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PRACTICULTURE AND PASTORALISM IN SCIENTIFIC RESEARCH

A reference work on grasslands

The achievements of PhD. Eng. Teodor Marușca in the field of grassland culture in particular and pastoralism, obtained through assiduous and systematic research of great scientific and practical value, become a heritage in the field that must be considered by all those who approach not only grasslands as a land holding, but also the entire area of activities that is related in one way or another to this field (climatic conditions, conditions and consequences of human activities, infrastructure and the set of economic activities with administrative and political decisions) regarding this extremely complex and important way of using agricultural land and more.

The results obtained by the author of the book through a scientific work at the highest level, constitute a true national heritage that in one form or another will be used by the generations of researchers and practitioners who come and willingly or unwillingly will be obliged to consult and take into account what Mr. PhD. Teodor Marușca and the people next to him achieved in a highly professional activity, in a human life.

I am more than convinced that such a book as the present one, consisting of nine chapters in which the problems of pratology, pratotechnique and pastoralism, followed by appendices, will be not only a way of presenting some scientific results obtained over the years, a rich bibliography, an inventory of doctoral theses in which the author participated as a scientific referent, being a development model not only of research in the field, but especially of practice and directions for development and capitalization of the immense wealth that Romania has, the permanent grasslands insufficiently exploited and often neglected with the irresponsibility that characterizes us in the last 30 years.

At first glance, the book seems, as the author wants to say, an end-of-activity work, a balance sheet. In my opinion, it is not. On the contrary, the book is an opening for study, analysis and offers the chance to find solutions to bring into the economic circuit a sector, the pastoral one, of utmost importance for animal breeding, biodiversity conservation, environmental protection, landscape integration and others.

In the first chapter of the book, the author develops topics such as the specifics of scientific research in practiculture, the Swiss pastoral system and the current situation of grasslands in Romania.

In the second chapter, the problem of the scientific research of grassland vegetation is deepened, as a research method, the floristic composition and classification of switchgrass, grasslands habitats and the technique of evaluating the productivity of grasslands, based on floristic survey.

In chapters 3 - 4, the author develops problems related to: combating harmful grassy and woody vegetation, fertilization techniques and improvement

of grasslands, by using chemical but also organic fertilizers by grazing with animals.

The fifth chapter presents problems related to the improvement and creation of new varieties of perennial grasses and legumes, as well as simple or complex mixtures of them for the establishment of temporary arable grasslands or the radical restoration of degraded ones.

In the sixth chapter, the solutions given by the methods of improving the grasslands degraded by *Nardus stricta*, a non-valuable species that dominates the grassy carpet of premontane to subalpine grasslands in the high mountains, are highlighted with great knowledge. Extremely well represented in chapters 7 - 8 are the solutions for the valorisation of grasslands by grazing with animals as well as the reconstruction by reforestation of land devoid of vegetation, for the protection of the environment and the completion of the landscape.

The last chapter is dedicated to agrosilvopastoral systems and climate change – determinants of the evolution of permanent and temporary grasslands. There is a presentation of the Romanian agrosilvopastoral systems to the development of which the author of the book made a decisive and I would say unique contribution through the method of calculation and especially interpretation. The book is supported by an excellent bibliography in the field.

Annex 1 presents a list of very valuable scientific works developed as a single author or in a collective.

The author of the book, PhD. Eng. Teodor Marușca, is an excellent publicist, being present with articles in specialized magazines, especially in the last quarter of a century.

These published articles, numbering in the hundreds, are of particular importance from a scientific and practical point of view, in the extension of research results.

The more than 800 titles of published works are mainly based on an impressive volume of field and laboratory experiences from the student period 1959-1964, and the research profession 1968-1977, respectively 1995-2022, amounting to 1966 variants with 4311 plots on 23 ha under control, which multiplied by years of experimentation add up to almost 20,000 plots, 171 ha and over 40,000 samples for different analyses.

As a good connoisseur of the field of grasslands, PhD. Eng. Teodor Marușca was a referent in 70 doctoral committees, thus contributing to the training and certification of a large number of specialists in research, education and production.

Professor *Valeriu TABĂRĂ*, PhD
President of the Academy of Agricultural and Forestry Sciences
„Gheorghe Ionescu - Șișești”

THE INFLUENCE OF FERTILIZATION ON THE DRY MATTER YIELD OF *FESTUCA RUPICOLA* GRASSLAND

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Abstract

Sown (temporary) grasslands are valuable agricultural crops due to the high yield of dry matter they achieve, but equally to the quality of the fodder obtained. In the present paper, we aimed to study the influence of organic and mineral fertilization on dry matter yield on a *Festuca rupicola* type of grassland from Turda, Cluj County. To answer the objectives of this research, an experience with 6 experimental variants, in four repetitions (blocks), was installed. The productivity of *Festuca rupicola*'s grassland increases proportionally as increases the amounts of fertilizers applied. We recommend a management plan which should contain adequate maintenance and a system of sustainable use and fertilization.

Keywords: Turda, productivity, *Festuca rupicola*'s grassland, fertilization, organic input

INTRODUCTION

Cultivated grass and leguminous species that are treated as agricultural crops benefit from free ecological niches, which makes their productivity under conditions of high trophicity remarkable.

In the competitive hierarchy of semi-dry grasslands, monocotyledonous species such as grasses are stronger competitors than forbs (PARTZSCH *et. al*, 2018).

More frequent and severe drought events are expected to have a negative impact on herbage

production and fodder quality of permanent grassland (HOFFSTÄTTER-MÜNCHBERG *et al.*, 2011). As man-made habitats, nutrient-poor dry grasslands harbor numerous species whose original habitats (floodplains, peatlands, and rocky outcrops) have been largely destroyed (BAUR, 2004).

Festuca taxa are important grassland species in the Pannonian vegetation, and they are a dominant component of the Pannonian vegetation where conditions are too extreme (FURÉSZ *et. al*, 2022

The Transylvanian Depression is famous for its extensive grasslands of various types, most of which have been used traditionally, until now, being manually mowed or extensively grazed (LOOS *et. al*, 2021).

MATERIAL AND METHOD

Our experiment was designed according to the method of randomized blocks, in four repetitions (blocks), with 6 experimental variants. The type of grassland was *Festuca rupicola*, and the area of an experimental plot was 20 m² (Figure 1). The experimental variants were the following: V1-control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Fertilization of the experimental variants was carried out in each experimental year (ie: the springs of 2018, 2019, 2020, 2021). Both mineral fertilizers and manure were applied annually at the optimal time. Biomass was harvested from each experimental variant with a mower (BCS 630 WS mower). The mowing height was 4 cm above the ground. Biomass harvesting was carried out only once a year at the optimal mowing time. The experiments were located on the surface of some grasslands at the Turda Agricultural Research and Development Station (ARDS Turda). The experiments were

Regarding these, we established to study the influence of organic and mineral fertilization on dry matter yield on a *Festuca rupicola* type of grassland from Turda, Cluj County, Romania.

located at an altitude of 398 m (according to the data taken with GPS GARIN GASPAM 66S), having the following coordinates: 46° 35' 15.0" N 23° 57' 49.3" E.

The experiments were carried out on an argiloiluvial chernozem soil type that has a sequence of Am-Bty-C horizons. In 2017, before the start of the experiments, a description of the soil profile was carried out and physico-chemical data were collected. The analyzes were carried out by the Office of Pedological and Agrochemical Studies in Cluj-Napoca, supported by colleagues from ARDS Turda.

The experimental data on the productivity of the grassland for each experimental year were processed with the analysis of variance, which is a statistical-mathematical method of processing the obtained data. Analysis of variance allows the simultaneous study of the variability of several experimental variants. This method presents an economic efficiency for experimentation, as it allows the identification of significant effects between variants, based on a small number of measurements. The

processing of these data was carried out with the PoliFact program.



Fig. 1 Protocol of the experiment with organic and mineral fertilizers
(V- fertilization variant; R-replication)

RESULTS AND DISCUSSIONS

As part of our experience, it was aimed to increase the yield of dry matter (DM) by applying organic and mineral fertilizers, experienced in the nemoral zone - the Transylvanian Plain on a type of *Festuca rupicola* grassland. The DM harvest of semi-natural grassland and especially of this type of grassland is different from one site to another, being between 2 and 13 t/ha⁻¹ DM (ELSASSER, 2004). As expected, since the first year (2018), the effect of organic and mineral fertilizers on the dry matter harvest can be observed, through the yield increases achieved by the

fertilized variants, compared to the control variant.

In the first year, the highest dry matter harvest, compared to the control, is obtained in the case of the variant with 10 t/ha⁻¹ manure + N₁₀₀P₅₀K₅₀, of 3.58 t/ha⁻¹ DM (150.5%), and the weakest in the variant with 10 t/ha⁻¹ manure, of 2.53 t/ha⁻¹ (106.3%; table 1).

In the variant with 10 t/ha⁻¹ manure, the difference in yield compared to the control is insignificant, on the other hand, in the case of the variants V4 with N₅₀P₂₅K₂₅, V5 (N₁₀₀P₅₀K₅₀) and V6 (10 t/ha⁻¹ manure + N₁₀₀P₅₀K₅₀) the differences are statistically ensured.

The effect of manure on the DM harvest is minimal in the first year and maximal in the second year, after which it gradually decreases, a fact observed over time by numerous researchers in this field (VÎNTU, *et. al.*, 2011, SAMUIL *et. al.*, 2017, MOTCĂ, 1978 etc.).

The productivity of *Festuca rupicola* grassland was low to medium which can support a grazing capacity between 0.4-0.6 LU/ha, according to specialized studies in this field (ROTAR *et al.*, 2010). The productive potential of this type of grassland varies

according to ecological factors, season (altitude, state of supply with mineral elements, etc.), floristic composition and applied management (especially fertilization-PORQUEDDU *et al.*, 2008).

The assignment of an agronomic value to each plant entity in grassland (genus, species, subspecies) may be relevant for some studies that aim to evaluate the productive potential of semi-natural grassland (ROGERRO *et al.*, 2002).

Table 1

The influence of fertilizers on dry matter harvest, year 2018

Variant	t/ha ⁻¹	%	Difference	Significance
V1	2.38	100.0	0.00	Mt.
V2	2.53	106.3	0.15	-
V3	2.60	109.5	0.22	-
V4	2.70	113.7	0.33	*
V5	2.83	118.9	0.45	**
V6	3.58	150.5	1.20	***

DL (p 5%) 0.24

DL (p 1%) 0.33

DL (p 0.1%) 0.46

Legend: V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 2

The yield differences among variants and their significance

Variations in increasing order of harvest	Dry matter harvest t/ha ⁻¹	Variations in increasing order of harvest				
		V 2	V 3	V 4	V 5	V 6
		t/ha ⁻¹				
		2.53	2.60	2.70	2.83	3.57
V 1	2.38	0.15	0.22	0.33	0.45	1.20
V 2	2.53		0.07	0.18	0.30	1.05
V 3	2.60			0.10	0.23	0.97
V 4	2.70				0.13	0.87
V5	2.83					0.75
V6	3.57					

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 3

The yield differences among variants and their significance

The error of the means $SX = 0,08(t/ha^{-1})$					
Distance in classification	V 2	V 3	V 4	V 5	V 6
Values q	3.01	3.16	3.25	3.31	3.36
Theoretical DS values	0.24	0.25	0.26	0.27	0.27

It is known that manure has a staggered effect in more years. Between the application of $10 t/ha^{-1}$ manure + $N_{50}P_{25}K_{25}$ and $10 t/ha^{-1}$ manure + $N_{100}P_{50}K_{50}$ a significant difference of $0.98 t/ha^{-1}$ DM is noticed. In the variants treated with organic and mineral fertilizers, the harvest is primarily due to the mineral fertilizers and, to a small extent, the organic ones.

In the second year of experiment (2019) the highest harvest of DM ($3.95 t/ha^{-1}$ DM) is achieved by the application of $10 t/ha^{-1}$ manure + $N_{100}P_{50}K_{50}$, with an additional harvest of $1.75 t/ha^{-1}$ DM, compared to the untreated variant, statistically very significant difference (table 4). The minimum increase compared to the control is registered when applying $10 t/ha^{-1}$ manure (126.1%), where the difference of $0.58 t/ha^{-1}$ is very significant. The dry matter harvest noticed in the variants with $10 t/ha^{-1}$ manure + $N_{50}P_{25}K_{25}$ ($2.88 t/ha^{-1}$ DM) is achieved on account of the mineral fertilizers applied as well as the manure applied one year later. These variants achieved a significant harvest of DM, a fact also confirmed by ROTAR *et al.* (2003), who state that organo-

mineral fertilization, in moderate doses, considerably increases the yield of DM.

The high level of the harvest is the result of the applied treatments, but also largely of the climatic conditions, which were very favourable for the growth of the grass in 2019. In a study carried out by SAMUIL *et al.*, in 2010, the productions obtained show that the chemical fertilizers applied $N_{200}P_{100} kg/ha^{-1}$ to a mixture consisting of *Medicago sativa* with a participation percentage of 70% and *Dactylis glomerata* 30% can be obtained a harvest of $11.66 t/ha^{-1}$ DM.

Thus, in the second experimental year (2019) all the experimental variants register increases in production compared to the control ($p > 0.05$). The highest increase in production is recorded in variant V6 where $10 t/ha^{-1}$ manure + $N_{100}P_{50}K_{50}$ was applied (179.5 %), followed by variants V5 ($N_{100}P_{50}K_{50}$) and V3 ($10 t/ha^{-1}$ manure + $N_{50}P_{25}K_{25}$).

Results similar to ours were also obtained by PĂCURAR in 2005, during an experiment with organic fertilizers on the Ghețari, Apuseni Mountains, when he showed that in the second year the

dry matter harvest increases simultaneously with the increase the manure amount from 2.70 t/ha⁻¹ DM (semi-natural grassland) to 7.74 t/ha⁻¹ DM (at variant fertilized with 30 t/ha⁻¹ manure), increases ensured from a statistical point of view.

The comparative analysis using the Duncan test at the level of 2019, with the analysis of the

overlap of the experimental treatments over the climatic conditions, shows the beneficial effect of the inputs applied with manure in combination with mineral fertilization (V6-10 t/ha⁻¹ manure + N₁₀₀P₅₀K₅₀) compared to the control variant (V1), the observed differences being statistically significant (table 5 and 6).

Table 4

The influence of fertilizers on dry matter harvest, year 2019

Variant	t/ha ⁻¹	%	Difference	Significance
V1	2.20	100.0	0.00	Mt.
V2	2.78	126.1	0.58	***
V3	2.88	130.7	0.68	***
V4	2.73	123.9	0.53	***
V5	3.08	139.8	0.88	***
V6	3.95	179.5	1.75	***

DL (p 5%) 0.24;

DL (p 1%) 0.34;

DL (p 0.1%) 0.46

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 5

The yield differences among variants and their significance, year 2019

Variations in increasing order of harvest	DM t/ha ⁻¹	Variations in increasing order of harvest				
		V 2	V 3	V 4	V 5	V 6
		DM t/ha ⁻¹				
		2.72	2.78	2.88	3.07	3.95
V 1	2.20	0.53	0.58	0.68	0.88	1.75
V 2	2.72		0.05	0.15	0.35	1.23
V 3	2.78			0.10	0.30	1.18
V 4	2.88				0.20	1.08
V 5	3.07					0.88
V 6	3.95					

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 6

The values of significance difference for the various limits of the comparison between variants, year 2019

The error of the means SX == 0,08(t/ha)					
Distance in classification	V 2	V 3	V 4	V 5	V 6
Values q	3.01	3.16	3.25	3.31	3.36
Theoretical DS values	0.25	0.25	0.26	0.27	0.27

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Numerous research from our country and beyond, show that the application of mineral fertilizers causes increases in yield on all types of semi-natural grassland (VIDICAN and ROTAR, 2003; VÎNTU *et al.*, 2011; MARUȘCA *et al.*, 2014). Nitrogen is the most important element that, depending on the dose, significantly influences the DM harvest (PĂCURAR, 2005). Phosphorus applied alone causes small increases in yield (BĂRBULESCU *et al.*, 1982). In general, phosphorus fertilizers increase yields, but applied in moderate doses of 50 – 60 kg/ha⁻¹ P₂O₅ and combined with nitrogen-based fertilizers.

In the third experimental year (2020), all the yield increases from the treated variants are significant compared to the control variant. The application of both mineral and organic fertilizers caused minor changes in the dry matter yield (table 7, 8 and 9) compared to the second experimental year. The highest yield is registered with the variant V6-10 t/ha⁻¹ manure + N₁₀₀P₅₀K₅₀ with a difference of 1.10 t/ha⁻¹, compared to the control (p<0.05). In the other treatments, even if there is an increase in the DM harvest, this does not present statistical assurance (p>0.05).

Table 7

The influence of fertilizers on dry matter harvest, year 2020

Variant	t/ha ⁻¹	%	Difference	Significance
V1	3.00	100.0	0.00	Mt.
V2	3.00	100.0	0.00	-
V3	3.08	102.5	0.08	-
V4	2.78	92.5	-0.22	-
V5	3.30	110.0	0.30	-
V6	4.10	136.7	1.10	***

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 8

The yield differences among variants and their significance, year 2020

Variations in increasing order of harvest	Dry matter harvest t/ha ⁻¹	Variations in increasing order of harvest				
		V 2	V 3	V 4	V 5	V 6
		SU t/ha				
		3.00	3.00	3.08	3.30	4.10
V 1	2.78	0.22	0.22	0.30	0.52	1.33
V 2	3.00		0.00	0.08	0.30	1.10
V 3	3.00			0.08	0.30	1.10
V 4	3.08				0.22	1.03
V5	3.30					0.80
V6	4.10					

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 9

The values of significance difference for the various limits of the comparison between variants, year 2020

The error of the means $SX = 0.08(t/ha)$					
Distance in classification	V 2	V 3	V 4	V 5	V 6
Values q	3.01	3.16	3.25	3.31	3.36
Theoretical DS values	0.36	0.38	0.39	0.39	0.40

In the fourth year of experience (2021) on the *Festuca rupicola* type of grassland, the results obtained highlight significant yield increases when mineral fertilizers are applied. As can be seen from Table 10, in 2021 the application of the dose of $10\ t/ha^{-1}$ manure + $N_{50}P_{25}K_{25}$ determined significant harvest increases, an aspect that highlights the high production potential of this

type of grassland in case which meets optimal pedo-climatic conditions for development (Table 11,12).

In the variant V5 fertilized only with mineral inputs ($N_{100}P_{50}K_{50}$), it shows a difference of $0.55\ t/ha^{-1}$ DM compared to the control and it is ensured from a statistical point of view.

Table 10

The influence of fertilizers on dry matter harvest, year 2021

Variant	t/ha^{-1}	%	Difference	Significance
V1	3.03	100.0	0.00	Mt.
V2	3.13	103.3	0.10	-
V3	3.38	111.6	0.35	*
V4	3.21	109.3	0.23	*
V5	3.58	118.2	0.55	**
V6	4.23	139.7	1.20	***

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha^{-1} organic manure; V3-10 t/ha^{-1} organic manure + $N_{50}P_{25}K_{25}$; V4- $N_{50}P_{25}K_{25}$; V5- $N_{100}P_{50}K_{50}$; V6-10 t/ha^{-1} organic manure + $N_{100}P_{50}K_{50}$.

Table 11

The yield differences among variants and their significance, year 2021

Variations in increasing order of harvest	Dry matter harvest t/ha^{-1}	Variations in increasing order of harvest				
		V 2	V 3	V 4	V 5	V 6
		DM t/ha^{-1}				
		3.03	3.13	3.38	3.57	4.23
V 1	2.80	0.23	0.33	0.58	0.77	1.43
V 2	3.03		0.10	0.35	0.55	1.20
V 3	3.13			0.25	0.45	1.10
V 4	3.38				0.20	0.85
V 5	3.57					0.65
V 6	4.23					

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha^{-1} organic manure; V3-10 t/ha^{-1} organic manure + $N_{50}P_{25}K_{25}$; V4- $N_{50}P_{25}K_{25}$; V5- $N_{100}P_{50}K_{50}$; V6-10 t/ha^{-1} organic manure + $N_{100}P_{50}K_{50}$.

Table 12

The values of significance difference for the various limits of the comparison between variants, year 2021

The error of the means SX = 0.11(t/ha)					
Distance in classification	V 2	V 3	V 4	V 5	V 6
Values q	3.01	3.16	3.25	3.31	3.36
Theoretical DS values	0.32	0.33	0.34	0.35	0.35

Regarding the analysis of the dry matter harvest over the entire experimental period (2018-2021), the difference in harvest determined by the application of mineral and organic inputs are, in general, statistically ensured, making only the treatment with mineral fertilization in the dose of N₅₀P₂₅K₂₅, when achieves a difference of only 0.10 t/ha⁻¹ DM and which does not present statistical assurance (table 13,14 and 15). The maximum level of harvest achieved in the variants with high doses of fertilizers is much higher

compared to that noticed in the control variant and presents distinctly significant statistical assurance.

We could thus state that the reaction of the phytocenosis to the application of organic and mineral inputs depends on the climatic conditions of a year and the physical-chemical properties of the soil. The utilization of mineral fertilizers on the type of *Festuca rupicola* grassland is very different from one year to another, depending on the climatic conditions recorded.

Table 13

The influence of fertilizers on DM,the average of the years 2018 - 2021

Variant	t/ha ⁻¹	%	Difference	Significance
V1	2.65	100.0	0.00	Mt.
V2	2.85	107.5	0.20	-
V3	2.98	112.3	0.32	**
V4	2.75	103.8	0.10	-
V5	3.18	119.8	0.53	***
V6	3.95	149.1	1.30	***

DL (p 5%) 0.32;

DL (p 1%) 0.44;

DL (p 0.1%) 0.61

Legend: DM-dry matter, V1- control (semi-natural grassland); V2-10 t/ha⁻¹ organic manure; V3-10 t/ha⁻¹ organic manure + N₅₀P₂₅K₂₅; V4- N₅₀P₂₅K₂₅; V5-N₁₀₀P₅₀K₅₀; V6-10 t/ha⁻¹ organic manure + N₁₀₀P₅₀K₅₀.

