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IMPACT OF FOLIAR ORGANIC FERTILIZING ON THE QUALITY OF FODDER FROM NATURAL MEADOW AND PASTURE GRASS STAND

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Abstract

Foliar fertilizing of meadow grass stand of type Chrusopogon gryllus L. type and pasture grass stand of Nardus stricta L. type with humate fertilizer, such as Biostim (400 ml/da) increases the crude protein content in dry matter by 34.2% and 31.3%, respectively. The highest energy and fodder nutritional value is the fodder mass of the variants treated with a dose of 400 ml/da (for Chrusopogon gryllus L.) and 200 and 300 ml/da (for Nardus stricta L.). The amount of gross energy in meadow grass stands is 1.0% lower than in pastures. The efficiency of the applied biofertilizer is most pronounced in the variants with 100 ml/da dose, where the amount of dry matter and crude protein reaches 808.80 kg and 79.55 kg - for meadow and 509.60 kg and 28.79 kg - for pasture grasslands. There is no difference in the total costs (7.87 BGN/da) regarding the application of foliar fertilizers in pasture and meadow grass stands. The total revenue, total profit, profitability and critical level of the yield from the conducted agrotechnical measure in the meadow grass stands are higher by 19.9%, 25.4%, 27.7% and 92.1% respectively compared to those of the pastures, but at a lower cost price.

***Key words*:** *foliar fertilizing of natural grass stands, humic fertilizer Biostim*

INTRODUCTION

Natural meadows and pastures are a low-cost and environmentally friendly resource for raising ruminants [9]. The applied technologies in their use and maintenance must ensure: optimal biodiversity and sustainability in local ecosystems, maintenance and improvement of soil fertility with the best economic results.

In this regard, organic farming integrates a number of biological, mechanical and agrophysical methods to improve soil structure and fertility [16]. The application of natural substances and processes favours the management of nutrients in the soil, plant growth and biodiversity in the composition of grass stands [3]. Biofertilizers are a technological solution in modern agricultural practices for the creation of environmentally friendly fodder products with high economic value [18, 22]. The use of bioproducts of organic origin has a specific effect on certain physiological functions and biochemical reactions in plants with morphogenetic or metabolic effect [8, 21, 5]. The effect of the compositions stimulates the biological potential of grass species, which leads to improved economic production indicators of grass mass [11].

Supplying of grass stands with biofertilizers promotes the realization of natural processes, preserves the environment and affects the quantity, quality and efficiency of fodder and animal products [7, 12]. Treatment with humate products (8 t/ha) increases the content of essential nutrients in the soil (by 0.2 to 4 mg/100 g), density and yield in natural grass stands [13]. Humus substances (HS) are the dominant components in soil organic matter and natural, effective growth stimulants in sustainable agriculture [14].

The application of foliar humate fertilizers with rich mineral composition increases the efficiency of nutrient utilization (including more inaccessible phosphorus) of plants, improves their photosynthetic activity, nitrogen and carbohydrate metabolism [10].

The aim of the present study is to determine the impact of annual treatment with foliar organic fertilizer Biostim on the quality and some economic indicators of fodder of natural

meadow grass stand of *Chrysopogon grullus* L type and pasture grass stand of *Nardus stricta* L., type located in the Central Balkan Mountains (Bulgaria).

MATERIALS AND METHODS

The experiment was conducted in the period 2011-2013 on a natural meadow - *Chrysopogon grullus* L. type (460 m above sea level) and natural pasture of *Nardus stricta* L. type (1,400 m above sea level) in the region of the Central Balkan Mountain. The effect of universal humic fertilizer Biostim was tested, and Table 1 shows the composition of the organic substance.

