Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 1, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

IMPROVING ECONOMIC EFFICIENCY ON DEGRADED PERMANENT MEADOWS BY VARIOUS MANAGEMENT SYSTEMS

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Abstract

The purpose of this research is to study the possibility of enhancing the multifunctionality of permanent degraded grasslands by overseeding, with special look on economic efficiency. The experience that is the subject of the research was organized in the Research and Development Station for Meadows, Vaslui area, on a Dichanthium ischaemum (L.) Roberty *meadow. In the study area there are large areas of permanent meadows, at different stages of degradation, due to the positioning on surfaces with different degrees of inclination, eroded or subject to erosion process, due to abandonment or non-rational use, with an inappropriate load of animals and failure to apply maintenance or improvement measures. Due to these aspects, the production is small and the floral composition is dominated by species with medium and low fodder value. In order to increase the production of permanent grassland in the area, it was considered necessary to apply organic fertilizers, and their effect was compared to that of abandonment, mulching or simple use, and with overseeding measures. Biological material used (a mixture of: 70% Bromus inermis* Leyss. *+ 30% Onobrychis viciifolia* Scop. *- 30 kg·ha^{-1} + 25 kg·ha^{-1}). Total expenses, net income and profitability rate (rate of return) were calculated. The lowest costs were recorded when the biomass was only harvested, no other action being performed. When overseeding and fertilization were overlapping the costs were the highest, the economic efficiency being carried close to zero, but more likely, the effect of fertilization has been greatly diminished due to poor climatic conditions.*

Key words**:** *abandonment, mulching, fertilization, biodiversity, productivity*

INTRODUCTION

The International Congress of Grasslands, in Leipzig in 1977, in its 13th edition, defines the term ”grassland” as exploitable agricultural land, used for cultivation for many years or permanently, with perennial grasses dominant in vegetation. In other words, the meadow is seen as a very cheap and accessible source of animals fodder.
Lately, the idea of multifunctionality of the grasslands has been developed, from focusing on the ecological role (wild animals habitats, preventing soil erosion, germplasm stock) to appreciating the importance of aesthetics that they offer to the landscapes. In addition to this, it must also be taken into account that grassland ecosystems seize significant amounts of carbon through the biomass produced, biomass that can be used as a renewable energy source [11], [16], [18].
According to data provided by FAOSTAT, 2023 [12], the estimated land area covered by grasslands in 2021 is 3.54 billion hectares, their area representing about 26.44% of land area, and forests occupy 4.45 billion hectares (33.22 %). This comparison emphasizes the grasslands role as a source of biomass. In

Romania, pastures and hayfields occupy 4,828.5 million ha, as shown by the Romanian Statistical Yearbook for 2022 [20], of which 3,272.2 million ha are pastures and 1,556.3 million ha are hayfields, representing 20.3% of the area total area of the country and 33% of the agricultural area.

Because forests, at the time of harvest provide a large amount of biomass, are seen as more suitable sources than grasslands, but biomass on grasslands regenerates year after year, while forests need tens or hundreds of years for regeneration, and the degree of accumulation of biomass is very small in the first years.

Over 55% of the areas occupied by Moldovan Forest-Steppe grasslands are located on sloping lands, subject to erosion, have a degree of vegetation cover of 60% or less and offer biomass production of 0.5-2 $Mg \cdot ha^{-1}$ DM [10]. To make a comparison, in the temperate zone, in a forest of *Fagus silvatica* L. after 12-24 years of vegetation biomass accumulation varied between 3.4-4.3 $Mg \cdot ha^{-1}$ DM [17].

In Romania, the decline of livestock in recent years has led to the abandonment of large areas occupied by permanent pastures. Simple non-use leads to continuous degradation. Stopping this phenomenon can be done by using the vegetation on these surfaces in order to obtain biofuels. In addition to the rational use, the simplest measure of improvement of grasslands, is represented by the overseeding with valuable species, which through the genetic potential and by the adaptability to the specific conditions of the area, will increase the amount of biomass harvested.

Other changes, such as those to the vegetal carpet's structure and the quality of the feed that can be obtained, must be considered in addition to the rise in biomass. Also, the economic impact of the measures taken must be as small as possible.

In Romania, the studies focused on obtaining biofuels from annual crops (corn, sorghum, etc.) or temporary grasslands. For the Moldovan Forest-Steppe, this study has a novelty character. Globally, there are studies that have focused on analyzing the ability of grasslands to sequester carbon (their ecological role), but there are also studies that have looked at the possibility of using biomass from permanent grasslands to obtain biofuel [6] [14] [13].

The studies carried out in Romania and abroad regarding the effect of overseeding on the degraded permanent grasslands followed, mainly, the effect on the obtained fodder (production and its quality). But, the feed differs from the biomass for fuel, in that is harvested in an advanced stage of vegetation, after the seeds maturation, when the amount of cell walls in the plants is maximum. This is another novelty of the study, namely, increasing the amount of biomass accumulated by overseeding with more productive herbaceous plant species.

