SUSTAINABLE MANAGEMENT FOR GRASSLAND AGROECOSYSTEM RESOURCES

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Abstract

The activity of an agricultural enterprise is run within an ecosystem, it being characterized by intertwining and integration of the two components. The achievement of this relationship depends on the resulting performance, which requires organization policies and strategies to be adopted for the biotechnical and economic processes. The agricultural ecosystem is essentially rendered artificial; therefore, it should be monitored and run according to well-defined rules, in order to preserve and improve not only biodiversity but also quality and profitability of production. Considering the above mentioned subject matter, this paper proposes an ambitious undertaking, i.e. an inter-disciplinary approach to issues regarding the sustainable development management of grasslands in the context of biodiversity conservation and improvement. This approach is not easy, despite the relevant interrelation between economic and biotechnological elements; nevertheless, it is supported by a successful management of the resources specific of pasture agro-ecosystem. The paper leads to the general conclusion that the promotion of eco-technical practices within the grassland agro-ecosystem results in a multifunctional meadow, primarily focused on obtaining a pastoral value with a corresponding loading expressed in livestock units per hectare of pasture, i.e. *biodiversity conservation and improvement of known, as Romanian grasslands are known for their varied floristic composition of high biodiversity indices.*

Key words: *biodiversity, biotechnological, conservation, sustainable, economic, ecosystem, management*

INTRODUCTION

The paper assumes that a sustainable agriculture development should aim at increasing production capacity whilst maintaining natural resources.

Agricultural ecosystems consist of specific subsystems, as our attention is being focused on the pasture agro-ecosystem, of which main objective is designing and implementation of long-term economically viable measures capable of providing a high pastoral value, namely biodiversity conservation and improvement [3,7]. Basically, we aim at integrating the sustainability principles into the grassland agroe-cosystem management, *i.e.* the life cycle management of the grassland agro-ecosystem and the resulting products in accordance with the objectives of the sustainable development management of grasslands concept. For this purpose, it is necessary to include other activities in addition to those specific to agricultural management; the newly included activities should be dedicated to stimulating biodiversity, ensuring harmonious development and integration of the grassland ecosystem in an environmentally friendly medium. It follows that a sustainable development management of the grassland agro-ecosystem is a complex process that relies on organizing, administration and management, as opposed to natural ecosystems that are self-organizing and cannot be maintained without human action. Man must intervene with external energy, *i.e.* crop energy, under two forms: biological (human and animal labor) and technological (machines, equipment, etc.) [6]. The relevance of the topic addressed lies is the fact that the status of permanent grassland is marked by a continuous process of pollution and damage due to human activities and natural phenomena such as excess moisture, drought, salinity, erosion, etc. This requires action aimed at restoring permanent grassland in order to introduce it into the economic cycle and to ensure its multi-functionality, outlining the need to preserve and improve biodiversity amid the existence of "different floral structures of higher biodiversity indices compared to many European countries" [5]. A sustainable development of the grassland agro-ecosystem is an urgent problem and we will attempt to provide a solution below. For this purpose, the diagnosis of the permanent grassland plays a decisive role in identifying its specificity, in order to design and implement long-term economically viable measures capable of providing a high pastoral value, namely biodiversity conservation and improvement. Our research aimed to achieve a high pasture value, *i.e.* biodiversity conservation and improvement by promoting the sustainable resource management of the specific measures characterizing the grassland agro-ecosystem, with a special focus on fertilization