Table 1. The agrochemical analysis of the imported biological product includes

reaction (Ph)	**6.8**	**nitrogen (N)**	**2.1%**
salt concentration	20.15	phosphorus (P)	1.54%
organic content	2.25	potassium (K)	11.2%
humic acids	up to 14%	calcium (Ca)	0.15%
fulvoacid	up to 7%	magnesium (Mg)	0.01%
zink (Zn)	0.037	iron (Fe)	0.024%
Macroelements:/total amounts/			
N	mg/l	1,650	
P_2O_5	mg/l	570	
K_2O	mg/l	10,700	
CaO	mg/l	87.9	
MgO	mg/l	22.5	
Macroelements:/digestible quantities/			
$N\text{-}NO_3$	mg/l	123	
$N\text{-}NH_4$	mg/l	48.3	
P_2O_5	mg/l	88	
K_2O	mg/l	7,712	
Na	mg/l	86	

Source: Ministry of Agriculture and Food, National Plant Protection Service, Central Laboratory for Chemical Testing and Control with test report № 1161-01-02 / 12.08.2008.

The experiment is based on the block method, in 4 replications and a plot size of 5 m^2. Experimental variants are:
1.Control (no fertilizing);
2.Foliar treatment at a rate of 100 ml/da;
3.Foliar treatment at a rate of 200 ml/da;
4.Foliar treatment at a rate of 300 ml/da;
5.Foliar treatment at a rate of 400 ml/da;

The treatment of grass stands is in a period of active vegetation of grasses, once in each experimental year. The mowing in the bunch grass meadow was conducted in the tasseling phase until the beginning of blossoming of *Chrysopogon grullus* L, and in the matgrass pasture until the ear formation of *Nardus stricta* L.
Samples for chemical analysis of fodder were taken from each regrowth, dried in a laboratory dryer at 60°C and ground in a laboratory mill to a particle size of 1.0 mm.
The main chemical composition of the dried grass mass was analyzed, including the following indicators:
-Crude fiber (CFr, g/kg) according to the *Weende* analysis - the sample was treated sequentially with solutions of 1.25% (w/v) H_2SO_4 and 1.25% (w/v) NaOH under special conditions. The residue was dried and incinerated;
-Crude protein (CP, %) according to *Kjeldahl* (according to BDS - ISO-5983)
-Crude fats (CF, %) by extraction in an extractor of Soxhlet type (according to BDS - ISO-6492). After extraction, the sample was dried at 95°C;
-Ash (%) - decomposition of organic matter by gradual combustion of the sample in a muffle furnace at 550°C (according to BDS - ISO-5984);
-Moisture content (%) - (according to BDS - ISO-6496) - drying of the sample at a temperature of 105ºC to constant weight;
-Dry matter (DM, %) - empirically calculated from % of moisture;
-Calcium (Ca, %) - according to Schottz (complexometric);
-Phosphorus (P, %) - with vanadate-molybdate reagent by the method of Guericke and Curmis and spectophotometer (*Agilent* 8453 UV - *visible Spectroscopy System*), measuring in the range of 425 ηm.
-NFE = 100 (CP, % + CFr, % + CF, % + Ash, % + Moisture, %);
The energy nutritional value [20] of biomass from grass stands was determined, which includes:
Gross energy (GE) = 0.0242*CP + 0.0366*CF + 0.0209*CFr + 0.017*NFE - 0.0007*Zx.

-Exchangeable energy (EE) = 0.0152*DP (Digestible Protein) + 0.0342*DF (Digestible Fats) + 0.0128*DF (Digestible Fibers) + 0.0159*DNFE (Digestible Nitrogen-Free Extractable substances) - 0.0007*Zx.
-Net energy (NE) = EE-HI, where HI is a heat increment (energy loss due to metabolic inefficiency).
-Feed units for milk (FUM) = EE*(0.075 + 0.039q).
-Feed units for growth (FUG) = EE*(0.04 + 0.1q).
The economic indicators are calculated on the basis of the obtained yield and the established values regarding the quality of the dry mass in the treated variants.

