NFE and 7.0-10.0% ash. GRYGIERZEC (2012) reported that the hay samples from the *Arrhenatherum elatioris* typicum community meadow had quality indices of 88-148 g/kg CP, 43.6-

91.4 g/kg ash, 224-342 g/kg CF, 450-569 g/kg NFE, 245-327 g/kg EE, 418-527 g/kg NDF, 307-437 g/kg ADF, 41.8-82.5 g/kg ADL and 236-383 g/kg cellulose.

MIRON & ȚÎȚEI (2025) found that the hay obtained from *Arrhenatherum elatius* grasslands contained 107-142 g/kg CP, 343-373 g/kg CF, 93-106 g/kg ash, 373-395 g/kg ADF, 595-648 g/kg NDF, 43-44 g/kg ADL, 57-85 g/kg total soluble sugars (TSS), 330-351 g/kg cellulose and 222-253 g/kg hemicellulose (HC), while the nutritive and energy values reached 58.1-61.9% DMD, RFV = 83-97, 11.53-12.21 MJ/kg DE, 9.47-10.03 MJ/kg ME and 5.49-5.74 MJ/kg NEL.

Preserved forages, such as silage and haylage, are essential components of intensive livestock systems. The prepared tall oatgrass silages were characterized by a uniform light olive colour, a pleasant smell reminiscent of pickled watermelon. The texture remained consistent compared with the original green mass, with no signs of mould or mucus formation. The biochemical composition and nutritional value of these silages are presented in Table 3. The fermentation profile of the prepared tall oatgrass silage showed a pH of 4.20-4.26, with total organic acids ranging from 24.20 to 29.60 g/kg, of which 75.62-78.00% was lactic acid. Butyric acid was detected only in very small amounts in the silage prepared during the third growing

season. The nutrient concentrations in the silage dry matter were as follows: 88-109 g/kg CP, 368-405 g/kg CF, 100-102 g/kg ash, 388-420 g/kg ADF, 632-724 g/kg NDF, 26-30 g/kg ADL, 56-74 g/kg TSS, 358-394 g/kg Cel, 244-304 g/kg HC, with nutritive and energy value 56.5-58.7% DMD, 11.25-11.64 MJ/kg DE, 9.19-9.56 MJ/kg ME and 5.21-5.57 MJ/kg NEI. As compared with the original green

mass, the prepared silages exhibited lower concentrations of cell wall fractions (NDF, ADF, ADL) and total soluble sugars, while the crude protein, mineral content and energy value increased. Notably, the silage obtained in the third growing season had particularly high protein content and low levels of structural carbohydrates, which had a positive impact on its nutritional and energy value.

Table 2.

The biochemical composition and nutritional value of *Arrhenatherum elatius* hay

Indices	growing seasons		
	II	III	IV
Crude protein, g/kg DM	77.00	100.00	89.00
Minerals, g/kg DM	80.00	94.00	86.00
Crude fibre, g/kg DM	414.00	399.00	393.00
Acid detergent fibre, g/kg DM	436.00	418.00	430.00
Neutral detergent fibre, g/kg DM	740.00	683.00	748.00
Acid detergent lignin, g/kg DM	40.00	38.00	40.00
Total soluble sugars, g/kg DM	98.00	78.00	90.00
Cellulose, g/kg DM	396.00	380.00	390.00
Hemicellulose, g/kg DM	304.00	265.00	318.00
Digestible dry matter, g/kg DM	549.00	563.00	554.00
Relative feed value	68.00	77.00	69.00
Digestible energy, MJ/ kg	10.97	11.21	11.05
Metabolizable energy, MJ/ kg	9.00	9.20	9.07
Net energy for lactation, MJ/ kg	5.02	5.23	5.09

According to DINIĆ et al. (2008), tall oatgrass silage prepared from freshly mown mass had a pH of 4.00, dry matter content of 233.8 g/kg, with 6.83% lactic acid, 2.45% acetic acid, 0.76% butyric acid, 14.42% CP, 4.93% EE, 71.17% NDF, 32.88% ADF, 18.23% total sugars, 38.28% HC, 10.28% ash, 0.47% Ca and 0.33% P. In contrast,

the silage prepared from wilted mass had a pH of 4.50, 392.0 g/kg DM, 4.11% lactic acid, 1.58% acetic acid, 0% butyric acid, 15.00% CP, 4.89% EE, 69.10% NDF, 33.52% ADF, 15.93% total sugars, 35.58% HC, 9.92% ash, 0.56% Ca and 0.33% P, respectively.

Table 3.

The biochemical composition and nutritional value of ensiled mass from *Arrhenatherum elatius*

Indices	growing seasons	
	II	III
pH index	4.26	4.20
Organic acids, g/kg DM	24.20	29.60
Total acetic acid, g/kg DM	5.90	6.10
Total butyric acid, g/kg DM	0.00	0.40
Total lactic acid, g/kg DM	18.30	23.10
Acetic acid, % of organic acids	24.38	20.60
Butyric acid, % of organic acids	0.00	1.40
Lactic acid, % of organic acids	75.62	78.00
Crude protein, g/kg DM	88.00	109.00
Crude fibre, g/kg DM	405.00	368.00
Ash, g/kg DM	100.00	102.00
Acid detergent fibre, g/kg DM	420.00	388.00
Neutral detergent fibre, g/kg DM	724.00	632.00
Acid detergent lignin, g/kg DM	26.00	30.00
Total soluble sugars, g/kg DM	74.00	56.00
Cellulose, g/kg DM	394.00	358.00
Hemicellulose, g/kg DM	304.00	244.00
Digestible dry matter, g/kg DM	565.00	587.00
Digestible energy, MJ/kg DM	11.25	11.64
Metabolizable energy, MJ/kg DM	9.19	9.56
Net energy for lactation, MJ/kg DM	5.21	5.57
Relative feed value	73	86

CONCLUSIONS

Tall oatgrass (*Arrhenatherum elatius*) is characterized by high biomass productivity and can be used as fresh mass, hay and silage in the diet of farm animals.

The forage obtained during the third growing season exhibited optimal concentrations of crude

protein, acid detergent lignin, cellulose and hemicellulose, along with improved digestibility and energy content.

The studied local ecotype of tall oatgrass (*Arrhenatherum elatius*) could serve as a valuable genetic resource for breeding and developing new grass cultivars for the production of forages.

