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ECONOMIC EVALUATION OF FORAGE PRODUCTION FROM GRASS MIXTURES IN THE MOUNTAIN REGIONS OF BULGARIA

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Abstract

Forage production from mixed grasslands is closely related to their productivity and quality. In this context, the correct selection of components in grass mixtures ensuring an environmentally acceptable grass association is essential, linked to the realization of cost-effective grass forage under sustainable management of natural resources. The object of the analysis is the characteristics of the main economic indicators in a scientific research experiment involving the following grass species: bird's foot trefoil + cock's foot; bird's foot trefoil and red fescue; bird's foot trefoil+ timothy; bird's foot trefoil + cock's foot + red fescue + timothy. The agrotechnical measures used and the costs involved are relevant to the amount of gross income, cost and profit of forage production. The high economic efficiency of the mixture of bird's foot trefoil + red fescue (82.65%) makes it the most suitable for hay in mountain regions. The realized forage production from it has the lowest production costs (19.57 BGN/da) and the lowest cost (0.018 BGN/kg). The high coefficient of economic efficiency makes it extremely profitable and suitable for practical application.

Key words**:** *sustainable agriculture, grass mixtures, economic indicators, economic efficiency*

INTRODUCTION

The production of forages based on modern technologies in line with climate change trends requires the introduction of new approaches and methods. Perennial grass species have a major role in creating high-quality forage for livestock [1]. Due to their well-developed root systems, they absorb nutrient and moisture from deeper soil layers more efficiently than other crops. Their rate of growth and development and their multi-year production cycle account for the lower material and production costs associated with basic and pre-sowing soil preparation, sowing, and crop care during the growing season [2]. The possibility of harvesting grasslands several times during the year and the low cost of forage make perennial grasses a suitable source of hay for ruminants [14].

Fertilization is an important agronomic measure affecting the efficiency of the forage produced by grasslands. Organic and mineral fertilizer inputs increase the productivity of grass species but increase production costs and reduce profitability. This is associated with higher fertilizer prices leading to rising forage prices [7].

The economic efficiency of mixed grasslands is largely determined by the type of components [16]. Legumes included in the composition of mixtures reduce the cost of forage and increase its profitability [6]. This is due to reduced nitrogen fertilizer costs because of the ability of legume grasses to fix nitrogen from the air [13, 17]. The gross and exchange energy of the obtained forage determines the energy cost structure of livestock production and depends on the animal breed and forage quality. Therefore, to assess the energy balance, it is essential to consider the criterion of economic evaluation of process technology in feed production, which is inextricably linked to the rational use of non-renewable and renewable energy [9].

Karbivska et al. (2020) [10] in a study of the economic and energy efficiency of forage from perennial legume grasses depending on fertilizers proved that forage without mineral fertilizers in the Carpathian region has a net profit of 11.1-21.9 thousand UAH/ha, the profitability level is 151-210%, and the cost of

1 ton of forage units is 1.6-2.0 thousand UAH/ha, BEC is 2.8-3.7 GJ/ha, CEE is 6.4-8.5 GJ/ha, energy cost for 1 ton of feed units is 3.1-4.3 GJ. The inclusion of bird's foot trefoil in mixed crops with perennial provides the highest economic and energy efficiency (Wysokiński et al., 2020) [17], and among the fertilizer options the best options for economic efficiency are with the application of phosphorus-potassium fertilizers at $P_{60}K_{60}$ rates.

Karbivska et al. (2021) [11] found the best economic and energy efficiency indicators for *Lolium perenne* L. and the lowest for *Festuca rubra* L., while *Dactylis glomerata* L., *Festuca orientalis*, *Bromus inermis* L., *Phalaris arundinacea* L. and *Phléumpraténse* L. occupied an intermediate position. Among the fertilizer options, the most effective is the full application of mineral fertilizer at a rate of $N_{90}P_{60}K_{60}$.

Studies related to the determination of economic efficiency and environmental effect in the production of forage from sown mixed grasslands are insufficient. This made it requirement to analyze the economic efficiency of forage production from a grass mixture including bird's foot trefoil and perennial forage grasses grown under mountain conditions.

The aim of the study is to make an economic evaluation of forage production from four variants of grass mixtures grown in the Central Balkan Mountains region in Bulgaria.

