Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 23, Issue 2, 2023
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ECONOMIC ANALYSIS AND ECOLOGICAL EFFECT OF FERTILIZING WITH ORGANIC PRODUCTS ON NATURAL GRASSLANDS UNDER THE CONDITIONS OF BIOLOGICAL FARMING

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Abstract

During the period 2013-2015, boron, molybdenum and phosphorohumate and their impact on the economic analysis and ecological efficiency of the obtained fodder production were tested on natural grassland of Chrysopogon gryllus type. Based on a comparative evaluation of the main economic indicators of different types of fertilizers and dry matter yield per decare, it was found that foliar treatment of natural grassland of Chrysopogon gryllus type with boron and molybdenum humate had a positive effect on dry matter productivity.The imported molybdenum humate realized the highest revenues and gross profit and determined these two bioproducts as the most economically efficient for obtaining high yield and quality of fodder. The ecological effect of foliar treatment with biofertilizers significantly affects the floristic composition of the grassland, reducing the share of the main species Chrysopogon gryllus and motley grasses in the formed aboveground mass and increased the share of Agrostis capillaris and legume meadow grasses, such as Trifolium campestre and Lotus corniculatus.

Key words**:** *natural grasslands, fertilizing, economic analysis, ecological effect*

INTRODUCTION

Natural grass associations are a huge natural resource that allows full, environmentally friendly and low-cost breeding of ruminants. Fodder production can be economically profitable provided that all agrotechnical events are applied in accordance with the requirements of grassland, in optimal terms, doses and norms, and the obtained yields are high enough to ensure production profitability (Georgiev et al., 2005) [6].

Natural meadows and pastures preserve much of the biodiversity of each country. Their use can be considered as a factor in maintaining the biological balance in nature (Kirilov, 2016) [9], as well as by the species involved in the grass composition (Hopkins and Holz, 2006; Iliev, 2014) [7, 8]. The content of protein, fat, crude ash, calcium and phosphorus in the fodder leads to the production of livestock products of extremely high quality (Stoeva and Vateva, 2011) [13].

Recently, the requirements for stable crop production have been constantly increasing, as they are associated with reduced investment in pesticides and mineral fertilizers and increased biodiversity. These conditions determine the integration of environmental aspects into the EU's Common Agricultural Policy (CAP). EU Directive 2092/91 enshrines biological farming as a low-investment production system.

Higher environmental efficiency can be achieved through limited mineral fertilizing and optimization of pesticide costs. This requires the implementation of effective measures and mechanisms for increasing productivity and reducing unwanted investments.

The changes that have taken place in the production of plant and animal products and especially in the prices of the material costs of production require its rethinking from an economic point of view. In a market economy, competition requires manufacturers to demand new technological solutions that lead to increased productivity, lower cost price and greater profitability and efficiency of production.

One of the strategies for the development of the agricultural sector is the use of foliar fertilizers and biostimulants, which affect the biological potential of plants, replace mineral

fertilizing and are an alternative to organic and sustainable agriculture (Mihova et al., 2017;Yakimov and Ivanov, 2017)[11, 18]. Their effect is associated with the stimulation of a number of processes in the plant organs, which leads to full absorption of nutrients and resistance to adverse climatic conditions (Doyle and Toop, 2004; Yakhin et al., 2017)[5, 17]. Their ecological impact is based on the ability of biological products to increase plant viability by reducing the amount of fertilizers used.

The introduction of biofertilizers containing humic and fulvic acids (Vasileva, 2008)[14] is an important element of the technology aimed at creating favorable conditions for the realization of the potential of plants and fodder quality. The stimulating effect of humate fertilizers on the growth and development of plants, the content of crude protein (Vasileva and Kostov, 2015)[16], macronutrients and water-soluble sugars in the aboveground biomass of plants (Vasileva and Ilieva, 2015)[15], as well as increasing the digestibility of dry and organic substance, gross and metabolic energy of fodder (Klimas et al., 2010)[10] determine the need for the application of these biofertilizers in modern production.