MATERIALS AND METHODS

The experiment was located on the North-Eastern top of the Cindrel mountains, at an altitude of approximately 1,430 m, near the Păltiniş mountain resort, on the summit called Vălari, covered by red fescue (*Festuca rubra*). Land exposure was Southern with a slight slope, approximately 5 %. The area was surrounded with vast spruce forests and large areas of natural grasslands. Weather conditions were characterized by annual average air temperatures below 5^0C on the slopes and the peaks of the middle mountains (4.5^0C Păltiniş – top, 4^0C - Păltiniş resort), falls below 0^0C on the high mountain peaks [1]. *Average annual rainfall* reached 910 mm in the middle mountains (Păltiniş) and increased to 1,350 mm on the alpine tops. On the Păltiniş experimental field, the soil was acid-brown belonging to the cryptosporidium subtype (hidden spode characters) on acid rock, of which morphologic, physical and chemical properties were as follows: small-medium grainy structure, slightly glomerular in the first 30 cm, polyhedral, sub-angular in the Bv horizon; loamy-sandy-dusty to loamy at 30 cm size fits the profile; low levels of absolute and apparent density, influenced by the high content in organic matter; good total porosity; the high content in organic matter, slightly or increasingly moist indicates a strongly moist soil (raw humus) with a high share of folic acids; pH varied between 4.62-5.10 in the aqueous extract and 3.78 -4.27 in the saline extract, indicating a strongly acidic reaction; the degree of base saturation values, of less than 30%, indicated an oligo-basic soil.

Knowing that grasslands in the area used to be utilized for both grazing and haymaking, we performed two similar experiences on the same location, one for each mode of use.

The experiment was conducted during a three year - time period, according to the method of subdivided lots with four separate blocks (replications) - each block consisting of three plots: unfertilized control, fertilized with manure (20 t/ha) and fertilized with minerals ($N_{100}P_{50}K_{100}$). The blocks were further divided into two variants (for haymaking and grazing, respectively), each having an area of $10m^2$ (5x2m). In the haymaking variant, production consisted in the scythed grass and after grass, while in the grazing one, based on *Festuca rubra*, three harvests were performed when plants reached their grazing height. Dry matter was determined by oven method. Yields were obtained by weighing the harvest immediately after mowing. Sampling was carried out following the dew disappearance, *i.e.* at noon and in the afternoon. The floristic composition was determined by the double meter method, that analyzes grass by linear vegetation surveys for each group. We chose the volume method consisting in identification of points located 5 cm away from each other into a circle of 2 cm diameter. Thus, we assigned a grade from 1 to 6, the sum of grades within a dot being 6, for each species grown within the area described above, which was measured at every 5 cm.

The design and implementation of measures aimed at restoring permanent grassland in order to introduce it into the economic cycle and to ensure multifunctionality and biodiversity preservation and improvement, starts from the diagnosis of vegetation state and production potential characterizing the grassland under study. For this purpose, we determined the floristic composition by preparing reports based on the double meter method. The data allowed calculation of the pasture value of the grasslands, as a result of the sum between the percentage of species participation in the grass coverage and their corresponding quality index, which we subsequently divided by 5, according to the following formula:

$$V.P. = \Sigma PC\ (\%) \times IC/5 \quad (1)$$

where: VP = pasture value indicator (0-100);
PC = participation in grass cover (%);
IC = fodder quality index.

RESULTS AND DISCUSSIONS

The floristic composition resulting from the diagnosis showed that Poaceae was predominant (67%) in yield formation and the grassland layer, where the main species was *Festuca rubra.* Other fodder-important *Poaceae* present in this type of grassland were *Antoxatum odoratum, Agrostis rupestris, Agrostis capillaris, Cynosurus cristatus, Phleum alpinum, Poa pratensis.* The share of fodder plants belonging to the Fabaceae family was low (17%) and exemplified by such species as: *Trifolium repens, Trifolium pratense, Trifolium alpestre, Lotus corniculatus,* plus *Genista tinctoria.* Plants from other families had a low share in the floristic composition and were represented by: *Achillea millefolium, Alchemila vulgaris, Taraxacum officinale, Leontodon autumnalis, Plantago lanceolata, Plantago media*. We also encountered plants with no or low fodder value, such as *Veronoca chamaedris* and *Rumex acetosela*, and even harmful plants such as *Nardus stricta* that equals or exceeds the share of *F. rubra*, the *Festuca rupicola* and *Genista tinctoria* species. Bushes and shrubs were also present: *Vaccinum mirtillus, Vaccinum vitis-idaea, Juniperus sibirica, Pinus mugo*, etc. In conclusion, it is estimated that the analyzed grassland had a poor floristic composition represented by 23 species of low fodder value, of which 10 belonged to the *Poaceae* family, 5 to the *Fabaceae* family and 8 to other botanical families. This showed that, although they represented an important fodder resource, grasslands were decaying as a result of poor management over the past recent years, requiring adoption of a sustainable management strategy leading to higher pasture value, as well as biodiversity conservation and improvement.