Table 14

The yield differences among variants and their significance, the average of the years 2018 - 2021

Variations in increasing order of harvest	dry matter harvest t/ha	Variations in increasing order of harvest				
		V 2	V 3	V 4	V 5	V 6
		SU t/ha				
		2.75	2.85	2.97	3.18	3.95
V 1	2.65	0.10	0.20	0.32	0.53	1.30

V 2	2.75		0.10	0.22	0.43	1.20
V 3	2.85			0.13	0.33	1.10
V 4	2.97				0.20	0.97
V5	3.18					0.77
V6	3.95					

Table 15

The values of significance difference for the various limits of the comparison between variants, the average of the years 2018 - 2021

The error of the means $SX = 0.07(t/ha)$					
Distance in classification	2	3	4	5	6
Values q	3.01	3.16	3.25	3.31	3.36
Theoretical DS values	0.21	0.22	0.22	0.23	0.23

CONCLUSIONS

The productivity of *Festuca rupicola*'s grassland increases proportionally as increase the amounts of fertilizers applied.

In the first experimental year (2018), the highest dry matter harvest, compared to the control, is obtained in the case of the variant with 10 t/ha⁻¹ manure + N₁₀₀P₅₀K₅₀ of 3.58 t/ha⁻¹ DM (150.5 %).

In the second experimental year (2019) all the experimental variants recorded increases in production compared to the control ($p > 0.05$). The highest increase in production is recorded in variant V6 where 10 t/ha⁻¹ manure + N₁₀₀P₅₀K₅₀ (179.5 %) was applied, followed by variants V5 (N₁₀₀P₅₀K₅₀) and V3 (10 t/ha⁻¹ manure + N₅₀P₂₅K₂₅).

In the third experimental year (2020), all the yield increases from

the treated variants are significant compared to the control variant.

In the fourth year of experience (2021) on the type of *Festuca rupicola* type of grassland, the results obtained highlight significant yield increases when mineral fertilizers are applied.

Regarding the analysis of the dry matter harvest over the entire experimental period (2018-2021), the difference in harvest determined by the application of mineral and organic inputs are, in general, ensured statistically except for the treatment with mineral fertilization in the dose of N₁₀₀P₅₀K₅₀, when achieves a difference of only 0.10 t/ha⁻¹ DM and which does not present statistical assurance.

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CONTRIBUTIONS TO THE ASSESSMENT OF THE QUALITY OF GRASSLANDS FORAGE COMPONENTS OF AGROSILVOPASTORAL SYSTEMS FROM SOUTH-EAST TRANSYLVANIA

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Abstract

The paper presents a new method for evaluating the quality constituents of grasslands fodder according to the index of pastoral value, established on the basis of a floristic survey. 85 floristic surveys were studied, from 6 areas in the South-East Transylvania area, of which: three in the oak tree, two in the gorun tree and one in the beech tree. Quality analyses were performed on the feed samples regarding the main nutritional parameters. Following the statistical analysis through the linear correlations performed, the results highlighted the possibility of calculating the fodder quality components, knowing the index of pastoral value for grasslands in a distinct physical-geographical area. The data obtained can lead to a rapid evaluation of the quality of grasslands fodder with lower expenses, necessary for the preparation of pastoral arrangements and animal nutrition.

Keywords: grassland fodder quality, pastoral value, agrosilvopastoral systems

INTRODUCTION

The fodder quality of permanent grasslands is next to production, one of the main indicators of productivity.

The determination of quality is usually carried out through laboratory analyses, according to various quite laborious and expensive methods, which we do not insist on in the present paper.

With the determination of the pastoral value based on the floristic survey, a new possibility has opened up for a faster evaluation of the quality of a grassland, by which the optimal load with animals per hectare is determined with sufficient accuracy

(DAGET, 1969; MOTCĂ *et al.*, 1994).

According to this working method, the pastoral value of the types of grasslands was determined for our country (ȚUCRA *et al.*, 1987) and practical habitats (MARUȘCA, 2008, 2021 a, b).

Following this, after establishing the pastoral value, it was possible to evaluate the cow's milk production during the grazing season (MARUȘCA *et al.*, 2018; MARUȘCA, 2023).

In the present paper, a first attempt is made to evaluate the fodder quality after establishing the pastoral value based on floristic survey in agrosilvopastoral systems.

MATERIAL AND METHOD

The studies were conducted over a period of three years (2020-2023). In order to establish the correspondence between the main substances and constitutive characteristics of the fodder quality

of grassland production, 6 agrosilvopastoral systems from 520 m to 1150 m altitude were studied, of which three in the oak area, two in the gorun floor and one in the the beech (Table 1).

Table 1

General data on agrosilvopastoral systems in Transylvania

No. c.	Physical-geographic area	Locality (county)	Alt. m	Tree area or floor	Number of surveys
1.	Hârtibaciu Plateau	Rupea (BV)	520	Gorun (<i>Quercus petraea</i>)	7
2.	Homorod Depression	Mercheașă - Homorod (BV)	530	Oak (<i>Quercus robur</i>)	20
3.	Brașov Depression	Dobolii de Jos - Ilieni (CV)	555	Oak (<i>Quercus robur</i>)	10
4.	Homorod Depression	Jimbor - Homorod (BV)	615	Oak (<i>Pyrus pyraeaster</i>)	20
5.	Baraolt Mountains	Herculian - Bățani (CV)	660	Gorun (<i>Quercus petraea</i>)	14
6.	Gurghiu Mountains	Dulcea - Ibănești (MS)	1150	Beech (<i>Fagus sylvatica</i>)	14
AVERAGE (TOTAL)		x	670	x	85

Were drawn up 85 floristic surveys according to the *Klapp-Ellenberg* method of assessing the percentage participation in the grass carpet, in order to further evaluate the pastoral value (MARUȘCA 2019).

After drawing up the floristic surveys, on 100 square meters, samples of 200 grams of green mass were taken from the same area for fodder quality analyses in the laboratory.

The 85 grass samples were analysed by the Near Infrared Spectroscopy (NIRS) method to determine the content in crude CP, ASH, CF, ADF, ADL, NDF, DDM and DOM. Through statistical calculations, the correlation coefficients between the pastoral value of each survey and the fodder quality data from the analysis of the grass sample harvested from the same area were established, and finally the corresponding equations and graphs.

RESULTS AND DISCUSSIONS

It resulted in a large volume of data from which we present the synthetic floristic surveys carried out in the 6 areas under study:

Rupea - BV, Mercheaşa - BV, Dobolii - CV, Jimbor - BV, Herculan - CV şi Ibăneşti - MS (Table2).

Table 2

Participation of forage and harmful species in the grass carpet
with the average pastoral value of the grasslands

Species	FI	1	2	3	4	5	6	Average
		Rupea	Mercheaşa	Dobolii	Jimbor	Herculian	Ibăneşti	
FORAGE GRASSES								
<i>Festuca rubra</i>	7	32,5	28,7	8,3	2,1	38,2	26,9	22,8
<i>Agrostis capillaris</i>	7	7,6	8,4	21,2	9,2	13,3	14,1	12,3
<i>Festuca valesiaca</i>	5	6,4			0,8			1,2
<i>Cynosurus cristatus</i>	7	6,0	1,6	6,6	1,3	1,2		2,8
<i>Festuca rupicola</i>	5	3,0			14,6			2,9
<i>Trisetum flavescens</i>	8	1,6						0,3
<i>Arrhenatherum elatius</i>	8	1,4			0,1	0,1	0,5	0,4
<i>Briza media</i>	5	1,0	0,2					0,2
<i>Dactylis glomerata</i>	9	1,0	0,2					0,2
<i>Festuca pratensis</i>	9	1,0	0,2		1,2	0,1		0,4
<i>Alopecurus pratensis</i>	8	0,4			0,1			0,1
<i>Bromus tectorum</i>	5	0,4						0,1
<i>Holcus lanatus</i>	6	0,4	0,1					0,1
<i>Poa pratensis</i>	8	0,3			0,6		7,0	1,3
<i>Lolium perenne</i>	9	0,3	12,3	30,1	25,9	2,5		11,9
<i>Anthoxanthum odoratum</i>	5		0,5					0,1
<i>Festuca arundinacea</i>	5		0,1					0,1
<i>Phleum pratense</i>	9		0,1	1,0	0,1			0,2
<i>Poa annua</i>	6		0,1				2,9	0,5
Species	FI	1	2	3	4	5	6	Average
<i>Agrostis stolonifera</i>	7			0,3				0,1
<i>Poa chaixii</i>	7						0,4	0,1
HARMFUL GRASSES								
<i>Nardus stricta</i>	3		1,6			8,9	23,1	5,6
<i>Deschampsia caespitosa</i>	3		0,2	2,7	0,8	0,9	2,6	1,2
<i>Danthonia decumbens</i>	3		0,5			0,3		0,1
<i>Bromus secalinus</i>	3		0,1					0,1
<i>Bromus hordiacens</i>	3				0,4			0,1
<i>Calamagrostis epigeios</i>	3						0,5	0,1

FORAGE LEGUMES								
<i>Trifolium repens</i>	8	0,4	9,6	12,4	15,7	8,5	4,1	8,5
<i>Lotus corniculatus</i>	8	3,0	2,6	0,8	0,5	1,3	0,2	1,4
<i>Trifolium pratense</i>	8	3,3	3,3	2,0	2,8	1,9	0,1	2,2
<i>Trifolium campestre</i>	7	6,0						1,0
<i>Medicago falcata</i>	7		0,1					0,1
<i>Trifolium ervense</i>	4				0,1			0,1
HARMFUL LEGUMES								
<i>Genista tinctoria</i>	3		1,5			0,4		0,3
<i>Genista sagittalis</i>	3					0,9		0,2
<i>Dorychnium pentaphyllum</i>	3		0,3					0,1
OTHER FORAGE SPECIES								
<i>Centaurea phrygia</i>	4	3,7	0,6	0,2	0,3	0,6		0,9
<i>Salvia pratensis</i>	4	1,6	0,5	0,3				0,4
<i>Plantago lanceolata</i>	6	1,2	2,5	1,4	1,4	2,1		1,4
<i>Filipendula hexapetala</i>	5	1,1	0,7					0,3
<i>Plantago major</i>	5	0,7	0,8	1,5	0,5	0,9		0,7
<i>Galium verum</i>	5	0,7	0,5		0,1		0,1	0,2
<i>Achillea millefolium</i>	6	0,6	1,7	2,5	1,7	1,2	1,5	1,5
<i>Taraxacum officinale</i>	5	0,4	3,2	1,2	1,2	0,9	0,1	1,2
<i>Thymus pulegioides</i>	4	0,3			1,6			0,3
<i>Leontodon autumnalis</i>	5		1,5			2,1	0,1	0,6
<i>Prunella vulgaris</i>	4		2,7	2,1	0,7	1,4	0,6	1,3
<i>Fragaria viridis</i>	4		1,0		1,3	0,4		0,5
<i>Daucus carota</i>	6		0,6	0,8	0,6			0,3
<i>Thymus montanus</i>	4		0,5			0,6	0,6	0,3
<i>Cichorium intybus</i>	5		0,2	0,8	0,2	0,2		0,2
<i>Carex pallescens</i>	4		1,1		0,3			0,2
<i>Polygonum aviculare</i>	5		0,9	0,5	1,2			0,4
<i>Alchemilla vulgaris</i>	6		0,1		0,2		0,1	0,1
<i>Capsella bursa pastoris</i>	4		0,1					0,1
<i>Mentha longifolia</i>	4		0,1		0,1			0,1
<i>Urtica dioica</i>	5		0,1		3,0	0,9	1,0	0,8
<i>Veronica chamaedrys</i>	4		0,1				0,9	0,2
<i>Convulvulus arvensis</i>	7			0,3				0,1
Species	FI	1	2	3	4	5	6	Average
<i>Symphytum officinale</i>	6				2,1			0,4
<i>Verbena officinalis</i>	4				0,1			0,1
<i>Hieracium pilosella</i>	4					0,6	0,3	0,2
<i>Luzula campestris</i>	4						0,1	0,1
<i>Carum carvi</i>	6						0,1	0,1
OTHER HARMFUL SPECIES								
<i>Lysimachia vulgaris</i>	3	1,4						0,2
<i>Prunus spinosa</i>	3	1,4						0,2

<i>Heleborus purpureus</i>	1	1,0						0,2
<i>Stellaria graminea</i>	1	0,9					0,2	0,2
<i>Myosotis sylvatica</i>	3	0,6						0,1
<i>Campanula patula</i>	3	0,3					0,3	0,1
<i>Echium vulgare</i>	3	0,3						0,1
<i>Eryngium campestre</i>	3	0,3			0,1			0,1
<i>Ranunculus arvensis</i>	1	0,3						0,1
<i>Stachys germanica</i>	3	0,3						0,1
<i>Pyrus pyraeaster</i> (juv.)	3		1,0	0,1		0,1		0,1
<i>Agrimonia eupatoria</i>	3		0,7	0,2	1,0	0,4		0,4
<i>Crataegus monogyna</i>	3		0,7	0,3	0,1	0,1		0,2
<i>Centaurea erythraea</i>	3		0,3			0,4		0,1
<i>Ranunculus acer</i>	1		0,3		0,2	0,1		0,1
<i>Potentilla reptans</i>	3		0,3		0,5	0,1	0,2	0,2
<i>Lysimachia nummularis</i>	3		0,2		0,1			0,1
<i>Ranunculus sardous</i>	1		0,2					0,1
<i>Rosa canina</i>	3		0,2	0,1	0,1	0,6		0,2
<i>Juncus tenuis</i>	3		0,3	0,5	0,2			0,2
<i>Juncus conglomeratus</i>	3		0,2		0,4			0,1
<i>Carduus acanthoides</i>	3		0,1		1,3	0,6	0,2	0,4
<i>Cirsium vulgare</i>	3		0,1	0,5	0,1			0,1
<i>Geranium pratense</i>	3		0,2	0,1				0,1
<i>Glechoma hederacea</i>	3		0,2	0,1	0,8		1,1	0,4
<i>Galium cruciata</i>	3		0,2	0,1		0,1		0,1
<i>Sisymbrium officinale</i>	3		0,1		2,1			0,4
<i>Filago arvensis</i>	3				0,4			
<i>Malva sylvestris</i>	3				0,2			0,1
<i>Stellaria media</i>	3				0,3		0,9	0,2
<i>Xanthium spinosum</i>	2				0,3			0,1
<i>Carlina vulgaris</i>	3					0,4		0,1
<i>Pteridium aquilinum</i>	3					0,4		0,1
<i>Oxalis acetosella</i>	3						0,2	0,1
<i>Fagus sylvatica</i> (juv.)	3						3,1	0,5
Other species*)	3		0,7	0,3	0,5	0,5	0,3	3,7
Number species		38	65	33	57	41	34	45
Vegetation cover (%)		93,1	97,9	99,0	99,6	94,3	99,6	97,3
Species		1	2	3	4	5	6	Average
Fodder plants (%)		86,3	87,6	94,1	91,6	79,0	77,4	86,0
Harmful plants (%)		6,8	10,3	4,9	8,0	15,3	22,2	11,3
Pastoral value		63,6	68,0	79,7	72,6	60,7	47,7	65,4
% Compared to the average		97	104	122	110	92	73	100
*) Other harmful species, with 0.1% participation in the grassy carpet of grasslands: <i>Euphrasia rostkoviana</i> (synthetic survey 2,5); <i>Quercus robur</i> (2); <i>Hypericum perforatum</i> (2,6); <i>Lamium maculatum</i> (2); <i>Myosotis arvensis</i> (2); <i>Viola arvensis</i> (3); <i>Dipsacus sylvestris</i> (3); <i>Ranunculus repens</i> (3); <i>Arctium lappa</i> (4); <i>Cirsium furiens</i> (4,5); <i>Eradium cicutarium</i> (4); <i>Eleocharis palustris</i> (4); <i>Gypophylla muralis</i> (4,5); <i>Helianthemum nummularium</i> (5); <i>Leucanthemum nummularium</i> (5); <i>Leucanthemum vulgare</i> (5); <i>Lycopodium clavatum</i> (6); <i>Euphorbia amygdaloides</i> (6)								

From these data, it follows that, on average, 45 species of cormophytes were found at a survey, which had a coverage of 97.3%, of which 86% with forage species and 11.3% with species harmful to the grass carpet and animals.

The best ratio between forage and harmful species of 94.1 - 4.9% was recorded in the agrosilvopastoral system with oaks from Dobolii - CV and the lowest ratio 77.4 - 22.2% in the beech floor at Ibănești – MS.

The participation of forage species in the grass carpet directly influences its pastoral value.

On average, the pastoral value in the agrosilvopastoral systems studied was 65.4 considered good, with large differences from 47.7 medium in the beech floor to 79.7 good - very good in the oak area (MARUȘCA, 2019).

Following the determinations made on the grass samples from each floristic survey, it was possible to statistically analyses the two variables, composed of the index of pastoral value and each element of forage quality (Table 3).

Table 3

Statistical indexes of the variables

	Valid N	Mean	Minimum	Maximum	Variance	Std.Dev.	Standard Error	Cv [%]
PV	85	64.40000	15.88889	88.88889	231.6985	15.22165	1.651019	23.6
CP	85	16.29176	7.10000	26.90000	17.2681	4.15550	0.450727	25.5
ASH	85	10.33882	6.30000	13.80000	1.9557	1.39848	0.151686	13.5
CF	85	30.87294	23.00000	46.70000	22.9639	4.79207	0.519773	15.5
ADF	85	35.07294	29.00000	49.20000	18.7903	4.33478	0.470173	12.4
ADL	85	3.54118	1.50000	5.90000	1.0875	1.04281	0.113109	29.4
NDF	85	58.83765	47.90000	79.10000	43.2821	6.57892	0.713584	11.2
DDM	85	60.72471	32.90000	78.80000	95.9881	9.79735	1.062672	16.1
DOM	85	57.36471	32.20000	75.30000	88.2937	9.39647	1.019191	16.4

* Pastoral Value (PV), Crude Protein (CP), Ash (ASH), Crude fiber (CF), Acid Detergent Fiber (ADF), Lignin (ADL), Neutral Detergent Fiber (NDF), Digestibility Dry Matter (DDM), Digestibility Organic Matter (DOM)

Table 3 presents the statistical indices (mean, minimum and maximum, variance, standard deviation, standard error and

coefficient of variation) of the nine studied variables.

Regarding the determined variables, from the total of the drawn up floristic surveys, the

lowest pastoral value (PV) was 15.88, the highest was 88.88 and the average pastoral value was 64.40.

The crude protein (CP) content of the analysed forages recorded a minimum value of 7.1% and a maximum value of 26.90%, the average value being 16.29%.

The crude ash content (ASH) recorded a mean value of 10.33% and the standard error was 0.15.

The digestibility coefficient of dry matter (DDM) averaged 60.72%, and the minimum value was 32.90% and the maximum value was 78.80%.

Analysing the size and significance of the determined correlation coefficients, it can be seen from Table 4, that between the pastoral value and the determined quality parameters there were statistically assured interdependence relationships.

Table 4

Matrix of correlation coefficients

	PV	CP	ASH	CF	ADF	ADL	NDF	DDM	DOM
PV	1.00	0.55	0.57	-0.57	-0.55	-0.59	-0.43	0.55	0.56
CP		1.00	0.82	-0.89	-0.89	-0.43	-0.78	0.93	0.92
ASH			1.00	-0.74	-0.77	-0.34	-0.78	0.68	0.67
CF				1.00	0.98	0.37	0.90	-0.93	-0.91
ADF					1.00	0.34	0.94	-0.93	-0.91
ADL						1.00	0.31	-0.34	-0.33
NDF							1.00	-0.79	-0.76
DDM								1.00	0.99
DOM									1.00

There was a statistically significant positive linear correlation ($p \leq 0.001$) between pastoral value and crude protein content ($r = 0.55^{***}$) (Figure 1 a). Also, a statistically assured positive linear correlation ($p \leq 0.001$) existed between pastoral value and crude

ash ($r = 0.57^{***}$) (Figure 1 b). A positive linear correlation ($p \leq 0.001$) was also established between pastoral value and digestibility coefficients (DDM and DOM) with correlation coefficients $r = 0.55^{***}$ and $r = 0.56^{***}$ respectively (Figure 1 c and Figure 1 d).