The economic efficiency of grasslands depends on the costs and returns associated with dry matter production and the nutritional value of the fodder (Omokanye et al., 2019)[12].

There are few research experiments on the significance of fertilizing with bioproducts of natural grasslands and their impact on biodiversity conservation. So far, no comprehensive assessment has been made from an economic and environmental point of view to determine the impact of fertilizing on the production of fodder from natural grasslands, the amount of production costs, profitability and cost-effectiveness and its role as an environmental factor.

MATERIALS AND METHODS

The experiment was conducted in the period 2013 - 2015 at an altitude of 500 m in the area of Makaravets with 5 different variants of fertilizing on natural grassland of *Chrysopogon gryllus* type.

The experiment is based on the block method in four replications with a plot size of 5 m^2. The treatment was carried out in May and the mowing in July.

The fertilizing variants studied in the experiment are presented in Table 1.

Table 1. Variants and fertilizing doze

Variants	***Fertilizing doze***
1.Control (C)	Without fertilizing
2.Phosphorus humate (PH)	300 ml/da
3.Boron humate (BH)	160 ml/da
4.Molybdenum humate (MH)	160 ml/da
5.Phosphorus humate (PH) + Boron humate (BH) + Molybdenum humate (MH)	200 ml/da + 100 ml/da + 100 ml/da

Source: Churkova and Churkova, 2022 [4].

The biological preparations included in the experiment (organic and organo-mineral fertilizers) are outlined as promising biotechnologies for agriculture, which are produced by AgroBioStim Ltd. in Kavarna.

The economic assessment is established on the basis of detailed technological maps developed for each fertilizing variant. The valuation of the seeds, fertilizers, materials, mechanized and hand labour used in the technology for calculation of the total production costs was performed at market prices as in 2016. The maintenance and haymaking were carried out with own mechanized equipment. The value of production was calculated on the basis of average prices for the analyzed period.

The main indicators determining the economic evaluation of the results of the experiment are gross revenues (BGN/da) and profitability (%) (Borisov & Dinceva, 2014)[3]. They give an idea of the economic efficiency of the applied types of bioproducts and doses of them.

The economic assessment was developed on the basis of total yield. The dry matter yield (kg/da) was recorded over the years and for the period for each variant of each replication by drying the average samples (200 g) under laboratory conditions to constant weight at 105°C. It was calculated on the basis of green matter yield and dry matter content.

Research indicators are: production costs (BGN/da) and gross profit (BGN/da) (Atanasov et al., 2016) [2].

The ecological effect of fertilizing was determined by the botanical composition of the grassland, as its components were divided into groups: grasses, legumes and motley grasses (%), and the groups were determined by species. Based on the obtained results, the impact of fertilizing on biodiversity conservation was determined as an assessment of the ecological effect.

Statistical processing of dry matter yield data was performed by variance analysis (ANOVA) to establish the reliability of ***LSD*** differences.

RESULTS AND DISCUSSIONS

The presented yield is on average for the three-year study period and on this basis all economic indicators listed in table are calculated (Figure 1). Fertilizing with Molybdenum humate at a dose of 160 ml/da showed the highest effect on dry matter yield, exceeding the control by 19.9%. The combined application of the three fertilizers registered a weaker effect on the yield compared to boron and molybdenum humate imported alone. The result of fertilizing by Phosphorus humate and the combination Phosphorus humate 250 ml/da + Boron humate 100 ml/da + Molybdenum humate 100 ml/da grassland is almost similar and lower than the untreated control.

Production costs (Figure 1) show an increase from 6.04 BGN/da to 11.64 BGN/da in the studied fertilizing variants compared to the control, which is 4.80 BGN/da. The analysis of the structure of the average annual costs shows that the price of bioproducts, the dose of their application and the price of fuel are decisive in the values of production costs. This shows that the costs of organic fodder production depend more on the cost structure than on the amount of fodder production obtained. The costs are mainly due to the activities of purchasing bioproducts and baling hay. Because the harvesting of natural grasslands relies entirely on mechanized activities, much of the cost goes to fuel. In this case, the price of fuel is essential and proving the obtained different values of production costs by options. To some extent, these activities shorten the savings in organic fodder production. Therefore, the production of fodder bioproducts is characterized by an increase in profitability by reducing production costs.

