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Research Article

Productivity and level of weed infestation of legume meadow grasses depending on grass species and fertilization

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Abstract: The experiment was conducted in the period of 2013-2015 in the experimental field of RIMSA-Troyan. The influence of bio-fertilizers, such as boron humate and molybdenum humate at doses of 1600 ml/ha, was studied. They were applied in the beginning of bud-formation period on legumes, such as bird's-foot-trefoil, sainfoin, and red clover. The highest positive effect of studied bio-fertilizers over productivity was found in the treatment of grassland of sainfoin. Its yield increased, after the application of boron humate, in comparison with the control by 8.3%, and molybdenum humate increased the productivity of red clover by 4.0%. Both bio-fertilizers showed a negative effect in relation to dry matter yield of bird's-foot trefoil. Foliar treatment with boron and molybdenum humate of bird's-foot-trefoil, red clover and sainfoin decreased the level of weed infestation of crops and had an influence over the biological characteristics of grass species and meteorological conditions. As a result of the influence of bio-fertilizers, the stem height of sainfoin and red clover increased, which had a favorable influence over productivity of their grasslands.

Keywords: bio-fertilizers; bird's-foot trefoil; legumes; level of weed infestation; productivity

Introduction

The high yields of legumes of high forage quality depend on cultivar composition of grasses, environmental conditions, application of chemicals and mechanization in their cultivation (Vasileva, 2011). Bio-fertilizers are recently more often applied in order to influence the productive indicators of forage grasses.

Bird's-foot trefoil (Chourkova, 2013), red clover (Naydenova, 2013; Drobná, 2009) and sainfoin (Kyuchukova and Radeva, 2002) are main representatives of natural (Iliev, 2014) and artificial grasslands (Vasileva and Vasilev, 2012), which are responsible for forage quality. As an alternative of chemization in agriculture, the application of organic products, used as nutrition for plants, is being recently introduced.

Their introduction in the practice is an important agro-technical measure and is characterized as an alternative to the chemical fertilizers. (Wu *et al.,* 2004). That kind of treatment does not have a risk of contamination for the environment and at the same time ensures optimal agro-ecological conditions, which improve soil fertility and increase the standard yields of species (Drevon and Hardwig, 1997; Vlahova and Popov, 2014). According to some authors (Vasilev and Kertikov, 2006; Tang *et al.,* 2001) the introduced preparations, which contain humic acids, participate directly in the formation and functioning of tubers of legumes.

Humic fertilizers contain a complex of macro and micro elements with an optimal balance among them, which have good solubility and saturation capacity (Valchev and Nikolova, 1996). Foliar fertilization has an additional and correcting character as a component from the whole system of mineral nutrition (Kerin and Berova, 2003). When bio-fertilizers are properly selected for the respective legume species and included in the cultivation technology of forage grasses, they increase the yields and quality of production in case when classical methods and means are less effective (Sevov, 2011). Their application leads to environmentally friendly forages, at a low cost of labour, energy and material. The new bio-fertilizers and treatment on a specific grass species impose to update and deepen these studies.

The aim of present research was to study the productivity and the level of weed infestation of some legume grasses depending on grass species and treatment with foliar bio-fertilizers.

Material and Methods

During the period 2013-2015 in the experimental field of RIMSA-Troyan was conducted a field experiment with the following legume grasses: bird's-foot-trefoil, sainfoin and red clover, treated by bio-fertilizers and molybdenum humate, at a dose of 1600 ml/ha. The experiment was set according to block method in 4 replications, with a size of the experimental plot of 5m2.

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The treatment was conducted annually by foliar nutrition in the beginning of bud-formation period of legumes with the above-mentioned doses in a compliance with the quantities recommended by the manufacturer (AgroBioStim). Deep ploughing of the area was conducted in the autumn. Before sowing disking and rotary tillage were applied till the soil was brought into a garden state. Sowing was manual, in a disperse manner with a sowing rate of 0.012 t.ha. The experimental area was rolled before and after sowing. The composition of boron humate is as follows: total nitrogen – 6%, boron – 5%, organic carbon – 0.4% and the following organic substances: humic acids, fulvic acids, amino acids: valine, glutamine, methionine, lysine, antibiotics, vitamins, and microelements – chelated iron. The composition of molybdenum humate involves natural stimulators + nitrogen – 6%, molybdenum – 9 %, organic carbon – 0.4%, humic acids, fulvic acids, amino acids: valine, glutamine, methionine, lysine, antibiotics, and vitamins.