In this context, **the purpose of this research** is to study the possibility of enhancing the multifunctionality of permanent degraded grasslands by overseeding, with special look on economic efficiency.

The objectives of the research were:

A. Main objective - Increasing the amount of biomass that can be obtained from permanently degraded grasslands;

B. Secondary objective - Analysis of the influence of overseeding on biodiversity;

C. Secondary objective - Economic efficiency analysis.

MATERIALS AND METHODS

The research from this study took place between March 2022 - August 2023, at the working point from Soleşti locality (46°45' North latitude and 27°48' East longitude) of Research and Development Station for Meadows, Vaslui (RDSM Vaslui). The study area is characterized by temperate climate with the influences of the Russian steppe area.

Description of the experiments

Biological material used (a mixture of: 70% *Bromus inermis* Leyss. + 30% *Onobrychis viciifolia* Scop. - 30 $kg \cdot ha^{-1}$ + 25 $kg \cdot ha^{-1}$) was from Research and Development Station for Meadows, Vaslui, Romania. The cost of overseeding was 1,200 $lei \cdot ha^{-1}$, the work being performed once every 6 years.

The experiment, established in spring 2022, was laid by randomized plots method in three

replicates, with a 100 m^2 plot size (10 m x 10 m) and a 81 m^2 harvested area (9 m x 9 m), and the total experimental area will be of 1,600 m^2 (Fig. 1).

Experimental factor - applied management, with five graduations:

v_1 - abandoned;

v_2 - harvested at seed maturation (control variant);

v_3 - overseeded and mulching;

v_4 - overseeded and harvested at seed maturation;

v_5 - overseeded, fertilized with sheep manure (10 $Mg \cdot ha^{-1} \cdot year^{-1}$) and harvested at seed maturation.

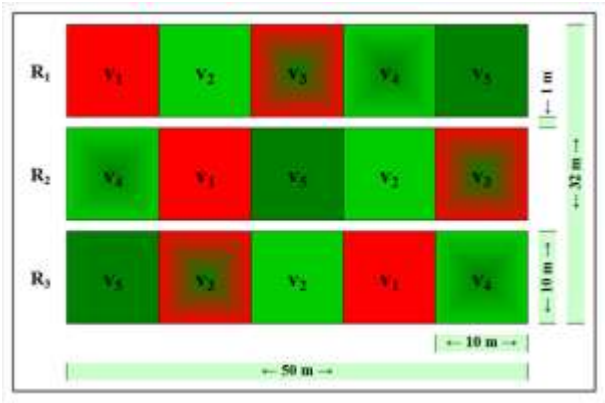

Fig. 1. Experimental design (randomized plots)
Source: Own design.

The overseeding was done mechanically (direct sowing).

Sheep manure was applied in spring at experiment establishment and in the second year of vegetation at the beginning of plant growth, in early spring.

Justification of the working variants chosen:

Abandonment (v_1) is very common on areas occupied by degraded meadows, so this variant serves as a comparison element regarding the improvements that can be made to this situation. The control variant (v_2) involves only the simple harvesting of biomass in the optimal epoch, but the long-term effect can be negative because nutrients in the soil are exhausted [8]. Even in the case of abandonment, the amount of organic matter can be increased by accumulating a larger amount of biomass in the soil by overseeding (v_3). Overseeding and harvesting biomass for biofuel in the optimal era (v_4) may be the best option. Fertilization with moderate doses of manure, where there are livestock, along with overseeding and biomass harvesting for biofuel in the optimal period (v_5), may be the best option [3].

Methodology applied

From the abandoned variants, the production was evaluated by harvesting a sample area of 1 m^2 that was weighed, and from the variants that involve harvesting, the production was evaluated by harvesting 81 m^2. By the halving method was carried to the laboratory a quantity of 1 kg of green mass for performing analyzes. The determination was made in the seed maturation and shaking phenophase for the dominant grass species in the the vegetation structure (to determine the production and quality of biomass that can be used for biofuels).

The analytical methodologies used were in accordance with national and international standards as well as agricultural experimental techniques regulations. The following were determined:

▫ dry matter content (DM) used at determining the amount of biomass that can be obtained ($Mg \cdot ha^{-1}$ DM) was established by drying at an oven at a temperature of 103°C for 3 hours; equipment: Thermo-adjustable Oven - Venticell 111 I; SR ISO 6496/2001;

▫ conducting the floristic study on the vegetation changes using the geobotanical method [23];

▫ the economic efficiency was calculated as follows:

- Total expenses (Ct), with the relation:

$$Ct = Cf + Cs \quad (1)$$

where:

Cf - fixed technological expenses ($lei \cdot ha^{-1}$);

Cs - represents the amount of expenses incurred for the factors used ($lei \cdot ha^{-1}$);

- Net income (Vn), according to the relation:

$$Vn\ (lei) = (Pv \times Qt) - Ct \quad (2)$$

where:

Pv = selling price (lei·ha-1);

Qt - total production (kg).

