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INFLUENCE OF SOME BIO-PRODUCTS ON THE BIOLOGICAL AND PRODUCTIVE CHARACTERISTICS OF BIRD'S FOOT TREFOIL GROWN FOR FORAGE

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Abstract: During the 2010-2012 period the influence of some bio-products being mainly a combination of macro and micronutrients at different concentrations on the productivity, botanical and morphological composition of bird's foot trefoil swards was studied. The experiment was carried out on the experimental field of the IMSA – Troyan by the completely randomized method with 4 replications and harvest plot size of 5 m^2. Four bio-products phosphorus humate in dose of 3000 l/ha, boron humate (1600 l/ha) and molybdenum humate (1600 l/ha) and their combination phosphorus humate (2500 l/ha) + boron humate (1000 l/ha) + molybdenum humate (1000 l/ha) were studied. They were applied at the 2-4 leaf. The results showed that solely phosphorus humate had a positive influence, which increased the dry matter yield only by 8.7% and the results were not statistically significant.. It was found that the data had a unidirectional character with regard to the leafiness degree during the years as a result of the applied bio-fertilizers. Their application had a positive effect on the leafiness. The phosphorus humate showed a tendency to increase the relative portion of stems in the sward from the first to the third year. The kind of the applied bio-fertilizers was not of substantial importance to the degree of stem growth and botanical composition of the sward.

Key words: bird's foot trefoil, bio-products, productivity, botanical and morphological composition.

Introduction

During recent years more and more attention has been paid to the search of alternative, ecologically friendly solutions for maintenance of the nutrient regime, which should correspond to the contemporary farming *(Kephart et al.,*

1995; Goranova, 2007; Liebman and Davis, 2009) One of the prerequisites for obtaining of high-productive and good-quality forage from bird's foot trefoil is to provide a suitable nutrient environment with optimal conditions for plant development *(Churkova and Lingorski, 2010).* Lately more and more attention has been paid to fertilizing by application of bio-products *(Kephart et al., 1995)*, which contain small quantities of nutrients. The bio-fertilizers are a solution in conformity with nature which can improve nutrient regime of plants and increase their productivity*(Vanotti et al., 1997)*. The series of Organic mineral fertilizers has been made with different proportions of nutrients according to the specific requirements of the agricultural crops by developmental stages. The micronutrients are in a chelated form for maximum availability.

The obtaining of a positive effect on the formation of forage yield conditions the necessity for a continuous influx of nutrients *(Nikolova, 2009)*. When expecting a higher yield the recommendation is for a starting foliar fertilizing at the stage of early vegetation with Nitrohumate at the dose of 3000 ml/ha and a supplementary fertilizing – after each cut with Nitrohumate and Phosphorus humate *(www.agrobiostim.com)* at the dose of 3000-3500 ml/ha with an working solution of 300-400 liters per hectare, aiming at fast growth of the plants and increase of the yield from the next cuts. In case of symptoms of potassium deficiency it is recommended to treat with potassium humate at the dose of 3000 ml/ha. The supplementary fertilizing with bio-fertilizers containing the main nutrients at the suitable ratio resulted in: an increase of the green mass yields of more than 80-100%, improvement of the produce quality and neutralization of the influence of herbicide residues in soil *(Watson et al., 2002)*.

For normal functioning of the root nodules and when growing bird's foot trefoil on grey forest soils it is necessary to treat the stands with a natural microfertilizer, such as boron and molybdenum humate.

The supplementary fertilizing of stands with the organic fertilizers supplies the plants with all necessary macro and micronutrients, because the bio-fertilizers have high content of zinc and manganese and readily available forms of boron and molybdenum.

In many countries these bio-preparations are at a stage of profound research. In Bulgaria the studies on their application to the forage crops are not sufficient.

The objective of this study was to investigate the influence of foliar treatment with different bio-fertilizers applied alone and combined on the growth and development, productivity, botanical and morphological composition of bird's foot trefoil swards.