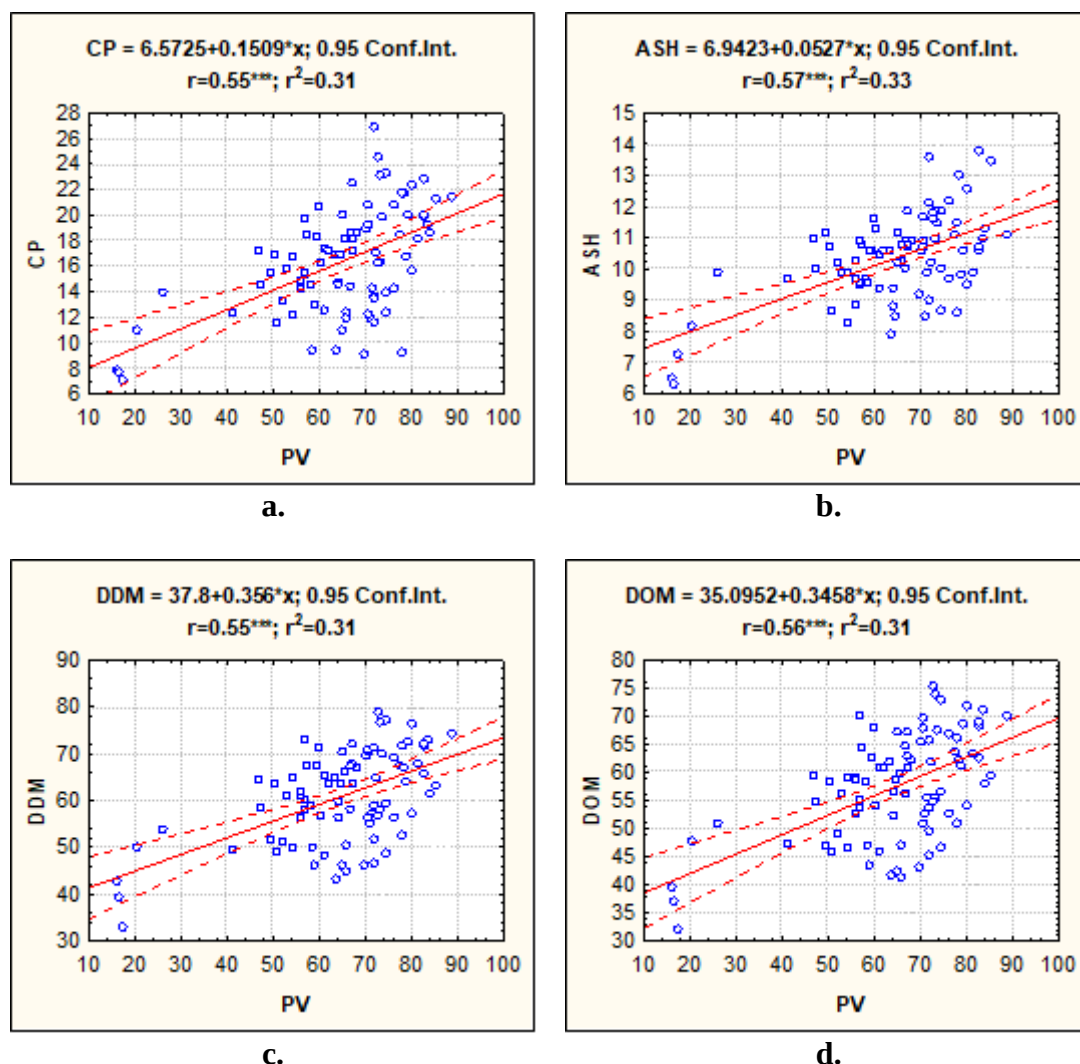


Fig. 1. Correlation between pastoral value and: a. CP, b. ASH, c. DDM, d. DOM

A statistically assured negative linear correlation ($p \leq 0.001$) was established between pastoral value and crude fiber content ($r = -0.57^{***}$). The pastoral

value was also negatively correlated with the content in cell walls: ADF ($r = -0.55^{***}$), ADL ($r = -0.59^{***}$) and NDF ($r = -0.43^{***}$).

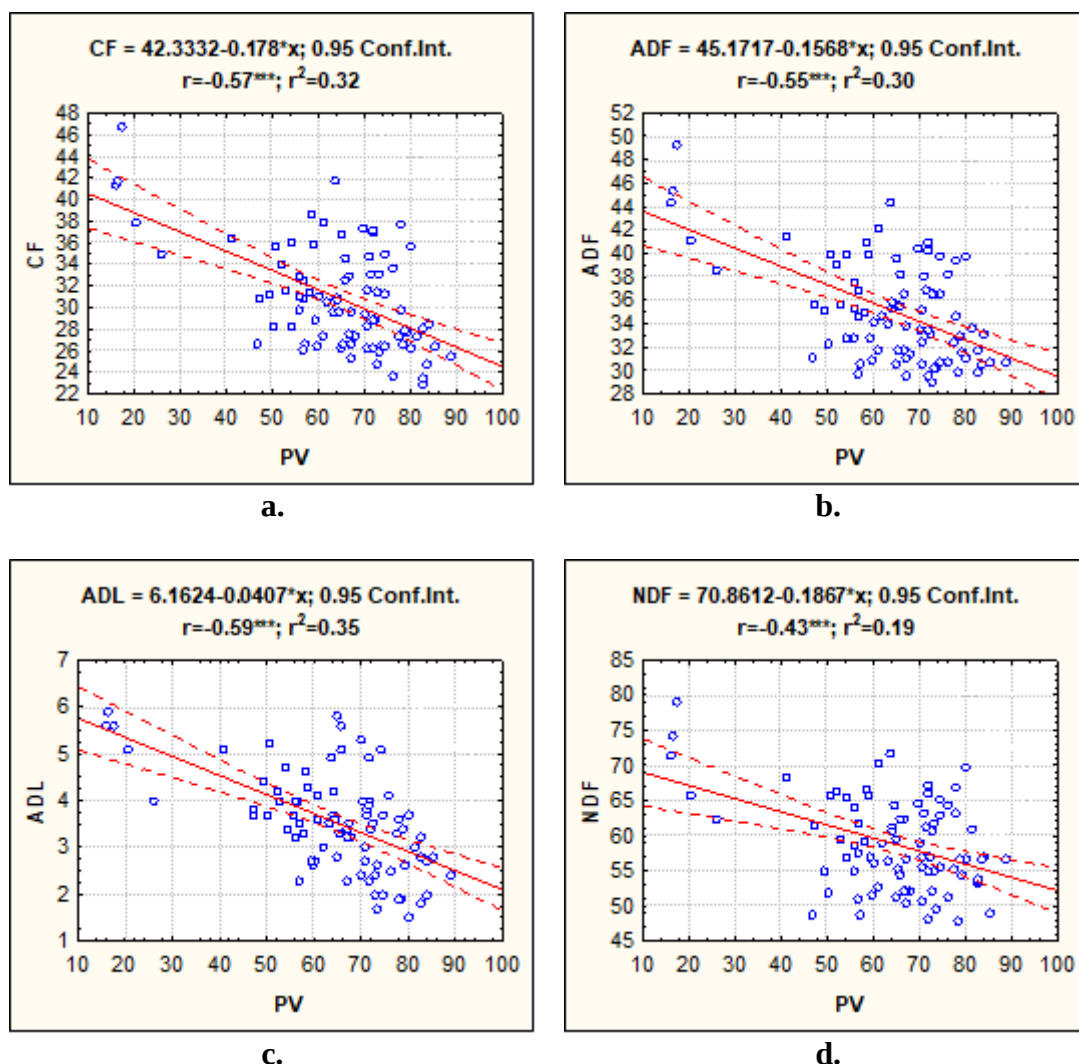


Fig. 2. Correlation between pastoral value and: a. CF, b. ADF, c. ADL, d. NDF

In conclusion, in the following agrosilvopastoral systems from South-East Transylvania, it will be possible to apply different

calculation formulas to estimate the fodder quality, after establishing the pastoral value based on the floristic survey (Table 5).

Table 5

Formulas for calculating feed quality elements
using pastoral value index (PV)

Parameter	Equation
CP	$= 6,5725 + 0,1509 * PV$
ASH	$= 6,9423 + 0,0527 * PV$
CF	$= 42,3332 - 0,1780 * PV$
ADF	$= 45,1717 - 0,1568 * PV$
ADL	$= 6,1624 - 0,0407 * PV$
NDF	$= 70,8612 - 0,1867 * PV$
DDM	$= 37,8000 + 0,3560 * PV$
DOM	$= 35,0952 + 0,3458 * PV$

This working method does not completely replace the classic forage quality analysis, but it can be

used for some faster evaluations with very little expense.

CONCLUSIONS

By drawing up floristic surveys and taking grass samples regarding the forage quality analysis for a physical-geographical area, they can be established by calculating the correlation between the pastoral value (PV) and the constituents of the respective grassland forage.

Pastoral value indices evaluated based on floristic survey are multiplied by the determining

correlation coefficients for each component of forage quality from CP, ASH, CF to DOM, finally resulting in their value level.

This index-based assessment model of pastoral value and concrete laboratory analyses, on a smaller area, can be generalized to larger bioclimatic areas with similar conditions and much lower expenses compared to known methods.

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KEY CONCEPTS IN THE USE OF MICROORGANISM AS INDICATORS OF GRASSLAND DEGRADATION

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Abstract

Grassland are one of the largest biomes on Earth, act as a reservoir of biodiversity and provide a multitude of ecosystem services. The continuous change of climatic conditions and the increased pressure of both ecological and anthropogenic activities act to degrade grasslands. Microbial communities respond rapidly to biotic and abiotic pressure, which makes microorganism good indicators of this phenomenon. The drivers and of degradation and the alteration of processes is visible in the diversity and activity of microorganisms. Shifts from generalist to specialized microbial communities and populations show the trend and magnitude of degradation. The rare and specialized rhizospheric taxa are a good indicator of degradation, along with the microbiomes associated with the invasive species. Microorganisms that grow in root of plants sustain their host growth and development, which enable the forecast of future successions and changes.

Keywords: degradation factors, community alteration, biogeochemical cycles, microbial functions, ecological pressure.

INTRODUCTION

Grasslands occupy almost a third of the total world's area and are characterized by a highly diverse plant and microbial communities that continuously interact to maintain the flow of biogeochemical cycles and the stability of these ecosystems (CORCOZ et al., 2022; PĂCURAR et al., 2021; STOIAN et al., 2022). The constant increase of human population directly influenced the share of grassland in the agricultural land, multiple grassland areas suffering a drastic management

change toward both intensification and abandonment (GAGA et al., 2022; PĂCURAR et al., 2023; ROTAR et al., 2020).

The type and number of plant species in the sward determine the assemblage of above-ground diversity, which is correlated with an even higher below-ground microbial diversity (CORCOZ et al., 2021; ROTAR et al., 2023; VIDICAN et al., 2015). In this context, the classification of grasslands can be viewed by both their origin and the specialization of

their microbial communities which have an impact ranging from stochastic to deterministic (DELGADO-BAQUERIZO et al., 2016; PEDRINHO et al., 2024; SVEEN et al., 2024; TOMAZELLI et al., 2023; Xu et al., 2022):

- a) *natural grasslands – microbial communities with a high share of generalists, that maintain the stability of plant community in the presence of environmental fluctuations;*
- b) *semi-natural grassland – a mixed microbial community with both types of microorganism (generalist and specialized), responsible for adaptation to extreme management changes;*
- c) *anthropogenic grasslands – microbial species and communities specialized for specific functions in ecosystem, with abilities for expansion in new habitats, for competition with native microflora, for partial to complete replacement of biogeochemical cycles stages.*

The entire grassland ecosystem relies on the biogeochemical cycle flow that recycle the nutrients, with the continuous conversion of both minerals and organic matter as a constant exchange of matter between plants and microbial communities (SANDOR et al., 2016; SMITH et al., 2015; SOKOL et al., 2022; SOLANKI et al., 2020). The type of soil, the quantity and

the quality of biomass produced in grasslands directly influence the functionality of nutrient cycles and depend on the share between generalist and specialized microorganisms. Microbial ability to form direct associations with plants or the lack of this ability, their location in ecosystem (rhizosphere, phyllosphere, soil) and the direction (positive – negative) of interactions with plant or other microorganism, is visible in the stability of ecosystem functions and historical diversity. Another important trait of microorganisms is their rapid reaction to both ecological and anthropogenic pressure, even at low levels, by changing partially or totally their metabolic pathways, or changing the interaction with other microorganisms or plants.

These species assemblages, their interactions and functions provide a base for a broad diversity, also under the influence of geographical location, soil type and climate traits (FUNK, 2021; LÓPEZ-ANGULO et al., 2020; SPEHN et al., 2005). The multitrophic organization of grasslands provides an interesting resilience and resistance status in the current context of increasing anthropogenic and climate pressure (Breure et al., 2012; Petermann et al., 2021). One of the most important concerns is the appearance of changes in the stability of these ecosystems, which produce irreversible transformations

beyond the resilience limits. These changes imply a different level of grassland degradation, extended in time from short- to long-term periods and with a low up to high amplitude.

The aim of this paper is to analyze the key-concepts necessary to assess the potential use of microorganisms as grassland degradation indicators, and their mitigation potential.

THE UNDERSTANDING OF GRASSLAND DEGRADATION

Grassland degradation need to be defined as a complex of drivers and processes, which act with different levels of pressure on the stability of these ecosystems (BARDGETT et al., 2021; LI et al., 2022; NELSON, 2005; TISCORNIA et al., 2019). The driver's magnitude is visible as a perturbation in the normal flow of processes and produces short and long-term effects, which provide the degradation level of grasslands.

TISCORNIA et al. (2019) proposed a conceptual frame to define the drivers, the processes and

consequences related to grassland degradation. In relation to this proposal, the rapid reaction of microorganism and microbial communities have an important role as indicators of potential degradation occurrence. Another aspect is that microorganisms can represent a driver for degradation, both in relation to human activities and natural events. Also, they sustain through metabolism the processes and the assemblage of sward.

MICROORGANISM AS INDICATORS OF DEGRADATION DRIVERS

The changes in the management and status of grasslands lead to a powerful variation of soil microbial communities' assemblage and functionality (Zhang et al., 2016). The shift from native to cultivated grasslands, lead to a change in plant species and the content of nutrients in soil. In relation to human activities (mowing, grazing etc.), a general shift of microbial community is visible in the share of bacteria and fungi. Higher biomass

yield stimulates the increases in saprophytic fungi populations, independent to plant species composition (DE DEYN et al., 2011). Soil tillage and mineral fertilizers modify the stability of microclimates where microbial communities proliferate, leading to a reorganization of interactions and metabolic pathways (ŞANDOR et al., 2016; SINGH et al., 2018; VIDICAN and ŞANDOR, 2015; YANG et al., 2021). The application of pesticides is visible in the

reduction of microbial biomass along with a reduction of sensitive species, while the acidification of soil due to application of chemical N led to a reduction of neutrophiles and alkaliphiles. The turnover of C and N rely on microbial biomass and diversity, and microorganisms involved in the transformation of these elements presents variable abundances in a direct relation with the element quantity.

In terms of sensitivity, fungal communities show a decrease in the number of species in relation to the degradation level, while bacterial communities maintain their diversity, but show a change in the species composition (MILLARD et al., 2010; WANG et

al., 2020; WU et al., 2021). Both the depletion, or the excess of nutrients, produce a rapid response in microbial communities, with a shift from autotrophic to heterotrophic species. This restricts the potential of nitrification and mineralization, maintaining an oligotrophic status and increasing the dependence of plants to microbial activities and processes.

In normal conditions microorganism are responsible for provisioning plants with nutrients, a flow that is interrupted by nutrient limitation which produce a change in microbial community from producers to consumers, toward a competition with plants (Cui et al., 2019).

MICROORGANISM AS PROCESSES INDICATORS IN DEGRADED GRASSLANDS

Grassland ecosystems are characterized by a high above- and belowground diversity. The magnitude of degradation is visible in the decrease of aboveground biomass and diversity, which is visible in the decrease of microbial biomass due to the reduction of root exudates and biomass for decomposition processes (LU et al., 2015). Fungal diversity is associated with plant diversity, while bacterial diversity is related to the quality of organic matter present in soil (MILLARD et al., 2010). A specific case is the mycorrhizal fungi, which increase their diversity in microbial communities as a response to an increase in plant diversity (DE

DEYN et al., 2011; STOIAN et al., 2019).

The community in grasslands is composed by both native and non-native species, and their extension is due to their survival potential. From this perspective, microorganisms are associated with both native and invasive plant species, also they can originate from the native community or transferred from other communities. The highest impact on plant species is related to the pathogenic and symbiotic microorganism, which can decrease drastically the number of sensitive individuals, respectively assuring

the maintenance of host in sward (VAN DER PUTTEN et al., 2007).

Invasive species act to produce changes in areas they colonize (Batten et al., 2006). After the establishment of new species, soil microbial communities show a shift to the new hosts from the sward. The differences from the native community can alter the soil microbial conditions at a level that block the re-establishment in future successions of the native flora. The invasive species produce a unique change in the soil microbiome

(GIBBONS et al., 2017; STEFANOWICZ et al., 2016), affecting in a higher proportion the specialized microflora, and only in a lower proportion the generalist microorganism. The changes produced in the soil microbiome by invasive species produce a loop in the activity of specialized microorganism, that increase the suitability of substrate for their plant hosts, assuring their survival followed by their dominance in the sward (BATTEN et al., 2008).

MICROBIAL REACTIONS AND DEGRADED GRASSLANDS

Plants harvest microorganisms especially in their rhizosphere, an area occupied by a diversity of species associated to root exudates and which act as a nutrient exchange community. The nutrient depletion or limitation induce a restriction in the microbial metabolic potential, a reduction of extracellular enzymes and a decrease of active function in the ecosystem (CUI et al., 2019; ZHANG et al., 2011). In this direction, a complex proposal for a rhizosphere soil microbial index (SINHA et al., 2009) comprises the microbial biomass (C), soil respiration and enzymatic activity, which are correlated with plant survival and performance.

Soil pH and salinity stress affect plants drastically and induce a higher magnitude reaction of fungi, compared to bacteria (TRUȘCĂ et

PROCESSES AS INDICATORS OF

al., 2022; TRUȘCĂ et al., 2023; WU et al., 2021). Both groups increase the dynamics of their positive interactions in microbial community, in order to mitigate the stress and to adapt faster to the new conditions.

The rapid adaptation of microorganism to stresses (and degradation) is visible in the maintenance of their activity, but only at lower values compared to their native status. Plant succession in grasslands gradually increase microbial groups and populations, within a time-frame of 5-10 year up to a significant increase in the activity (ZHANG et al., 2021).

A promising direction toward the most suitable microbial indicators are the rare species (LIU et al., 2023; MA et al., 2022; SINGH et al., 2023). Their specialized activity and interactions,

along with their lower share in microbial community, makes them good candidates for monitoring degradation in grasslands.

Both rhizosphere and non-rhizosphere microbiomes should be taken into account in the degradation assessment (BREIDENBACH et al., 2022; HU et al., 2024; KARIMI et al., 2017;

REN et al., 2021; ZHAO et al., 2020). The rhizosphere can indicate changes associated with one species, while the non-rhizosphere microbiome can indicate an alteration of the more general processes and modification of biogeochemical cycles.

CONCLUSIONS

The constant activity and interaction between generalist and specialized microbial communities maintain the soil functionality in grassland ecosystems.

The rapid reaction of microorganism to ecosystem pressure and their adaptation

potential makes them good candidates to assess grassland degradation.

Plant successions in grasslands are sustained by shifts in microbial communities, from generalized microbiome up to the rare and specialized taxa.

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THE IMPACT OF GLOBAL WARMING ON DECOMPOSITION OF ORGANIC MATTER IN GRASSLAND ECOSYSTEMS – SHORT REVIEW

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Abstract

Grasslands, as dominant terrestrial ecosystems, play key roles in maintaining biodiversity, carbon sequestration and soil fertility. However, their vulnerability is increasing due to natural disasters and human-induced disturbances, which are amplified by climate change. The aim of this research is to analyze the process of decomposition in grassland ecosystems, focusing on how climate change and other disturbances influence this essential process. Understanding how the rate and efficiency of organic matter decomposition in these natural environments can be affected by climate variability, including changes in temperature and precipitation patterns. Organic matter decomposition in grasslands plays an important role in the global carbon cycle, storing soil carbon and controlling atmospheric CO₂ concentrations. Therefore, understanding and controlling the decomposition process in grassland ecosystems is essential for the conservation and sustainable management of these natural environments.

Keywords: grasslands ecosystems, climate change, plant species, microorganisms, decomposition, organic matter.

INTRODUCTION

Grasslands are essential terrestrial ecosystems (SCHOLTZ et al. 2022), being the most dominant form of land cover and providing a rich array of renewable natural resources. They perform various vital ecological functions such as soil stabilization, water conservation and maintenance of biodiversity (HOPKINS & HOLZ, 2006; BENGTSSON et al. 2019; LAL, 2014). They are also essential for agriculture, economy and tourism, contributing to the income of many communities. At the same

time, the natural landscapes of grasslands and the cultural elements of the communities that use them are landscape resources of great cultural and ecological importance (WANG et al. 2022).

Grasslands are fragile ecosystems are often vulnerable to natural disasters (FANG et al. 2022), such as fire (JOSEPH et al. 2024; CURY-LINDALH, 2019), drought and insect attacks. Even small changes in surface area can have significant consequences for the dynamic processes in these

ecosystems. Monitoring human activities and natural disasters is therefore crucial for grassland management and post-disaster reconstruction, as well as for the sustainable development of these natural resources. (WANG et al. 2022; LEAD et al. 2005).

Grassland are dominated by herbaceous plants (DIXON et al. 2014; GAUJOUR et al. 2012) and are often found in areas with unfavorable climatic conditions for growing trees. Some grasslands are regularly managed by humans and are called semi-natural grasslands (BENGTSSON et al. 2019). Dead organic matter, such as leaves, needles, twigs and roots of plants, form plant litter, which is present both above and below ground. In terrestrial environments, the layer of plant organic matter plays a vital role in controlling biogeochemical cycles. By maintaining soil fertility and nutrient availability, it influences plant growth processes, diversity, composition, structure, and productivity (HASSAN et al. 2021).

Grasslands play a major role in the global carbon cycle, covering about 40% (LEI et al., 2020) of the Earth's land surface, excluding the areas permanently covered by ice. These large ecosystems contribute significantly to carbon sequestration and soil carbon flux dynamics (WANG & FANG, 2009). Grassland ecosystems are one of the most important carbon (C) reservoirs on Earth and sequester

about 20% of total global soil carbon (ZHAO et al. 2022).

Grasslands are more susceptible to disturbance than other ecosystems (LI & GUO, 2014), and climate change, through increased frequency and intensity of droughts, has a considerable impact on their functioning and structure. In the current context of climate change, it is essential to analyze the response of grasslands to drought (CRAINE et al. 2013; WELLSTEIN et al. 2017), as extreme weather events are becoming more frequent. In recent decades, droughts have become longer, more frequent, and more intense, especially in semi-arid and arid regions (LEI et al. 2020).

The grassland ecosystems (Fig.1.) are crucial for sustaining the nutrient cycle (FRISSEL, 2012), within the Earth's terrestrial ecosystems. Nevertheless, over fifty percent of the world's grassland regions have experienced considerable degradation (LIU et al. 2019; BARDGETT et al 2021), primarily as a result of extensive human activity and the effects of global climate change. These disturbances not only change soil physico-chemical characteristics such as salinity, moisture, and nutrient availability, but also negatively affect the productivity, stability and resilience of grassland ecosystems over time (LI et al. 2023).

The aim of this study is to highlight the implications of climate change

on the microbial community involved in the decomposition of

organic matter in grassland ecosystems.