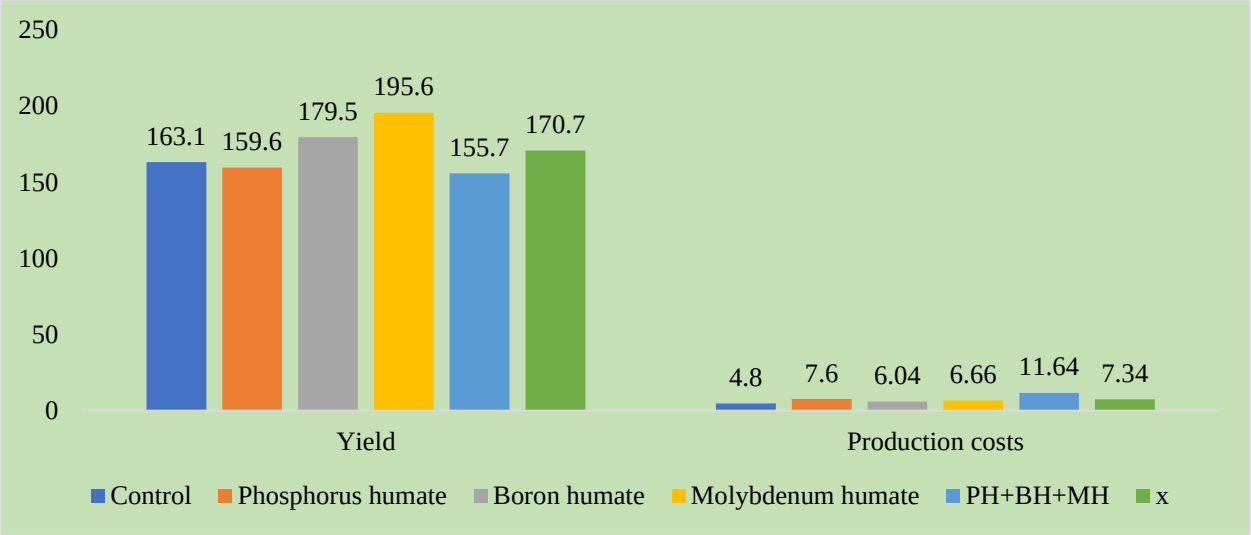

Fig. 1. Yield(kg/da) and production costs (BGN/da) of a natural meadow of *Chrysopogon gryllus* type, treated with humate fertilizers during the period 2013-2015.
Source: data from annual reports on project G 100 of the Bulgarian Agricultural Academy and own calculations.

Cost price (Table 2) is one of the main indicators for determining the economic efficiency in the production procedure for realization of production from natural

grasslands. The production of hay from bunch meadow grasses depends on the costs invested in the application of bioproducts, mowing, baling, transportation. Cost price fluctuates within the narrowest limits between the studied variants of self-imported biofertilizers and varies from 0.035 to 0.075 BGN/kg.

Cost price of the produced fodder production for bunch grass meadow, fertilized with Phosphorus humate 250 ml/da + Boron humate 100 ml/da + Molybdenum humate 100 ml/da was the highest, respectively 0.075 BGN/kg. The increase in cost price is explained by the obtained low dry matter yield, as well as by the negative impact of the increased production costs. As the production of fodder from natural grassland is linked to more mechanized production procedures, the production costs determine the lower cost price of fodder. After the unfertilized control, in which the lowest cost price of the treated hay (0.030 BGN/kg) was reported, from the variants with applied organic fertilizing the lowest was the cost price of grassland fertilized by boron humate (0.035 BGN/kg).