Climatic characteristics in the experimental area

In terms of climate, the territory of the experiments is included in the Pre-Balkan (foothill) climate region of the temperate-continental climate subregion [17]. The climate is characterized by great diversity due to the physical and geographical conditions of the Troyan region assigned to the Stara Planina region, including the Balkan Mountains and the Pre-Balkans [6]. Temperatures bear the marks of continental influence. The average annual temperature is 10-11°C and is characterized by territorial differentiation (from north to south) with increasing altitude [15]. The distribution of precipitation was uneven (maximum in summer: 309.0 mm and minimum in winter: 168.0 mm). In spring and autumn the registered rainfall was 242 mm and 209 mm, respectively. The annual amount of precipitation in the Pre-Balkans reached from 567 mm to 1,200 mm.

RESULTS AND DISCUSSIONS

Main chemical composition of fodder from natural grass stands treated with humic fertilizer

Foliar fertilizing with humic fertilizer Biostim led to positive changes in the chemical composition of the dry mass in meadow and pasture grass stands (Table 2).

In **the meadow grass stand of *Chrysopogon gryllus*** L., type with the highest content of crude protein (87.38 g/kg DM) and crude fat (19.52 g/kg DM) was the variant treated with a dose of 400 ml/da. The values of the indicators exceeded the average by 14.7% and 19.9%, respectively. The foliar treatment variants registered higher values regarding the concentration of nitrogen-free extractable substances (by 1.1 to 5.8%), ash (by 5.1 to 14.0%) and calcium (by 26.1 to 48.5%) compared to the control. The treated variants also had a lower content of crude fiber (by 3.6 to 13.2%) compared to the untreated ones.

Table 2. Main chemical composition (g/kg DM) of natural meadow and pasture grass stand treated with biofertilizer (average for the period)

Variants	CP	CF	CFr	NFE	Ash	Ca	P
***Chrysopogon gryllus* L.**							
Control	65.12	16.31	396.17	452.47	69.92	4.60	0.93
100 ml/da	71.84	14.08	382.50	457.24	74.34	6.03	0.77
200 ml/da	69.49	15.54	362.32	478.79	73.86	5.80	0.83
300 ml/da	87.04	15.93	350.03	467.26	79.74	6.83	1.20
400 ml/da	87.38	19.52	359.49	460.12	73.49	6.37	1.14
Average	***76.17***	***16.28***	***370.10***	***463.18***	***74.27***	***5.93***	***0.97***
SD	***10.36***	***2.00***	***18.77***	***10.24***	***3.52***	***0.84***	***0.19***
***Nardus stricta* L.**							
Control	59.48	16.77	356.41	510.00	57.34	6.27	0.95
100 ml/da	56.65	16.02	370.21	499.83	57.29	4.43	1.10
200 ml/da	59.95	10.85	382.84	492.49	53.88	4.90	1.49
300 ml/da	59.79	13.95	390.72	485.59	49.94	5.33	1.57
400 ml/da	78.12	14.72	354.52	489.91	62.73	5.87	1.47
Average	***62.80***	***14.46***	***370.94***	***495.56***	***56.24***	***5.36***	***1.32***
SD	***8.67***	***2.30***	***15.92***	***9.59***	***4.74***	***0.74***	***0.27***

Source: Own research.

With a higher phosphorus content was the dry matter of grass stands treated with 300 ml/da (1.20 g/kg DM) and 400 ml/da (1.14 g/kg DM). The excess in the values of the indicator compared to the average and the control is respectively 23.7 and 29.0% (for the variant with a dose of 300 ml/da) and 17.5 and 22.6% (for the variant with a dose of 400 ml/da).