Two cuttings were performed during the years, and the grassland was harvested in the beginning of flowering of legumes. The indicators of dry matter yield (kg/da) and level of weed infestation of grassland ware studied in weight percentage %. Dry matter yield was determined by cutting of each plot, by replications, followed by drying of plant samples in laboratory conditions at 105°C from 200 g till constant weight was reached, as it was pre-calculated for 1 da on the basis of dry matter obtained. The height of grassland (cm) was determined regarding different mowing during harvesting of grassland, as the stem height of 40 plants was measured, taken from all variants and replications of sown grass species.

The level of weed infestation, expressed by the botanical composition of grassland was determined by its weight percentage through an analysis of fresh mean grass samples, taken during mowing of each variant and each replication, as the percentage share of sown grass species and weeds was determined individually (totally). Dry matter yield results were processed with the method of analysis of variance (Lidanski, 1988).

Results and Discussions

Vegetation precipitation and air and soil temperature have a significant role for the growth and development of legume forage grasses. Precipitation in the year of sowing in April (92.1 l/m^2) and May (90.3 l/m^2) was sufficient for the normal germination and development of sown legume grasses. Vegetation precipitation amount for 2014 was by 115.4 l/m^2 more than in 2013, and with 148.6 l/m^2 more than 2015. The precipitation increase in the second year of the experimental period had a positive influence over the value of forage grass yields. The average air temperature for the vegetation period in 2013 and 2014 varied within small ranges (16.0 and 16.5^{0}C). The values of air temperature were slightly lower in 2014 (15.3^{0}C), in comparison with the other two years of study period. During the first year of study period (Table 1), boron humate manifested itself as more effective only for red clover, whose yield was higher than the control by 14.9%. Molybdenum humate had almost a similar effect in the treatment of grassland of bird's-foot-trefoil and red clover, as the excess in comparison with control was respectively 9.9 and 8.2%.

Table 1: Dry matter yield in different years and average for the period, t.ha^{-1}

Variants	2013		2014		2015		Mean for the period	
	t.ha^{-1}	%	t.ha^{-1}	%	t.ha^{-1}	%	t.ha^{-1}	%
bird's-foot trefoil	4.6	100.00	14.3	100.00	892.6	100.00	928.7	100,00
red clover	4.0	100.0-	16.4	100.0-	1009.1	100.0	1018.7	100.0
sainfoin	5.2	100.0-	12.3	100.0 -	4.6	100.0	750.0	100.0
bird's-foot trefoil + boron humate	3.8	82.7-	11.8	82.9	9.4	106.3-	8.3	90.3-
red clover + boron humate	4.6	114.9-	14.3	87.7	9.8	94.1-	9.6	94.6-
sainfoin + boron humate	4.9	94.2-	13.7	111.4	5.6	121.7++	8.1	108.3-
bird's-foot trefoil +molybdenum humate	5.1	109.9-	12.6	88.8	9.8	110.8-	9.2	99.5-
red clover + molybdenum humate	4.3	108.2-	16.5	101.1	10.8	107.4+	10.6	104.0-
sainfoin +molybdenum humate	470.2	90.0-	11.7	94.8	5.1	111.4	7.2	96.2-

In the second year (2014) the effect of the applied fertilizers was best expressed in sainfoin, which was treated by boron humate, as it realized dry matter yield that exceeded the control by 11.4% The lower temperatures and high atmospheric humidity can be pointed as a reason for the relatively higher effect of applied bio-fertilizers in legumes, occurring for an extended period after the treatment, as well as the specific biological characteristics of different species of legume forage grasses. There was an insignificant difference in grassland productivity of bird's-foot-trefoil and red clover, treated by boron and molybdenum humate, as dry matter yield was lower than untreated control, respectively by 12.3% and 11.2%. The introduced molybdenum humate in case of red clover led to a symbolic positive impact over the yield, which respectively was 1.1% and the yield was not statistically proven.

The best expressed positive impact of bio products over the productivity of sainfoin was determined

in the third year of the experimental period. After treatment with boron humate, its productivity exceeded the control by 21.7%, and after molybdenum humate by 11.4%. In case of bird's-foot trefoil after the application of boron humate, dry matter excess was 6.3%, and after molybdenum humate-10.8%. The increase of yields for these two cultures could be attributed to the occurring biological and morphological changes in plants. Thus the introduction of products with high content of humic acids and microelements stimulates the root system of plants, the coefficient of using of nutrients increases, which participate directly in the formation and functioning of tubers in legumes (Tang *et al.,* 2001). Boron humate had a negative influence over dry matter yield of red clover, and molybdenum humate increased it by 7.4%.