Table 2. Cost price of production of a natural meadow of *Chrysopogon gryllus* type, treated with humate fertilizers during the period 2013-2015

Variants	*Cost price BGN/kg*
1.Control (C)	0.030
2.Phosphorus humate (PH)	0.048
3.Boron humate (BH)	0.035
4.Molybdenum humate (MH)	0.036
5.Phosphorus humate (PH) + Boron humate (BH) + Molybdenum humate (MH)	0.075

Source: own calculations.

Data on the cost price of fodder production resulting from the applied humate fertilizers could be explained by the structure of production costs. The very technological process of surface and basic improvement of natural meadows allows the inclusion of a large number of mechanized processes in the production of fodder, which in turn reduces the complexity of obtaining organic products. The costs for bioproducts are relatively constant by years and the highest, but they directly affect the production of higher yields and lower production cost price. It is necessary to work in the direction of increasing the cost of biological fertilizers, increasing the processes of mechanization in the production activity, as a result of which the productivity and quality of the obtained fodder production will increase. The application of a set of measures including meeting the needs of plants with appropriately applied cultivation technology can lead to economic efficiency of the applied biofertilization.

Increased revenue growth (Figure 2) is observed in treatment with Molybdenum humate, as it reflects the highest yield. Only fertilizing with Phosphorus humate + Boron humate + Molybdenum humate tends to decrease revenues - 28.03 BGN/da compared to the variant without fertilizing (control) - 29.35 BGN/da. The data show that the increased volume of fodder production has a positive effect on revenues. The highest efficiency was in the biologically obtained fodder after fertilizing with molybdenum and boron humate, as the increase in the revenues compared to the control was by 5.86 and 2.96 BGN/da.

The amount of gross sales revenue from hay when fertilizing with these two organic products determines the higher economic efficiency compared to fertilizing with phosphorus humate and the combination of the three organic products. The total value of the received revenues from the realized bioproduction of fodder in all variants of fertilizing was higher than the amount of the made production costs, as they were formed only from sales revenues. Their sales price was relatively good, the value of production costs was low and covers the revenues received.

The gross profit (Figure 2) is a result of the revenues and expenses realized during the studied period, made during fertilizing with humate fertilizers and gives an idea of its exact amount. It is an absolute indicator and characterizes the result of fertilizing in quantitative terms. Calculating the exact amount of profit from biofertilizing in fodder production is of great practical significance, as it is the source for paying costs, covering annual taxes and fees and for making new

investments in economic activity. The calculation of gross profit is one of the most important concepts for organization and management in the production of fodder from natural grasslands.