Material and methods

The trial was carried out during the 2010-2012 period in the experimental field of IMSA - Troyan by completely randomized method with 4 replications and harvest plot size of 5 m^2 with bird's foot trefoil variety Targovishte 1. The following bio-fertilizers were tested: Phosphorus humate, Boron humate and Molybdenum humate. All preparations are products of the manufacturer company Agro Bio Stim – Bulgaria. The biofertilizer application was conducted with an working solution of 3000 liters per hectare at the 2-4 leaf stage of bird's foot trefoil in the first year and at the beginning of vegetation in every next year. The following variants were studied: control – zero, phosphorus humate (3000 l/ha), boron humate (1600 l/ha) and molybdenum humate (1600 l/ha) and phosphorus humate (2500 l/ha) + boron humate (1000 l/ha) + molybdenum humate (1000 l/ha). The treatment with the mentioned doses was in conformity with the quantities according to the recommendations of the manufacturer company. A generally adopted technology for growing of bird's foot trefoil for forage was applied. The sward sowing was conducted by hand, broadcast, at the sowing rate of 0.12 tha^{-1}.

The phosphorus humate is a combination of nitrogen, phosphorus and potassium in the composition of 4-12-4%, magnesium - 0.5% and the micronutrients: calcium, boron, iron, manganese, cobalt, zinc and molybdenum, as well as the organic substances: humic acids and fulvic acids. The boron humate composition is the following: total nitrogen - 6%, boron - 5%, organic carbon - 0.4% and the organic substances: humic acids, fulvic acids, amino acids: valine, glutamine, methionine, lysine, antibiotics, vitamins, micronutrients – chelated iron. The molybdenum humate composition includes as follows: natural stimulants + nitrogen – 6%, molybdenum – 9%, organic carbon – 0.4%, humic acids, fulvic acids, amino acids: valine, glutamine, methionine, lysine, antibiotics, vitamins.

The following characteristics were recorded: dry matter yield (tha^{-1}) determined by cuts and years by drying of average samples to constant weight at 105 C^0. botanical composition of the sward determined just before harvesting of the first cut in a weight percentage (%) through taking of average samples from each replication; morphological composition – determined by weighing an average sample of stems, leaves and generative organs from each variant and each replication; plant height (cm) – measured at the stage of budding-early flowering of 40 plants from each variant taken from each replication. We conducted the sward harvesting at the stage of budding-early flowering.

Mathematical processing of the primary data on the studied characteristics was performed according to *Lidanski* (*1988*).

Results and discussion

The fertilizing effect is connected to a great extent with the climatic conditions. The year 2010 was considered favourable with regard to the rainfalls, when these were distributed evenly in the months of the growing season. The average daily air temperature of 10.8 C^0 and rainfall quantity of 112.6 l/m^2 in April had a favourable effect on the normal emergence of bird's foot trefoil. The 2-4 leaf phenological stage occurred normally in mid-April, and the budding in mid-June. That contributed to formation of a comparatively good first cut, being harvested in late June, when the stage of budding-early flowering occurred. The high soil moisture due to the rainfall quantity of the range of 76.7 and 132.7 l/m^2 ensured fast growth and development of bird's foot trefoil after its mowing and formation of a second cut of 33-day duration.

In the second year there was a considerably smaller quantity of rainfalls in the months of March (41.7 l/m^2); April (68.0 l/m^2) and May (69.1 l/m^2) in comparison with the months of June (98.4 l/m^2), July (72.9 l/m^2) and August (96.8 l/m^2). That did not influence the sward productivity, and as a result, high productivity of the sward was recorded in all variants after the biofertilizer application.