MATERIAL AND METHOD

Information and data were collected using the Web of Science platform. Specific keywords, combination between: grasslands ecosystems, climate change, plant species, microorganisms, decomposition, and organic matter were used to

obtain this data, all directly related to the decomposition process of organic matter. This search method allowed access to a wide range of relevant studies and articles on the subject.

MANAGEMENT STRATEGIES AND MICROBIAL INFLUENCE ON SOM DECOMPOSITION

The primary strategy of management to prevent land degradation (PANDIT et al. 2018), and to restore ecological integrity to disturbed ecosystems is to conserve agricultural land by allowing spontaneous succession to happen. This approach is associated with the enhancement of ecosystem services provided by the vegetation that naturally grows on these lands. Changes in microbial community composition are essential for this transition and can be assessed by monitoring the activity of soil microorganisms (DALE et al. 2005). These activities are mainly related to the vital roles of these microorganisms in the cycling and release of nutrients, including carbon, nitrogen and phosphorus, and how they respond to changes in the environment (LI et al. 2020).

Soil carbon pools are influenced by inputs of organic matter, such as plant litter and root exudates (LEI et al. 2023; PANCHAL et al. 2022), and losses of organic matter due to

decomposition, erosion and leaching. The decomposition of plant litter is central to the global carbon cycle, releasing a significant amount of carbon into the atmosphere (GOUGOULIAS et al. 2014), about ten times more than the annual burning of fossil fuels. This litter contains resistant polymeric compounds such as lignin and cellulose, which are broken down by extracellular enzymes into smaller components. In contrast, root exudates are considered largely labile and are rapidly taken up by microorganisms due to their high energy content (ULLAH et al. 2023; MA et al. 2022). Soil organic matter (SOM) decomposition is mainly mediated by microbial processes that depend on extracellular enzymes to break down organic polymers into oligomers and monomers (DE BEECK et al. 2021; WALLENSTEIN & BURNS, 2011). The "selective conservation" of SOM by microbial processes has proposed that the pool of labile C, including proteins, aminosaccharides and

carbohydrates of plant and microbial origin, is depleted over time. What remains is a suite of recalcitrant organic compounds, including lignin, tannin and condensed aromatic C, which require more energy to be broken down by microorganisms (GLEIXNER et al. 2001; FIELD, 2001). The theory of 'selective conservation' suggests that the microbial community regulates the decomposition of C, thereby determining OM transformations in the soil (ZHAO et al. 2022).

The capacity to use different carbon sources is closely connected to the production of extracellular enzymes (RATHNAN et al. 2013). Most studies use either individual fungal substrates and species or combinations, and often measure only a few specific enzymes. However, litter decomposition is a

complex process involving a variety of different enzymes (HATTENSCHWILER et al. 2005).

The chemistry of the litter, including its quality, has a significant influence on the functional ability to decompose (WARDLE et al. 2002). A key aspect of litter chemistry is the amount of water-soluble carbon and the identity and availability of certain carbon sources. These elements can affect the relative abundance of different individual species, thus influencing the composition of the fungal community. Decomposition of litter is also affected by variables such as plant species, type of plant tissue (e.g. leaves or branches), and the diversity and number of litter types present, along with the nutrient status of the litter and soil (LEIFHEIT et al. 2024).

DECOMPOSITION DYNAMICS: CLIMATE EFFECTS ON SOIL MICROORGANISMS

Changes in climate can influence decomposition processes through short-term variations in soil moisture or temperature, which have a direct impact on biological activities in the soil, including the composition and activity of microbial and soil communities (GREGORICH et al. 2017). Climate change may indirectly alter decomposition through litter chemistry changes at the level of individual plants and changes in plant species composition (WALTER et al. 2013).

A changing global climate is expected to bring modifications in growing season precipitation patterns (WELTZIN et al. 2003), possibly reducing total precipitation amounts.

These changes will directly influence ecological processes (BARDGETT et al. 2008), including those regulating carbon cycling and storage, through their impact on the spatio-temporal patterns of plants and solar processes influenced by soil moisture. Finally, a change in the amount of carbon exchanged between the atmosphere and ecosystems will be observed. However, a precise understanding of how these processes will respond to climate change is still lacking. It is well known that drought will have significant effects on microbial communities in terms of biodegradation (BOGATI & WALCZAK, 2022). In general, reduced rainfall and lower substrate moisture make decomposition more difficult (SANAULLAH et al. 2012).

Climate change can affect soil organic matter (SOM) decomposition by altering the balance of plant supply and

microbial degradation. In general, higher temperatures can stimulate microbial activity (DALAL et al. 2011), which can degrade SOM rapidly. There is an increased enzyme activity stimulated by high temperature. Studies have shown that there is generally a significant positive correlation between average annual temperature and SOM degradation rate, resulting from increased enzyme activity stimulated by high temperature (BLAGODATSKAYA et al. 2016; CHEN et al. 2020; CONANT et al. 2011).

Precipitation also plays a significant role in modifying soil organic matter (SOM). In general, an increase in rainfall can reduce drought stress, improve soil nutrient use and promote plant and microorganism growth. At the same time, an increase in soil moisture can enhance enzyme activity, which accelerates SOM decomposition (CHEN et al. 2020).

Soil structure has a major control on microbial decomposition processes in terrestrial ecosystems. Organic matter is physically protected in the soil, allowing a significant amount of readily decomposable compounds to accumulate in close proximity to microbial populations (VAN VEEN & KUIKMAN, 1990).

Biotic and abiotic factors influence the structure and activity of the microbial community, including soil biota, climate, soil chemistry and the quality of organic matter (KUMAR & KARTHIKA, 2020). Diversity at the local scale can influence composition at the regional scale, while organic matter quality can influence microbial dynamics (PAUL, 2016), at the local scale. The relative importance of environmental factors and organic

matter quality in the decomposition process is still under discussion. The transfer of organic material between sites may alter the effects of these factors, depending on the adaptation of local communities to faster decomposition of certain types of organic material. However, if the type of organic material influences decomposition independently of the site, microbes may be considered redundant in their function of decomposing organic material (McGUIRE & TRESEDER, 2010). To better understand the factors influencing microbial decomposition, it is necessary to analyse the interactions at local and regional scales over time, as well as the diversity and origin of the organic material. Biotic and abiotic factors change as the decomposition process progresses, affecting the associated microbial community and extracellular enzyme activity. The differential response of microorganisms to chemical changes in the organic material is essential to classify them according to their specific role in the decomposition process (BURESOVA et al. 2019).

It is well recognised that the process of breakdown of litter is influenced by several factors, including climate, quality of litter and soil microorganisms (ZHANG et al. 2008). For example, higher quality waste tends to decompose faster. At the regional level, waste quality has been considered as the main factor controlling decomposition, while at the global level, climate may play a predominant role. Recent models suggest that climate and waste quality together contribute about 60-70% to the decay rates of litter. However, the impact of soil fauna on waste

decomposition remains unclear. It is possible that soil fauna play a crucial role in waste decomposition (KUMAR & SINGH, 2016), because, in addition to direct effects such as fragmentation and waste consumption, soil fauna can influence the structure and activity of microbial communities and indirectly affect the waste decomposition process (SONG et al. 2020).

The decomposition of organic matter is essential in the cycling of nutrients in terrestrial ecosystems (HORWATH, 2007; FINDLAY, 2021). Different types of organic matter added to the soil change the content of nutrients such as carbon, nitrogen, phosphorus, etc., resulting in changes in the activity of extracellular enzymes in the soil. These enzymes, which are mainly produced by microorganisms, are crucial for the breakdown of soil carbon and nutrient mineralisation (LI et al. 2023).

MICROBIAL DECOMPOSER DYNAMICS IN GRASSLAND ECOSYSTEMS

The decomposition of organic matter and nutrient mineralisation in soil is governed mainly by the activity of microorganisms, in particular bacteria and fungi (ESMAEILZADEH & AHANGAR, 2014). These microorganisms have a major impact on the terrestrial carbon equilibrium and hence on the response to climate change. Although both bacteria and fungi in soil are affected by warming-induced climate change and shifts in precipitation patterns (HU et al. 2023), they may react differently to these factors. For example, fungi appear to be more resilient to warming-induced

water stress and decreased precipitation compared to bacteria. This is partly due to the distinct morphology and cell structure of fungi, which gives them the ability to access nutrients and water from the soil over longer distances, with their thicker cell walls and extensive hyphal networks (QIU et al. 2023).

Soil microorganisms are fundamental to the balance and health of terrestrial ecosystems, playing a vital role in nutrient cycling and maintaining carbon stability in both the soil and the atmosphere. Bacteria and fungi are two main categories of microorganisms that make their essential contribution by breaking down organic materials and mineralising nutrients, processes that are vital for their availability to plants. They also have a significant impact on how terrestrial ecosystems respond to climate change (QIU et al. 2023).

Soil microorganisms play a vital role in grassland ecosystems, influencing the dynamics of organic matter decomposition and nutrient availability to plants (RIGGS & HOBBIE, 2016). They are also crucial in regulating carbon exchange and nutrient cycling in all types of terrestrial ecosystems. Changes in land use, land cover, plant management and productivity can affect the biomass, structure and functional processes of soil microorganisms by altering the amount and types of organic matter present. Bacterial species are sensitive to environmental changes due to their high growth and short life cycle. Fluctuations in soil microbial biomass are related to modifications in microbial community composition, with specific attention to changes in the ratio of bacteria to fungi (JIN et al. 2010).

Fungi and bacteria are considered to be the main agents responsible for the breakdown of soil organic matter and generally account for more than 90% of soil microbial biomass (CONDRON et al. 2010). However, their relative contribution to the decomposition process remains unclear and may be influenced by a number of factors, including the quality of carbon in plant material. Fungi usually use more recalcitrant carbon sources, while bacteria can respond quickly to increasing resource levels and colonise more labile organic materials. Fungi are equipped with well-developed extraradical mycelium and aggressive enzyme systems for hydrolytic and lignolytic activities. On the other hand, a more labile vegetal substrate can lead to a shift in microbial dominance from fungi to bacteria. However, relationships between carbon substrate quality and the microbial community are complex, and fungi and bacteria may adopt mixed strategies of substrate utilisation (ULLAH et al. 2023).

Fungi have long been recognised as the main agents in the decomposition of complex substrates, but recently increased attention has been paid to the role of bacteria in this process. Bacterial groups such as Actinobacteria, Proteobacteria, Firmicutes and Bacteroidetes are known for their ability to secrete extracellular enzymes and to be active in the degradation of organic materials (De BOER et al. 2005). For example, Actinobacteria can synthesise lignolytic enzymes and secondary metabolites, exhibiting strategies similar to those of fungi, such as filament formation. This suggests that bacteria may be involved in the decomposition process to a greater extent than previously thought.

However, research exploring the interactions and interdependencies between fungi and bacteria during the decomposition process is still in its early stages. Investigating the patterns of coexistence between these two microbial groups under the influence of different abiotic factors could provide a better understanding of the mechanisms involved in the decomposition of organic materials in terrestrial ecosystems (BANI et al. 2018; FUKAMI et al. 2010; GLASSMAN et al. 2018).

The crucial role of soil bacteria in interacting with plants and in the decomposition of organic matter and plant litter underlines their importance in the cycling of soil elements, with a particular focus on the carbon cycle and its impact on global warming. Global greenhouse gas fluxes can be significantly affected by even small changes in the activity of these microbial organisms. Understanding how microbial communities change over the course of ecological succession is essential for designing and managing restoration of degraded areas (ZENG et al. 2017).

Degradation of grassland is a serious problem (ZHOU et al. 2005), leading to loss of biodiversity and damage to essential ecosystem functions. Soil microorganisms such as bacteria and fungi play a crucial role in maintaining the health and functionality of grasslands (MEETEI et al. 2022). However, more research is needed to understand how the diversity, structure and network characteristics of interactions of these microorganisms respond to the degradation of grasslands.

Studies by Wu et al. showed that in the soil microbiome, the dominant bacterial

groups were represented by Actinobacteria, Proteobacteria, Chloroflexi and Acidobacteria, while the predominant fungal filaments were Ascomycota, Basidiomycota and Zygomycota. As the degree of grassland degradation increased, the relative abundance of some bacterial taxa, such as Actinobacteria, Gemmatimonadetes, Firmicutes and Deinococcus-Thermus, increased, while those affiliated with Acidobacteria and Nitrospirae showed a decreasing trend. As for fungi, the relative abundance of most phyla decreased as the degree of grassland degradation increased (WU et al. 2021).

The degradation of grassland can have significant consequences for the soil ecosystem and its microorganisms (LORANGER-MERCIRIS et al. 2006). A crucial aspect is the influence on soil physico-chemical properties as well as on vegetation characteristics. These properties include salinity, moisture and nutrient availability, all of which play an important role in the health and functioning of soil microorganisms. For example, degradation can alter soil salinity levels, which has been linked to changes in the diversity and structure of microbial communities (ZAMAN et al. 2018). Studies indicate a decrease in

the biomass, activity and diversity of microorganisms with increasing soil salinity. This phenomenon affects bacterial and fungal communities differently, with a tendency for the proportion of bacteria to increase in saline soils. In addition, soil nutrient availability and content can be negatively affected by degradation, inhibiting microbial activity and reducing their abundance. These changes can lead to a decrease in the richness and diversity of microorganisms in degraded soils (THOMPSON & KAO-KNIFFIN, 2019).

A fascinating issue is the identity of a significant interplay between improved precipitation and decomposition, which shows that the effect of precipitation on decay would possibly fluctuate depending on the composition of the available organic matter. It is also demonstrated the important role of soil water content in regulating litter decomposition in different grassland types. The complexity of interactions between climatic conditions and litter composition in controlling nutrient cycling in grassland ecosystems are a critical study for the establishment of coherent actions (SU et al. 2022).

CONCLUSIONS

Grasslands have a crucial role in maintaining soil stability, water retention, biodiversity, and other ecological processes. They are also an important source of resources for the tourist, agricultural, and economic sectors.

Natural catastrophes and human activity-induced degradation of these grasslands are a major threat to the resilience and stability of ecosystems.

It is essential to monitor and manage grasslands after a disaster in order to

recover ecosystems and use resources sustainably.

In grassland ecosystems, soil microorganisms, such as bacteria and fungi, have a significant impact on the breakdown of organic matter, the availability of nutrients, and the cycling of carbon. The increase of droughts and other extreme weather events is a major

characteristic of climate change and a major threat to grassland ecosystems. Variations in

temperature and precipitation patterns have a direct impact on the breakdown of organic matter and microbial activity, which in turn impacts the cycling of nutrients and the overall health of ecosystems.

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THE LONG-TERM EFFECT OF CALCIUM AMENDMENT AND GRUBBING UP ON THE SUBALPINE GRASSLANDS OF THE BUCEGI MASSIVE (SOUTHERN CARPATIES)

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Abstract

*In the Bucegi Massif on a subalpine grassland dominated by *Nardus stricta* located at 1800 m altitude, three options of intervention on the grassy carpet and the soil were followed in the period 1995-2023: 1-Control, unprocessed; 2-Treatment with the milling cutter at 10-12 cm; 3-Amendment with CaO in a dose of 7t/ha and processing with a milling cutter. The grassland was naturally cultivated with species from the spontaneous flora, no chemical or organic fertilizers were applied and it was extensively grazed with transhumance dairy cows. By applying the amendments after 28 years the pH index increased from 4 to 5.5, the production of green forage mass from 1.7 to 9.7 t/ha, the pastoral value from 18 to 70 and the production of cow's milk from at 930 it reaches 3500 liters/ha. The rest of the agrochemical characteristics of the soil are better, as well as the content of microelements compared to the control without intervention. The effect of calcium amendment to correct soil acidity exceeds 30 years with high economic efficiency.*

Keywords: subalpine pastures, calcium amendment, agrochemical properties, soil microelements, plant productivity.

INTRODUCTION

The favourable effect of calcareous amendments on acid soils on the growth and development of grassland grasses is well known in specialized and practical literature (PUȘCARU et al. 1956, SAFTA et al. 1962, BĂRBULESCU, MOTCĂ 1983, MARUȘCA 2022a), less studied was the duration of the effect of soil acidity correction, due to the follow-

up of experiences that usually did not exceed 3-5 years, with few exceptions a longer period (MARUȘCA 2021a, b, 2022; MARUȘCA et al. 2008, 2010, 2014).

The present paper continues the long-term research on the effect of calcareous amendments on acidic soils after 28 years of application.

MATERIAL AND METHOD

The research was carried out at the Blana - Bucegi mountain

grasslands research base, located at 1800 m altitude in the subalpine

bioclimatic floor of juniper thickets (*Pinus mugo*) on a grassland dominated by *Nardus stricta* in a proportion of almost 70% in the grassy carpet.

The initial soil reaction in 1995 at the depth of 0-15 cm was 3.9 and at the depth of 15-30 cm 4.1, mobile aluminium 11.210 and 9.840 me per 100 g soil, degree of saturation in bases VAh (%) 17.6 and 13.5 on the two depths, very little supplied in nitrogen, phosphorus and potassium and very rich in raw humus.

In the summer of 1995, 3 large variants were studied:

1. Witness, without intervention on the grass carpet;
2. Use the milling cutter on the grassland at a depth of 10-12 cm, allowed to weed by itself with species from the spontaneous flora;
3. Applied 7 t/ha of lime powder (CaO) to correct 2/3 of the

hydrolytic acidity of the milled soil at 10-12 cm, natural grass.

Grubbed up variants 2 and 3, with and without calcium amendment, were originally prepared for another purpose, namely the cultivation of some species and varieties of perennial grassland grasses and legumes for harsher climatic conditions in the high mountains.

Since due to lack of funds, this theme was abandoned and the land was gradually filled with species from the spontaneous flora under the influence of permanent grazing with transhumance dairy cows.

In 2014, after 19 years after the intervention on the grass carpet, it was observed that in the process of adding grasses on the amended version, the species *Nardus stricta* is almost absent and on the version without amendment it was much more abundant.

Table 1

Soil reaction and agrochemical content limits
(Florea et al. 1987)

Soil reaction		Soil content				
pH in H ₂ O	Indices	Proprieties	Al ³⁺ me/100g	Humus %	P _{AL} mg/kg	K _{AL} mg/kg
Very strongly acidic	3,6 - 4,3	Extremely low	< 0,3	< 1,1	-	-
Strongly acidic	4,4 - 5,0	Very low	0,4-0,8	1,2-2,2	< 9	< 66
Moderately acid	5,1 - 5,8	Low	0,9-2,0	2,3-5,5	9-18	66-130
Low acid	5,9 - 6,8	Average	2,1-4,0	5,6-8,5	19-36	131-200
Neutral	6,9 - 7,2	High	4,1-6,5	8,6-11,9	37-72	201-300
Low alkaline	7,3 - 8,4	Very high	6,6-10,0	12,0-24,0	> 72	> 300
Moderately alkaline	8,5 - 9,0	Extremely high	> 10,1	> 24,1	-	-

As a result of these findings, floristic surveys were carried out and soil samples were taken at the 2 depths, 0-15 and 15-30 cm.

Current agrochemical analyses were performed as well as on some microelements.

The evaluation of agrochemical analyses was carried out according to the usual scale of values of ICPA Bucharest (Table 1) and of microelements according to the reference values of MAPPM (Table 2).

Table 2

Reference values for trace chemical elements in soil
Inorganic compounds (mg/kg dry matter)
(MAPPM Order 756/13.11.1997)

Traces	Normal values	Alert thresholds		Intervention thresholds	
		Types of uses		Types of uses	
		Sensitive	Less sensitive	Sensitive	Less sensitive
Cadmium (Cd)	1	3	5	5	10
Cobalt (Co)	15	30	100	50	250
Chromium (Cr)	1	4	10	10	20
Copper (Cu)	20	100	250	200	500
Manganese (Mn)	900	1500	2000	2500	4000
Nickel (Ni)	20	75	200	150	500
Lead (Pb)	20	50	250	100	1000
Zinc (Zn)	100	300	700	600	1500

The productivity of these improvement variants was carried out on the basis of floristic surveys (MARUŞCA 2019), to which was added the evaluation of milk production, by multiplying the pastoral value by the transformation coefficient 51.24, determined in a

20-year experience with cows of milk (MARUŞCA et al. 2018).

The botanical and soil analyses of the 3 variants were repeated in 2023, in order to know the evolution in dynamics, after 28 years after the intervention on the grassland grassy carpet and amendment.

RESULTS AND DISCUSSIONS

Following the current agrochemical analyses of the soil, very large changes are observed, especially due to calcium amendment to correct the acid reaction (Table 3).

Thus, the pH index after 19 years registers a slight increase as a result of rational grazing with dairy cows and their manure.

Table 3

Dynamics of basic agrochemical properties of subalpine grassland soils

Specification	UM	Variant	2014 (after 19 ani)		2023 (after 28 ani)	
			0-15	15-30	0-15	15-30
pH (H ₂ O)	ind.	1. Witness	4,2	4,1	4,9	4,8
		2. Milling cutter	4,0	4,1	4,9	4,8
		3. Ca + Milling cutter	4,8	5,0	5,3	5,5
		Difference %	2 - 1	95	100	100
			3 - 1	114	122	108
			3 - 2	120	122	108
Al ³⁺	me100 g sol	1. Witness	5,600	5,380	4,276	3,920
		2. Milling cutter	6,960	6,480	4,276	4,514
		3. Ca + Milling cutter	0,520	0,420	0,812	0,633
		Difference %	2 - 1	124	120	100
			3 - 1	9	8	19
			3 - 2	7	6	17
V _{Ah}	%	1. Witness	33,2	20,9	25,7	23,2
		2. Milling cutter	19,6	18,4	23,7	22,8
		3. Ca + Milling cutter	52,4	51,1	48,1	49,8
		Difference %	2 - 1	59	88	92
			3 - 1	158	244	187
			3 - 2	267	278	203
Humus	%	1. Witness	18,28	11,56	17,43	11,63
		2. Milling cutter	15,22	10,73	15,28	13,31
		3. Ca + Milling cutter	15,22	12,86	14,83	11,34
		Difference %	2 - 1	83	93	88
			3 - 1	83	111	85
			3 - 2	100	120	97
P - AL	ppm	1. Witness	27,5	15,5	10,0	4,0
		2. Milling cutter	19,0	9,8	14,0	8,0
		3. Ca + Milling cutter	15,0	9,8	10,0	4,0
		Difference %	2 - 1	69	63	140
			3 - 1	55	63	100
			3 - 2	77	100	71
K - AL	ppm	1. Witness	202	97	378	154
		2. Milling cutter	152	66	330	232
		3. Ca + Milling cutter	113	50	240	106
		Difference %	2 - 1	75	68	81
			3 - 1	56	52	63
			3 - 2	74	76	73

After the same interval in the sampled version without amendment on the 0-15 cm depth, a 5% decrease in pH is observed compared to the control version, the rest of the values are identical.