Average for the study period, boron humate showed insignificantly higher productivity of sainfoin, and molybdenum humate for red clover, as a result dry matter yield exceeded the control, respectively by 8.33 and 4.0%. The effect of application of bio products was more pronounced for sainfoin and red clover, which some authors (Vasileva and Kertikov, 2004) explained by the more effective nutrient utilization of plants. This in turn promotes the formation of a large amount of over ground biomass (Sreenivas *et al.,* 2000). The treatment of grassland of bird's-foot-trefoil with bio-fertilizers appeared irrational, which was obvious by the lower dry matter yield.

Dispersion analysis of yield data (Table 2) allows for a full successful assessment of the tested organic products. The difference in yields for the first two years and average for the period was not proven (Table 1). Only in the third year of the experiment, the difference was very well mathematically proven in sainfoin yields, treated by boron humate, and it was well proven for red clover, treated by molybdenum humate (Table 1). The results give reason to conclude that boron humate had a positive influence over the productive performances of sainfoin. The combination of boron with humates creates conditions for accumulation of larger amount of vegetation, and increases growth and development of plants, which confirms the opinion of Kyuchukova and Radeva (2002) that boron is a necessary element for legumes. Average for the period of study, the difference between yields of sainfoin and red clover, treated respectively by boron and molybdenum humate was well proven as negative. These results showed that legume grass species responded differently depending on the type of the bio product and meteorological conditions of the year. For bird's-foot trefoil and red clover, despite unproven differences in yields, the application of molybdenum humate was greater, and for sainfoin - of boron humate. In terms of climate characteristics, especially during the years of the experiment, the highest yields were obtained from all variants in 2014, which was characterized by high soil and relative air humidity.

Table 2: Disperse analysis of dry matter yield

t.ha^{-1}	Compared to var.1				Compared to 2				Compared to 3			
	2013	2014	2015	Average for the period	2013	2014	2015	Average for the period	2013	2014	2015	Average for the period
GD 5%	2.5	3.6	1.2	2.2	1.2	5.2	0.6	21.3	2.5	5.0	0.6	1.9
GD 1%	3.8	5.5	1.8	3.4	1.9	8.0	10.4	3.2	3.7	7.7	0.9	3.0
GD 0.1%	6.1	8.9	3.0	5.5	3.1	12.8	16.8	5.2	6.0	12.3	1.5	4.8
%	Compared to var.1				Compared to var. 2				Compared to var. 3			
	2013	2014	2015	Average for the period	2013	2014	2015	Average for the period	2013	2014	2015	Average for the period
GD 5%	53.8	25.8	14.0	24.5	31.6	32.2	6.85	21.0	47.9	40.2	13.6	26.6
GD 1%	81.5	39.0	21.2	37.1	47.9	48.8	10.37	31.8	72.5	60.9	20.6	40.3
GD 0.1%	130.9	62.7	34.1	59.5	76.9	78.4	16.7	51.1	116.5	97.8	33.0	64.8

In the first experimental year, the treatment with both bio-fertilizers showed a significant effect over the percentage share of sown grass species in grassland (Table 3). Molybdenum humate for red clover and sainfoin provided nearly 100 percentage share in the grassland. Red clover presented with 99.5% in the grassland (variant 8), and sainfoin with 99.0% (variant 9). The highest level of weed infestation was found for bird's-foot trefoil, whether the variants were treated or not by foliar fertilizer. The level of weed infestation was respectively 16.1% (variant 4) for the non-treated control and 10.7 (variant 4) and 15.7%% (variant 7) for the treated variants.

In the second year, legumes preserved a high presence in the grassland with a low level of weed infestation. A high relative share of three species of legume grasses was reported in crops. The effect of boron humate was best expressed in red clover, which participated with 97.4%, with 89.7% in the grassland for the non-treated variant. The effect of molybdenum humate was better manifested in bird's-foot trefoil, and boron humate for red clover, which was obvious by the presented level of weed infestation, respectively 2.3% (var. 7) and 2.6% (var. 5). There were not significant differences regarding share participation of legumes in grassland as a result of application of both bio products. Bird's-foot trefoil presented in the grassland, which was treated by molybdenum

humate with 97.7% (var. 7), and red clover with boron humate with 97.4% (var.5) and was almost similar. There was the slightest effect of boron and molybdenum humate in sainfoin, whose share participation was high, both for the control 95.5% (var. 6) and 96.7% (var.9).

Table 3: Level of weed infestation of grassland (%) of bird's-foot-trefoil, red clover and sainfoin, after treatment with boron and molybdenum humate in different years.