MATERIALS AND METHODS

In a field experiment on light grey pseudopodzolic soil during 2016-2019 in the experimental field of Research Institute of Mountain Stockbreeding and Agriculture - Troyan the following grass species were tested in mixed grasslands: bird's foot trefoil (*Lotus corniculatus* L.), cock's foot (*Dactylis glomerata* L.), red fescue (*Festuca rubra* L.) and timothy (*Phleum pratense* L.). It was sown bird's foot trefoil (variety *"Targovishte 1"*) and cock's foot (variety *"Loke"*), red fescue (variety *"Ryder"*), and timothy (variety *"Erecta"*). Bird's foot trefoil (100% - control); bird's foot trefoil + cock's foot (50:50); bird's foot trefoil + red fescue (50:50); bird's foot trefoil + timothy (50:50); bird's foot trefoil + cock's foot + red fescue + timothy (25:25:25:25). Sowing was carried out at a seed rate of 1.2 kg/da for bird's foot trefoil and 2.5 kg/da for all cereal grasses. Fertilization was carried out as a single stock fertilizer application at $P_{40}K_{40}$ rates and nitrogen fertilizer was applied annually at 6 kg/da. The main soil treatments deep ploughing, disking, milling, sowing and raining we carried out according to the technology adopted at the Research Institute of Mountain Stockbreeding and Agriculture for creating artificial grasslands [3]. The main forage harvesting activities included: cutting, hay turning, baling, transporting and storage.

Economic indicators were calculated based on the average dry matter yield over a four-year period (kg/da) and the obtained results analysed. For this purpose, process maps [12] were developed to calculate the production costs (BGN/da), cost price (BGN/kg), gross revenue (BGN/da), gross profit (BGN/da) of dry matter yield of sown mixed grasslands. Economic efficiency was determined by gross revenue and production costs. The analysis was carried out on data from the above economic indicators. A tabular and graphical method was applied [8].

RESULTS AND DISCUSSIONS

Table 1 shows that, on average, all the mixed grasslands exceeded the self-seeded crop of bird's foot trefoil in dry matter yield over the study period.

The highest value was recorded in the mixture of bird's foot trefoil + cock's foot, realizing a dry matter yield of 1,212.77 kg/da with an excess over the Control of 23.17%.

The second most productive mixture was bird's foot trefoil + red fescue (1,105.14 kg/da), which out-yielded the bird's foot trefoil self-seeded crop by 12.2%.

All other mixtures were also more productive than the Control, which proves the statement of Churkova (2010) [3] and Churkova and Churkova (2023)[5] that mixed grasslands of bird's foot trefoil are more productive than growing them in pure condition.

Table 1. Dry matter yield (kg/da) of mixed grasslands averaged over the period

Variants	*Average over the period*	
	kg/da	*%St*
1.Bird'sfoot-trefoil (100% - control)	984.57	100.00
2.Bird'sfoot -trefoil +cock's foot(50:50)	1,212.77	123.17
3.Bird'sfoot-trefoil + redfescue (50:50)	1,105.14	112.2
4.Bird'sfoot-trefoil + timothy (50:50)	1,051.49	106.79
5.Bird'sfoot-trefoil +cock'sfoot + redfescue+ timothy(25:25:25:25)	1,078.47	109.53
GD 5%	149.22	13.15
GD 1%	209.46	18.45
GD 0.1%	295.70	26.05

Source: Data from annual reports of Project P 163 of the Agricultural Academy of Bulgaria [15] and publication of Churkova and Churkova, 2021 [4].

In the production of grass mixtures, the largest inputs are made in the first year, i.e. at the establishment of the grassland. A large number of manual and mechanised activities are involved, which explains the increased production costs. The phosphorus and potassium fertilization carried out in the first year alone also increased the production costs. It should be noted that the cost of seed is most important in the first year of sowing and is the most important factor in determining the cost of each individual grass mixtures.