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**THE QUALITY INDICES OF FRESH BIOMASS AND SILAGE
FROM DENT CORN (*Zea mays* var. *indentata*)
AND SWEET CORN (*Zea mays* convar. *saccharata*) IN MOLDOVA**

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Abstract. This article presents the results of an evaluation of the biochemical composition and nutritive value of fresh biomass (green mass) and silage from dent corn (*Zea mays* var. *indentata*) hybrid ‘Porumbeni 374’ and sweet corn (*Zea mays* convar. *saccharata*) hybrid ‘Porumbeni 343’, grown in the central part of the Republic of Moldova. The quality indices of the dry matter from the whole corn plants ranged between the following values: 8.4-12.7% CP, 5.2-12.5% ash, 24.8-33.6% CF, 27.1-34.7% ADF, 47.4-53.9% NDF, 3.8-4.8% ADL, 22.3-30.9% Cel, 19.2-20.3% HC, with 619-678 g/kg DDM, RFV=107-133, 10.02-10.90 MJ/kg ME, and 6.04-6.91 MJ/kg NEL. The prepared corn silage had a pH of 3.74–3.77, and contained 10.3-13.3 g/kg acetic acid, 38.1-39.7 g/kg lactic acid and 0.02 g/kg butyric acid. The silage dry matter nutrients were 8.0-9.6% CP, 5.9-9.3% ash, 25.8-34.0% CF, 25.8-34.0% ADF, 46.9-53.0% NDF, 3.1-3.6% ADL, 22.1-30.9% Cel, 19.0-21.1% HC, with 624-688 g/kg DDM, RFV=110-136, 10.10-11.04 MJ/kg ME, and 6.12-7.06 MJ/kg NEL.

Keywords: corn hybrids, quality indices, green mass, silage, dent corn hybrid ‘Porumbeni 374’, sweet corn hybrid ‘Porumbeni 343’

INTRODUCTION

Zea mays L., commonly known as maize or corn, is an annual, monocotyledonous herb of the family Poaceae (the grass family). It is monoecious – bearing separate male and female flowers on the same plant – and uses the C4 photosynthetic pathway. Maize is native to the Americas but has expanded over time and is now cultivated widely, occurring in the Northern Hemisphere up to about 58°N (e.g., Canada and Russia) and in the Southern Hemisphere to about 42–43°S (e.g., New Zealand). Corn

is a vital food, feed, and industrial crop globally, grown in roughly 160 countries with diverse soils, climates, biodiversity, and management systems. It ranks as the third most important cereal crop after rice and wheat and contributes significantly to global grain production for human and animal consumption, forage production, and various industrial applications.

Due to its genetic diversity and the morphological characteristics of its endosperm, maize exhibits several distinct types, each with specific properties that make it

suitable for particular uses. These range from dent corn (*Zea mays* var. *indentata*), primarily cultivated for animal feed, to types used predominantly for human consumption, such as flint corn (*Zea mays* var. *indurata*), sweet corn (*Zea mays* var. *saccharata*), popcorn (*Zea mays* var. *everta*), and pod corn (*Zea mays* var. *tunicata*). Industrial applications commonly rely on waxy corn (*Zea mays* var. *ceratina*) and flour corn (*Zea mays* var. *amylacea*).

Globally, the largest cultivated areas are planted with hybrids and varieties of dent corn (*Zea mays* var. *indentata*), which is used mainly for grain production but also serves as an important fodder crop for fresh forage and silage.

Sweet corn (*Zea mays* var. *saccharata*) is a highly valued corn type cultivated worldwide for its tender kernels consumed as a vegetable. Global demand for sweet corn has increased steadily over the past two decades, driven by shifting dietary preferences, urbanization, and growing health awareness. These trends have intensified research efforts in breeding, agronomy, and improving the crop's adaptability to a wide range of agro-climatic conditions. In addition, several

research centers are investigating the use of residues from sweet corn cultivation and industrial cob processing as potential sources of animal feed and energy biomass (IDRIS et al. 2000; CHEVA-ISARAKUL et al. 2001; MUSTAFA et al. 2004; IDIKUT et al. 2010; PANYASAK & TUMWASORN, 2014; CHAUDHARY et al. 2016; NAZLI et al. 2018; ZHANG et al. 2022; NASIR & KAMARUDDIN, 2023).

Whole-plant corn forage is an important source of fiber and energy and is widely used in the nutrition of ruminant animals to enhance production performance, dry matter intake, average daily gain, and milk yield. It provides substantial amounts of energy-rich fodder for animal diets, and, unlike sorghum species, can be safely fed at all growth stages without the risk of oxalic or prussic acid toxicity.

The main objective of this study was to evaluate the chemical composition and nutritive value of whole-plant forages from the dent corn hybrid 'Porumbeni 374' and the sweet corn hybrid 'Porumbeni 343' grown under the environmental conditions of the central region of the Republic of Moldova.

MATERIALS AND METHODS

The local dent corn (*Zea mays* var. *indentata*) hybrid 'Porumbeni 374' and sweet corn (*Zea mays* convar. *saccharata* var. *rugose*) hybrid 'Porumbeni 343',

both developed at the Institute of Crop Science "Porumbeni" and registered in Catalog of Plants Varieties in the Republic of Moldova, were the subjects of this research.

The corn hybrids studied were sown in May at a density of 60,000 seeds per hectare, with a row spacing of 70 cm. All agronomic practices during the growing season were identical for both hybrids. The dent corn whole plants were harvested manually at the kernel wax stage, while sweet corn plants were collected at the technological maturity stage, after the ears of sweet corn (fruit corn) at the milk stage had been harvested for human consumption. The harvested plants were chopped into 1.5–2.0 cm pieces using a laboratory forage chopper. Dry matter content was determined by drying samples to a constant weight at 105°C. The silage was prepared from the chopped green mass, compressed into well-sealed glass containers, and stored at ambient temperature (18–20°C). After 45 days, the containers were opened, and the sensory and fermentation indices of the preserved forage were assessed according to standard laboratory procedures outlined in the Moldavian standard SM 108*. The fresh biomass and fermented fodder samples were dehydrated in an oven with forced ventilation at 60°C. After

dehydration, the biological material was finely ground in a laboratory ball mill. The quality of the forage was evaluated by analyzing indices such as crude protein (CP), crude fiber (CF), crude ash (CA), acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL), which were determined using near-infrared spectroscopy (NIRS) with the PERTEN DA 7200, at the Research and Development Institute for Grassland, Braşov, Romania. The concentrations of hemicellulose (HC), cellulose (Cel), digestible dry matter (DDM), digestible energy (DE), metabolizable energy (ME), net energy for lactation (NEL), and relative feed value (RFV) were calculated according to standard procedures. The evaluation of silage pH, and the concentrations of organic acids (lactic, acetic, and butyric) in both free and bound forms, was carried out at the Laboratory of Nutrition and Forage Technology of the Scientific-Practical Institute of Biotechnology in Animal Husbandry and Veterinary Medicine, Maximovca, in accordance with established methodological guidelines.

RESULTS AND DISCUSSION

The bio-morphological characteristics of the whole corn plant had a significant impact on productivity, fodder quality, and forage value. It was found that the dent corn hybrid ‘*Porumbeni 374*’

reached a height of 249–252 cm at harvest, with a dry matter yield of 1.8 kg/m², while the plant height of the sweet corn hybrid ‘*Porumbeni 343*’ was lower, ranging from 175 to 193 cm, with a dry matter yield of

0.92 kg/m² from the plant after ear removal.