In **the pasture grass stand of *Nardus stricta* L. type**, the variants treated with the highest dose of humate fertilizer (400 ml/da) had again the highest content of crude protein (78.12 g/kg DM). In contrast to the results obtained in meadow grass stand, the content of crude fiber in the dry matter of treated pasture grass stands is higher by 3.9 to 9.6% compared to the control (except for the fertilizer variant with 400 ml/da, where the values are insignificantly lower compared to the control by 0.5%). A significant difference in the composition of pasture grass stands with foliar fertilizing compared to meadow is the lower content of nitrogen-free extractable substances, ash (exception is the variant with imported dose - 400 ml/da, where the excess over the control is 9.4%) and calcium compared to untreated variants. The biomass of the treated pastures has a high concentration of phosphorus. The values of the indicator exceeded the control from 15.8 (100 ml/da) to 65.3% (300 ml/da).

Energy nutritional value of fodder from natural grass stands treated with humic fertilizer

Nutritional energy value is the main criterion for assessing the quality of fodder, determined by the feed units for milk and growth [19]. The production of biomass with high nutritional value and degree of digestibility implies its full absorption and assimilation by ruminants [1, 2, 4].

In the case of **meadow grass stand of *Chrysopogon gryllus* L. type**, the total energy value of the fodder after applied foliar biofertilizer varied from 17.95 MJ/kg (300 ml/da) to 18.17 MJ/kg (400 ml/da). The excess (by 0.7%) compared to the average value of the indicator (18.05 MJ/kg) is observed only in the variants with the maximum treatment dose. Biomass in the variants with doses of 200 ml/da and 400 ml/da is characterized by a slightly higher content of exchangeable and net energy compared to the untreated control and the average value of the indicators.

The predominance (compared to the control) in the number of feed units for milk and growth (FUM = 0.79 units in kg DM and FUG = 0.74 units in kg DM) registered the grass stand treated with a dose of 200 ml/da.

Table 3. Energy and feed nutritional value of natural meadow and pasture grass stand treated with biofertilizer (average for the period)

Variants	GE, MJ/kg	EE, MJ/kg	NE, MJ/kg	FUM	FUG
***Chrysopogon gryllus* L.**					
Control	18.15	8.42	4.70	0.78	0.73
100 ml/da	18.02	8.39	4.69	0.78	0.73
200 ml/da	17.96	8.46	4.74	0.79	0.74
300 ml/da	17.95	8.40	4.70	0.78	0.73
400 ml/da	18.17	8.46	4.73	0.79	0.73
Average	***18.05***	***8.43***	***4.71***	***0.79***	***0.73***
SD	***0.10***	***0.03***	***0.02***	***0.00***	***0.00***
***Nardus stricta* L.**					
Control	18.17	6.97	3.76	0.63	0.54
100 ml/da	18.19	6.97	3.76	0.63	0.54
200 ml/da	18.22	6.98	3.77	0.63	0.55
300 ml/da	18.38	7.03	3.79	0.63	0.55
400 ml/da	18.17	6.94	3.75	0.62	0.54
Average	***18.23***	***6.98***	***3.76***	***0.63***	***0.54***
SD	***0.09***	***0.03***	***0.02***	***0.00***	***0.00***

Source: Own calculation.

In **the pasture grass stand of *Nardus stricta* L**. type, the total energy in the dry matter of the fodder is higher (by 1.0%) compared to that in the meadow grass stands (18.05 MJ/kg). The values of the indicator vary from 18.17 to 18.38 MJ/kg, as the grass stands with imported dose of 100 ml/da (by 0.1%), 200 ml/da (by 0.3%) and 300 ml/da (by 1.2%) humate fertilizer had an excess compared to the untreated control. The amount of exchange and net energy in the variants fed with Biostim, at a dose of 200 and 300 ml/da exceeds the controls by 0.1-0.9% (for EE) and 0.3-0.8% (for NE), respectively. In both variants, the number of fodder units for growth in dry matter was 1.9% higher compared to the number of fodder units for growth in dry matter of untreated variants (0.54 units in kg DM).