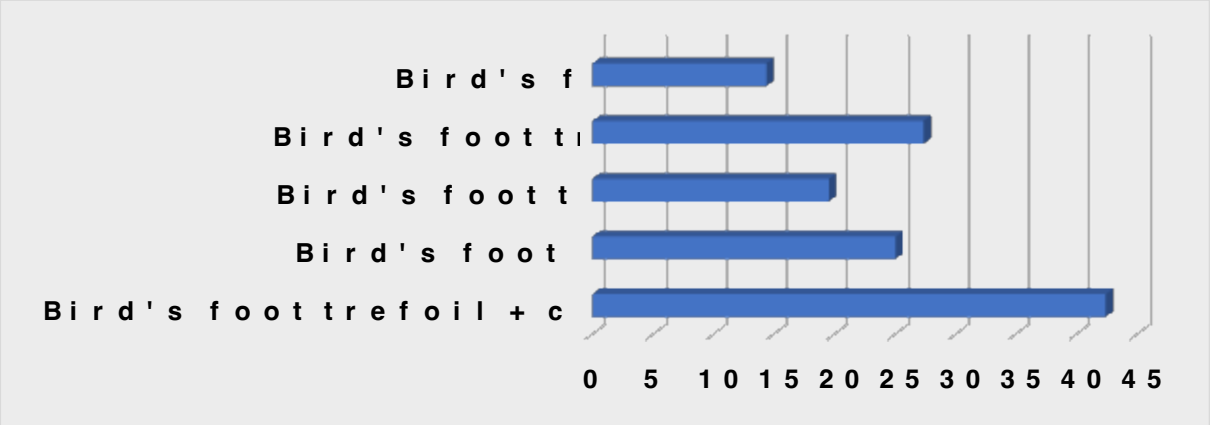

Fig. 1. Production costs (BGN/da) of forage production from grass mixtures on average over the period
Source: Own calculations.

From Figure 1, it can be seen that the combination of all grass mixtures studied had the highest costs on average over the study period. For the mixture composed of bird's foot trefoil + cock's foot + red fescue + timothy (var. 5), the costs were 42.45 BGN/da due to the seed inputs of the four components grass mixture. Similarly, this is the lowest cost value in the control, where we only have inputs for the purchase of bird's foot trefoil (*Lotus corniculatus* L.) seeds. In the other variants of bird's foot trefoil mixtures, the only influence is the price of the seed. Because of this fact, the mixture of bird's foot trefoil with cock's foot has a higher production cost (27.39 BGN/da) than that of bird's foot trefoil + timothy (25.07 BGN/da) and even higher than that of bird's foot trefoil + red fescue (19.57 BGN/da). All the other operations are identical and they cannot give such a large reflection in forming the costs of the different grass mixtures.

Table 2. Cost price (BGN/kg) of forage from grass mixtures production averaged over the period

Variants	*Cost price (BGN/kg)*
1.Bird's foot trefoil (Control)	0.015
2.Bird's foot trefoil + cock's foot	0.023
3.Bird's foot trefoil + red fescue	0.018
4.Bird's foot trefoil + timothy	0.024
5.Bird's foot trefoil + cock's foot + red fescue + timothy	0.039

Source: Own calculations.

The cost price of production was determined based on yield and production costs, with the

mixture *Lotus corniculatus* L. + *Dactylis glomerata* L. +*Festuca rubra* L. + *Phleum pratense* L. (var. 5) showing the highest values, respectively 0.039 (BGN/kg). Quite predictably, the control had the lowest cost price (0.015 BGN/kg), followed by the combination of bird's foot trefoil and red fescue (0.018 BGN/kg). The calculated cost values for bird's foot trefoil + cock's foot and bird's foot trefoil + timothy are similar, respectively 0.023 BGN/kg and 0.024 BGN/kg.