By calcium amendment the pH values have an increase of 0.6-0.8 units compared to the control and simple milling.

In 2023, after another 9 years from 2014 and 28 years from 1995, the amended variant registered an increase of 0.4-0.7 pH units compared to the control without intervention on the grass carpet, rational grazing with animal manure also contributing to this.

One of the most spectacular reductions through amendment was recorded in the content of mobile aluminium, which from 10-11 me/100 g soil in 1995 by regulating grazing drops by half and through amendment by 80-90%.

Milling without amendment increased the mobile aluminium content by up to 15-24% compared to the control without intervention after 19 and 28 years. In the same way, the degree of saturation in bases (VAh) decreases by 8-40% on the depth of 0-15 cm in the milled version without amendment compared to the control.

By intervention on the grass carpet and amendment in almost all cases the humus content is lower compared to the control through the mineralization processes of the organic matter accumulated in excess.

The phosphorus and potassium content of the soil in variants 2 and 3 have the same downward trend compared to variant 1, the control.

Important changes were also identified in the content of microelements in the soil (Table 4).

The highest total content of microelements is recorded in version 1 (control) and the lowest in version 2 (Miller) where in the soil there is 59% on the depth of 0-15 cm and 72% on 15-30 cm, content of elements before d witness

On the two levels of soil depth, at 0-15 cm, a 16% higher total amount of microelements was recorded in the control (1), 4% less in the Miller (2) and 10% more in the CaO+Miller (3) from the 15-30 cm level.

Most microelements have values below normal in all variants, except for lead which has a higher value only in the control variant at the depth of 0-15 cm. The lowest contents in microelements were found in variant 2 (mill) followed by variant 3 (CaO + Milling). In general, a deficiency in microelements can be appreciated in the soils and variants studied.

The agrochemical properties of the soil and the microelement content of the analysed variants had a direct influence on the botanical composition (Table 5).

Thus, the dominant species *Nardus stricta* from 68% participation in the grassy carpet in

1995 before the intervention is maintained after 19 years at 65% in the control variant, 25% is

established after simple milling and barely 1% in the amended variant.

Table 4

Soil content in trace elements (mg Kg⁻¹)

Element	1. Witness	2. Milling 0-12 cm		3. CaO -7 t/ha, milling		
		Value	% to variant 1	Value	% to variant 1	% to variant 2
A. Depth 0 - 15 cm						
Zn	43,0	29,0	67	43,0	100	142
Cu	8,9	5,4	61	6,2	70	115
Mn	257,0	130,0	51	216,0	84	166
Ni	11,2	10,2	91	11,8	105	116
Cr	11,7	12,1	103	15,0	128	124
Co	5,6	7,2	129	6,0	107	83
Pb	25,2	19,8	79	24,1	96	122
Cd	0,6	0,6	100	0,6	100	100
TOTAL A	363,2	214,3	59	322,7	88	151
B. Depth 15 - 30 cm						
Zn	50,0	32,0	64	38,0	76	119
Cu	5,6	5,4	96	6,0	107	111
Mn	209,0	149,0	71	202,0	97	136
Ni	9,8	9,5	97	10,1	103	106
Cr	14,9	13,1	88	14,3	96	109
Co	7,3	5,0	68	6,1	84	122
Pb	14,9	9,6	64	16,3	109	170
Cd	0,8	0,6	75	0,7	88	117
TOTAL B	312,3	224,2	72	293,5	94	131
Diff. A-B%	116	96	x	110	x	x

After another 9 years (2023) and a final 28 years (after 1995) *Nardus stricta* decreases to 55% on the control variant, reaches 75% on simple milling and 8% on the amended variant, which proves the particular importance of correcting the acidity of the soils further evolution of the productivity of these grasslands.

The amendment created conditions for *Trifolium repens*, the most valuable forage species in the

subalpine floor, to reach 40% participation in the grass carpet,

The production of green fodder mass increases substantially on the amended version up to 8.28-9.73 t/ha and decreases on the phrased version compared to the control, where it was evaluated 1.58-2.10 t/ha, about 5 times less. Likewise, the pastoral value (VP) on the basis of which the cow's milk production was evaluated recorded the highest values in variant 3 (amended, milled and naturally

improved grass carpet), where an amount of over 3500 litters of

milk/cow/ha was evaluated after 28 years.

Table 5

The dynamics of the floristic composition and the productivity of the grassland after calcium amendment and the processing of grass carpet with the miller

Species	Indices		1995	2014 (after 19 ani)			2023 (after 28 ani)		
	F	M		1*	2**	3***	1*	2*	3*
<i>Nardus stricta</i>	3	0	68	65	25	1	55	75	8
<i>Festuca nigrescens</i>	7	5	7	10	15	45	10	5	22
<i>Agrostis rupestris</i>	5	1	2	5	25	10	5	2	+
<i>Phleum alpinum</i>	6	3	3	1	+	5	5	4	2
<i>Agrostis capillaris</i>	7	5	1	+	+	6	+	+	8
<i>Deschampsia flexuosa</i>	4	3	+	3	+	-	+	+	-
<i>Deschampsia caespitosa</i>	3	0	2	2	5	8	10	3	2
Alte graminee	5	3	+	1	+	+	+	+	+
<i>Trifolium repens</i>	8	5	4	+	3	5	5	5	40
<i>Potentilla ternata</i>	4	1	5	8	15	-	5	3	5
<i>Ligusticum mutellina</i>	7	1	2	3	2	5	2	2	-
<i>Alchemilla vulgaris</i>	6	4	+	-	-	8	-	-	6
<i>Taraxacum officinale</i>	7	3	-	-	-	+	-	-	1
<i>Polygonum bistorta</i>	5	4	2	-	-	+	-	-	1
Alte specii	3	0	4	22	5	7	3	1	5
Producția MV (t/ha)			1,69	1,58	2,72	8,28	2,10	1,37	9,73
Valoare relativă (%)			100	93	161	490	124	81	576
Valoare pastorală			18,1	19,2	36,9	63,2	22,4	15,3	68,4
Lapte vacă L/ha			930	985	1,870	3240	1150	785	3505
Valoare relativă (%)			100	106	201	348	124	84	377
Efect frezare (%)			x	100	190	x	100	68	x
Efect CaO (%)			x	x	100	173	x	100	446

* 1 = Witness ** 2 = Milling *** 3 = Ca+Milling

The effect of processing with the miller after 19 years was favorable with 90% (1870 liters/ha) compared to the control (985 liters/ha) after which in 2023 it decreases to 68% (785 L/ha) compared to the control (1150 L/ha).

These animal production data in long-term experience are of particular importance in appreciating the necessity and economic efficiency of correcting soil acidity by calcium amendment.

CONCLUSIONS

The existing subalpine pastures at 1800 m altitude in the Bucegi massif invaded by *Nardus stricta*, located on acid soils, can be improved by calcareous amendment, loosening with the miller and natural improvement of grass carpet with more valuable species from the spontaneous flora.

Applying 7 t/ha of CaO and processing with a miller at 10-12 cm, after 28 years, the pH index increases from 4 to 5.5, the participation of the species

Nardus stricta after clearing settles only 8%, the production of green mass increases by at 1.7 to 9.7 t/ha, the pastoral value increases from 18 to almost 70 and milk production reaches 3500 liters/ha.

The effect of calcium amendment exceeds 30 years in the conditions of increasing the productivity of subalpine pastures, improving the agrochemical properties and the microelement content of the soil, with a very high economic efficiency.

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CONTRIBUTIONS TO THE ASSESSMENT OF THE PRODUCTIVITY OF FORAGE GRASS VEGETATION IN THE DANUBE DELTA

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Abstract

*The grassy vegetation of the Danube Delta is extremely diverse due to the water regime from surplus to very reduced, soil texture from coarse to very fine, different stages of salinity, zooanthropic influence and other factors. 27 plant vegetal associations belonging to 10 alliances, 6 orders and 5 phytosociological classes were determined. The grassy carpet is dominated by hydrophilic species with no fodder value such as reeds (*Phragmites australis*), reeds (*Typha* sp.), sedges (*Carex* sp) and some species on salt soils (*Juncus* sp. and others). On average, the pastoral value (PV) of 7.2 and green fodder mass production (DM) of 0.86 t/ha are considered degraded and can only provide 0.08 LU/ha in 160-day grazing season, for times below the established level of 0.30 LU/ha, for granting subsidies. In addition, the hay produced from cane, rushes and sedges in fodder value is only 50% of the value of cereal straw and 5 times weaker than alfalfa hay. With a few exceptions, such as the associations of *Puccinellietum limosae* on salt soil and *Festucetum beckeri* on beams that can be classified as permanent grasslands, the rest of the phytocenoses with very low fodder productivity are not part of this mode of agricultural use.*

Keywords: Delta Dunării vegetation, pastoral value, production of green fodder mass, animal load, hay quality

INTRODUCTION

The evaluation of the productivity of permanent grasslands (pastoral value, production of green mass and livestock, etc.) is the main component of pastoral arrangements and optimal management further (MARUȘCA et al., 2014).

In a first approximation, the productivity of the permanent grasslands habitats in our country was evaluated, which partially included those in the plains, meadows and Delta Dunării area

(MARUȘCA et al., 2020, 2021; MARUȘCA, 2022; MARUȘCA, VINȚAN 2022; MARUȘCA et al., 2022 a, b, c, d, e; OPREA, MARUȘCA, 2022; MARUȘCA, 2023; MARUȘCA et al., 2023 a, b).

In addition to these, the entire Delta Dunării was studied, as an integral part of the Biosphere Reserve, with grassy vegetation, partly used as fodder for the livestock of the inhabitants of the area.

MATERIAL AND METHOD

For this purpose, the synthesis work "Vegetation of the Delta Dunării" published in 1997 under the care of the Mureş County Museum, MARISIA publication, vol. XXV, 126 pages, with authors Popescu A., Sanda V., Oroian Silvia with the collaboration of Chifu Th., Ştefan N and Sârbu I., some of the most important geobotanists in our country.

The floristic surveys were compiled and classified according to the Braun-Blanquet phytosociological method (Anghel et al., 1971; Coldea, 1991; Cristea et al., 2004).

The herbaceous vegetation was classified into 5 classes, 6 orders, 10 alliances and 27 phytosociological associations with 276 floristic surveys as follows:

HELOPHILOUS VEGETATION (PALUSTRA)

CL. **PHRAGMITETEA** Tx et Prsg. 1942

Ord. **PHRAGMITETALIA** Koch 1926 emend Pign 1953

Al. **Phragmition** Koch 1926

1. As. *Scirpo - Phragmitetum* Koch 1926

(Syn. *Phragmitetum communis* (All. 1922) Pign 1953; *Scirpo-Phragmitetum austro-orientale* Soó 1957, *Phragmitetum natans* (Borza 1960, Nedelcu 1967)

2. As. *Typhetum angustifoliae* (All. 1922) Pign. 1943

3. As. *Glycerietum maximae* Hueck 1931

(Syn. *Glycerietum aquaticae* Nowinski 1928)

4. As. *Schoenoplectetum (Scirpetum) lacustris* Eggler 1933

HALO - PSAMOPHILOUS VEGETATION

CL. **JUNCETEA MARITIMI** Br.-Bl. 1931

Ord. **JUNCETALIA MARITIMI** Br.-Bl. 1931

Al. **Juncion maritimi** Br.-Bl. 1931

5. As. *Juncetum maritimi* (Rübel 1930) Pign 1953

6. As. *Juncetum littoralis* Popescu et al. 1992

(Syn. *Juncetum acuti* Popescu et Sanda 1976)

Al. **Armerion maritimae** Br.-Bl. Et DeL. 1936

7. As. *Plantaginetum coronopi* Tx. 1937

HALOPHILOUS VEGETATION

CL. **PUCCINELLIO - SALICORNIETEA** Țopa 1939

Ord. **SALICORNIETALIA** Br.-Bl. (1928) 1933

Al. **Thero-Salicornion** Br.-Bl. (1928) 1933

8. As. *Salicornietum europaeae* Wendelbg 1953
9. As. *Suaedetum maritimae* Soó 1927
10. As. *Aeluropo Salicornietum* Krausch 1965
11. As. *Puccinellio - Salicornietum* Popescu et al. 1987
Ord. *PUCCINELLIETALIA* Soó 1940
- Al. ***Puccinellion limo sae*** (Klika 1937) Wendelbg 1943
12. As. *Puccinellietum limosae* Rapaics 1927
13. As. *Plantaginetum maritimae* Rapaics 1927
14. As. *Agrostetum ponticae* Popescu et Sanda 1973
15. As. *Aeluropetum littoralis* (Prodan 1939) Şerbănescu 1965
16. As. *Limonio - Aeluropetum littoralis* Sanda et Popescu 1992
17. As. *Aeluropo - Puccinellietum limosae* Popescu et Sanda 1975
- Al. ***Cypero - Spergularion*** Slavnic 1948
18. As. *Acorelletum pannonicum* Soó 1939
19. As. *Spergularietum mediae* (Şerbănescu 1965) Popescu et al. 1992
20. As. *Polypogonetum monspeliensis* Moraru 1957

COASTAL DUNE VEGETATION

CL. ***AMOPHILETEA*** Br.-Bl. et Tx.1943

Ord. *ELYMETALIA ARENARIAE* Br.-Bl. et Tx 1943

Al. ***Elymion gigantei*** Morariu 1957

21. As. *Elymetum (gigantei) sabulosi* Morariu 1957 corr.hoc.loco.

22. As. *Secaletum sylvestre* Popescu et Sanda 1973 non Şerbănescu

Al. ***Agropyro - Minuartion*** Tx.1945 apud Br.-Bl. et Tx.1982

23. As. *Aperetum maritimae* Popescu,Sanda,Doltu 1980

(Syn. *Aperetum spicae-venti* Soó 1953 subass *ponticum* Popescu et Sanda 1972)

CL. ***FESTUCETEA VAGINATAE*** Soó 1969

Ord. *FESTUCETALIA VAGINATAE* Soó 1957

Al. ***Festucion vaginatae*** Soó 1929

24. As. *Festucetum beckeri nomen novum*

(Syn. *Festucetum vaginatae* (Rapaics 1923) Soó 1929 subass. *arenicolum* Popescu et Sanda 1976)

25. As. *Koelerio glaucae-Stipetum borysthenicae* Popescu et Sanda 1987

Al. ***Scabiosion argenteae*** (Boşcaiu 1975) Popescu et Sanda 1987

26. As. *Scabioso argenteae - Artemisietum campestris* Popescu et Sanda 1987

27. As. *Scabioso argenteae-Caricetum colchicae*(Simon1960) Krausch 1965 (Syn. *Caricetum colchicae* Simon 1960)

The evaluation of the pastoral value and the production of green fodder mass was carried out according to the new method based on the floristic survey (Maruşca 2019).

According to this method, numerous phytocoenoses of lowland grasslands were evaluated, most of them published in this journal, so we will not return to this method.

In addition to this evaluation of the productivity that refers to the green mass of the grasslands used occasionally by grazing with the animals, studies were carried out on the vegetation of the permanent grasslands of Sf. Gheorghe - Delta as part of a pastoral management project.

From the very beginning we noticed the very strong invasion of

reeds (*Phragmites australis*), rushes (*Typha angustifolia*) and sedges (*Carex* sp.) of permanent grasslands with excess moisture due to the rise of the water table as a result of the digging of a Cordon Litoral channel parallel to the shore of the sea from Sf. Gheorghe towards Sulina and of the non-harvesting of hay necessary for the wintering of livestock in that area (Maruşca 2017).

The feed analysis was carried out at ICD Pajişti - Braşov using the Near Infrared Spectroscopy (NIRS) technique.

Hay quality was achieved according to the standards of the United States Department of Agriculture regarding the nutritional value of forages (Table 1).

Table 1

Quality classes assigned by American Forage & Grassland Council, Hay Marketing Task Force (adapted*)

APPRECIATION CLASS	% CP	% ADF	% NDF	% DSU	RFV
Excellent	>19	<31	<40	>65	>151
Very good	17-19	31-35	40-46	62-65	125-151
Good	14-16	36-40	47-53	58-61	101-124
Middle	11-13	41-42	54-60	56-57	86-100
Poor	8-10	43-45	61-65	53-55	77-85
Very poor	<8	>45	>65	<53	<76

*Alex Rocateli, Hailin Zhang, Forage Quality Interpretations, Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University, <http://osufacts.okstate.edu>

For comparison on the fodder quality of the reed hay from the Delta Dunării, alfalfa hay and two-row barley straw were additionally analyzed as controls, although in a monographic work there is no reference that the reed

would have fodder value (Rudescu et al., 1965).

In this way, a concrete and complete answer is given on the fodder productivity of the grassy vegetation used as green mass through grazing and the optimal

load with animals, as well as for the fodder value of the hay they are fed

with during the stalling period.

RESULTS AND DISCUSSIONS

The grassy vegetation in the Delta Dunării is strongly influenced by the excess or lack of moisture, the coarse texture of the substrate in different stages of salinization, the degree of salinity, the zooanthropic impact through grazing, harvesting, fires and other factors.

Phytodiversity in the 27 plant vegetation associations is very different, with an average of 32 cormophytes, being quite low (Table 2).

The phytocoenoses richest in species were *Scirpo-Phragmitetum* (68 sp), *Typhetum angustifoliae* (65) and *Juncetum maritimi* (56).

The fewest species are in the associations *Spergularietum mediae* (11 sp), *Puccinellio - Salicornietum* (12) and *Aeluropo - Puccinellietum limosae* (16 species).

Regarding the participation of forage species, only two

associations have more than 85%, namely *Puccinellietum limosae* (90%) from the salt soil and *Festucetum beckeri* (86%) from the sandy soils of the shingles, the only ones that we can consider as permanent grasslands. With 38% participation, *Puccinellio - Salicornietum* is present, the rest of the associations have between 1 - 25% participation of forage species in the grassy carpet.

Within the limits of 1 - 5%, the grassy associations should no longer be included in the category of permanent grasslands and those between 6 - 25% on salt or sand after improving the texture and reaction of the soil with environmental protection reserves in the protected areas would could improve and finally pass to the category of permanent grasslands.

Table 2
Forage structure and pastoral productivity of grassland from the Delta Dunării

Nr crt	The grassland association	No. surveys	No. cormophyte	vegetation structure (%)		Pastoral value (ind)	Production	
				Fooder	Harmful		Green mass	
							t/ha	%
	Al. <i>Phragmiton</i>							
1	<i>Scirpo - Phragmitetum</i>	15	68	6	94	3,4	0,72	78
2	<i>Typhetum angustifoliae</i>	19	65	4	96	1,9	0,46	50
3	<i>Glycerietum maximae</i>	11	41	2	98	0,6	0,13	14
4	<i>Schoenoplectetum lacustris</i>	6	19	4	96	2,9	0,43	47

Nr crt	The grassland association	No. surveys	No. cormophyte	vegetation structure (%)		Pastoral value (ind)	Production	
				Fooder	Harmful		Green mass t/ha	%
	Al. <i>Juncion maritimi</i>							
5	<i>Juncetum maritimi</i>	18	56	5	95	2,5	0,21	23
6	<i>Juncetum littoralis</i>	13	24	1	99	0,6	0,10	11
	Al. <i>Armerion maritimae</i>							
7	<i>Plantaginietum coronopi</i>	10	24	5	95	3,2	0,22	24
	Al. <i>Thero-Salicornion</i>							
8	<i>Salicornietum europaeae</i>	22	38	1	99	0,5	0,03	3
9	<i>Suaedetum maritimae</i>	14	23	1	99	0,3	0,02	2
10	<i>Aeluropo Salicornietum</i>	8	23	12	88	7,6	0,51	55
11	<i>Puccinellio - Salicornietum</i>	10	12	38	62	29,4	2,27	247
	Al. <i>Puccinellion limosae</i>							
12	<i>Puccinellietum limosae</i>	11	43	90	10	65,9	5,91	642
13	<i>Plantaginietum maritimae</i>	3	24	2	98	1,1	0,08	9
14	<i>Agrostetum ponticae</i>	11	53	9	91	6,5	0,56	61
15	<i>Aeluropetum littoralis</i>	9	21	2	98	1,6	0,11	12
16	<i>Limonio - Aeluropetum littoralis</i>	15	20	24	76	18,8	1,38	150
17	<i>Aeluropo - Puccinellietum limosae</i>	7	16	25	75	18,5	1,35	147
	Al. <i>Cypero - Spergularion</i>							
18	<i>Acorelletum pannonicici</i>	6	37	1	99	0,7	0,08	9
19	<i>Spergularietum mediae</i>	6	11	4	96	3,4	0,38	41
20	<i>Polypogonetum monspeliensis</i>	8	31	2	98	1,2	0,10	11
	Al. <i>Elymion gigantei</i>							
21	<i>Elymetum (gigantei) sabulosi</i>	10	32	1	99	0,4	0,04	4
22	<i>Secaletum</i>	9	31	15	85	9,7	0,56	61

Nr crt	The grassland association	No. surveys	No. cormophyte	vegetation structure (%)		Pastoral value (ind)	Production Green mass	
				Fooder	Harmful		t/ha	%
	<i>sylvestre</i>							
	Al. <i>Agropyro - Minuartion</i>							
23	<i>Aperetum maritimae</i>	7	34	3	97	1,8	0,18	20
	Al. <i>Festucion vaginatae</i>							
24	<i>Festucetum beckeri</i>	5	22	86	14	47,8	8,27	871
25	<i>Koelerio glaucae-Stipetum borysthenicae</i>	10	29	4	96	2,3	0,29	32
	Al. <i>Scabiosion argenteae</i>							
26	<i>Scabioso argenteae-Artemisietum campestris</i>	10	26	4	96	2,8	0,38	41
27	<i>Scabioso argenteae-Caricetum colchicae</i>	10	36	1	99	0,6	0,06	7
	AVERAGE	11	32	13	87	8,7	0,92	100

Participation in the grassy carpet of forage plants directly influences the pastoral value and the production of usable green mass through livestock.

