RESEARCH ARTICLE

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Correlation and regression dependences between quantity and quality indicators depending on fertilizing of bird's-foot-trefoil with humate fertilizers

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ABSTRACT

During the period of 2013-2015 in the experimental field of RIMSA-Troyan was conducted an experiment. The experimental design was a block with 4 replications with a plot size of 5 m^2 of grassland with 'Targovishte 1' bird's-foot-trefoil cultivar. The following fertilizing variants were examined: control - null, 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). Obtained correlation dependencies and regression equations are made between quantitative and qualitative indicators depending on fertilization with humate fertilizers. The crude protein content has been found to have high positive correlations with the percentage of leaves in the grassland (r = 0.8173) and the weight percentage of bird's-foot-trefoil (r = 0.7835), which allows the development of graphical regression models. There is a high correlation between the height of the plants and the relative share of the stems in the grassland (r = 0.8058), as well as between Feed units for growth and milk (r = 0.9457). The high coefficient of determination between the percentage share of bird's-foot-trefoil and the quantity of the stems R^2 = 0.9087 determines the equation of the regression dependence between these two components (y = 1.2167x-65,001).

Key words: *Lotus corniculatus*, biofertilizers, correlation and regression dependences

Introduction

Bird's-foot-trefoil (*Lotus corniculatus* L.) is a forage legume culture suitable for growing in the foothills and mountainous regions of Bulgaria (Churkova, 2013).

It is a perennial legume crop that creates conditions for nitrogen enrichment of soil and provides high quality animal fodder (Churkova, 2011). Plant productivity is largely determined by the availability of nutrients to all parts of plants. Ensuring the plants with the necessary types of fertilizers and their norms is essential in the formation of the yield (Vlahova, 2013).

Foliar application of organic fertilizers is essential for obtaining more and better fodder production (Kertikov et al., 2016; Lambers et al., 2006; Churkova, 2013; Bozhanska, 2017; 2018; Marinova et al., 2019). In recent years, the use of biofertilizers, which provide more protein, increases the digestibility and nutritional value of feed (Klimas and Balezentiene, 2010; Churkova, 2013). The application of humate fertilizers leads to stimulation of the growth of the root system, greater absorption of the nutrients from the plants, increase the resistance of the plants to the unfavourable factors and increase their productivity (Kulikova et al., 2005; Pavlov and Valchev, 2013). Statistical data processing allows for a complete characterization of test specimens of bird's-foot-trefoil, which proves the highest correlation between the percentage of stems and the dry matter yield, and in the case of cuttings for seeds among the number of seeds per pod and yields of seeds (Churkova, 2007; 2011).

The aim of the present study is to establish correlation dependences between quantity and quality indicators and to develop regression equations for indicative prediction of the quality of biomass of bird's-foot-trefoil with humate fertilizers.

Materials and Methods

Way of setting experience

The experiment was carried out during the period 2010-2012 in the experimental field of RIMSA - Troyan. The experimental design was a block method with 4 replications with a plot size of the 5 m^2 with 'Targovishte 1' cultivar. The following biofertilizers were tested: Phosphorus humate, boron humate and molybdenum humate. All preparations are made by the producer company Agro Bio Stim – Bulgaria. Fertilizing is carried out with 3000 liters of working solution per hectare in the 2-4 leaf stage of bird's-foot-trefoil in the first year and the beginning of the vegetation in each subsequent year. The following variants have been examined: control - null, 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 at the indicated doses is consistent with the amounts as recommended by the manufacturer. A commonly accepted technology for the cultivation of bird's-foot-trefoil for fodder was applied. Sowing was done manually, as it was spread at sowing rate of 0.12 t/ha.

Indicators studied

The following indicators were taken: dry matter yield according to cuttings over the years year and average for the period; average samples were dried to a constant weight at 105^0C and recalculated according to the percentage of dry matter in the green mass (t/ha); botanical composition of the grassland, determined immediately before harvesting of the first regrowth in weight percentage (%) by taking a mean sample of each replication; morphological composition - determined by weight of average sample of each variant and each replications of stems, leaves and generative organs; plant height (cm) - measured in phase of budding - beginning of flowering of 40 plants of each variant taken from each replication (Churkova, 2013).

Samples for chemical analysis of fodder were taken in the bud-formation period - beginning of flowering of each regrowth during the years of the experimental period. The chemical composition includes content of crude protein (CP), crude fiber (CFr), crude fat (CF), and nitrogen-free extractable substances (NFE), measured in g kg^{-1} and determined by the classic Weende method (AOAC, 2000). Crude protein values were recorded on a nitrogen-based basis by conversion of N x 6.25 according to Kjeldahl method (AOAC, 1995). Crude fibers were determined by the method of Heteron and Jensen based on the solubility of the non-cellulosic ingredients in solutions of sulfuric acid and potassium hydroxide. The energy nutritional value (FUM and FUG) is measured by the Bulgarian system (Todorov and Darzhenov, 1995), by coefficients based on equations based on the values of the basic chemical composition of nutrients (Churkova, 2013).

Statistical analysis

A statistical processing was made on the basis of the data obtained from the above mentioned indicators, which are published in both publications. For this purpose, Analysis Toolpak software for Microsoft Excel 2010 and Statgraphics Plus v.2.1 is used, and correlation dependencies and regression equations are made.

Results and Discussion

The crude protein content in the harvested biomass in a bird's-foot-trefoil grassland (Table 1) shows the highest positive correlation with the indicator - percent share of leaves in the grassland (r = 0.81) and weight percentage of bird's-foot-trefoil (r = 0.78). The crude protein correlates positively with stem values (r = 0.61) and their height (r = 0.51). There is a negative correlation of this indicator with the yield (r = - 0.66).