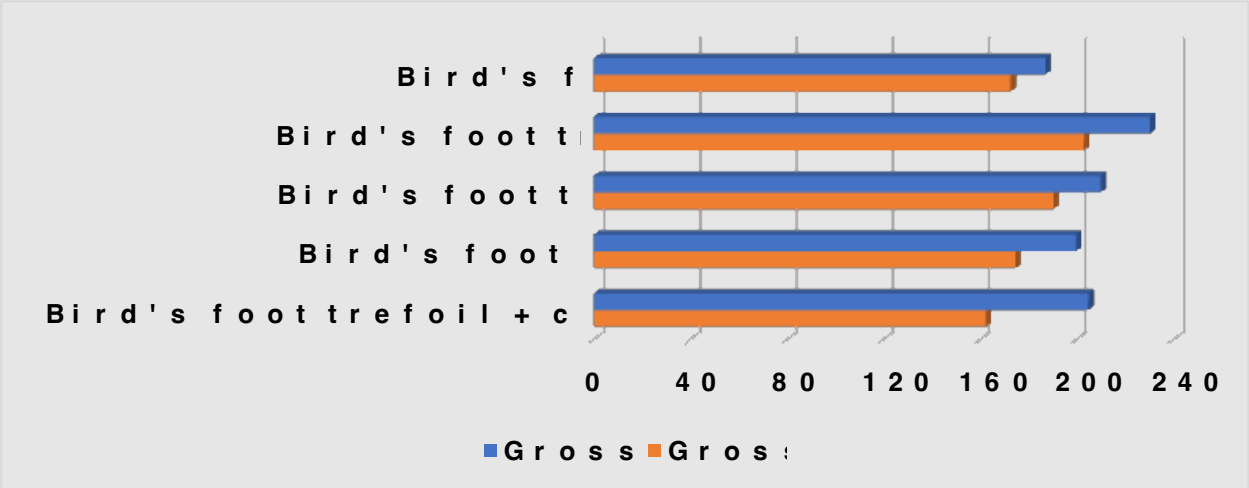

Fig. 2. Gross revenue (BGN/da) and gross profit (BGN/da) in the production of forage from grass mixtures averaged over the period
Source: Own calculations.

Gross revenues are most strongly influenced by the yield obtained. Averaged over the study period, the highest yield was recorded for the forage obtained from the mixture of bird's foot trefoil with cock's foot, which determined the highest revenues obtained, respectively 230.43 BGN/da (var. 2). The relatively high yield of forage from the mixture of bird's foot trefoil with red fescue, marked high revenues (209.98 BGN/da) due to the high productivity, respectively 1,105.14 kg/da. Similarly, the gross profit was the highest for the mixture of bird's foot trefoil and cock's foot, at 203.04 BGN/da (var. 2), followed by the mixture of bird's foot trefoil + red fescue, at 190.41 BGN/da (var. 3).

When calculating the gross profit, the close values of the control and the mixture of bird's foot trefoil + timothy, 172.66 BGN/da and 174.71 BGN/da, respectively, are remarkable, which is explained by the close values of the dry matter yield obtained. However, it should be noted here that the grass mixture of bird's foot trefoil + cock's foot + red fescue + timothy had the lowest realized profit of 162.46 BGN/da, which is due to the highest production costs incurred during the period analyzed.

Table 3. Economic efficiency of production of forage from grass mixtures

Variants	K_{ef}	*%*
1.Bird's foot trefoil (Control)	12.98	100.00
2.Bird's foot trefoil + cock's foot	8.41	64.80
3.Bird's foot trefoil + red fescue	10.73	82.65
4.Bird's foot trefoil + timothy	7.97	61.39
5.Bird's foot trefoil + cock's foot + red fescue + timothy	4.83	37.18

Source: Own calculations.

This type of mixture does not produce a high dry matter yield and, on this account, the inputs involved in its creation are not justified as they cannot ensure and guarantee a good profit for the farmers.

The economic efficiency ratio represents the economic efficiency of grass forage production represented by the ratio of revenue to costs. The difference between the values of the efficiency ratios for production of fodder for individual grass mixtures ranges from 4.83 to 10.73%, without taking into account the control, which is 100%. The mixture with the highest percentage of economic efficiency, approaching that of the control, was the mixture of bird's foot trefoil + red fescue (82.65%), and the lowest for the mixture of bird's foot trefoil + cock's foot + red fescue + timothy (37.18%). The variants of the grass mixtures bird's foot trefoil + timothy and bird's foot trefoil + cock's foot had efficiency coefficients of 7.97% and 8.41%, which were approximately similar.

CONCLUSIONS

From the analyzed economic indicators of forage production from four grass mixtures, it can be concluded that the grass mixture of bird's foot trefoil + red fescue has the lowest production costs and the lowest cost price, but the mixture of bird's foot trefoil + cock's foot realizes the highest revenue – 230.43 BGN/da and the highest gross profit – 203.04 BGN/da. In practice the most unsuitable mixture for rearing was bird's foot trefoil + timothy, with gross revenue of 199.78 BGN/da and profit of 174.71 BGN/da. This same grass mixture also stands out with the lowest total yield of the other grass mixtures at 1051.49 kg/da.

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