The highest pastoral value (PV) in this case is *Puccinellietum limosae* (65.9) and *Festucetum beckeri* (47.8) where we also record the highest productions of green fodder mass (GM) 5.91 for the first and 8.27 t/ha in the second association, being considered medium and good in terms of productivity.

Only one association, *Puccinellio - Salicornietum*, is mediocre from a productive point of view, having 29.4 PV index, below 5 being degraded, between 5 -15

poor from a qualitative point of view.

The production (GM) except for the first two associations (*Puccinellietum* and *Festucetum*) is between 0.02 - 2.27 t/ha, respectively from almost non-existent to very weak.

On average, for all associations, the participation of 13% in the grass carpet of forage species and 87% of worthless, harmful species with 8.7 PV (very poor) and 0.92 t/ha GM (very low) can be considered as a whole degraded from the point of view of productivity.

Analysis of grazing capacity in approx. 160 days normal season, i.e., the optimal load with animals

was carried out at the level of phytosociological alliance that assimilates with the practical

habitats accepted in the European Union (Gafta, Mountford, 2008) (Table 3).

Table 3

Forage green mass production and possible grazing animal loading of herbaceous vegetation at phytosociological alliance level

Phytosociological Alliance	Pastoral value (ind)	Green mass production (t/ha)	Possible loading in 160 days		Appreciation
			LU/ha	%	
1. <i>Phragmition</i>	2,2	0,44	0,04	50	Degraded
2. <i>Juncion maritimi</i>	2,6	0,16	0,02	25	Degraded
3. <i>Armerion maritimae</i>	3,2	0,22	0,02	25	Degraded
4. <i>Thero-Salicornion</i>	9,5	0,71	0,07	88	Degraded
5. <i>Puccinellion limosae</i>	18,7	1,57	0,15	188	Degraded
6. <i>Cypero - Spergularion</i>	1,8	0,19	0,02	25	Degraded
7. <i>Elymion gigantei</i>	5,1	0,60	0,06	75	Degraded
8. <i>Agropyro - Minuartion</i>	1,8	0,18	0,02	25	Degraded
9. <i>Festucion vaginatae</i>	25,1	4,28	0,41	513	Poor
10. <i>Scabiosion argenteae</i>	1,7	0,22	0,02	25	Degraded
AVERAGE	7,2	0,86	0,08	100	DEGRADED

In this case, with 7.2 PV and 0.86 t/ha, on the current grassy vegetation in the Delta Dunării, only 0.08 LU/ha can be maintained on average, 4 times fewer grazing animals than the mandatory scale of over 0.30 LU/ha equivalent to 3 ha, required for 1 LU, for EU grassland grants granted by APIA.

Between alliances (habitats) there are very large differences from 0.02 - 0.41 LU/ha depending on PV and GM production previously evaluated.

The only alliance that meets the APIA eligibility condition is *Festucion vaginatae* on beams with consolidated sandy soils, the rest of the alliances are below this level.

Exceeding these optimal animal load levels can seriously

damage phytodiversity and grassland biodiversity in general.

With 1 LU per 15 hectares of animal load, 5 alliances *Juncion maritimae*, *Armerion maritimae*, *Cypero - Spergularion*, *Agropyro - Minuartion* and *Scabiosion argenteae* are registered, followed by 1 LU for 7.5 ha at *Phragmition*, 5ha for *Thero - Salicornion* and *Elymion gigantei* finally 2 ha needed for the phytocoenoses of the *Puccinellion limosae* alliance.

With the exception of the *Festucion vaginatae* alliance, which has a productivity assessed as poor, all other alliances (habitats) are considered degraded from a forage point of view, lacking economic efficiency through animal grazing.

The improvement of the grassy carpet of these areas with grassy vegetation degraded from a fodder point of view involves very expensive agropedo-ameliorative land improvement works that contradict the conservation of the current biodiversity imposed by the Delta Dunării Biosphere Reserve.

The only way to improve the grass carpet in this case is to regulate the optimal animal load per hectare, where grazing does not affect biodiversity.

In addition, compared to the evaluation of PV and GM based on the floristic survey of the grassy phytocenoses, an analysis of the quality of the harvested hay for the animal housing season was carried out.

For this purpose, 3 average samples of hay produced on the Cazacu and Crasnicol bales were taken from freshly harvested and stored bales (Table 4).

Table 4

The nutritional value of some hay samples from the Danube Delta

Parameter	A. Grindul Cazacu				B. Grindul Crasnicol			
	1	2	3	Average	1	2	3	Average
Crude protein	2,8	3,7	4,6	3,7	3,5	4,3	3,4	3,7
Ash	5,3	7,2	7,8	6,8	8,4	7,0	6,6	7,3
Crude fibre	56,8	49,1	41,0	49,0	55,0	45,6	49,9	50,2
NDF*	86,7	83,1	78,6	82,8	82,7	82,8	84,5	83,8
ADF**	61,4	53,7	46,7	53,9	59,1	49,4	53,0	53,8
ADL***	8,7	7,1	5,5	7,1	7,3	5,6	6,0	6,3
DMD****	15,2	26,2	33,4	24,9	20,8	35,4	31,7	29,3
DOM*****	12,1	22,0	25,9	20,0	15,5	31,3	27,2	24,7

*NDF = Neutral Detergent Fibre, **ADF = Acid Detergent Fibre, ***ADL = Acid Detergent Lignin, ****DMD = Digestibility dry matter, *****DOM = Digestibility organic matter

Finally, the data on the qualities of the traditionally harvested hay from the two bales were compared with those of an alfalfa hay and two-row barley straw, harvested in the same year 2017 at ICD Pajişti – Braşov (Table 5).

Crude protein content is one of the most widely used indices for forage quality characterization. Delta hay was very low in crude protein (3,7%) compared to two-row barley straw (8,3%) and alfalfa

hay (17,1%). The increased value of the ADF content of the hay from the delta places it in a very poor-quality class, according to the specialized literature (Canbolat et al., 2006; Schroeder, 2006), knowing that too much accumulation of the portion of acid detergent fibre (ADF) can affect feed digestibility and implicitly its consumption by animals. The deterioration of hay quality is also due to the high content in lignin (6,7%). In order to obtain a better digestibility of the

feed, it is indicated that this lignin content is as low as possible, because it can affect both the digestibility and the quality of the feed (Schroeder, 2006).

Thus, the current hay in the delta has a nutritional value more than 50% lower than the value of two-row barley straw and 5 times

lower than that of alfalfa hay, results based on which this plant material cannot be considered forage for animal feed.

It is no coincidence that animals fed exclusively with this type of hay, very poor in nutrients, do not all survive until the grass turns in the spring!

Table 5

Comparative data on the nutritional value of delta hays, alfalfa and straw

Parameter	Alfalfa hay (%)	Two-row barley straw (%)	Deltă hay (%)	Differences (+, -) deltă hay versus:		Relative value (%) to:	
				Alfalfa	Two-row barley	Alfalfa	Two-row barley
Crude protein	17,1	8,3	3,7	- 13,4	- 4,6	22	45
Ash	9,4	9,9	7,0	- 2,4	- 2,9	74	71
Crude fibre	34,3	43,4	49,6	+ 15,3	+ 6,2	145	114
NDF	48,3	75,2	83,0	+ 34,7	+ 7,8	172	110
ADF	37,4	48,6	53,9	+ 19,2	+ 5,3	155	111
ADL	3,0	6,1	6,7	+ 3,7	+ 0,6	223	110
DDM	63,1	32,6	27,1	- 36,0	- 5,5	43	83
DOM	59,7	29,9	22,3	- 37,4	- 7,6	37	75

Currently, homesteaders buy alfalfa hay bales from outside the delta, where this forage cannot be grown.

As the quality of the current hay made from cane, rushes, sedges and other species of excess moisture is very low, it is preferable to bring in grain straws that have double the protein content of what is made now as coarse fodder in cattle feed.

All these actions must be in harmony with the indications of the Delta Dunării Biosphere Reserve which include these wet grasslands,

where animal breeding activity in the "bio" system is accepted but with severe restrictions on the use of pesticides, chemical fertilizers and the introduction of some plant species that they are not present in the spontaneous flora.

Through these radical measures, it will be possible to ensure milk and meat both for the needs of the population and for the booming agritourism and heliomarine leisure guesthouses in this part of the country.

CONCLUSIONS

The grassy vegetation in the Delta Dunării in the 10 alliances has an average pastoral value (PV) of 7.2 (degraded) and a production of 0.86 t/ha green mass (GM), which ensures 0.08 LU/ha 4 times lower than the level required to grant subsidies from the European Union, (0.30 LU/ha) on permanent grasslands.

The most degraded phytosociological alliances (habitats) with a possible load of 0.02-0.04 LU/ha are: *Phragmition*, *Juncion maritimi*, *Armerion maritimae*, *Cypero - Spergularion*, *Agropyro - Minuartion*, *Scabiosion argenteae*, which are also the most widespread, can only be classified as permanent grasslands after extensive and expensive land improvement works, which contravene the restrictions imposed by the Management Plan of the Delta Dunării Biosphere Reserve.

Hay produced from reeds (*Phragmites australis*, *Typha sp.*,

Carex sp. and other hydrophilic species), has an extremely low fodder quality of barely 50% of the value of cereal straw and 5 times lower than that of alfalfa and cannot be considered coarse fodder.

The only associations of the 27 described that can fit into permanent grasslands are *Puccellietum limosae* on salted soil (65.9 PV and 5.91 t/ha GM) and *Festucetum beckeri* on beams with consolidated sandy soils (47.8 PV and 8, 27 t/ha GM), used by grazing with animals.

The management of grass vegetation for the conservation of biodiversity at the level of phytosociological alliances (habitats) will have to take into account the very reduced capacity of support and load with animals in the grazing season and prohibition of the harvesting of reeds for hay for animals, which is the main nesting habitat of waterfowl.

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RESILIENT ECOSYSTEMS GRASSLAND STRESS PHYSIOLOGY

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Abstract

Stress in grasslands arises from both abiotic factors, such as drought, extreme temperatures, nutrient deficiencies, soil salinity, and biotic factors. These stressors can disrupt the physiological processes of grassland plant communities, leading to reduced growth, impaired reproductive success, increased mortality and disturb dominance of sensible species. Plants have evolved a variety of mechanisms to cope with stress, ranging from morphological adaptations and changes in root architecture to biochemical and molecular responses that enhance tolerance degree and resilience. Understanding the stress physiology of grasslands is crucial to managing and preserving these ecosystems, particularly in the face of increasing environmental stressors such as climate change, drought, and human activity improper interventions. In this context, the study of stress physiology in grasslands is not only important for ecological research but also for practical applications in agriculture, conservation, and land management.

Keywords: grassland dynamics, physiological responses, resistance, stress responses, resilience.

INTRODUCTION

More and more extreme events because of climate warming will be encountered and in the current context of changes produced by regional climate it is important to have sufficient tools to predict the vegetation shifts and overall the ecosystems severe stress (Van Peer et al., 2004). As extreme weather is predicted along climate changes patterns, heat waves along intensive drought periods will represent the major thread for grasslands and agriculture with increased concern

in central Europe (Signarbieux and Feller, 2012).

One of the third terrestrial surface, grasslands, represent 70% from the agricultural area (Reynolds and Frame, 2005). The particular importance of grasslands is due to its higher resilience toward heat stress compared to forests and represents a carbon sink that can store more than 50% more carbon in comparison with forests ecosystems (Conant, 2010; Reinermann et al., 2020). The grasslands high biodiversity represents an essential

ecosystem service along with purifying water, preventing erosion, landscape sightseeing, stable carbon pool (Păcurar et al., 2014; Reinermann et al., 2020; Stoian et al., 2022). and provided agriculture and livestock resources (Van Peer et al., 2004). Plants will be exposed to warmer and drier conditions, therefore will suffer severe or even lethal stress levels (Signarbieux and Feller, 2012). Also, plant communities' composition and distribution will change because of the climatic changes especially in grasslands. Diversity loss affect plant communities' resistant to extremes and accelerate the overall diversity decline (Van Peer et al., 2004).

Grassland contain woody shrubs, grasses (Letts et al., 2010) and also annual plants (Signarbieux and Feller, 2012). Woody shrubs and grasses usually manifest competition by co-occurrence in grasslands ecosystems (Clarke and Knox, 2009). Annual plants possess stress mechanisms to avoid water-loss together with the ability to reduced metabolism activity sometimes become dormant due to intensive stress generically called physiological adjustments (Zavalla, 2004). Understanding how stress physiology and plant community structure interact to assure resistance and resilience is essential to overcome stress (Ungar, 2018; Yang et al., 2023). Increased species richness could sustain the

probability that a single or a group of plants drought tolerant with specific adaptation sustain the grassland functioning and persistence of the species (Nijs and Impens, 2000). An alternative mechanism linking diversity to resistance might arise from the dominance of highly productive species in species-rich mixtures (Van Peer et al., 2004).

The interspecific differences between plants could be influenced by morpho-eco-physiological interactions and determine changes in phenology, physiological characteristics and rooting depth (Vico et al., 2015).

The methodology proposed for highlighting the research interest in the subject selected implied a search in WOS –Web of Science database sustained by Clarivate (accessed on 30.05.2024). The topic field was selected and “grassland stress physiology” was then filtered from the scientific database. A number of 109 articles were found of which 98 were articles, 9 were reviews, 2 were proceeding papers and one was early access. The time interval with this subject interest in research and publication was between 2011-2024 with 83% from the total number of online articles (17% were published between 1994-2010). The aim of the study was set to highlights the most important aspects interdisciplinary connected with the plants physiology under stress in grasslands.

STRESS CATEGORIES IN GRASSLANDS

Grasslands face a range of abiotic and biotic stressors (Surówka et al., 2020) that can impact growth, development and reproduction of grassland plants. Abiotic stressors encompass drought, extreme temperatures,

nutrient deficiencies, and soil salinity, while biotic stressors include herbivory, pests, and diseases. Plants adapt to abiotic challenges and stress by metabolic transformation in response to all threats (Fig. 1).

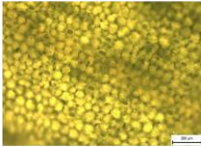
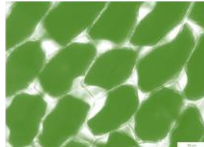
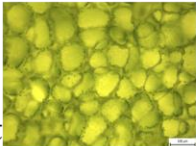
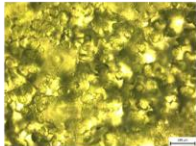
PHYSIOLOGICAL RESPONSES TO DROUGHT  Stomatal closure Leaf abscission Root system adjustment Osmotic adjustment	HEAT STRESS RESPONSE  Heat shock proteins Membrane stabilization Antioxidant production
NUTRIENT DEFICIENCY RESPONSES  Chlorophyll content Nutrient efficient use Root growth enhancement Mycorrhizal associations	SALINITY STRESS RESPONSES  Ion homeostasis Compatible solute sequestration Salt exclusion and sequestration

Fig. 1 Categories of abiotic stress for grasslands plant species

PHYSIOLOGICAL RESPONSE TO DROUGHT

Drought represents one of the most significant stressors for grasslands. Plants respond to water deficit through a range of physiological mechanisms (Kang et al., 2021):

Stomatal closure: To minimize water loss, grassland plants often close their stomata, the pores on their leaves, which also reduces gas exchange, transpiration and in the end photosynthetic activity.

Leaf abscission: Shedding leaves can reduce water loss and preserve essential nutrients under drought stress periods.

Root system adjustment: Plants may develop deeper or more extensive root systems to access water from deeper soil layers.

Osmoregulation: solutes accumulation like proline and sugars helps maintain cell turgor and enzyme function under drought conditions.

The search performed to highlight connections between grassland stress physiology for ensuring ecosystem resilience provide us useful insights for further interdisciplinary research.

In the last 24 years, drought was the most studied abiotic stress (Loka et al., 2019) with a share of 22% from the total 10 keywords selected from the published articles from the WOS (Fig. 2).

Close connected with this first research subject, high percentages of interest of climate changes effect and eco-physiological conditions influence of grassland resilience around 18%.

Abiotic stress was also in an increased share of 11%, for this class were counted articles with water stress, temperature stress,

extreme events or multiple stress which determine plant physiological changes (Fig. 2). Community composition, dynamics along with competition (8%) for providing resilience (7%) from increasing the plants tolerance, were studied in the presence of different nutrients (5%).

Physiological assessment was concentrated on osmoregulation (5%), stomatal conductance (4%) and the lowest percentage was found for chlorophyll content only 2%. Future research perspectives must be related with this physiological parameter respectively chlorophyll content (Tong and He, 2017), the pigment which is sensitive to reflectance index in the red to near red-edge wavelength between 660-720 nm (Sims and Gamon, 2002).

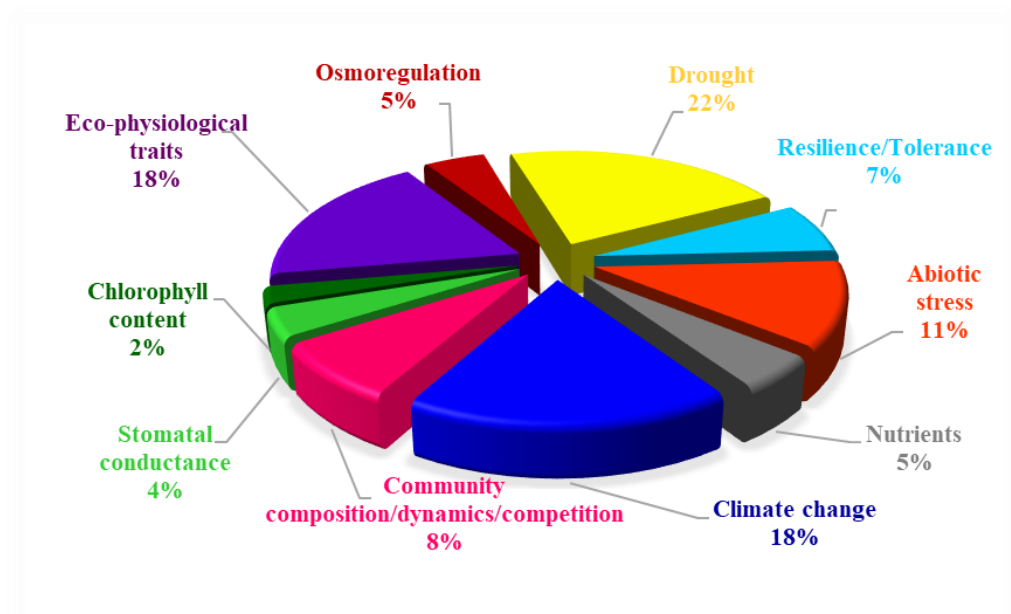


Fig. 2. Results obtained after applying filters to the WOS database after a search based of combined keywords “grassland stress physiology”

HEAT STRESS RESPONSE

Heat stress can damage cellular structures and disrupt metabolic processes. Grassland plants employ several strategies to cope with high temperatures (Hemantaranjan et al., 2018):

Heat shock proteins (HSPs): These proteins help in stabilizing and refolding denatured proteins, ensuring cellular function.

Membrane stabilization: Adjusting the composition of membrane lipids helps maintain membrane fluidity and integrity under heat stress.

Antioxidant production: To combat oxidative stress caused by high temperatures, plants increase the production of antioxidants like superoxide dismutase and catalase.

NUTRIENT DEFICIENCY RESPONSES

Nutrient deficiencies, particularly of nitrogen and phosphorus, can limit growth and productivity in grasslands (Hill et al., 2006). Plants adapt through:

Chlorophyll content: The plant chlorophyll content represents an indicator of growth, development, photosynthetic activity and biochemical properties of grassland plant providing an overview about plants physiological status (Shiflett et al., 2014; Zang et al., 2020). Higher leaf nitrogen provides increased growth rates and photosynthesis, also provide

resistance and persistence of plants under stress (Shiflett et al., 2014).

Efficient nutrient use: Improving the efficiency of nutrient use by optimizing metabolic pathways to make the most of available resources.

Enhanced root growth: Increasing root biomass and root hair development to explore a larger soil volume for nutrients (Corcoz et al., 2022).

Mycorrhizal associations: Forming symbiotic relationships with mycorrhizal fungi, which enhance nutrient uptake (Stoian et al., 2019; Corcoz et al., 2021).

SALINITY STRESS RESPONSES

Soil salinity represents another critical stressor, especially in arid and semi-arid grasslands (Truşcă et al., 2022; Truşcă et al., 2023). Plants adapt to salinity through:

Ion homeostasis: Maintaining ions balance within cells to prevent toxicity.

Compatible solute accumulation: Synthesizing compounds like glycine betaine and proline to protect cellular structures.

Salt exclusion and sequestration: Excluding salt from uptake or sequestering it in vacuoles to prevent damage to vital cellular processes.

BIOTIC STRESS RESPONSES

Grasslands face biotic stresses from herbivores, pests, and pathogens (Sánchez-Sánchez and Morquecho-Contreras, 2017). Plants have evolved various defense mechanisms:

Physical defenses: Developing structures like thorns and trichomes to discourage herbivores approach.

Chemical defenses: Producing secondary metabolites such as

alkaloids, terpenoids, and phenolics that are toxic or unpleasant to herbivores and pathogens.

Induced resistance: Activating systemic acquired resistance (SAR) and induced systemic resistance (ISR) pathways to enhance defense against a broad range of pathogens and pests.

GRASSLAND MANAGEMENT IMPLICATIONS

Understanding grassland stress physiology is essential for developing strategies to manage and conserve these ecosystems (Truşcă et al., 2022; Milazzo, et al., 2023). This includes:

Selecting drought-resistant species: Utilizing plant species or cultivars that are more resistant to drought and other stresses.