Variants	2013		2014		2015	
	Grass species	Weeds	Grass species	Weeds	Grass species	Weeds
bird's-foot trefoil	83.9	16.1	90.9	9.1	94.1	5.9
red clover	92.6	7.4	89.7	10.3	85.4	14.6
sainfoin	92.2	7.8	95.8	4.2	62.5	37.5
bird's-foot trefoil + boron humate	89.3	10.7	92.7	7.3	92.0	8.0
red clover + boron humate	97.6	2.4	97.4	2.6	96.3	3.7
sainfoin + boron humate	93.4	6.6	95.5	4.5	76.9	23.1
bird's-foot trefoil + molybdenum humate	84.3	15.7	97.7	2.3	94.7	5.3
red clover + molybdenum humate	99.5	0.5	89.3	10.7	87.0	13.0
sainfoin + molybdenum humate	99.0	1.0	96.7	3.3	69.2	30.8

In the third year, the lowest level of weed infestation was reported for the red clover, which was treated by boron humate – 3.7% (var. 5), as the highest level was for sainfoin, treated by both bio-fertilizers (23.1% and 30.8%). Bird's-foot-trefoil preserved a comparatively high relative share, respectively 92.0% (var. 4) and 94.7% (var.7), according to its growth and development, which underlined the stimulating effect of bio-fertilizer treatment. Compared with red clover and bird's-foot trefoil the presence of sainfoin in the grassland was significantly less. Its percentage share in case of treatment with boron humate provided a higher and relative share in the grassland, respectively 76.9%, compared to 69.2% after treatment with boron humate.

Both bio-fertilizers showed a different effect in relation to growth rate of plants of legume grasses during years of study (Table 4). In the first year of study period, both boron and molybdenum humate had a stronger influence over the growth of sainfoin, and boron humate showed a highly pronounced influence for red clover in relation to stem height. Both bio-fertilizers increased values of growth for bird's-foot trefoil, as the stem height increased in comparison with the control by 9.6 cm after treatment with boron humate and by 3.8 cm after introducing of molybdenum humate. The growth of red clover was almost the same, respectively the values of stem height exceeded those of control by 6.2 and 8.0 cm. Of all the three legume grasses, the boron humate had the strongest effect in relation to growth rate, as the excess was by 11.4 cm. The treatment with molybdenum humate had a relative good influence over the growth of stems of sainfoin, as the value was over the control by 8.1 cm.

In the second year, the highest values of stems were measured for the three-grass species, which explained by their maximum development in that period. The effect of boron humate for bird's-foot trefoil was more strongly manifested, and that of molybdenum humate was negative. The growth rate of stems of red clover after application with boron and molybdenum humate was almost identical, as the excess of that indicator in comparison with the control was respectively by 6.1 and 7.0 cm. The effect of both bioproducts for sainfoin in relation to values of stem height was analogical with that for red clover. It is obvious from the obtained values, which exceeded insignificantly the control, respectively by 4.4 (var. 6) and 6.6 cm (var. 9).

Table 4: Stem height of bird's-foot-trefoil, red clover and sainfoin after treatment by boron and molybdenum humate in different years (cm)

Variants	2013	2014	2015
bird's-foot trefoil	35.20	54.05	43.68
red clover	25.35	50.65	54.73
sainfoin	37.80	88.90	50.3
bird's-foot trefoil + boron humate	44.85	59.20	46.60
red clover + boron humate	31.55	56.50	60.40
sainfoin + boron humate	49.20	93.30	51.8
bird's-foot trefoil + molybdenum humate	39.05	52.85	44.35
red clover + molybdenum humate	33.35	57.60	59.48
sainfoin + molybdenum humate	45.95	89.55	54.6

In the third year, the stems of plants for all the three-grass species were again higher than these of non-treated variants, but the excess was in narrow limits after the treatment of both bioproducts. In comparison with boron humate, the excess in bird's-foot trefoil was by 3.08 cm, in comparison with red clover by 5.7 cm, and in comparison, with sainfoin by 1.5 cm. After the application with molybdenum humate the growth rate of species was the following: for bird's-foot trefoil with 0.67 cm, red clover with 4.8 cm and sainfoin with 4.3 cm. There was a tendency for a slighter effect over the growth rate of stems of legumes with advancing age of grassland.

Conclusion

The highest positive influence of the studied bio-fertilizers - boron and molybdenum humate over productivity was observed in sainfoin, at doze of 1600 ml/ha in a grassland of bird's-foot-trefoil, red clover and sainfoin. Its yield after application of boron humate increased in comparison with the control by 8.3%, and molybdenum humate

increased the productivity of red clover by 4.0%. The treatment of grassland of bird's-foot-trefoil with bio-fertilizers appeared irrational, which was obvious by the lower dry matter yield.

In case of treatment of bird's-foot-trefoil, red clover and sainfoin with boron and molybdenum humate, weed infestation of crops was slight and was influenced by biological characteristics of grass species and meteorological conditions. The introduction of bio-fertilizers had a positive influence over the growth rate of sainfoin and red clover, which had a favorable effect over productivity of grassland.

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