Multiple studies have provided data on the corn forage productivity. SUTHAR et al. (2012) revealed that yield of sweet corn varieties was 8.64-12.66 t/ha green cobs and 15.91-26.54t/ha green fodder. NAZLI et al. (2018) mentioned that sweet corn plant in milk kernel stage had 208.7 cm height, and dry matter yield was 2.28 t/ha leaves, 4.26 t/ha stems, 0.38 t/ha tassels and 10.6 t/ha cobs. SCARLAT et al. (2019) remarked that corn forage yield varied from 12.65 to 20.99 t/ha dry matter. COȘMAN & COȘMAN (2023) found that yield of studied corn hybrids varied from 16.44 to 22.36 t/ha dry matter. KINTL et al. (2023) reported that in Czech Republic the fresh matter yield of *Zea mays* crop was 61.34 t/ha with 26.9% dry matter content.

Analyzing the nutrient concentrations of the green fodder from the studied corn hybrids (Table 1), the biochemical composition of the dry matter was found to be: 8.4-12.7% CP, 5.2-12.5% ash, 24.8-33.6% CF, 27.1-34.7% ADF, 47.4-53.9% NDF, 3.8-4.8% ADL, 22.3-30.9% Cel, 19.2-20.3% HC. The dry matter of sweet corn hybrid 'Porumbeni 343' was characterized by a higher content of crude protein, minerals, and fibers, whereas the dent corn hybrid 'Porumbeni 374' had lower concentrations of crude protein, minerals, and cellulose, but higher levels of acid detergent lignin and hemicellulose, which affected its

digestibility and energy value. The green fodder from dent corn hybrid 'Porumbeni 374' was characterized by a higher relative feed value and concentrations of metabolizable energy and net energy for lactation.

Different results regarding the biochemical composition and the nutritive value of the corn fresh biomass are given in the specialized literature. According to IDRIS et al. (2000) at the normal harvesting age of 75 days, the protein and metabolizable energy concentration of corn stover were 9.6% and 7.82 MJ/kg. CHEVA-ISARAKUL et al. (2001) found that residue of sweet corn cannery contained 197.5 g/g DM with nutrient composition 6.86% CP, 3.21% EE, 3.97% ash, 70.89% NDF, 35.61% ADF and 15.07% NFC. MUSTAFA et al. (2004) reported that sweet corn stover had 239 g/kg DM, 58.2% NDF, 28.3% ADF and 3.4% CP. DALE et al. (2011) reported that the nutrient content of dry matter from corn stalks and leaves ranged from 3.79 to 7.97 % CP, 38.94-46.46 % CF, 45.51-56.22% ADF, 72.48-79.66% NDF, 6.14 -9.89% ADL. In contrast, the nutrient content of corn ear mass ranged from 2.51 to 5.83 % CP, 6.93-12.94 % CF, 2.48-16.81% ADF, 18.11-35.43% NDF, 0.51-4.13% ADL. SUTHAR et al. (2012) mentioned that the dry matter of green fodder from the studied sweet corn varieties contained 4.73-4.97 % CP and 87.9-90.8 % TDN. FERREIRA et al. (2013) found that

the forage quality of corn hybrid plants without ears was 5.08-7.14 % CP, 3.40-8.23 % WSC, 33.29-42.09% ADF, 64.88-74.55% NDF, 3.38 -7.20% ADL with 41.58-58.84% IVDMD. PANYASAK & TUMWASORN (2014) remarked that the chemical characteristics of sweet corn waste were characterized by the following indices: 155.6 g/kg DM, 7.54% CP, 0.93% EE, 3.14% ash, 32.77% CF, 78.98% NDF, 43.87% ADF, 7.96 % ADL and 55.62% NFE with a gross energy of 3,983.41 cal/g. CHAUDHARY et al. (2016) mentioned that sweet corn forage had 375.0 g/kg DM, 6.45% CP, 40.50% CF, 81.50% NDF, 49.95% ADF, 5.00% ADL, 5.19% ash and 53.65% IVDOM, but forage corn had 230.0 g/kg DM, 9.63% CP, 30.0% CF, 67.80% NDF, 37.60% ADF, 3.40% ADL, 6.10% ash and 66.25% IVDOM. CARPICI et al. (2017) reported that the forage quality of second-crop maize varied depending on plant density and nitrogen fertilization rate. Thus, it ranged from 4.7 to 7.9% CP, 20.2-27.7% ADF, 39.6-50.6%. SCARLAT et al. (2019) revealed that, depending on the hybrids, plant density and row distance, the corn forage quality were: 8.37-10.25% CP, 24.93-27.93% ADF, 35.32-40.23% NDF, RFV=155.7-182.7. NAZLI et al. (2018) remarked that the nutritional quality indicators of sweet corn forage were: 10.7-11.7% CP, 60.0-66.2% NDF, 26.5-44.1% ADF, 5.49-6.35% lignin, 22.1-38.7% HC, 546-650 g/kg DDM, 567-668

g/kg TDN, 10.5-12.3 MJ/kg DE, 8.58-10.13 MJ/kg ME, but the forage from grain corn – 9.6-11.8% CP, 63.5-65.2% NDF, 31.3-43.0% ADF, 7.08-7.66% lignin, 21.8-32.2% HC, 551-645 g/kg DDM, 571-641g/kg TDN, 10.5-11.8 MJ/kg DE, 8.56-9.71 MJ/kg ME, respectively. COȘMAN & COȘMAN (2023) found that studied corn hybrids contained 307.3-345.0 g/kg DM, 6.68-8.01% CP, 15.11-19.55% CF, 65.44-69.69%NFE, 0.79-2.30% sugars, 31.27-28.61% starch, 3.50-4.10% EE, 3.47-3.90% ash, 1.7-2.8 g/kg Ca, 2.1-2.9 g/kg P, 9.53-9.93 MJ/kg ME. NASIR & KAMARUDDIN (2023) reported that the leaves of sweet corn contained 19.04% CP, 5.22% EE, 27.05% CF, 43.55% NFE, 5.44% ash, and sweet corn stalk had 10.47% CP, 1.32% EE, 23.88 % CF, 51.42% NFE and 4.56% ash and 27.05 % CF, while kernel corn leaves 15.41% CP, 2.79%EE, 25.83% CF, 46.64% NFE, 5.22% ash and stalk -4.09% CP, 0.47% EE, 27.23% CF, 60.99% NFE, 2.67% ash. DYK (2025) found that sweet corn waste contained 193.1-298.5 g/kg DM, 6.90-11.70% CP, 13.47-24.26% NFC, 55.27-67.40%NDF, 3.57-5.77% EE, 3.83-12.37% ash, 0.5-2.5 g/kg Ca, 0.7-3.0 g/kg P, 637.4-787.0 g/kg TDN, RFQ=131-189, 1.08- 1.39 Mcal/lb ME, 0.65-0.82 Mcal/lb NEI. Silage is a method of preserving forage through fermentation in an anaerobic environment. It is a preferred method of feed storage for energy-dense crops. Corn silage is an important

feed source for dairy cattle in recent years, being a key component of the

balanced feeding rations for farm animals throughout the year.