The agro-meteorological characteristics of the third year differed very much from the other two years. The uneven rainfall distribution by months was very pronounced, characterized by a good water supply in May (174.1 l/m^2) and a lack of rainfall in July. The drought affected the later summer months, when the second cut had been already harvested. The good supply of soil in the first months of the growing season contributed to obtaining of a good and stable yield from the first cut, which in combination with the high drought resistance of bird's foot trefoil, necessary for formation of a second cut, ensured a good yield for the year.

In the first year, the individual treatment of bird's foot trefoil with Phosphorus humate and Molybdenum humate showed a higher dry matter yield (Table 1) than that of the control. At doses of Phosphorus humate of 3000 ml/ha and Molybdenum humate of 1600 ml/ha the exceeding at the sward harvesting was by 8.0 and 3.8%. The bird's foot trefoil treatment with boron humate and the combination of the three bio-products decreased the fertilizing effect and the yields obtained for these treatments were lower than the control

Table 1. Dry mass yield (tha^{-1}) by years and on average for the period

Variants	2010		2011		2012		On average for the period	
	tha^{-1}	%	tha^{-1}	%	tha^{-1}	%	t.ha^{-1}	%
Control - untreated	38.9 -	100.0	116.8	100.0	82.1-	100.0	79.3	100.0
Phosphorus humate	42.0-	108.0	123.9-	106.0	92.5-	112.7	86.1-	108.7
Boron humate	32.6-	83.8	106.9-	91.5	79.2-	96.5	72.9-	92.0
Molybdenum humate	40.4-	103.8	112.1-	96.0	73.4-	89.4	75.3-	95.0
Phosphorus humate + Boron humate + Molybdenum humate	38.3-	98.3	116.2-	99.4	77.3-	94.1	72.2-	97.4
GD 5%	16.9	43.5	18.9	16.25	15.5	19.0	16.0	20.3
GD1%	23.7	61.0	26.6	22.8	21.8	26.6	22.5	28.4
GD 0,1%	33.5	86.1	37.6	32.2	30.8	37.6	31.8	40.1

In the second year, the highest dry matter yield was recorded for bird's foot trefoil treated with Phosphorus humate (123.9 tha^{-1}), what exceeded over the control 6.0%. All other doses and kinds of bio-fertilizers showed negative effect on the bird's foot trefoil productivity. The lowest effect on the productivity was recorded for the treatment with Molybdenum humate (106.9 tha^{-1}), which was 8.5% lower than the control.

In the last year, the highest dry matter yield of 92.6 tha^{-1} was recorded for the treatment with Phosphorus humate what was 12.7% over the control. The high productivity in this variant was due to the role of the organic mineral fertilizer Phosphorus humate to increase the plant resistance to low temperatures and drought, which confirmed the characteristics of this bio-fertilizer provided by the its producer. When treating bird's foot trefoil with boron and molybdenum humate and the combination of the three bio-fertilizers, the effect was reduction of the yield, but it was not statistically significant. The variant treated with Molybdenum humate had the lowest productivity and as a result the dry mass yield was 73.4 tha^{-1}, which was 10.6% lower than the control and as a result of this was determined statistical significant difference between phosphorous humate and Molybdenum humate, at level 005.

When examining the bird's foot trefoil treatment with the different bio-fertilizers and the applied combination during the three years, it is noticeable that Phosphorus humate alsvaus gave positive effects on yield. That was due to stimulation of the growth and development of the root system because of the easy assimilability of the bio-product.

On average for the period of study the productivity for the treatment with Phosphorus humate alone at the dose of 3000 ml/ha was the most efficient, and as a result the productivity exceeded the control by 8.7%. There was not determined significant difference between the treatment and control. The productivity in all other variants was lower, which was of importance to differentiated use of the bio-

preparations and their careful application as a stage of the bird's foot trefoil technology.