Sustainable grazing practices: Implementing grazing regimes that minimize stress on plants and allow for recovery and regeneration.

Soil management: Enhancing soil health through practices that improve water retention, nutrient availability, and microbial activity

Plant physiology in grasslands assessment could provide vital information about net primary production (Ling et al., 2019), nutrients status (Moran, 2000) and stress level (Netto et al., 2005). The health and physiological function is provided by the vegetation chlorophyll, today many nondestructive methods could be used for evaluation this physiological indicator. The estimation and prediction of chlorophyll content can be also quantified using remote sensing (Tong and He, 2017).

CONCLUSIONS

The stress physiology of grasslands encompasses a complex interplay of mechanisms that plants use to survive and thrive under adverse conditions.

For ensuring practical applications in agriculture, conservation, and land management,

the studies of stress physiology in grasslands should provide information connected with stress resistant species, species specific responses and ecosystem resilience.

Dominant species under different eco-physiological conditions should be proposed for

reshaping grasslands community composition in the regions or areas with altered climatic parameters like low precipitation level and increased heat events.

One of the most important physiological parameter is

chlorophyll content hereby further studies should be concentrated for assessing this pigment change for different plant species in different grasslands type along with management implications.

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THE ADAPTATION OF THE GALLOWAY BREED IN THE CLIMATIC CONDITIONS OF THE COJOCNA FARM

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Abstract

Due to the large areas of grassland in our country, which are not exploited to their maximum potential, an analysis was made of the possibilities of exploiting these resources with the Galloway breed, which can convert either good or mediocre quality grass into quality meat. The study was carried out at Cojocna Farm -USAMV Cluj, both on the existing grassland and on the Galloway breed. The grassland study was carried out at the Cojocna farm on an area of 20 ha from plot 13 belonging to the Natura 2000 Site ROSCI0238 Suatu – Cojocna – Suatu-Cojocna-Crairât, the aim being the study on the adaptability of the Galloway breed in an extensive system in the pedoclimatic conditions at the Cojocna farm, where the following objectives were pursued: Study of the effect of Galloway grazing on the ecological and agronomic value of Natura 2000 habitats; Identification of the correlation between ADG (average daily growth) and the floristic composition of the pasture at the Cojocna farm; Elaboration of specific measures to improve the types of grassland) Elaboration of measures regarding the exploitation technology of Galloway beef cows raised in an extensive system.

The research activity was carried out the year 2023. The research methods used are: weighing the calves according to the official performance control (COP) methodology to determine the average daily gain ADG and the geobotanical method using the Braun-Blanquet interpretation scale to identify the types of grassland on the 2 descriptive plots (PD1 and PD2).

Spores are within breed performance even if the grassland type is Festuca rupicola and Stipa capillata - moderately tolerant to grazing. A rational grazing system, cleaning of grassland and vegetation, combating leeches and toxic plants is recommended.

Keywords: Galloway breed, grassland, adaptability, average daily gain

INTRODUCTION

The Galloway breed is one of the oldest and purest domestic breeds in the world. Galloway cows are originally from south-west Scotland, first developed in the 17th century. In 1570, the Scottish historian Hector Boece wrote about this breed and about the south-western part of Scotland "in this area the oxygen is

wonderful and the meat from the black cattle is delicious and tender, because the fat is deposited on the most valuable parts, thus the meat is mixed with fat, that is, well marbled", (Pruitt, 2004). The Galloway is now found in many parts of the world, having been exported to

Canada in 1853, the USA in 1882 and Australia in 1951.

The Galloway Cattle Society was formed in 1877 and the Herd Book was established in 1878, but cattle breeding in south-west Scotland goes back to the 1100.

The breed enjoyed great success in the 1950 as the beef market demanded low-input (feeder) cattle with high-quality meat. Recent years have seen changes in the breed, as leaner carcasses have been demanded from the market.

Today, the breed still prides itself on its original qualities and attributes, with farmers adopting low-input systems now in vogue. At the 2009 Royal Highland Show, Galloways won all major trophies, including individual competitions. Never has one breed dominated all the premier cattle championships in Scotland.

They are renowned for their hardiness and can thrive in harsh or mountainous climates, even where other breeds would struggle to survive. Galloway offer the highest quality beef and are in high demand by many butchers whose customers are looking for meat from naturally raised cattle (Cirebea, M. 2020).

The Galloway breed is ideal for people looking for red meat from sustainable, pasture-based systems with animal welfare. This breed makes good use of the natural pasture without too high demands on the quality of the grass. Galloways have thick skin with two layers of wavy hair. These thick layers of hair

insulate the body so well that they have a minimal outer layer of body fat. The meat is known for its tender, fine texture and good fat marbling, which gives the meat an excellent flavor, rich in protein, minerals and antioxidants, while being low in cholesterol and saturated fat, and the fat has a ratio of exceptionally good Omega 3:6.

Galloway cows are known for their well-developed maternal instinct and calving ease. This gives them excellent quality and longevity, with the freedom to express their normal behavior in natural habitats. Galloway calves, both purebred and crossbred, are strong, vigorous and have a "will to live" that quickly grows and nurses them on their mothers rich milk, (<https://www.gallowaybeef.co.uk>).

In Germany the Galloway breed was officially important for the first time in June 1973. The first Galloways were brought from Scotland. The special qualities of this very old but still very modern breed of cows, not only because they maintain the landscape, but also their meat is of superior quality, have long been discussed and recognized in the professional world. The Galloway provides services that no other breed can provide on this scale. The only obligation for the breeder and keeper is to let the Galloway remain the Galloway, as the Scots have been doing for nearly two thousand years. (Grubbe, 2011).

Galloway cows are used exclusively for meat production. The

animals are robust, have very good physical resistance, grow freely, outside the stables, even in winter, reproduce easily, are particularly fertile and live an average of 20 years. The basic characteristic of this breed is the lack of horns, a characteristic pursued by breeders in the activity of selection and improvement (<https://www.revista-ferma.ro>).

Statistical data show that it was imported to Romania in 2006. The service for determining the genetic quality of animal breeds from the Galloway breed (but also for other breeds with a small share in our country such as: Highland, Hungarian Gray and Aubrac) , was entrusted to an association from Suceava in 2014, by the National Agency for Animal Husbandry, (Fengels J. and Kraft H. 2019; <http://www.anarz.eu>).

Galloway cows have a black color with a shade of brown, dark gray with black, white belted or riggitt. The hair is long, soft and curly. The outer hair, thicker, forms a shield for winds and rains, and the softer and thinner underhair provides thermal and water-repellent insulation. They are genetically hornless, and instead have a bony knob in the upper part of the skull, called a "poll". This character is easily transmitted to hybrids, so they do not need to be dehorned.

Galloway bulls weigh from 770 kg to 1045 kg, with an average of 820 kg. Cows of the same breed have a weight that varies from 450

kg to 675 kg with an average of 565 kg. Calves weigh, at birth, between 31 and 36 kg. The waist of adult animals is 122 cm for cows and 137 cm for bulls. Calves weaned at 205 days weigh about half the weight of their mothers, (Onaciu G. and Jurco E.,2013; <https://www.revista-ferma.ro>).

The Galloway breed is a maternal breed, the cows calve easily and have a high enough milk production to ensure satisfactory calf growth. The lifespan of cows is long, they regularly produce a calf every year, with most cows still productive between 10 and 15 years. Cows of this breed have a reputation for living a very long time, up to the age of 17-20 years. Moreover, they behave well and will produce calves even when fed with poor winter rations, but also by grazing on unimproved natural pastures. Galloway cows represent an ideal starting point for obtaining products with strong hybrid vigor (Onaciu G. and Jurco E. 2014;<http://www.thedairysite.com>;<https://ourworldindata.org>).

The temperament of cows is calm, having a very strong maternal instinct, which will lead them to defend their calf against any perceived threats. Taurines of this breed are very docile, but brave. They are said to pair up and attack predators to protect their calves. Even if there are only a few Galloway cows in a flock of sheep, they will behave the same, defending the sheep from dogs and predators.

Cows of this breed have easy calvings, with a low incidence of dystocia at calving (0.8%). The calf weaning percentage is high, 95.5% and the survival rate is very high, 95.2% in comparison to other breeds (Bignal E. and Mccracken D. 1996;<https://www.galloway-deutschland.de>).

The Galloway breed was created in adverse climatic conditions, which ensured increased resistance to diseases and the ability to survive in the harshest conditions. Due to the natural density of the hair of Galloway animals, it provides good insulation against low temperatures, which leads to a thinner protective layer of subcutaneous fat, fat that is not used after slaughter. Although it is considered to be a breed adapted to cold northern climatic conditions, the Galloway adapts very well to warmer regions in the world (<https://www.galloway-schlachter>; <https://fermierinromania.ro>).

Cows of this breed are resistant to acute conjunctivitis, external parasites, insects and limb problems. In this breed, congenital

problems and dwarfism are unknown diseases.

Galloway calves, both purebred and hybrids, are robust, resistant, vigorous and very quickly come to suckle after birth. So that, although they are small at birth, they will have a high growth rate based on mother's milk by Sambraus Hans H. 2016).

The purpose of this research was to study the adaptability of the Galloway breed in extensive system in the pedoclimatic conditions of the Cojocna farm, where the following objectives were pursued: a) Study of the effect of Galloway grazing on the ecological and agronomic value of Natura 2000 habitats; b) Identification of the correlation between ADG (average daily growth) and the floristic composition of the pasture at the Cojocna farm; c) Elaboration of specific measures to improve the types of grassland); Elaboration of measures regarding the exploitation technology of Galloway beef cows raised in an extensive system.

MATERIAL AND METHOD

The research activity was carried out at the Cojocna Farm, Cluj county, located at an altitude of 369 m and characterized by an average annual temperature of 8.5 - 9 °C and annual precipitation of 867 mm/year.

The Cojocna farm has an area of 667 ha, of which 400 ha is arable land, 267 ha are grassland and hay

fields. In the perimeter of the Cojocna Farm is the Natura 2000 site (grassland) ROSCI0238 Suatu-Cojocna-Crairat.

Data analysis

The area of 20 ha of Natura 2000 site grassland was freely grazed extensively with 10 head of Galloway bulls, thus resulting in a

load of approximately 0.4-0.5 LU/ha.

Grazing was not done rationally (on grazing plots) because the breed prefers large, open spaces.

Weighing calves according to the methodology of COP (official production control) and breeding program.

ADG (average daily growth) has been calculated with specific formulas. The study of the floristic composition - the geobotanical method using the Braun-blauquet scale (Păcurar and Rotar, 2014). The

types of grasslands were classified according to Țucra et al. 1987. The agronomic analysis of the grassland plots was carried out with the specific methodology.

In 2022, 10 heifers and a bull of the Galloway breed were imported from Germany for exploitation in an extensive system at the Cojocna Farm.

Cattle were registered in the Breed Registry and in the breeding program, both the imported herd and the resulting products.

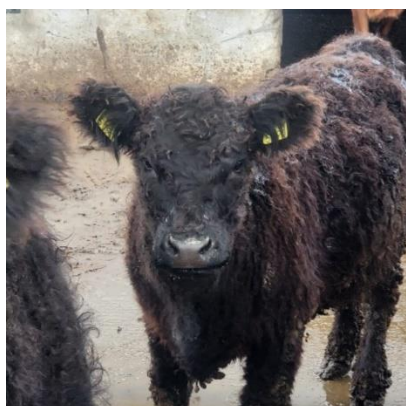
RESULTS AND DISCUSSIONS

Calves small at calving, without dystocia. The age at the time of weighing is very variable, so the weight of the animals and the average daily gain (ADG) presented are within the normal limits according to the breed, with values of 455 and 861 g/day. Cows are not milked, calves suck all the milk,

helping to accumulate daily weight. (Fig.1,2 and Table 1).

Statistical significance is where there are differences between the weights of males and females P1-P3- and P4 and at P2 there are no differences between the weights between females and males, Table 1.

Fig. 1 Galloway calf



(Source: original)

Fig. 2 Galloway on the grassland



(Source: original)

Table 1

Official performance control of the Galloway breed

Sex	Birth weight (kg)- P1	Age in days (at weaning 210±45) 21.09.2023	Weight (kg) on the date of weighing (21.09.2023)	ADG-gr. (Average Daily Gain) P2	Age in days (20.11.2023)	Weight (kg) on the date of weighing (21.11.2023)	ADG-gr. (Average Daily Gain) P3	Age in days (22.02.2024)	Weight (kg) on the date of weighing (22.02.2024)	ADG-gr. (Average Daily Gain) P4	TAG-gr. (Total Average Gain)
M	30	283	207	626	343	250	642	437	265	538	602
M	32	259	287	985	319	315	887	413	326	712	861
M	29	246	217	765	306	258	749	400	275	615	709
M	32	293	226	662	353	268	669	447	286	568	633
F	25	267	230	768	327	235	642	421	253	542	651
M	32	300	251	730	360	271	664	454	287	562	652
F	28	269	166	513	329	176	450	423	198	402	455
F	26	238	155	542	299	185	532	392	201	447	507
	P1		P2		P3		P4				
M	31.00±0.63b		753.54±62.8a		722.09±45.13b		599.05±30.9b				
F	26.33±0.88a		607.84±80.56a		541.44±55.75a		463.41±41.2a				
M= Male						F= Female					

Average daily gains are given as mean of four replicates $\pm$ standard deviations. P1 -Birth weight (kg), P2 -Average Daily Gain (ADG-gr); P3 -Average Daily Gain (ADG-gr); P4 -Average Daily Gain (ADG-gr);

Effects were accepted as statistically significant if $p \leq 0.05$. Values in the same column followed by a common letter are not significantly different according to the Tukey HSD test.

Beef cows stay on pasture all year round (extensive system). Feeding during the winter (November-April) is done only with hay, minimum 12-15 kg/hay per adult animal. Daily water consumption (50–100 l per mother cow unit) is provided from existing sources at discretion.

Following the application of grazing, 2 grassland plots with a specific floristic composition were delimited, as follows: PD1 - *Festuca rupicola* grassland type; PD2 - grassland type *Stipa capillata* – *Bothriochloa ischaemum* (Fig. 3). PD1 - *Festuca rupicola* grassland type (representative of the area) is located at the base of the slope area of 6 ha. The cows grazed in the afternoon and evening, the degree of consumption was 70%.

PD2- grassland type *Stipa capillata* – *Bothriochloa ischaemum* The grassland plot is located in the middle and top of the slope with a large area of 14 ha. Cows grazed in the morning until noon (watering time). The degree of consumption was 5-10%. The floristic composition of the *Festuca rupicola* type is represented by 50%, *Poaceae*, 19% *Fabaceae*, and 18,5%

OBF (other botanical families). Among the *Poaceae*, in addition to the dominant species *Agropyron intermedium* and *Agrostis capillaris* have a participation of 8% coverage. *Fabaceae* are represented by the *Medicago sativa* și *Trifolium intermedium*, *Trifolium repens* and *Vicia cracca* with 8% cover each species. The plants from other botanical families are represented *Achillea millefolium* and *Taraxacum officinale* 5%, (Table 2).



Fig. 3 The distribution of the grassland, grazed with Galloway (Source: The original map QGIS)

Table 2

Floristic composition of the type of grassland *Festuca rupicola* and specific requirement on ecological, agronomic, and anthropogenic

Ecological factors					Agronomic factors					Anthropo-genic factors		Species	ADM (%)
B	T	U	R	N	C	P	S	VF	SO	H	UR		
-	-	-	-	-	-	-	-	-	-	-	-	<i>Agropyron repens</i>	8
HT	x	x	x	4	6	5	5	n	6	2 - 4	3	<i>Agrostis capillaris</i>	8
HT	x	5	x	6	8	4	6	n	9	3 - 4	3	<i>Dactylis glomerata</i>	5
H	7	3	8	2	7	7	7	n	4	2 - 3	2	<i>Festuca rupicola</i>	29
POACEAE													50
HT	5	3	9	3	7	2	2	n	9	3 - 5	2	<i>Medicago sativa</i>	8
-	-	-	-	-	-	-	-	-	-	-	-	<i>Trifolium intermedium</i>	8
HT	7	2	8	6	3	4	3	n	6	2 - 3	3	<i>Trifolium pratense</i>	0.5
ChRs	x	x	x	6	8	8	8	n	8	3 - 5	3	<i>Trifolium repens</i>	2.5
FABACEAE													19
ChRs	x	4	x	5	7	4	5	n	6	2 - 4	3	<i>Achillea millefolium</i>	5
HRs	6	4	8	5	4	5	5	n	5	3 - 5	3	<i>Cichorium intybus</i>	0.5
HR	x	5	x	5	7	7	7	n	5	3 - 4	3	<i>Leontodon autumnalis</i>	2.5
HR	x	x	x	x	7	6	6	n	6	2 - 4	3	<i>Plantago lanceolata</i>	2.5
HR	x	4	8	3	4	8	8	n	5	2 - 4	2	<i>Plantago media</i>	2.5
HRs	6	7	x	8	6	4	4	n	5	2 - 4	2	<i>Symphytum officinalis</i>	0.5
HR	x	5	x	6	8	7	7	n	7	3 - 5	3	<i>Taraxacum officinale</i>	5
OBF													18,5

Legend: (B - BioForm, T - temperature, U - humidity, R - soil reaction, N – nutrition, C - tolerance of mowing, P - tolerance of grazing, S - tolerance of crushed, VF - fodder value, H - hemeroby, UR - urbanophile, SO - sozological category, ADM-abundance-dominance)

Following the ecological spectrum, it is found that the phytocenosis of the *Festuca rupicola* grassland type is meso-xerophilic ($U_p=3.6$), moderat acidophilic ($R_p=8.2$) and oligotrophic ($N_p=3.5$).

From an agronomic point of view, the phytocenosis of the *Festuca rupicola* type is medium tolerant to mowing ($C_p=6.9$), medium tolerant to grazing ($P_p=5.8$) and crushing ($S=6.0$).

VF (pastoral value) is 5.8 which means that the grassland falls

into the fifth class, the category of good grassland and supports a load of 0.61-0.80 LU/ha (table 3).

In the phytocenosis *Festuca rupicola* grassland type, the ballast species occupy a percentage of 29%, and the average forage species have a participation of only 22%, followed by the 2 good forage species with 7.5% coverage (*Trifolium repens* și *Taraxacum officinale*). Excellent fodder species two species with 13% coverage (*Dactylis glomerata* și *Medicago sativa*) (Table 3).

Table 3

The ecological and agronomic spectrum of the *Festuca rupicola* grassland type

Ecological Indexes	Ecological spectrum										VIMnp
	1	2	3	4	5	6	7	8	9	x	VIMp
U_{np}	0	1	2	3	3	0	1	0	0	3	4.2
U_p	0	0.5	37	8	12.5	0	0.5	0	0	13	3.6
R_{np}	0	0	0	0	0	0	0	4	1	8	8.2
R_p	0	0	0	0	0	0	0	32.5	8	31	8.2
N_{np}	0	1	2	1	3	4	0	1	0	1	4.9
N_p	0	29	10.5	8	8	13	0	0.5	0	2.5	3.5
Agronomic Indexes	Agronomic spectrum										VIMnp
	1	2	3	4	5	6	7	8	9	x	
C_{np}	0	0	1	2	0	2	5	3	0	0	6.3
C_p	0	0	0.5	3	0	8.5	47	12.5	0	0	6.9
P_{np}	0	1	0	4	2	1	3	2	0	0	5.5
P_p	0	8	0	11	8.5	2.5	36.5	5	0	0	5.8
S_{np}	0	1	1	1	3	2	3	2	0	0	5.6
S_p	0	8	0.5	0.5	13.5	7.5	36.5	5	0	0	6.0
VF_{np}	0	0	0	1	4	4	1	1	2	0	6.2
VF_p	0	0	0	29	6	16	5	2.5	13	0	5.8
The legend											
U	moisture		C	mowing		VF	fodder value				
R	soil reaction		P	pasture		n.p	unweighted (depending on the number of species)				
N	soil trophicity		S	crushed		p	weighted (depending on species coverage)				

In the second plot the type of grassland is *Stipa capillata* – *Bothriochloa ischaemum*. The floristic composition of the type have 53% *Poaceae*, 12% OBF (other botanical families). Among the *Poaceae*, in addition to the dominant species *Brachypodium pinnatum*

have a participation of 8% coverage and *Bromus arvensis*, *Festuca rupicola*, *Festuca valesiaca* și *Stipa tirsia* with 2,5% cover each species.

Among the plants from other botanical families is *Salvia nemorosa* and *Thymus glabrescens*, with 2.5% each species (Table 4).