Table 1.

The biochemical composition and nutritional value of fresh biomass from the studied corn hybrids

Indices	'Porumbeni 374'	'Porumbeni 343'
Crude protein, g/kg DM	84	127
Minerals, g/kg DM	52	125
Crude fiber, g/kg DM	248	336
Acid detergent fiber, g/kg DM	271	347
Neutral detergent fiber, g/kg DM	474	539
Acid detergent lignin, g/kg DM	48	38
Cellulose, g/kg DM	223	309
Hemicellulose, g/kg DM	203	192
Digestible dry matter, g/kg DM	678	619
Relative feed value	133	107
Digestible energy, MJ/ kg	13.28	12.21
Metabolizable energy, MJ/ kg	10.90	10.02
Net energy for lactation, MJ/ kg	6.91	6.04

Table 2.

The fermentation quality, nutrient content and energy value of silage from studied corn hybrids

Indices	'Porumbeni 374'	'Porumbeni 343'
pH index	3.77	3.74
Content of organic acids, g/kg DM	48.6	53.2
Total acetic acid, g/kg DM	10.3	13.3
Total butyric acid, g/kg DM	0.2	0.2
Total lactic acid, g/kg DM	38.1	39.7
Acetic acid, % of organic acids	21.19	25.00
Butyric acid, % of organic acids	0.41	0.38
Lactic acid, % of organic acids	78.40	74.62
Crude protein, g/kg DM	80	96
Crude fibre, g/kg DM	245	333
Minerals, g/kg DM	59	93
Acid detergent fibre, g/kg DM	258	340
Neutral detergent fibre, g/kg DM	469	530
Acid detergent lignin, g/kg DM	37	31
Cellulose, g/kg DM	221	309
Hemicellulose, g/kg DM	211	190
Digestible dry matter, g/kg DM	688	624
Relative feed value	136	110
Digestible energy, MJ/ kg DM	13.45	12.30
Metabolizable energy, MJ/ kg DM	11.04	10.10
Net energy for lactation, MJ/ kg	7.06	6.12

The quality indices of the prepared silages from the studied corn hybrids are shown in Table 2. The tested corn silages were characterized by suitable fermentation characteristics, good color, pleasant smell, and were free from mold. Upon opening the containers and conducting the organoleptic evaluation of the ensiled mass, it was determined that the silage from sweet corn hybrid 'Porumbeni 343' was characterized by green leaves and yellowish-green stems, with a pleasant smell reminiscent of pickled watermelon. In contrast, the silage from the dent corn hybrid 'Porumbeni 374' had a homogeneous light yellow color and a pleasant smell of pickled apples. The pH index of the studied corn silages did not differ, showing optimal values. The concentrations of organic acids varied from 48.6 g/kg dry matter (DM) in the 'Porumbeni 374' silage to 52.5 g/kg DM in the 'Porumbeni 343' silage, with most of the organic acids present in the fixed form. The lactic acid constituted 74.62- 78.60% of total organic acids. The higher content of acetic acid was detected in 'Porumbeni 343' silage. The concentrations of nutrients and energy in the prepared silages were 8.0-9.6% CP, 5.9-9.3% ash, 25.8-34.0% CF, 25.8-34.0% ADF, 46.9-53.0% NDF, 3.1-3.6% ADL, 22.1-30.9% Cel, 19.0-21.1% HC, with 624-688 g/kg DDM, RFV=110-136, 10.10-11.04 MJ/kg ME, and 6.12-7.06. MJ/kg NEL. It was found that

during the ensiling process, the amounts of crude protein and minerals decreased considerably in the 'Porumbeni 343' silage compared to the initial fresh biomass. In both corn silages, the concentrations of lignin decreased. The higher level of crude protein and the lower level of acid detergent lignin were detected in the silage from hybrid 'Porumbeni 343'. The silage from the dent hybrid 'Porumbeni 374' stands out due to its lower concentration of crude cellulose, higher level of hemicellulose, and better digestibility and energy supply.

Authors have reported various findings regarding corn silage quality. According to IDRIS et al. (2000) the silage product from sweet corn had 8.2% CP and 5.86 MJ/kg ME. CHEVA-ISARAKUL et al. (2001) found that silage from sweet corn residue had 219.8 g/kg DM, pH=4.21, 6.27% CP, 2.28% EE, 3.10% ash, 77.32 % NDF, 33.90% ADF and 11.03% NFC. DYK (2009) noted that the fermentation profile of silage from the studied corn hybrids, specifically sweet corn waste, had a pH range of 3.7-4.0, with 5.05-10.46% total acids, 1.21-6.60% lactic acid, 3.09-6.67% acetic acid, and 0.01% butyric acid. IDIKUT et al. (2010) mentioned that the quality of silage from sweet corn was 208.9 g/kg DM, pH=3.72, 97.21 g/kg lactic acid, 14.64 g/kg acetic acid, 0.46 g/kg butyric acid, 10.31 % CP, 5.21% ash, 42.90 % NDF, 25.17% ADF,

579.9 g/kg OMD, 8.60 MJ/kg ME, while the silage from conventional corn – 241.3 g/kg DM, pH=3.74, 58.15 g/kg lactic acid, 11.98 g/kg acetic acid, 0.35 g/kg butyric acid, 9.46 % CP, 4.93% ash, 47.82 % NDF, 26.32% ADF, 592.9 g/kg OMD, 8.8.83 MJ/kg ME. COȘMAN (2014) studied the silage quality from diverse crops, and found that dent corn silage contained 310.7 g/kg DM, pH=3.51, 37.0 g/kg lactic acid, 5.3 g/kg acetic acid, 4.44% CP, 2.84% EE, 21.61% CF, 4.91% ash and 15.2 mg/kg carotene; sugar sorghum silage – 213.4 g/kg DM, pH=3.49, 32.1 g/kg lactic acid, 23.0 g/kg acetic acid, 3.25% CP, 2.41% EE, 32.97% CF, 6.43% ash and 4.3 mg/kg carotene; but in amaranth silage – 232.9 g/kg DM, pH=4.02, 25.7 g/kg lactic acid, 10.1 g/kg acetic acid, 9.69% CP, 3.58% EE, 26.19% CF, 10.1% ash and 11.4 mg/kg carotene. CHAUDHARY et al. (2016) remarked that the silage from sweet corn had 354.5 g/kg DM, 6.10% CP, 36.00% CF, 76.80% NDF, 46.95% ADF, 4.55% ADL, 5.24% ash and 56.90% IVDOM, but silage from forage corn had 220.0 g/kg DM, 8.00% CP, 27.80% CF, 65.95% NDF, 36.55% ADF, 3.10% ADL, 6.30% ash and 67.65% IVDOM. HERRMANN et al. (2016) remarked that corn silage had 302 g/kg dry matter and 95.8 % organic matter, pH= 3.7, 5.1 % lactic acid, 1.6 % acetic acid, 7.8 % CP, 2.6 % EE, 41.2 % NDF, 24.0 % ADF, 2.9 % ADL. CARPICI et al. (2017)