Biofertilizers efficiency expressed by the amount of dry matter and crude protein when applying 1 kg of liquid humic fertilizer

On average for the period, the amount of dry matter and crude protein obtained from 1 kg of liquid foliar fertilizer Biostim, in meadow grass stand of *Chrysopogon gryllus* L. type are 502.75 kg and 58.03 kg, respectively (Table 4).

Table 4. Efficiency of biofertilizers for meadow grass stand of *Chrysopogon gryllus* L. type expressed by the amount of dry matter and crude protein with the application of 1 kg liquid biofertilizer

Variants	2011	2012	2013	Average for the period
Dry matter				
Control	-	-	-	-
100 ml/da	-155.40	1524.10	1057.60	808.80
200 ml/da	-270.80	1036.80	329.90	365.30
300 ml/da	-3.50	905.10	820.60	574.10
400 ml/da	-17.60	509.90	296.10	262.80
Average	***-111.83***	***993.98***	***626.05***	***502.75***
Crude protein				
Control		-	-	-
100 ml/da	11.11	149.77	77.78	79.55
200 ml/da	-15.90	96.78	19.45	33.44
300 ml/da	22.91	126.08	73.50	74.16
400 ml/da	48.69	65.86	20.37	44.97
Average	***16.70***	***109.62***	***47.78***	***58.03***

Source: Own calculation.

Table 5. Efficiency of biofertilizers for pasture grass stand of *Nardus stricta* L. type according the amount of dry matter and crude protein when imported 1 kg of liquid biofertilizer

Variants	2011	2012	2013	Average for the period
Dry matter				
Control	-	-	-	-
100 ml/da	-528.70	-401.10	2458.60	509.60
200 ml/da	-416.60	-156.00	599.80	9.10
300 ml/da	-294.50	-96.90	236.90	-51.50
400 ml/da	-104.40	-21.50	17.80	-36.00
Average	***-336.05***	***-168.88***	***828.28***	***107.80***
Crude protein				
Control		-	-	-
100 ml/da	-80.02	-8.49	174.87	28.79
200 ml/da	-42.42	-1.37	48.25	1.49
300 ml/da	-28.71	-1.65	21.57	-2.93
400 ml/da	-6.51	-1.00	20.66	4.38
Average	***-39.42***	***-3.13***	***66.34***	***7.93***

Source: Own calculation.

The fodder in the second experimental year (993.98 kg and 109.62 kg) had the highest values. Negative dry matter values in the first year are a result of the difference in dry matter

values in the treated and non-treated variants.

For the experimental period, the fodder mass of the lowest dose variants (100 ml/da) recorded the highest amount of dry matter (808.80 kg) and crude protein (79.55 kg) per unit of liquid fertilizer.

In ***Nardus stricta* L.** pasture grass stand, fertilizing with biofertilizers in the first and second experimental years was with low efficiency in terms of dry matter and crude protein, which correlated with the negative values obtained when 1 kg of liquid Biostim was introduced (Table 5).

Positive values in the third experimental year determine of 100 ml/da as the most effective treatment. The highest amount of dry matter and crude protein was registered in these variants. The values of the indicators per year and average for the period of the experiment are respectively 2,458.60 kg and 509.60 kg (dry matter) and 174.87 kg and 28.79 kg (crude protein).

Economic efficiency of biofertilizer Biostim for natural grass stands

Quantitative assessment of economic indicators is a key criterion for the effect of applied organic fertilizing [11]. The comparison of invested and received funds are the main economic indicators of economic significance of the factors for intensification of production.

In assessing the effectiveness of fertilizing in natural meadow and pasture grass stands, the costs incurred, revenues, profits and profitability are essential (Table 6). There is no difference in the total costs (7.87 BGN/da) regarding the application of foliar fertilizing in pasture and meadow grass stands. The total revenue, the total profit, the profitability and the critical level of the yield from the conducted agrotechnical measure in the meadow grass stands are higher by 19.9%, 25.4%, 27.7% and 92.1% respectively compared to those of the pastures, but at lower cost price.