In the first year, an average value of leafiness of X=44.6% was recorded (Table 2), the maximum being in the sward treated with Boron humate – 46.3 %. In the second year, the combination of Phosphorus humate + Boron humate + Molybdenum humate proved to be the most efficient with regard to this character. In 2012 the plants treated with Phosphorus humate had a leafiness percentage of 45.1%, at an average value of X=42.9%. During all years a low degree of variability for this character was recorded. The kind of the bio-products applied, had no influence on the stem quantity in the first year. In all variants they were more than those in the control variant, but in the treated variants they were 39.3 to 43.6%.

Table 2. Morphological analysis (%) by years for first cut

Variants	Leaves			Stems			Generative organs		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Control - untreated	43.2	39.4	41.7	29.1	49.4	45.6	27.7	11.2	12.7
Phosphorus humate	43.6	38.0	45.1	43.6	54.0	50.5	12.7	8.1	4.4
Boron humate	46.3	43.7	41.2	42.3	48.7	47.1	11.3	7.6	11.6
Molybdenum humate	46.4	40.3	36.7	39.3	52.8	45.7	14.3	6.8	7.6
Phosphorus humate + Boron humate + Molybdenum humate	43.6	44.0	39.8	41.3	49.2	48.7	15.2	6.8	11.5
X	44.6	41.1	42.9	39.1	50.8	47.5	16.2	8.1	9.6
SD	1.6	2.7	2.9	5.8	2.4	2.1	6.6	1.8	3.5
VC	3.4	6.5	6.7	14.9	4.7	4.4	40.5	22.5	36.3
Min	43.2	38.0	39.8	29.1	48.7	45.6	11.3	6.8	4.4
Max	46.4	44.0	46.7	43.6	54.0	50.5	27.7	11.2	12.7

The stem quantity in the second year considerably exceeded their quantity in the first year. During the three years they were in the maximum quantity in the sward treated with Phosphorus humate (43.6; 54.0; 50.5%). In the first year the variation coefficient was the highest CV=14.9, and the degree of variability was medium. According to the variation coefficients in the second and third year (CV=4.7 and 4.4%), the degree of variability for this character was very low. The generative organs during the three years were in the maximum quantity in the control variant - 27.7; 11.2 and 12.7%, and the degree of variability was very high.

In the first year of the experimental period, the highest values of the stem height (Table 3) were found for the plants treated with Phosphorus humate - 31.7 cm. The average value of stem height was 29.7 cm. In the second year, the bird's foot trefoil stems were considerably taller than those in the first year for the

variants treated with all kinds of bio-products, those treated with Molybdenum humate having a value of 49.8 cm. In the third year, the heights had values almost similar to those in the second year. They varied from 43.3 to 45.4 cm, at an average value of 44.4 cm. On average for the period of study, all treated variants showed higher growth, as compared to the control. The kind of the applied bio-fertilizers was not of substantial importance to the degree of stem growth. That was evident from the difference in the values between the treated variants, being 40.0 to 41.7 cm. The degree of variability of the height character, according to the variation coefficient, was very low by years, as well as on average for the period – VC=7.0; 6.8; 2.0 and 4.5%.

Table 3. Stem height (cm) by years and on average for the period

Variants	2010	2011	2012	On average for the period
Control - untreated	26.1	41.2	43.3	36.9
Phosphorus humate	31.7	46.8	43.8	40.8
Boron humate	30.1	45.4	45.4	40.3
Molybdenum humate	30.4	49.8	44.9	41.7
Phosphorus humate + Boron humate + Molybdenum humate	30.2	44.8	45.0	40.0
X	29.7	45.6	44.5	39.9
SD	2.1	3.1	0.9	1.8
VC	7.0	6.8	2.0	4.5
Min	26.2	41.2	43.3	36.9
Max	31.7	49.8	45.4	41.7

The effect of fertilizing with bio-fertilizers was exceptionally favourable on bird's foot trefoil at all doses and kinds with regard to the botanical composition of the sward (Table 4). The bird's foot trefoil participation in all variants exceeded that of the control. In first cut the highest portion of bird's foot trefoil was recorded when applying boron humate (95.8%). Among the treated variants, the degree of weed infestation was the highest for the bird's foot trefoil treatment with Molybdenum humate (16.3%).