mentioned that corn silage quality was characterized by: 329.5- 358.6 g/kg DM, pH= 3.78-3.92, 6.94-7.38% CP, 24.64-26.01% ADF, 52.16-53.45% NDF and 2.15-2.25% WSC. GAAFAR et al. (2017) mentioned that corn silage quality was: pH = 4.15 -4.10, 4.52-4.62 % lactic acid, 332.0 -328.6 g/kg DM, 93.60-93.73% OM, 8.37-8.15% CP, 26.43- 25.77% CF, 2.92-2.85% EE, 55.88 -56.99% NFE, 6.40-6.24% ash, 49.60- 47.85% NDF, 29.70-28.35 % ADF, 5.70- 5.48% ADL, 65.37-65.80% TDN, 5.62-5.39% DCP, 4.419-4.423 Mcal/kg GE, 2.856-2.885 Mcal/kg GE, 64.38-66.23 % OMD, and 64.42-66.99% IVDMD. ȚÎȚEI & ACBAȘ (2018) reported that the dry matter content and forage value of *Zea mays* silage were 294.6 g/kg DM, pH=4.25, 27.6 g/kg lactic acid, 6.2 g/kg acetic acid, 6.52% CP, 3.23% EE, 20.33% CF, 65.66% NFE, 4.26% ash, 25.34 % ADF, 48.47 % NDF, 3.35% ADL, 23.13% HC, 21.99% Cel, 70.1% DDM, 64.4% DOM, RFV=132. LI et al. (2021) mentioned that the chemical composition of the silage from dual-purpose corn type was 333.4 g/kg DM, pH 3.84, 48.6 g/kg lactic acid, 10.2 g/kg acetic acid, 8.73% CP, 2.38% EE, 27.75 % starch, 2.26 %WSC, 43.12 % NDF, 22.49 % ADF, 2.47 % ADL, 4.90% ash, 71.84% TDN, but from silage-specific corn 293.7 g/kg DM, pH 3.88, 50.6 g/kg lactic acid, 13.8 g/kg acetic acid, 8.82% CP, 2.08% EE, 22.90 % starch, 2.29 %WSC, 50.34 % NDF, 25.97% ADF, 3.14 % ADL,

and 4.88% ash, 68.36 % TDN. ESEN et al. (2022), mentioned that the dry matter content and the chemical composition of corn ensiled material was: 247.1 g/kg DM with 7.54% CP, 6.73% ash, 55.44 % NDF, 30.90% ADF, 4.73% ADL, 24.54% HC, 26.17% Cel, pH =3.90, 3.95 g/kg free lactic acid, RFV=108.9. ZHANG et al. (2022) found that whole plant corn silage had pH =3.82, 7.6 g/kg lactic acid and 1.14 g/kg acetic acid contained 294.2 g/kg DM with nutrient composition 10.32 % CP, 2.06 % EE, 4.33% ash, 48.36% NDF, 30.38 % ADF and 28.56 % starch; sweet corn stalklage had pH =4.53, 3.84 g/kg lactic acid, 0.56 g/kg acetic acid, 252.1 g/kg DM, 11.41 % CP, 1.78 % EE, 4.26 % ash, 50.57 % NDF, 36.35 % ADF, 19.37 % starch; corn stalklage had pH =4.14, 4.67 g/kg lactic acid, 0.74 g/kg acetic acid, 344.7 g/kg DM, 9.68 % CP, 1.13 % EE, 6.18 % ash, 62.72 % NDF, 39.36 % ADF and 13.48 % starch. KINTL et al. (2023) noted that the dry matter content and forage value of *Zea mays* silage was 212.3 g/kg DM, 15.6% CP, 2.24% EE, 23.48% CF, 12.37% carbohydrates, 19.83 % starch, 4.90% ash, 27.68 % ADF, 58.11 %

NDF, 3.43% lignin. According to COȘMAN et al. (2023), the quality of the silage prepared from dent corn plant harvested in kernel milk stage was 202.5-262.8 g/kg DM, 7.63-9.13% CP, 2.35-3.27% EE, 26.65-28.05% CF, 45.85-50.72% NFE, 1.35-1.79 % sugar, 15.15-28.00 % starch, 5.50-7.43% ash, 2.2-3.1 g/kg Ca, 1.7-2.2 g/kg P, 15.15-28.00 mg/kg carotene; corn silage prepared in kernel milk-wax stage – 277.0-317.2 g/kg DM, 5.56-8.00% CP, 2.19-4.02% EE, 18.42-26.48% CF, 54.47-61.35% NFE, 1.65-6.56 % sugar, 10.18-17.33 % starch, 3.92-5.63% ash, 1.6-3.8 g/kg Ca, 1.2-2.2 g/kg P, 10.80-16.17 mg/kg carotene; while silage prepared in kernel wax stage – 30.73-40.96 g/kg DM, 6.63-7.31% CP, 2.82-3.82% EE, 14.50-18.41% CF, 61.63-66.90% NFE, 1.59-2.47 % sugar, 19.32-27.45 % starch, 3.41-3.93% ash, 1.6-3.3 g/kg Ca, 1.5-2.9 g/kg P, 19.67-21.02mg/kg carotene SHARIF et al. (2023) reported that the the quality of corn silage was pH=3.90, 327.8 g/kg DM, 1.95 % lactic acid, 1.28 % acetic acid, 8.35 % CP, 2.34 % EE, 22.12% CF, 5.12% ash, 51.12 % NDF, 26.12 % ADF.

CONCLUSIONS

The forages from sweet corn hybrid '*Porumbeni 343*' was characterized by a higher level of crude protein and a lower level of acid detergent lignin.

The forages from the dent corn hybrid '*Porumbeni 374*' stands out due to its lower concentration of crude cellulose, higher level of hemicellulose, and better digestibility and energy supply.