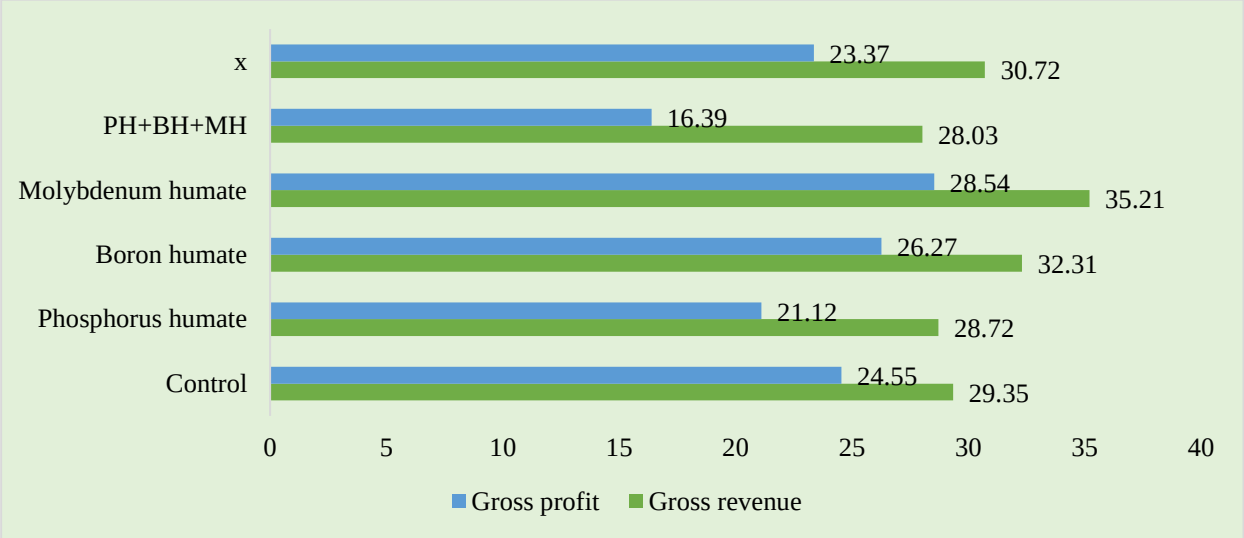

Fig. 2. Gross revenue (BGN/da) and profit (BGN/da) of production of a natural meadow of *Chrysopogon gryllus* type, treated with humate fertilizers during the period 2013-2015.
Source: Own calculations.

The analysis of the impact of production costs and gross revenues shows that an increase in gross profit of 28.54 BGN/da was observed when using Molybdenum humate at a dose of 160 ml/da. Only in the case of the combination of fertilizers (fifth variant) a significantly small value of the gross profit was reported compared to all other variants, namely16.39 BGN/da. Even the control (first variant) had a higher profit - 24.55 BGN/da. Fertilizing with Phosphorus humate at a dose of 300 ml/da is also characterized by a low profit - 21.12 BGN/da, which is lower than that of the control. Fertilizing with Boron humate at a dose of 160 ml/da shows a tendency to increase the profit compared to the first, second and fifth variant of fertilizing. The gross profit of the sold fodder could be higher, as in this case the bioproduction is realized at prices of its conventional equivalents. The fluctuation in the prices of fodder from natural grasslands, obtained as a result of applied biofertilizing and the lack of precisely established ones, mainly leads to serious negative consequences on the final result of the fodder production.

Profitability (Table 3) is a summary indicator of economic efficiency and is a numerical expression of the percentage ratio between gross profit and production costs. Significant differences were observed in terms of the profitability rate, as it was the highest in the control variant (without fertilizing) with 523.04%. This is due to the low investment compared to all other variants. It is followed by the profitability rate using boron humate (160 ml/da) with 447.09% and that of feeding with Molybdenum humate (160 ml/da) with 438.66%.

Table 3. Profitability of production of a natural meadow of *Chrysopogon gryllus* type, treated with humate fertilizers during the period 2013-2015

Variants	*Profitability %*
1.Control (C)	523.04
2.Phosphorus humate (PH)	278.54
3.Boron humate (BH)	447.09
4.Molybdenum humate (MH)	438.66
5.Phosphorus humate (PH) + Boron humate (BH) + Molybdenum humate (MH)	141.71

Source: own calculations.

They are followed by Phosphorus humate (300 ml/da) with 278.54%. The lowest profitability was observed in the last (fifth) variant, namely 141.71%, i.e. the least

effective variant.

The economic efficiency of the bioproduction of fodder production of bunch type natural grassland depends on a complex of factors, such as gross profit and production factors. According to data obtained from Agapieva-Aliosman (2019) [1], the profitability rate determines the degree of return on equity. The higher profitability rate as a result of fertilizing with boron and molybdenum humate allows for the realization of expanded reproduction, which outlines a correct direction of the technology for the production of bio fodder production. The analysis of data shows that the efficiency of the bio fodder production obtained as a result of fertilizing with bioproducts increases with the rise of the gross profit per unit of fodder obtained and the reduced production costs. The dynamics of change in the value of gross profit depends on the degree of change in the average dry matter yield, production costs and sales prices by year. The data show that these three components are extremely dynamic over the years of the experimental period and have a different impact on the gross fodder production per decare. The favorable combination of increased dry matter yield, increase in the purchase prices of hay and reduction of production costs determine and prove the obtained high profitability rate in fertilizing with boron humate. This gives us reason to recommend the fertilizing with boron humate at a dose of 160 ml/da, as an economically effective measure of the technology for receiving fodder production by natural grassland of *Chrysopogon gryllus* type.