In the case of meadow **grass stands**, the variants treated with the highest dose (400 ml/da) of foliar fertilizer have the highest values of total revenues (43.61 BGN/da) and total costs (9.84 BGN/da). With the highest total profit (43.15 BGN/da), profitability (628.72%) and critical yield level (89.49 kg/da) are the variants fertilized with a dose of 300 ml/da. There is no difference in the costs of biofertilizers in the variants with meadow grass stands.

Table 6. Economic efficiency of biofertilizers for natural meadow and pasture grass stands (average for the period)

Variants	Total expenditures BGN/da	Total revenues BGN/da	Total profit BGN/da	Cost price BGN/da	Profitability %	Critical level of yield kg/da
***Chrysopogon gryllus* L.**						
Control	5.35	34.88	29.52	0.02	551.44	53.54
100 ml/da	7.16	43.48	36.32	0.02	507.55	70.93
200 ml/da	8.05	42.18	34.13	0.02	423.81	80.53
300 ml/da	8.95	52.1	43.15	0.02	628.72	89.49
400 ml/da	9.84	45.39	35.54	0.02	361.03	83.48
Average	***7.87***	***43.61***	***35.73***	***0.02***	***494.51***	***75.59***
***Nardus stricta* L.**						
Control	5.35	35.45	30.09	0.03	562.10	26.77
100 ml/da	7.16	45.64	38.48	0.04	537.69	35.78
200 ml/da	8.05	35.81	27.76	0.05	344.68	40.26
300 ml/da	8.95	32.36	23.41	0.06	261.58	44.74
400 ml/da	9.84	32.57	22.72	0.06	230.79	49.22
Average	***7.87***	***36.37***	***28.49***	***0.05***	***387.37***	***39.35***

*Critical level of yield (C) – this is the yield, where there is no profit, neither loss. C = (Y*R)/P; Y – yield (kg/da); R – expenditures (BGN/da); P – revenues (BGN/da)

Source: Own calculation.

In the case of **pasture grass stands**, the total income and the profit after the applied foliar fertilizing are the highest in the variants treated with a dose of 100 ml/da. The values exceed the average by 25.5% and 35.1%, respectively. At all rates of treatment in the pasture grass stands, the profitability of the leaf spray is lower than the control. The critical yield shows at what values the revenues are equal to costs and no profit is formed. The excess in the average values of the indicator are by 2.3% (200ml/da), 13.7% (300 ml/da) and 25.1% (400 ml/da), respectively.

Foliar fertilizing with humate fertilizer Biostim (dose - 400 ml/da) increases the content of crude protein in the dry matter of meadow and pasture grass stands by 34.2% and 31.3%, respectively.

The highest energy and feed nutritional value is the feed mass of the variants treated with 400 ml/da dose (for *Chrusopogon gryllus* L.) and 200 and 300 ml/da (for *Nardus stricta* L.). The amount of gross energy in meadow grass stands is 1.0% lower than in pastures.

The efficiency of the applied biofertilizers is most pronounced in the variants with 100 ml/da dose, where the amount of dry matter and crude protein reaches 808.80 kg and 79.55 kg - for meadow and 509.60 kg and 28.79 kg - for pasture grass stands.

CONCLUSIONS

Foliar fertilizing with humate fertilizer Biostim (dose - 400 ml/da) increases the content of crude protein in the dry matter of meadow and pasture grass stands by 34.2% and 31.3%, respectively.

The highest energy and feed nutritional value is the feed mass of the variants treated with 400 ml/da dose (for *Chrusopogon gryllus* L.) and 200 and 300 ml/da (for *Nardus stricta* L.). The amount of gross energy in meadow grass stands is 1.0% lower than in pastures.

The efficiency of the applied biofertilizers is most pronounced in the variants with 100 ml/da dose, where the amount of dry matter and crude protein reaches 808.80 kg and 79.55 kg - for meadow and 509.60 kg and 28.79 kg - for pasture grass stands.

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