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NUTRITIONAL EVALUATION OF STRAW FROM LEGUMINOUS CROPS GROWN IN THE REPUBLIC OF MOLDOVA

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Abstract. This article presents the results of a study on the biochemical composition and nutritive value of crop residues (straw) from several leguminous crops – chickpea (*Cicer arietinum*), soybean (*Glycine max*), grass pea (*Lathyrus sativus*), white lupin (*Lupinus albus*), pea (*Pisum sativum*), fenugreek (*Trigonella foenum-graecum*), and faba bean (*Vicia faba*) – cultivated in the central zone of the Republic of Moldova. The biochemical composition of investigated leguminous crops straw was characterized by the following indices: 75-128 g/kg CP, 57-104 g/kg ash, 380-459 g/kg CF, 400-553 g/kg ADF, 593-807 g/kg NDF, 72-102 g/kg ADL, 328-439 g/kg Cel, 118-256 g/kg HC. The forage value indices of investigated leguminous straw were 460-531 g/kg DDM, RFV=53-90, 7.7-9.4 MJ/kg ME and 3.76-5.43 MJ/kg NEL. These findings suggest that straw from *Glycine max*, *Pisum sativum*, *Vicia faba*, *Trigonella foenum-graecum* and *Cicer arietinum* may be used as a part of diversified livestock diets.

Keywords: biochemical composition, nutritive value, crop residues - straw, *Cicer arietinum*, *Glycine max*, *Lathyrus sativus*, *Lupinus albus*, *Pisum sativum*, *Trigonella foenum-graecum*, *Vicia faba*

INTRODUCTION

Ruminant animals play a major role in the production of meat, milk, and other animal-derived raw materials for various industries, as well as in supporting farmers' livelihoods and rural development. Ruminant animals have a unique ability to utilize roughages. Currently, livestock production is increasingly constrained by feed shortages and rising input costs, driven by climate change, competition for land use, and growing livestock populations. Conventional feeding systems based on cereals and cultivated forages are

becoming less sustainable due to their dependence on costs of oil resources, irrigation, fertilizers, and mechanization. Consequently, there is increasing interest in the rational use of grasslands, the exploration of new forage plant species, and the utilization of alternative and underexploited forage resources, including crop residues, that can support livestock productivity while reducing environmental impacts and production costs (COȘMAN et al. 2023). Plants of the family Fabaceae (syn. *Leguminosae*, *Papilionaceae*) are an important source of protein

and other nutrients for human and animal nutrition, as well as feedstock for biorefineries, various industrial products, and bioenergy. Annual leguminous crops serve as excellent preceding crops for cereals and autumn-sown forage crops, contributing to improved crop rotations and more sustainable agricultural practices. It is expected that the cultivated area and diversity of multipurpose, protein-rich leguminous crops will expand in Europe. This expansion is likely to be driven by EU policies promoting leguminous crops as part of sustainable agriculture and by efforts to reduce dependence on imported genetically modified soybean from the USA, Brazil, Argentina, and China (European Parliament resolution, 2018). At the “Alexandru Ciubotaru” National Botanical Garden (Institute) of Moldova State University, the gene pool of Fabaceae species has been expanded over recent decades through the mobilization of material from both

the spontaneous flora and various floristic regions of the world. Several of these species have been studied for their potential use as food and fodder plants, melliferous resources, and energy crops (TELEUȚĂ et al., 2015; TELEUȚĂ & ȚIȚEI 2016; ȚIȚEI 2021, 2022, 2023, 2025; ȚIȚEI & COZARI, 2022; ABABII et al., 2023; COȘMAN et al. 2023; ȚIȚEI et al. 2024). Among the feed resources commonly used in ruminant nutrition, some remain underutilized, such as leguminous straw, largely due to limited information on their chemical composition and nutritive value. To formulate balanced diets that include leguminous straw, it is essential to understand the nutritive value of this roughage and its variability, as different straw sources differ in nutrient content and digestibility. The objective of this study was to determine the biochemical composition and nutritive value of crop residues (straw) obtained after grain harvest of leguminous crops.

MATERIALS AND METHODS

Chickpea (*Cicer arietinum*), soybean (*Glycine max*), grass pea (*Lathyrus sativus*), white lupin (*Lupinus albus*), pea (*Pisum sativum*), fenugreek (*Trigonella foenum-graecum*), and faba bean (*Vicia faba*) were cultivated in a non-irrigated experimental plot at the “Alexandru Ciubotaru” National Botanical Garden (Institute), Moldova State University, Central

zone, Republic of Moldova. Samples of crop residues (straw) were collected after grain harvest (threshing) and chopped into 1.5–2.0 cm pieces using a laboratory forage chopper. Dry matter content was determined by drying the samples at 105°C until a constant weight was achieved. For biochemical analysis, the straw samples were milled in a beater mill equipped with a 1 mm sieve. Key biochemical parameters –

including crude protein (CP), ash, acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL) – were assessed using near-infrared spectroscopy (NIRS) with a PERTEN DA 7200 instrument at the Research and Development Institute

for Grasslands in Brașov, Romania. The concentration of hemicellulose (HC), cellulose (Cel), digestible dry matter (DDM), metabolizable energy (ME), net energy for lactation (NEL) and relative feed value (RFV) were calculated according to standard procedures.

RESULTS AND DISCUSSION

The performance, welfare, and health of livestock are strongly influenced by feed quality. The analysis of the biochemical composition of the collected straw from the studied leguminous crops (Figs. 1-6) showed that straw dry matter contained 75-128 g/kg crude protein (CP), 57-104 g/kg ash, 380-459 g/kg crude fiber (CF), 400-553

g/kg acid detergent fiber (ADF), 593-807 g/kg neutral detergent fiber (NDF), 72-102 g/kg acid detergent lignin (ADL), 328-439 g/kg cellulose (Cel), and 118-256 g/kg hemicellulose (HC). The straw from *Pisum sativum*, *Trigonella foenum-graecum*, *Vicia faba*, and *Glycine max* exhibited higher crude protein content, exceeding 10%.

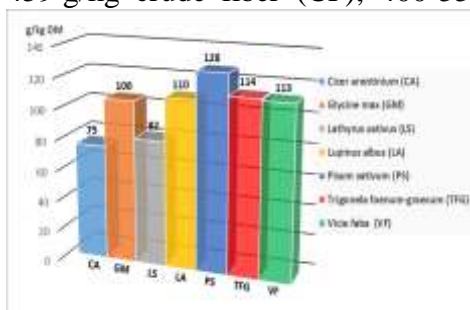


Fig. 1. Crude protein, g/kg dry matter

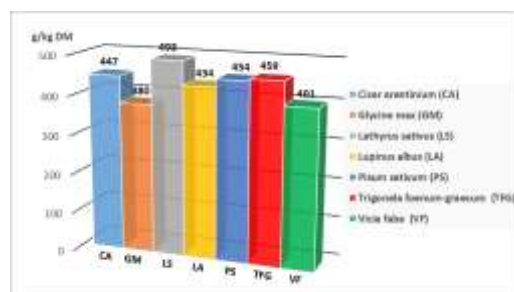


Fig. 2. Crude fibre, g/kg dry matter

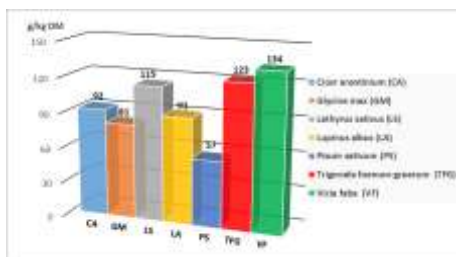


Fig. 3. Minerals, g/kg dry matter



Fig. 4. Acid detergent lignin, g/kg dry matter

Moreover, the straw from *Vicia faba* and *Glycine max*

contained lower amounts of crude fiber, although still higher than that

in *Lathyrus sativus* straw. The mineral content in *Pisum sativum* straw was considerably lower than that in *Trigonella foenum-graecum*, *Vicia faba*, and *Lathyrus sativus* straw. The acid detergent lignin