Table 4

Floristic composition of the type of grassland *Stipa capillata* – *Bothriochloa ischaemum* and specific requirement on ecological, agronomic, and anthropogenic factors

Ecological factors					Agronomic factors					Anthropogenic factors		Species	%
B	T	U	R	N	C	P	S	VF	SO	H	UR		
H	7	3	X	3	-	-	-	n	3	3 - 4	2	<i>Bothriochloa ischaemum</i>	17.5
GRs	5	4	7	4	3	6	6	n	5	2 - 3	2	<i>Brachypodium pinnatum</i>	8
												<i>Bromus arvensis</i>	2.5
H	7	3	8	2	7	7	7	n	4	2 - 3	2	<i>Festuca rupicola</i>	2.5
H	7	2	8	2	7	7	7	n	4	2 - 3	1	<i>Festuca valesiaca</i>	2.5
H	7	2	8	2	2	3	3	n	3	2 - 4	1	<i>Stipa capillata</i>	17.5
-	-	-	-	-	-	-	-	-	-	-	-	<i>Stipa tirsia</i>	2.5
POACEAE													53.0
H	7	3	8	4	2	6	1	n	2	4 - 6	3	<i>Artemisia austriaca</i>	0.5
TT	5	3	X	8	3	7	3	n	2	3 - 5	3	<i>Carduus acanthoides</i>	0.5
TT	7	4	8	4	-	-	-	n	1	4 - 5	2	<i>Consolida regalis</i>	0.5
H	7	3	8	4	2	4	3	n	2	2 - 4	2	<i>Eryngium campestre</i>	0.5
H	X	4	8	X	4	8	7	n	1	2 - 4	2	<i>Euphorbia cyparissias</i>	0.5
HT	5	4	7	3	5	4	4	n	5	2 - 3	2	<i>Galium verum</i>	0.5
-	-	-	-	-	-	-	-	-	-	-	-	<i>Linum austriacum</i>	0.5
-	-	-	-	-	-	-	-	-	-	-	-	<i>Potentilla arenaria</i>	0.5
H	X	2	5	1	3	4	4	n	4	2 - 4	2	<i>Potentilla argentea</i>	0.5
-	-	-	-	-	-	-	-	-	-	-	-	<i>Salvia austriaca</i>	0.5
H	6	3	7	3	-	-	-	n	4	3 - 4	1	<i>Salvia nemorosa</i>	2.5
-	-	-	-	-	-	-	-	-	-	-	-	<i>Teucrium chamaedrys</i>	0.5
-	-	-	-	-	-	-	-	-	-	-	-	<i>Thymus glabrescens</i>	2.5
-	-	-	-	-	-	-	-	-	-	-	-	<i>Torilis arvensis</i>	0.5
-	-	-	-	-	-	-	-	-	-	-	-	<i>Veronica spicata</i>	0.5
-	-	-	-	-	-	-	-	-	-	-	-	<i>Xeranthemum annuum</i>	0.5
OBF													12.0

Legend: B - BioForm, T - temperature, U - humidity, R - soil reaction, N – nutrition, C - tolerance of mowing, P - tolerance of grazing, S - tolerance of crushed, VF - fodder value, H - hemeroby, UR - urbanophile, SO - sozological category, ADM-abundance-dominance

Following the ecological spectrum, it is found that the phytoceno-

sis of the *Stipa capillata* – *Bothriochloa ischaemum* grassland type is

xerophilic ($Up=2.8$), low acidophilic ($Rp=7.7$) and oligotrophic ($Np=2.8$).

From an agronomic point of view, the phytocenosis of the *Stipa capillata* – *Bothriochloa ischaemum* type is moderate tolerant to mowing ($Cp=3.1$), moderat tolerant to grazing ($Pp=4.5$) and crushing ($S=4.4$).

VF (pastoral value) is 3.4 which means that the grassland falls into the third class, the category of degraded grassland and supports a load of 0.21-0.40 LU/ha (Table 5).

In the *Stipa capillata* – *Bothriochloa ischaemum* phytocenosis, 2 toxic species (*Consolida regalis* and

Euphorbia cyparissias) and 3 species harmful to animal products (*Artemisia austriaca*, *Carduus acanthoides* and *Eryngium campestre*) were identified. Also, 2 species with low fodder value and harmful to grasslands vegetation (*Bothriochloa ischaemum* and *Stipa capillata*) and 4 ballast species were identified, which have an 8% participation in the vegetal cover. There are also 2 medium forage species (*Brachypodium pinnatum* and *Galium verum*) with a total cover of 8.5%, and good forage and excellent forage are missing.

Table 5

The ecological and agronomic spectrum of the *Stipa capillata* – *Bothriochloa ischaemum*

Ecological Indexes	Ecological spectrum										VIMnp
	1	2	3	4	5	6	7	8	9	x	VIMp
Unp	0	3	6	4	0	0	0	0	0	0	3.1
Up	0	20.5	24	9.5	0	0	0	0	0	0	2.8
Rnp	0	0	0	0	1	0	3	7	0	2	7.5
Rp	0	0	0	0	0.5	0	11	24.5	0	18	7.7
Nnp	1	3	3	4	0	0	0	1	0	1	3.3
Np	0.5	22.5	20.5	9.5	0	0	0	0.5	0	0.5	2.8
Agronomic Indexes	Agronomic spectrum										VIMnp
	1	2	3	4	5	6	7	8	9	x	VIMp
Cnp	0	3	3	1	1	0	2	0	0	0	3.8
Cp	0	18.5	9	0.5	0.5	0	5	0	0	0	3.1
Pnp	0	0	1	3	0	2	3	1	0	0	5.6
Pp	0	0	17.5	1.5	0	8.5	5.5	0.5	0	0	4.5
Snp	1	0	3	2	0	1	3	0	0	0	4.5
Sp	0.5	0	18.5	1	0	8	5.5	0	0	0	4.4
VFnp	2	3	2	4	2	0	0	0	0	0	3.1
VFp	1	1.5	35	8	8.5	0	0	0	0	0	3.4
The legend											
U	moisture	C	mowing	VF	fodder value						
R	soil reaction	P	pasture	n.p	unweighted (depending on the number of species)						
N	soil trophicity	S	crushed	p	weighted (depending on species coverage)						

CONCLUSION

The import of Galloway beef cows can be done keeping the origin of the animals only if they are registered in the National Breed Register.

The Galloway breed adapted very well to the conditions at Cojocna.

The free-extensive grazing was suitable for the breed, but overgrazing was recorded on certain portions and installation of *Festuca rupicola* grassland type (representative of the area) with certain nitrophilous species.

The Galloway breed makes good use of moderately productive pastures and can contribute to the preservation and improvement of the

conservation status of the Natura 2000 habitat Suatu-Cojocna-Crairat.

Under the conditions at Cojocna, the Galloway breed registered weight increases corresponding to the breed. Abandonment of grassland areas has led to severe degradation of the sward and depreciation of grassland class, category and livestock load.

RECOMMENDATION

Continuing and deepening research. Improving the grazing system by delimiting at least 2 two grazing plots. Mowing after grazing for uniform regeneration of the vegetation cover.

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THE QUALITY OF FODDER BEET IN THE REPUBLIC OF MOLDOVA

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Abstract. The results of the evaluation of the biochemical composition and nutritive energy value of local cultivars of fodder beet – *Beta vulgaris*: 'Ciugur' and 'Ruja', created at the “Selectia” Research Institute of Field Crops Bălți and cultivated in the experimental plot of the “Alexandru Ciubotaru” National Botanical Garden (Institute) MSU, Chisinau, Republic of Moldova, are presented in this article. It was established that fodder beet roots from the studied cultivars contained 104.5-152.5g/kg DM, and its biochemical composition was: 6.37-8.67% CP, 0.37-0.77 % EE, 9.91-12.08% CF, 69.64-76.78% NFE, 48.05-49.62 % soluble sugars, 5.01-5.10 % starch, 6.57-8.84% ash, 1.5-1.6 g/kg Ca, 1.7 g/kg P with nutritive energy value 16.99-17.10 MJ/kg GE, 11.47-11.98 MJ/kg ME and 7.23-7.60 MJ/kg NEL.

Keywords: *Beta vulgaris*, biochemical composition, cv. 'Ciugur', cv. 'Ruja', fodder beet roots, nutritive energy value

In modern animal husbandry, forage crops have an undeniable role in providing nutrients and meeting the energy requirements of farm animals. Feeding the livestock high quality forage can be very useful and effective for their breeding, reproduction, meat, dairy, leather and wool. Livestock production relied on a large diversity of fodder crops to sustain animals year-round, including root crops.

The genus *Beta*, subfamily *Betoideae*, family *Amaranthaceae* (formerly *Chenopodiaceae*) consists of 9 accepted species of annual, biennial and perennial plants, often with fleshy, thickened roots. The best known member is the common

beet, *Beta vulgaris*. About 2500 years ago, the first beets were domesticated. Historically, beets have been used as both food for people and fodder for animals. The first recorded use of beets is from the Middle East. The development of cultivated beets is characterized by breeding to obtain the desired characteristics for various applications, and for a wide variety of shapes and colours, especially in the root swollen parts. The classification of both wild and cultivated forms of *Beta vulgaris* is confusing. It is generally accepted that all cultivated beets belong to the *Beta vulgaris* subsp. *vulgaris*. Currently, *Beta vulgaris* subsp. *vulgaris* has an immense economic

importance as sugar crop (*Beta vulgaris* subsp. *vulgaris*, var. *altissima*), and a great importance as a vegetable crop (*Beta vulgaris* subsp. *vulgaris*, var. *flavescens* and *Beta vulgaris* subsp. *vulgaris*, var. *cicla*), and as fodder crop (*Beta vulgaris* subsp. *vulgaris*, var. *crassa*). This species is also used as medicinal plant, ornamental plant, dye and as renewable energy resource (LANGE et al. 1999; MIRAJ, 2016; AL JBAWI, 2020; KUMAR et al. 2022).

Fodder beet, *Beta vulgaris* subsp. *vulgaris*, var. *crassa*, syn. *Beta vulgaris* ssp. *vulgaris* var. *alba*; *Beta vulgaris* ssp. *vulgaris* var. *rapacea* is a biennial plant. In the first year of growth, the vegetative part develops. The dark green, heart-shaped leaves are borne in a rosette, lying horizontally to catch as much light as possible. In the underground part, the fleshy and swollen root system develops intensively. In the second year, if the root is not harvested and after exposure to cold, the rosette turns into a 50-120 cm tall, erect, branched, ribbed, striate flower stalk, bears small, green, bisexual flowers without petals. The ovary forms a fruit which is embedded in the base of the perianth of the flower. Fruits with monogerm seeds are formed when a flower occurs singly, multigerm seeds are formed by an aggregation of 2 or more flowers.

Fodder beet cultivars occur in different root shapes (flat globe,

globe, spindle, cylinder) and colours (yellow, orange, red, white and purple). Fodder beet crops are cultivated as annual crops and the roots must be harvested before winter since they do not withstand frost.

Fodder beets are considered more drought-tolerant than other root crops, and less sensitive to weather variations than turnips and rutabagas. This crop is associated with favourable agronomic characteristics such as tolerance to salinity and drought, less water requirement and proper nutritional characteristics such as production of forage and silage with high nutritional value, good taste and good resistance to environmental changes. The fodder beet root and leaves contain valuable nutrients, pigments and vitamins, hydrocarbons, mineral salts and organic acids. The yields and chemical composition of fodder beet varies between cultivars, growing conditions, and among shoots and roots of the plant. Its inclusion in the diet of animals improves their balanced nutrition and it is eagerly eaten by cattle, pigs, rabbits, goats, sheep and horses. Usually, the fodder beet root is given to animals chopped and mixed with hays or straws (HEUZÉ et al., 2020).

The fodder beet is researched in various universities and research centres, creating new cultivars, elaborating technological elements of cultivation, harvesting and preservation, developing techniques

of including it in the diet of different species and breeds of animals (CLARK et al., 1987; AVARVAREI, 1999; NAESCU, 2001; ZAMFIR et al. 2001; MOISUC et al., 2010; TURK, 2010; COJOCARIU et al., 2011; MATTHEW et al. 2011; ADIE et al., 2018; MIHAI, 2018; ENCHEV & BOZHANSKA, 2022, 2024). Fodder beet is currently cultivated in almost all European countries, Asia, Africa, America, New Zealand and Australia. In the Catalogue of Plant Varieties of the Republic of Moldova, there are 3 registered cultivars of fodder beet *Beta vulgaris*, including, two local cultivars 'Ciugur' and 'Ruja', created at the "Selectia" Research Institute of Field Crops Bălți. The cultivar 'Ciugur' is multigerm, polyploid, the root shape is cylindrical-conic with greenish-white colours, the potential yield 200–210 t/ha roots and 38–40 t/ha leaves. The cultivar 'Ruja' is multigerm, polyploid, resistant to cercospora, mildew and fusarium rot; the potential yield 150–170 t/ha roots and 33–35 t/ha leaves (BOINCEN et al. 2020).

The goal of the current study was to evaluate the biochemical composition and nutritive energy value of fodder beet root from local cultivars 'Ciugur' and 'Ruja'.

MATERIALS AND METHODS

The local cultivars of fodder beet *Beta vulgaris*: 'Ciugur' and 'Ruja', created at the "Selectia" Research

Institute of Field Crops Bălți and cultivated in the experimental plot of the "Alexandru Ciubotaru" National Botanical Garden (Institute) MSU, Chisinau, Republic of Moldova served as subjects of the research. The samples of fodder beet roots were collected at the end of September. The dry matter content was detected by drying samples up to constant weight at 105°C. The manually chopped fodder beet roots to 1.5-2.0 cm were dehydrated in an oven with forced ventilation at a temperature of 60°C; at the end of the fixation, the biological material was finely ground in a laboratory ball mill. The evaluation of fodder quality: crude protein (CP), crude fat (EE), crude cellulose (CF), nitrogen-free extract (NFE), soluble sugars (SS), starch, ash, calcium (Ca), phosphorus (P) were carried out in the Laboratory of Nutrition and Forage Technology of the Scientific-Practical Institute of Biotechnology in Animal Husbandry and Veterinary Medicine, in accordance with the methodological indications. The gross energy (GE), metabolizable energy (ME), net energy for lactation (NEL) were calculated according to standard procedures.

RESULTS AND DISCUSSION

We found that the dry matter content in fodder beet root mass of the studied cultivars varied from 104.5 g/kg in cv. 'Ciugur' to 152.5 g/kg in cv. 'Ruja'. The biochemical

composition and nutritive energy value of studied fodder beet cultivars are presented in Table 1. We would like to mention that the concentration of nutrients in fodder beet root dry matter was 6.37-8.67% CP, 0.37-0.77 % EE, 9.91-12.08% CF, 69.64-76.78% NFE, 48.05-49.62 % soluble sugars, 5.01-5.10 % starch, 6.57-8.84% ash, 1.5-1.6 g/kg Ca, 1.7 g/kg P with nutritive energy value 16.99-17.10 MJ/kg GE, 11.47-11.98 MJ/kg ME and 7.23-7.60 MJ/kg NEL. The root dry matter of cv. 'Ciugur' was characterised by

optimal amounts of crude protein, crude fats, crude cellulose, ash and calcium. The root dry matter of cv. 'Ruja' contained higher concentration of nitrogen free extract, soluble sugars and low concentration of crude celluloses, which had a positive impact on energy concentrations, but where was also a lower amount of crude protein, crude fats, ash. It has been determined that fodder beet root dry matter of the studied cultivars does not differ significantly in the starch and phosphorus content.

Table 1.

The biochemical composition and nutritional energy value of fodder beet root cultivars

Indices		Cultivars	
		'Ciugur'	'Ruja'
Dry matter, % root fresh mass		10.45	15.25
Crude protein, g/kg	dry matter	86.7	63.7
	fresh mass	9.1	9.7
Crude fats, g/kg	dry matter	7.7	3.7
	fresh mass	0.8	0.6
Crude cellulose, g/kg	dry matter	120.8	99.1
	fresh mass	12.6	15.1
Nitrogen free extract , g/kg	dry matter	696.4	767.8
	fresh mass	72.8	117.1
Soluble sugars, g/kg	dry matter	480.5	496.2
	fresh mass	50.2	75.7
Starch, g/kg	dry matter	50.5	50.1
	fresh mass	5.3	7.6
Ash, g/kg	dry matter	88.4	65.7
	fresh mass	9.2	10.0
Calcium, g/kg	dry matter	1.6	1.5
	fresh mass	0.2	0.2
Phosphorus, g/kg	dry matter	1.7	1.7
	fresh mass	0.2	0.3
Digestible energy, MJ/ kg	dry matter	16.99	17.10
	fresh mass	1.78	2.61
Metabolizable energy, MJ/ kg	dry matter	11.47	11.98
	fresh mass	1.20	1.83
Net energy for lactation, MJ/ kg	dry matter	7.23	7.60
	fresh mass	0.76	1.16

Different results regarding the nutrient content and energy value of root mass from *Beta vulgaris* are given in the specialized literature. According to CLARK et al. (1987) the fodder beet root contained 159-214 g/kg DM, 6.2 % CP, 12.7 % NDF, 64.9% WSC, 16.0 MJ/kg GE, 14.0 MJ/kg DE and 11.8 MJ/kg ME. TURK (2010) mentioned that fodder beet cv. Ecdogelb contained 117.7-121 g/kg DM, 8.32-8.83 % CP, 14.07-14.96% ADF 19.49-20.73% NDF. MATTHEW et al. (2011) revealed that the nutritional profile of fodder beet root was as follows: 6.2-10.7 % CP, 9.4-11.6% NDF, 59.6-62.8 % SS, 14.2-14.7 MJ/kg ME, but fodder beet leaf, respectively, 22.2-25.3 % CP, 26.9-27.2% NDF, 8.8-11.6 % SS, 10.4-11.2 MJ/kg ME. SINGH & GARG (2012) compared the dry matter content and the biochemical composition of the roots of sugar beet and fodder beet and found that fodder beet cultivars contained 100-140 g/kg DM, 5.7-10.9 % CP, 0.5-1.1 % EE, 3.6-6.6% CF, 1 g/kg Ca, 1-2 g/kg P, but sugar beet cultivars had 110-180 g/kg DM, 4.3-8.4 % CP, 0.5-0.8 % EE, 3.6-6.6% CF, 1-2 g/kg Ca, 1-2 g/kg P. EDWARDS et al. (2014) mentioned that fodder beet roots contained 150-181 g/kg DM, 10.4-10.8 % CP, 20.5-20.6 % NDF, 56.4-57.0 % WSC, 12.1-12.2 MJ/kg ME. SAKR et al. (1914) revealed that fodder beet roots contained 8.5 % CP, 8.1% CF, 4.4% DCP and 81% TDN. SORATHIYA et al. (2015) mentioned that the composition of

sugar beet tubers was 5.20% CP, 1.60 % EE, 12.30% CF, 78.80% NFE and 6.10% ash. HEUZÉ et al. (2020) reported that fodder beet roots contained 79-214 g/kg dry matter with 4.6-14.6% CP, 4.3-11.6% CF, 10.2-27.2% NDF, 5.4-17.0% ADF, 0.1-2.8% EE, 0.8-1.0% lignin, 54.7-81.9% SS, 3.5-32.7 % ash, 0.8-14 g/kg Ca, 1-5 g/kg P, 89.8% OMD, 15.6-16.6 MJ/kg GE, 11.5MJ/kg ME for ruminants. DALLEY et al. (2017) found that fodder beet root contained 7.9 % CP, 6.7% ADF, 11.7% NDF, 72.5 % soluble sugars and starch, but fodder beet whole plant – 7.6 % CP, 19.0% ADF 30.9% NDF, 48.6 % soluble sugars and starch, respectively. ADIE et al. (2018) reported that the nutritive value of the fodder beet roots was: 6-10% CP, 70-80% digestible and 12-13 MJ/kg ME. FLEMING et al. (2018) revealed that the quality indices of the fodder beet root were 203 g/kg DM with 94.7 % OM, 8.5 % CP, 6.7% ADF 14.2% NDF, 54.9% WSC. SALAMA & ZEID (2017) mentioned that fodder beet root contained 108-110 g/kg DM with 24.1 % NDF, 12% ADF and 2.65 % ADL. AL JBAWI et al. (2018) reported that, depending on the organic and potassium fertilizers applied, the fodder beet root contained 110-131 g/kg DM with 13.01-14.66 % CP, but fodder beet shoot contained 114-131 g/kg DM with 7.50-8.37 % CP. DALLEY et al. (2020) mentioned that the quality indices of the fodder beet root were 187 g/kg DM with 95.2 %OM, 9.1 %

CP, 5.6% ADF, 9.3% NDF, 65.7% SS, 91.7% DOM, 14.7MJ/kg ME, 0.11% P, 0.14% Ca. MOFEEDA et al. (2020) found that the forage quality of fodder beet root was 6.35-7.04 % CP, 2.38-3.06% DCP, 7.67-7.87% CF, 68.68-69.32% carbohydrates, 85.60-85.63% TDN. KUMAR et al. (2022) found that the dry matter, the biochemical composition and nutritive value of the fodder beet roots were 161 g/kg DM, 4-10 % CF, 5-10 % CP, 9.5% ADF, 16% NDF, 55.7% TS, 16.2MJ/kg GE, 13.2 MJ/kg ME. SAYED et al. (2023) mentioned that the main quality indices of fodder beet were 5.85-10.89 % CP, 7.78-12.51 % CF, 62.85-68.38 % carbohydrates. WHEADON et al. (2023) reported that the whole plant of fodder beet contained 140-166 g/kg DM, 10.4-13.2 % CP, 13.8-16.8 % NDF, 44.0-55.7 % soluble sugars, 2.7-3.3 g/kg Ca, 1.3-2.1 g/kg P and 12.5-14.1 MJ/kg ME. WOODS et al. (2023) mentioned that fodder beet contained 12.9 % CP, 23.9 % NDF, 40.6 % SS, 12.2-12.9 MJ/kg ME, 0.21 % P, 0.38 % Ca. ENCHEV & BOZHANSKA (2022, 2024) reported that the chemical composition and the nutritional value of root dry matter of fodder beet was: 13.99-15.64 % CP, 0.53-0.91 % EE, 6.65-9.19% CF, 66.48-

68.31% NFE, 8.92-9.42% ash, 7.0-12.8 g/kg Ca, 1.8-2.1 g/kg P, 16.48-16.50MJ/kg GE, 11.45-11.60 MJ/kg ME, 1.17-1.19 feed units for milk (FUM) and 1.27-1.29 feed units for growth (FUG), but – of sugar beet root – 9.11-9.58 % CP, 0.24-0.35 % EE, 4.77-6.88% CF, 77.66-81.88% NFE, 3.54-6.00% ash, 8.70-8.75 g/kg Ca, 1.13-1.40 g/kg P, 16.51-16.86 MJ/kg GE, 12.59-13.14 MJ/kg ME, 1.32-1.38 FUM/kg and 1.48-1.57 FUG/kg, respectively.

CONCLUSIONS

1. The studied local fodder beet cultivars '*Ciugur*' and '*Ruja*' contain a lot of nutrients, which make them suitable to be used as a part of diverse livestock diets.
2. The root dry matter of cv. '*Ciugur*' was characterised by optimal amounts of crude protein, crude fats, crude cellulose, ash, calcium. The root dry matter of cv. '*Ruja*' had higher concentration of nitrogen free extract, soluble sugars and low concentration of crude celluloses.
3. It is necessary to continue the research on the quality indices of fodder beet root, the impact of delayed harvest time and conditions of storage during the winter-spring season.

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