Ct = Total expenses ($lei \cdot ha^{-1}$);

- Profitability rate analysis (rate of return) with the relation:

$$R\ (\%) = (Vn \cdot Ct^{-1})\ x100 \quad (3)$$

Statistical analysis of obtained data it was achieved by calculation of variance analysis, least significant differences (LSD).
The results of this study will help to increase profitability of permanent grassland degraded by overseeding.

RESULTS AND DISCUSSIONS

Permanent meadows, from the perspective of obtaining feed for domestic animals, in different management conditions, have been studied by many authors [1], [2], [4], [9], [19], [22].
The research conducted in 2022-2023 agricultural period at the RDSM Vaslui addresses another perspective of the use of biomass resulting from these ecosystems, in the absence of livestock.
The reason is that in our country the herds of cattle, sheep and goats, horses, decreased from approximately 8.76 million livestock units in 1990, at 4.04-4.4 million livestock units in the period 2010-2021 [20].
Under these conditions there is the possibility of alternative use of biomass from increasingly large areas of abandoned meadows. This biomass can be used rudimentarily on meadows, to prevent degradation and erosion, in the form of mulches. Also, it can be used as a source of organic matter in arable land or for obtaining biofuel (biogas, pellets, or other forms).
The additional amount of nutrients brought by applying fertilizers on degraded permanent grassland is not used optimally by plants existing in the structure of the vegetable carpet. This issue can be remedied by improving the structure of the vegetable carpet and the amount of biomass produced can only be appropriate under over-seeding conditions with valuable species.
In generating the production of meadows and for the most efficient use of mineral or organic fertilizers by plants on these surfaces, the climatic factor plays a very important role.
The vegetation of the meadows in the study area was negatively influenced by the long periods of time with lack of precipitation and higher than normal temperatures.
Figure 1 shows the climate diagram of the period 2022-2023, and where these periods of stress are observed.

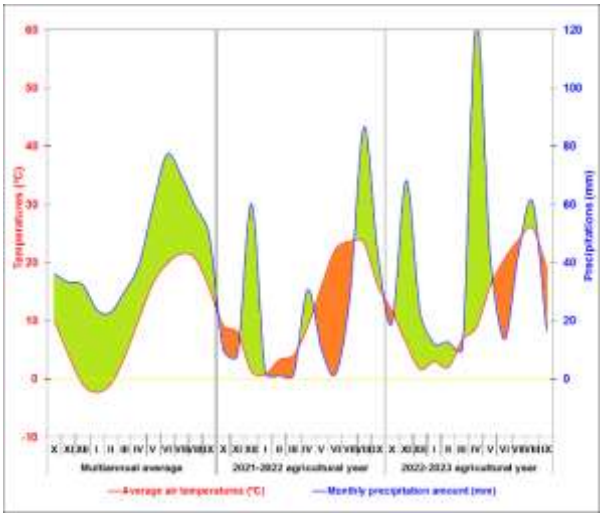

Fig. 2. Climate conditions in the 2022-2023 period
Source: Own data, taken from from RDSM Vaslui weather station (Station II - Soleşti locality) [21].

The experience that is the subject of the research was organized in the Research and Development Station for Meadows, Vaslui area, on a *Dichanthium ischaemum* (L.) Roberty (synonyms: *Bothriochloa ischaemum* (L.) Keng; *Andropogon ischaemum* L.) meadow. In the study area there are large areas of permanent meadows, at different stages of degradation, due to the positioning on surfaces with different degrees of inclination, eroded or subject to erosion process, due to abandonment or non-rational use, with an inappropriate load of animals and failure to apply maintenance or improvement measures. Due to these aspects, the production is small and the floral composition is dominated by species with medium and low fodder value. In order to increase the production of permanent grassland in the area, it was considered necessary to apply organic fertilizers, and their effect was compared to that of abandonment, mulching or simple use, and with overseeding measures.
Dry matter production in the 2022-2023 period (Table 1) varied, on average, between 1.16 $Mg \cdot ha^{-1}$ in abandoned variant and 1.34

Mg·ha^{-1} in harvested at seed maturation variant (control), up to 2.25 Mg·ha^{-1} in the overseeded variant, normally harvested and 2.36 Mg·ha^{-1} in overseeded, fertilized with sheep manure (10 Mg·ha^{-1}·year^{-1}) and harvested at seed maturation variant.
In 2022 the obtained productions were much lower due to the extreme drought, especially during the growing season.