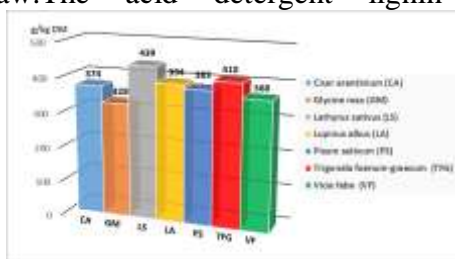


Fig. 5. Cellulose, g/kg dry matter

content in *Lathyrus sativus*, *Lupinus albus*, *Trigonella foenum-graecum* straws reached 103-107 g/kg dry matter, significantly higher than in the *Glycine max* and *Cicer arietinum* straws.

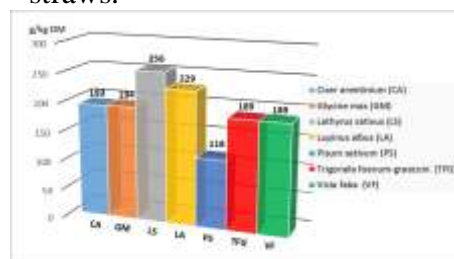


Fig. 6. Hemicellulose, g/kg dry matter

Cellulose content did not differ significantly between *Cicer arietinum* and *Vicia faba* straw and was lower than in *Lathyrus sativus*

and *Trigonella foenum-graecum* straw, but higher than in *Glycine max* straw.



Fig. 7. Digestible dry matter, g/kg dry matter

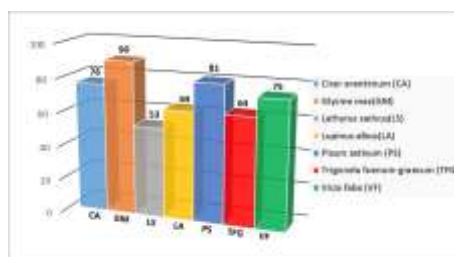


Fig. 8. Relative feed value

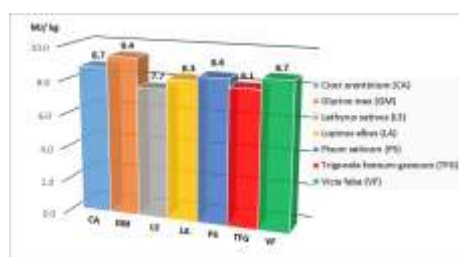


Fig. 10. Metabolizable energy, MJ/kg

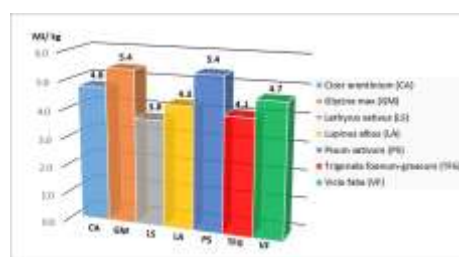


Fig. 11. Net energy for lactation, 9.4 MJ/kg

Hemicellulose concentration was lower in *Pisum sativum* straw and higher in *Lathyrus sativus* and *Lupinus albus* straw. Straw from *Cicer arietinum*, *Glycine max*, *Trigonella foenum-graecum*, and

Vicia faba had comparable hemicellulose concentrations.

The concentration of structural carbohydrates directly influences forage digestibility, feed value, and energy supply. *Glycine*

max straw had 577 g/kg digestible dry matter (DDM), relative feed value (RFV) = 90, 9.4 MJ/kg metabolizable energy (ME), and 5.4 MJ/kg net energy for lactation (NEL), whereas *Lathyrus sativus* and *Trigonella foenum-graecum* straw had 460–486 g/kg DDM, RFV = 53–64, 7.7–8.1 MJ/kg ME, and 3.8–4.1 MJ/kg NEL. Some authors mentioned various findings about the biochemical composition and nutritional value of crop residues after grain threshing of leguminous crops. According to Mustafa et al. (1996) the chemical composition of fenugreek straw was 5.2% CP, 73.7% NDF, 57.1% ADF, 10.6% ADL, 5.8% ash and 424 g/kg IVDDM. NEIJAT & GALLAGHER (1997) reported that nutritive value of pea straw was 974.2 g/kg DM with 5.06% ash, 0.84% N, 73.74% NDF, 55.96% ADF, 9.48% ADL, 46.48% Cel, 17.78% HC and 413 g/kg IVDDM. ABREU & BRUNO-SOARES (1998) mentioned that the nutritional quality of chickpea straw was 5.0% CP, 50.6% CF, 75.5% NDF, 57.9% ADF, 14.2% ADL, 4.7% ash; horse bean straw- 6.60% CP, 46.7% CF, 72.3% NDF, 55.4% ADF, 11.6% ADL, 7.6% ash; field pea straw -9.7% CP, 34.2% CF, 58.0% NDF, 40.0% ADF, 8.3% ADL, 10.1% ash; white lupin straw - 5.9% CP, 55.3% CF, 82.4% NDF, 63.8% ADF, 12.6% ADL, 4.1% ash. LOPEZ et al. (2005) noted that nutritional compositions and feeding quality of straws from *Cicer arietinum* was 920-924 g/kg DM

with 4.3-7.2% CP, 1.0-1.6% EE, 63.9-66.9 % NDF, 46.8-47.7% ADF, 10.1-11.5 % ADL, 6.5-7.2%ADL, 54.3-61.0% DDM and 7.2 MJ/kg ME; *Lathyrus sativus* 907 g/kg DM, 92% CP, 2.4% EE, 53.9% NDF, 38.4% ADF, 8.2% ADL, 68.2 % DMD and 7.6; *Lupinus albus* 943 g/kg DM, 5.6% CP, 0.8% EE, 58.8% NDF, 42.0% ADF, 6.1% ADL, 69.3 % DMD and 7.7 MJ/kg ME, *Pisum sativum* 897 g/kg DM, 6.5 %CP, 2.1% EE, 54.8% NDF, 38.4% ADF, 6.0% ADL, 70.4% DMD and 7.7 MJ/kg ME. SAINI (2005) found that *Trigonella foenum-graecum* straw had 885.0 g/kg DM, 88.40% OM, 11.50% CP, 37.00% CF, 1.20% EE, 38.70% NFE, and 11.60% ash. MULE et al. (2008) revealed that nutritional value of soybean straw was as 884.5 g/kg DM, 7.88%CP, 1.25% EE, 38.10% CF, 38.99% NFE, 13.78% total ash 49.50-54.66% DMD depending of treatment effect. EL-BORDENY & EBTEHAG (2010) remarked that remarked that faba bean straw contained 912.0 g/kg DM, with 83.80% OM, 4.60% CP, 37.50% CF, 1.25% EE, 16.204% ash, 40.45% NFE, while chick-pea straw respectively 876.0 g/kg DM, 94.10% OM 8.10% CP, 32.80% CF, 1.70% EE, 5.9% ash, 51.50% NFE. MAHERI-SIS et al. (2011) mentioned that the forage nutritional quality of soybean straw was 891.8 g/kg DM, 5.10% CP, 2.85% EE, 96.90% OM, 80.80% NDF, 63.20% ADF, 13.00% ADL. GOLSHANI et al. (2012) noted that chickpea straw