The pasture of the analyzed grasslands was estimated as being of a medium value, which required the application of value-adding works aimed at biodiversity conservation and improvement. The works consisted in destroying the molehills and removal of the woody vegetation, autumn and spring fertilization. The experiment used both mineral and organic fertilizers. The overseeding was carried out to make a mixture of fodder plants suitable for mixed exploitation. This was done both to cover the vegetation-free areas following the destruction of the moss and wood vegetation and to improve the floral composition using a mixture consisting of: *Poa pratensis, Festuca pratensis, Trifolium repens, Lotus corniculatus.*

The impact of these works on the analyzed grassland showed an improvement in production and forage quality, which required special attention to biological resources and the use of organic materials as strategies of the sustainable management adoptated in grassland agroecosystem [4].

The evolution of floristic composition throughout the experimental period, both in the variant used for haymaking and the grazing one, showed that plants belonging to *Poaceae* family were predominant among the participating species, followed by *Fabaceae* and other botanical families. Analyzing the evolution of the main plant species within each participating group (Table 1), we see that the following *Poaceae* species were predominant: *Festuca rubra* (27% in V_2 and 32% in V_3), followed by *Agrostis capillaris* (8% in V_2 and 9% in V_3) and *Poa pratensis* (6% in V_2 and 5% in V_3), the other species being under-represented. For the Fabaceae family, the share of the species was fairly uniform, with a slight predominance of *Trifolium repens* (6% inV_2 and 5% in V_3), followed by *Lotus corniculatus*

(6% in V_2 and 3% in V_3). The plants belonging to other botanic families included both fodder species, such as *Achillea millefolium* (4% in V_2 and 6% in V_3) and *Taraxacum officinale* (3% in V_2 and 3% in V_3), as well as other species *Veronica chamaedrys* (8% in V_2 and 9% in V_3) or soil-acidity indicators such as *Campanula abietina, Rumex acetosella.*