In the second year, the fertilizing with bio-fertilizers proved to be very efficient with regard to the bird's foot trefoil participation. Bio-fertilizers had no positive influence on the botanical composition of the sward. In this year a positive tendency was retained towards a decreased degree of weed infestation after the application of all bio-fertilizers. That was connected to a great extent with the bird's foot trefoil biology and its maximum rate of growth and development in the second year of the experimental period. The difference between the variants in the weed infestation degree was insignificant being by variants: 0.3%; 0.4%; 0.3% and 1.3%, respectively.

Table 4. Botanical composition of the sward by years for first cut (%)

Variants	2010		2011		2012	
	Bird's foot trefoil	Weeds	Bird's foot trefoil	Weeds	Bird's foot trefoil	Weeds
Control - untreated	80.0	20.0	98.9	1.1	84.5	15.5
Phosphorus humate	93.3	6.7	99.7	0.3	88.7	11.3
Boron humate	95.8	4.2	99.6	0.4	80.9	19.1
Molybdenum humate	83.7	16.3	99.7	0.3	89.8	10.2
Phosphorus humate + Boron humate + Molybdenum humate	90.4	9.6	98.7	1.3	82.4	17.6

In the third year of the experimental period in first cut, the highest relative portion of bird's foot trefoil in the sward was found for its treatment with molybdenum humate, and as a result its participation was 89.2%. The sward treated with Phosphorus humate also had a low degree of weed infestation– 11.3% and a comparatively high presence of bird's foot trefoil, 88.7%.

Conclusion

Among the studied bio-products, the organic mineral fertilizer phosphorus humate had the strongest effect and when applying it to a pure sward in the first year at the 2-4 leaf stage, and in the next years at the beginning of vegetation it increased the dry matter yield and could be applied as an additional element of the technology for bird's foot trefoil. As a result of the applied bio-product at the dose of 3000 ml/da on average for the period of study the productivity exceeded the control by 8.7%, but there was not determined statistical significant difference.

It was found that the data had a unidirectional character with regard to the degree of leafiness during the years as a result of the applied bio-fertilizers. The phosphorus humate showed a tendency to increase the relative portion of the stems in the sward from the first to the third year.

The kind of the applied bio-fertilizers was not of substantial importance to the degree of stem growth and botanical composition of the sward.

Uticaj nekih bio-proizvoda na biološke i proizvodne osobine žutog zvezdana kao krmnog bilja

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Rezime

U periodu 2010-2012 ispitivan je uticaj nekih bio-proizvoda, uglavnom kombinacija mikro i makro elemenatau različitim koncentracijama na produktivnost, botanički i morfoloških sastav žutog zvezdana.Eksperiment je izveden na oglednom polju IMSA – Troyan, sa 4 ponavljanja i parcelama veličine 5 m^2.

Ispitivana su četiri bio-proizvoda fosfor humat u dozi od 3000 l/ha, bor humat (1600 l/ha) i molibden humat (1600 l ha) i njihova kombinacija fosfor humat (2500 l/ha) + bor humat (1000 l/ha) + molibden humat (1000 l/ha). Rezultati su pokazali da samo fosfor humat imapozitivan uticaj, što je povećalo prinos suve materije za samo 8,7%, a rezultati nisu bili statistički značajni.

Utvrđeno je da su podaci imala jednosmerna karakter u odnosu na stepena olistalosti tokom godina, kao rezultat primenjenih bio-đubriva. Njihova primena je imala pozitivan efekat na olistalost.Fosfor humat je pokazao tendenciju da poveća relativni deo stabljike u busenu od prve do treće godine.

Vrsta primenjenih bio-đubriva nije od suštinskog značaja za stepen raststabljike i botanički sastav.

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