had 921.8 g/kg DM, 92.00% OM, 6.05% CP, 5.50% EE, 34.30% CF and 46.15% NFE. MELGAREJO et al. (2014) found that pea residual biomass contained 26% cellulose, 20.5% hemicellulose and 3.92% lignin and soybean hulls respectively 46-51% cellulose, 16-18% hemicellulose and 1.4-2% lignin. SHERASIA et al. (2015) reported that chickpea straw had 91.7% OM, 4.9% CP, 2.0% EE, 45.1% CF, 65.2% NDF, 46.3% ADF, 18.9% HC, 8.3% ash, 7.8 g/kg Ca, 1.3 g/kg P, 50.5 %TDN, 7.5 MJ/kg ME, 4.2 MJ/kg NEL, but fenugreek straw - 94.9% OM, 7.2% CP, 0.7% EE, 59.0% CF, 72.7% NDF, 54.8% ADF, 17.9% HC, 5.1% ash, 4.2 g/kg Ca, 0.9 g/kg P, 41.5 %TDN 5.8 MJ/kg ME, 2.7 MJ/kg NEL. HEUZÉ et al. (2015, 2016) reported that pea straw contained 888g/kg DM with 8.2% CP, 36.3% CF, 54.9% NDF, 38.7% ADF, 7.2% lignin, 9.8% ash, 23.7 g/kg Ca, 1.1 g/kg P, 57.5% DOM, 18.1 MJ/kg GE, 9.8 MJ/kg DE and 7.9 MJ/kg ME; chickpea straw - 904g/kg DM with 5.4% CP, 41.0% CF, 65.6% NDF, 46.9% ADF, 11.9% lignin, 7.4% ash, 9.4 g/kg Ca, 1.6 g/kg P, 45.0% DOM, 18.1 MJ/kg GE, 7.5 MJ/kg DE and 6.1 MJ/kg ME; soybean straw - 890g/kg DM with 6.9% CP, 44.2% CF, 79.7% NDF, 59.9% ADF, 16.4% lignin, 7.9% ash, 52.8% DOM, 19.0 MJ/kg GE, 9.4 MJ/kg DE and 7.5 MJ/kg ME. KILIÇALP et al. (2017) mentioned that nutrients contents of chickpea straw were ranged from 5.61 to 7.42% CP, 51.33 to 56.0% ADF,

63.67 to 67.0% NDF, 8.0 to 9.0% ash, with 49.65 to 54.91% potential degradability and 5.96 to 7.37 MJ/kg ME. MALUSHI SIBAOUEIH (2017) revealed that the nutritive value of pea straws was 915-918 g/kg DM, 7.6-9.8% ash, 7.3-11.1%CP, 36.3-46.3% CF, 1.0-1.9% EE, 53.3- 65.4% NDF, 42.3-50.4% ADF, 8.1-10.7%ADL. DRONCA et al. (2018) reported that nutritional compositions of fenugreek husk were 884 g/kg DM with 7.81% CP, 1.3-1.6% EE. BAL BAHADUR (2019) remarked that chemical composition of soybean straw was 891.8 g/kg DM, 5.10%CP, 2.85% EE, 96.90% OM, 80.80% NDF, 63.20%ADF, 13.00% ADL. MADAVI et al. (2019) observed that soybean straws containing 7.15% CP, 1.52% EE, 38.29% NFE, 41.29% CF and 11.86 % ash. MAWAL NILESH et al. (2019) found that soybean straw containing 876.2 g/kg DM with 6.13% CP, 2.51% EE, 37.29% CF, 44.21% NFE and 9.86% ash. SIBAOUEIH et al. (2021) revealed that the nutritional compositions of chickpea crop residues.was: 8.85% ash, 7.14% CP, 58.76 % NDF, 40.17 %ADF, 10.34%ADL. ALAEI et al. (2022). remarked that the chemical composition of green pea residues was 971.7g/kg dry matter, 9.66% crude protein, 8.49% ash, 47.33% ADF, 62.66% NDF, 44.9% cellulose, 20.4% hemicellulose, and 13.7% lignin. MAIA et al. (2023) mentioned that the nutritive value of straw from *Lupinus albus* was

4.37% ash, 5.30% CP, 0.54% EE, 66.5 % NDF, 51.3% ADF, 10.3% ADL, 18.3 MJ/kg ME, while from *Lupinus angustifolius* 5.11% ash, 6.89% CP, 0.55% EE, 65.9 % NDF, 50.0% ADF, 10.7%ADL, 18.3 MJ/kg ME, but from *Lupinus luteus* respectively 5.32% ash, 5.83% CP, 0.57% EE, 64.8 % NDF, 49.0% ADF, 11.1%ADL and 18.3 MJ/kg ME. KEHSRI al. (2024) reported that nutritional composition of

soybean straw can vary depending on variety, growing conditions, and harvesting methods, on average, it contains: 880-920 g/kg DM, 4-7% CP, 65-75% NDF, 45-55% ADF, 7-10% lignin, 5-8% ash. PINKOWSKA et al. (2024) noted that dry matter compositions of white lupin straw was 921g/kg DM with 4.8% CP, 41.54% Cel, 13.45% HC, 19.82% sulfuric acid-insoluble lignin, 5.2% ash.

CONCLUSIONS

Straw from *Glycine max*, *Pisum sativum*, *Vicia faba*, *Trigonella foenum-graecum*, and *Cicer arietinum* demonstrated favorable forage quality and can serve as a valuable feed resource suitable for inclusion in diverse livestock feeding systems, including goats, sheep, cattle, and buffalo. In contrast, straw from *Lathyrus sativus* and *Lupinus albus* has nutritional limitations that require careful diet

formulation and supplementation; however, various treatment methods can improve its feeding value.

Crop residues (straw) from leguminous crops can contribute to cost-effective and sustainable ruminant production systems, particularly in regions with limited grassland availability or where fodder crop production is affected by drought, such as during periods of fodder shortage.

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