Table 1. Calculation of the pasture value over the entire experimental period

Species	V1 – unfertilized			V1 – manure 20 t/ha			V3 – $N_{50+50}P_{50}K_{100}$		
	%PC	IC	PC x IC	%PC	IC	PC x IC	%PC	IC	PC x IC
Poaceae	**67.0**			**62.0**			**70**		
Festuca rubra	30.0	3	90.0	27.0	3	81.0	32.0	3	96.0
Antoxacum odoratum	7.0	1	7.0	3.0	1	3.0	4.0	1	4.0
Agrostis rupestris	5.0	1	5.0	6.0	1	6.0	4.0	1	4.0
Agrostis capillaries	4.0	3	12.0	8.0	3	24.0	9.0	3	27.0
Briza media	4.0	1	4.0	1.0	1	1.0	2.0	1	2.0
Cynosurus crestatum	3.0	3	9.0	2.0	3	6.0	3.0	3	9.0
Phleum alpinum	3.0	2	6.0	3.0	2	6.0	4.0	2	8.0
Poa pratensis	2.0	3	6.0	6.0	3	18.0	5.0	3	15.0
Nardus stricta	6.0	x	X	1.0	x	X	2.0	x	X
Festuca rupicola	3.0	1	3.0	2.0	1	2.0	2.0	1	2.0
Trisetum flavescens	-	-	-	3.0	4	12.0	-	-	-
Poa annua	-	-	-	-	-	-	3.0	2	6.0
Leguminous plants	**17.0**			**21**			**12**		
Trifolium repens	3.0	4	12.0	6.0	4	24.0	5.0	4	20.0
Trifolium pratense	3.0	4	12.0	4.0	4	16.0	2.0	4	8.0
Trifolium alpestre	5.0	2	10.0	4.0	2	8.0	1.0	2	2.0
Lotus corniculatus	4.0	4	16.0	6.0	4	24.0	3.0	4	12.0
Genista tinctoria.	2.0	x	-	0.5	x	X	1.0	x	X
Oxalis acetossela	-	-	-	0.5	x	X	-	-	-
Other families	**16.0**			**17**			**18**		
Achillea millefolium	5.0	2	10.0	4.0	2	8.0	6.0	2	12.0
Alchemila vulgaris	2.0	2	4.0	2.0	2	4.0	3.0	2	6.0
Taraxacum officinale	2.0	2	2.0	3.0	2	6.0	3.0	2	6.0
Leontodon autumnalis	1.0	1	1.0	1.0	1	1.0	1.0	1	1.0
Plantago lanceolata	2.0	2	4.0	2.0	2	4.0	2.0	2	4.0
Plantago media	2.0	2	4.0	1.0	2	2.0	1.0	2	2.0
Veronica chamaedris	1.0	x	-	1.5	x	X	0.5	x	x
Runex acetosela	1.0	x	-	1.0	x	X	0.5	x	x
Potentilla erecta	-	-	-	1.5	1	1.5	0.5	1	0.5
Campanula abietina	-	-	-	0.5	x	X	0.5	x	x
Luzula luzuloides	-	-	-	0.5	x	X	-	-	-
TOTAL	**23**		**216**	**28**		**259.5**	**26**		**247.5**
Pasture value	43			51.9			49.5		
Pasture value assessment / UVM*ha^{-1}	Average		1.12	Good		3.02	Average-good		2.9

Source: Own determinations.

The evolution of the floristic composition stressed that the application of measures to improve permanent natural grasslands contributed to biodiversity conservation and improvement, acting both for the conservation and improvement of natural resources, and the improvement of grassland quality and profitability. Thus, Table 1 shows an increase in number of the species on the grassland from 23 species in the controls to 28 species on the manure-fertilized grassland and 26 species into the mineral-fertilized soil. This shows the method of integrating the activities of agrifood and agricultural products in the sense of

biodiversity preservation and increase by observing sustainable development principles.
Grassland biodiversity is influenced by several management factors, among which fertilization, oversowing, rational use [2].
In our experiment, the most improtant impact on grassland biodiversity resulted from organic fertilization (Table 1), manifested both in its structure, by an increase in number of species, and in the floristic composition, by the increase in share of valuable plants [8,9].

CONCLUSIONS

Sustainable development of the grassland agroecosystem is complex and long, requiring an organized application of complex measures and works ensuring soil protection and a sustainable protection of the degraded lands. Reconstruction of a permanent grassland in the analyzed area is necessary, due to the level of degradation.
This measure should be directed towards adoption of specific measures aimed at changing soil fertility, favoring the presence of leguminous plants in plant structure and environmental protection.
Land use decisively contributes to sustainable development of the grassland, emphasizing its mixed use by a combination of corresponding fodder plants.
The reconstruction measures applied to the studied grassland led to the change in its natural productivity by the implementation of some specific measures – molehill destruction and removal of woody plants, autumn and spring fertilization both with mineral and organic fertilizers, followed by oversowing in order to obtain a combination of fodder plants suitable for mixed use.
Manure fertilization was an adequate management strategy for biodiversity conservation and improvement.
The evolution of the floristic composition shows that the application of the improvement measures for the permanent natural grassland contributed to biodiversity conservation and improvement both for the conservation and improvement of the natural resources, and the quality and profitability improvement of the grassland.

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