Ecological impact

Vegetation in natural meadows and pastures is of interest in terms of its specificity, diversity of plant communities and floristic richness. It is highly vulnerable to ongoing global climate change and anthropogenic interference. Communities that are distributed in areas with insufficient moisture are adversely affected by climate drought processes, and changes in pasture load are another factor that affects grass vegetation in these areas. This necessitates the development of appropriate measures to maintain their favourable condition. One of these measures is the fertilizing of natural grasslands with bioproducts and determining their impact on biodiversity conservation, as an assessment of the ecological effect.

The treatment with humate fertilizers was reflected differently during the years of the experimental period, which is evident from the botanical composition of the grassland presented in Fig. 3.

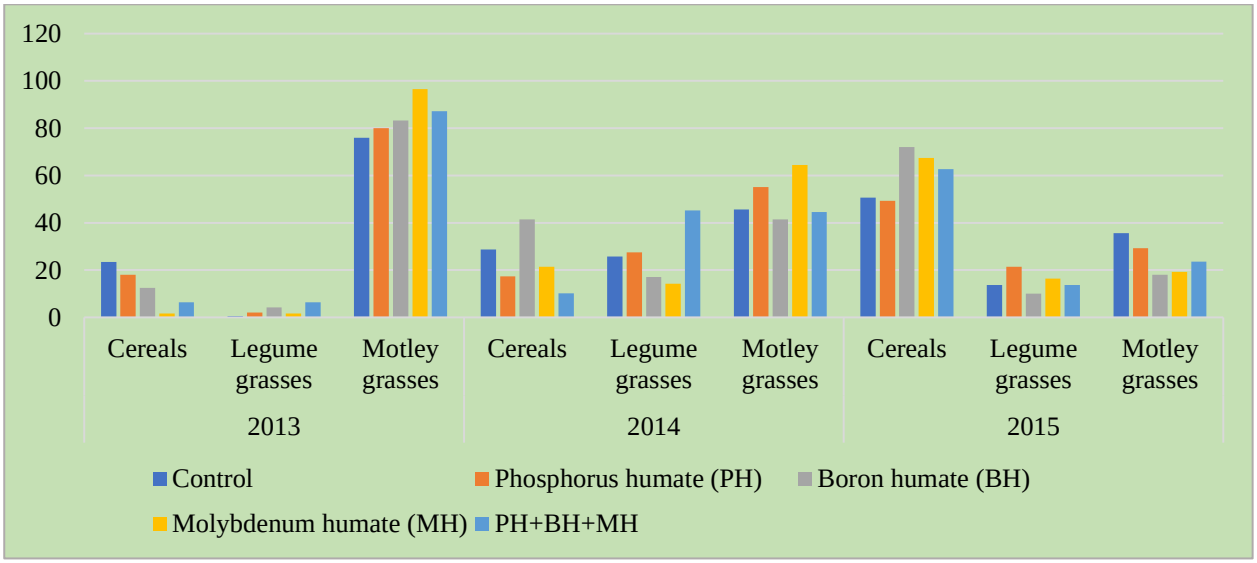

Fig. 3. Botanical composition of a natural meadow of *Chrysopogon gryllus* type, treated with humate fertilizers during the period 2013-2015.

Source: data from annual reports on project G 100 of the Bulgarian Agricultural Academy.

In the first year of the experimental period, the natural grassland cover was dominated by motley grasses, which participated with a share from 76.0 96.6 to 84.6% in the composition of the natural grassland. Grass components predominated in the grassland (from 1.7 to 18.0%) over legumes, whose relative share was from 0.6% in the unfertilized control to 6.4% in the combination of phosphorus humate + boron humate + molybdenum humate. Grass species are presented by *Agrostis capillaris*, *Bothriochloa ischaemum*, *Chrysopogon gryllus*, *Festuca ovina*), and legume species by *Trifolium campestre*, *Lotus corniculatus*.