Table 1. Dry matter production in the 2022-2023 period

Variant		DM production (Mg·ha^{-1})		
		2022	2023	Average
v_1 - abandoned;		0.70	1.61	1.16
v_2 - harvested at seed maturation (control variant);		0.99^{C}	1.68^{C}	1.34^{C}
v_3 - overseeded and mulching;		1.23	2.37	1.80
v_4 - overseeded and harvested at seed maturation;		1.31	3.20*	2.25*
v_5 - overseeded, fertilized with sheep manure (10 Mg·ha^{-1}·year^{-1}) and harvested at seed maturation.		1.29	3.42**	2.36*
LSD	*0.5*	*0.46*	*0.75*	*0.61*
	0.1	*0.67*	*1.09*	*0.88*
	0.01	*1.01*	*1.64*	*1.32*

Source: Own calculation.

The floristic structure was influenced by the following vectors: vegetation season, management mode (abandonment, mulching, mowing), manure application and overseeding. Their combined effect can be distinguished in Table 2, especially in the case of variants v_4 - overseeded and harvested at seed maturation and v_5 - overseeded, fertilized with sheep manure (10 Mg·ha^{-1}·year^{-1}) and harvested at seed maturation, where the degree of vegetation cover was 100% and the percentage of leguminous species increased.

Table 2. Main vegetation changes in the 2022-2023 period

Variant	2022				2023			
	G	L	F	ga	G	L	F	ga
	Coverage degree (%)							
v_1	71	2	15	12	85	1	10	4
v_2 (C)	68	2	17	13	75	4	21	0
v_3	63	6	24	7	71	2	24	3
v_4	63	10	27	0	73	8	19	0
v_5	66	12	22	0	69	10	21	0
G - grasses; L - leguminous; F - forbs; ga - gaps.								

Source: Own calculation.

In the agricultural field, the cost of any share must be recovered by capitalizing on the production increase obtained. In the case of research carried out in the 2022-2023 period within the RDSM Vaslui the following results were obtained (Table 3):

▫ in case of variant v_1 - abandoned, there is no talk of economic efficiency, because no action is taking place;
▫ in case of variant v_2 - harvested at seed maturation (control variant), the R value was 14.5 %, a very small value, due to the lack of inputs and the small productive potential of the meadow (Ct value includes the expenses related to the mowing, rake and baling works, respectively 125, 75 and 150 lei·ha^{-1}, on average);
▫ in case of variant v_3 - overseeded and mulching, also there is no talk of economic efficiency, because the production on this variant remains on the ground, and the activities performed generated only costs (Ct value includes the expenses related to the mowing, rake and overseeding, respectively 125, 75 and 200 lei·ha^{-1}, on average);
▫ in case of variant v_4 - overseeded and harvested at seed maturation, the R value was 22.7 %, also a very small value, due to the costs of inputs (Ct value includes the expenses related to the mowing, rake, baling and overseeding works, respectively 125, 75, 150 and 200 lei·ha^{-1}, on average);
▫ in case of variant v_5 - overseeded, fertilized with sheep manure (10 Mg·ha^{-1}·year^{-1}) and harvested at seed maturation, the R value was only 1.1 %, due to the very high costs of inputs (Ct value includes the expenses related to the mowing, rake, baling, overseeding and fertilization works, respectively 125, 75, 150, 200 and 150 lei·ha^{-1}, on average).

Table 3. Economic efficiency in the 2022-2023 period

Variant	Qt (average)	Pv	Pv·Qt	Ct	Vn	R	
	Kg·ha^{-1}	Lei·Kg^{-1}	Lei·ha^{-1}			%	Difference %
v_1	1160	abandoned					
v_2 (C)	1340	0,3	402	350	52	14,5	100
v_3	1800	0,3	540	400	140	mulching	
v_4	2250	0,3	675	550	125	22,7	153,0
v_5	2360	0,3	708	700	8	1,1	7,7

Source: Own calculation.

Although the differences between the studied variants appeared from the first year of study, the trends obtained may have some changes if the experiment will continue longer, so that it can be included in the study normal years in terms of climatic configurations or even with precipitation surplus. These aspects are

highlighted by other studies [5], [7], [15], [24].

CONCLUSIONS

The aspects detached from the study can be concluded in the fact that regardless of the actions performed on the degraded permanent meadows, their costs can be recovered by capitalizing on the production increase obtained.

The lowest costs were recorded when the biomass was only harvested, no other action being performed.

When overseeding and fertilization were overlapping the costs were the highest, the economic efficiency being carried close to zero, but more likely, the effect of fertilization has been greatly diminished due to poor climatic conditions.

As a general recommendation, which can be deduced from this research, overseeding can contribute to increasing the amount of biomass that can be harvested from degraded permanent grasslands.

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