The treatment with humate fertilizers had a smaller effect on the relative share of grass species, which is evident from their smaller share in the composition of the grass mass compared to those in the control. Legumes fertilized with Molybdenum humate were 1.7%, and those with the combination Phosphorus humate + Boron humate + Molybdenum humate were 6.4%, compared to 0.6% for the control. In the second experimental year, the composition of the natural grassland was dominated by grass components, such as *Agrostis capillaris* L., *Bothriochloa ischaemum* L., *Chrysopogon gryllus* L., *Festuca ovina* L., *Anthoxanthum ododratum* L., *Holcus lanatus* L., *Cynosurus cristatus* L., and legumes species, such as *Trifolium campestre* L., *Lotus corniculatus* L., *Vicia sativa* L., motley grasses share is reduced compared to the first year and is from 41.5% to 64.4%. Meadow grasses predominated compared to the control in the variant treated with boron humate (41.4%). Phosphorus humate (300 ml/da) and the combination of humate fertilizers (Phosphorus humate250 ml/da + Boron humate100 ml/da + Molybdenum humate100 ml/da) positively affected the share of legumes and increased their participation in grassland respectively from 27.5% to 45.2%.

The effect of the imported humate fertilizers in the third experimental year was very well expressed. A variety of meadow grass species was observed. Of interest is the displacement of *Chrysopogon gryllus* L. by *Bothriochloa ischaemum* L. and *Agrostis capillaris* L. The highest percentage share of *Agrostis capillaris* was observed in the unfertilized control and the lowest in the variant with combined action of humate fertilizers. Phosphorus humate determines the percentage share of species in the composition of the grassland.

Bothriochloa ischaemum L. predominates in grassland, as it was fertilized with Molybdenum humate and the combination of Phosphorus humate + Boron humate + Molybdenum humate. Fertilizing with humate fertilizers had an extremely favorable effect on the relative share of legume components in the grassland, with *Lotus corniculatus* L., *Trifolium campestre* L., *Trifolium pratense* L. and *Vicia sativa* L. predominating. Phosphorus humate determined a share of up to 21.4%. Bird's-foot-trefoil dominated the grassland, as Molybdenum humate increased its share. In the group of clover, except for *Trifolium campestre* L., no other representatives were found. The presented botanical composition of the grassland proved the stimulating effect of humate fertilizers expressed by reducing the degree of weed infestation and increasing the share of legume components in the grassland. In this way, the role of biofertilizers for conservation and improvement of biodiversity is determined by increasing the useful species in natural grasslands, which determines the environmental benefits of this technological solution.

CONCLUSIONS

The foliar treatment of natural grassland of *Chrysopogon gryllus* type with boron and molybdenum humate had a positive effect on dry matter productivity. The impact of other humate products was less pronounced, as the probable reason for this was the specific interactions between the specific climate conditions during the year, the type of grassland, the fertilizing rate and the method of fertilizer application.

Fertilizing a natural grassland of *Chrysopogon gryllus* type with boron humate at a dose of 160 ml/da of showed the lowest production costs, the lowest cost price and the highest profitability rate in the production of fodder.

The imported molybdenum humate realized the highest revenues and gross profit. The obtained results determine thefertilizing with these two bioproducts, used as individual preparation, as the most economically efficient for obtaining high yield and quality of fodder from natural grasslands.

The ecological effect of foliar treatment with biofertilizers had a significant effect on the floristic composition of the grassland. The percentage and species share of the main biological groups (grasses, legumes, motley grasses) in the natural grassland was changing positively. There was a reduced presence of the main species *Chrysopogon gryllus* L. (characterizing the grass community) and motley grasses in the formed aboveground mass. The share of *Agrostis capillaris* and legume meadow grasses (*Trifolium campestre* L. and *Lotus corniculatus* L.) significantly increased, which suggests better qualitative indicators of grass biomass.

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