The theoretical regression line and the equation of the regression dependence between the crude protein content and the weight percentage of leaves in the dry biomass of bird's-foot-trefoil are depicted in Figure 1, where y = 6.8806 x - 147.23 at a relatively high determination coefficient R^2 = 0.6679.

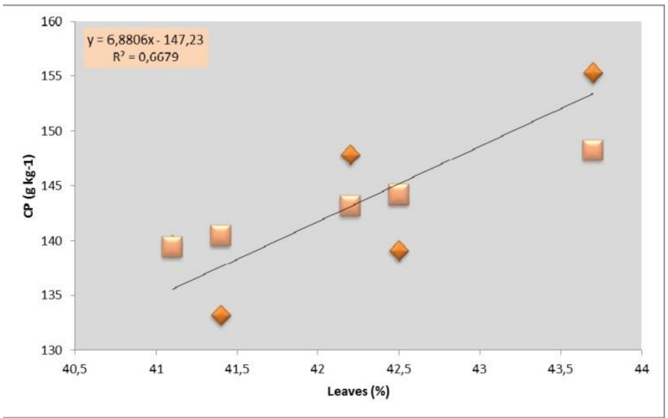

Figure 1. *Regression dependence between crude protein content and the relative share of leaves in the grassland of bird's-foot-trefoil as a pure crop after fertilizing with humate fertilizers.*

Efficient use of grassland with bird's-foot-trefoil and its nutritional value are closely related to the analysis of the basic chemical composition and composition of cell wall components. The amount of crude fibers is in a relatively good correlation with the crude protein content - r = 0.59. There is a positive correlation between crude fiber values with stem height (r = 0.41) and between crude fibers with leaves (r = 0.33).

Fertilizing has the highest impact on the change in the mean values of the stems and the relative share of bird's-foot-trefoil in the grassland. The results of the analysis show a positive correlation (r = 0.95) between the indicators. Negative correlation is observed between the weight percent of bird's-foot-trefoil versus the amount of the generative organs (r = -0.92).

Table 1. Correlation dependences between indicators for content, nutritional value and digestibility of bird's-foot-trefoil depending on the fertilizing with humate fertilizers.

Indicators	Leaves	Stems	Generative organs	Height	Bot. composition % Bird's-foot-trefoil	Crude protein	Crude fibers,	Crude fats.	NFE	FUM	FUG
Leaves	**1**										
Stems	0.33	**1**									
Generative organs	-0.32	-0.93	**1**								
Height	0.14	0.80	-0.95	**1**							
Botanical composition % Bird's-foot-trefoil	0.43	0.95	-0.92	0.78	**1**						
Crude proteins	0.81	0.61	-0.66	0.51	0.78	**1**					
Crude fibers	0.33	0.01	-0.31	0.41	0.23	0.59	**1**				
Crude fats	0.62	-0.11	0.07	-0.20	0.16	0.66	0.57	**1**			
NFE	-0.23	-0.86	0.64	-0.45	-0.73	-0.31	0.46	0.28	**1**		
FUM	0.83	0.22	-0.35	0.32	0.25	0.61	0.45	0.29	-0.04	**1**	
FUG	0.76	0.50	-0.61	0.58	0.48	0.66	0.40	0.12	-0.28	0.94	**1**

Legend: NFE – nitrogen-free extractable substances; FUM – free units for milk; FUG – free units for growth.

Feed units for growth and milk correlate strongly with the percentage of leaves in the grassland. Their statistical correlation coefficients (r = 0.83 and r = 0.76) show that the correlation dependence between the analyzed laboratory parameters is strong. Established graphical regression models reveal a good opportunity for referential determination of crude protein content in the fertilized grassland with bird's-foot-trefoil, through the percentage share of bird's-foot-trefoil.

The equation (Figure 2), by which it is possible to predict the amount of crude protein by the relative share of bird's-foot-trefoil is: y = 3.0086 x - 131.03 at the determination coefficient R^2 = 0.6125. There is a high correlation dependence between the height of the plants and the relative share of the stems in the grassland - (r = 0.80), as well as between FUM and FUG (r = 0.94).

There is a very high correlation between the nutritional value of the fodder, the feed unit of milk and growth in kg DM, which is expressed by a high correlation coefficient r = 0.94 (the highest one among all other indicators). The high correlation dependence between the relative share of the leaves and the FUM and FUG content allows these two parameters, which determine the nutritional value of fodders, to be determined with a relatively high accuracy by the amount of leaves in the grassland.

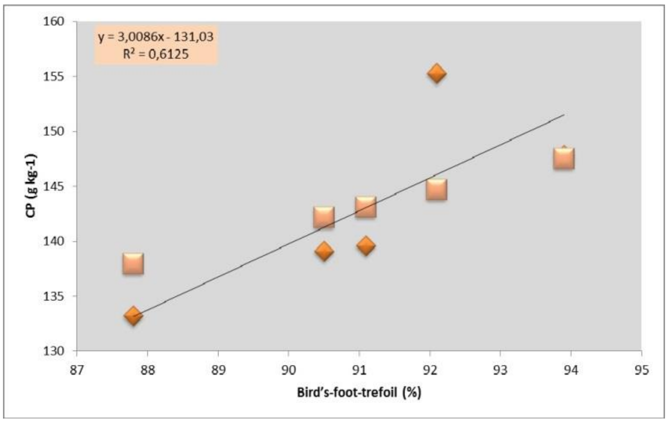

Figure 2. *Regression dependence between crude protein content and the relative share of bird's-foot-trefoil in the grassland after fertilizing with humate fertilizers.*

Crude fibers as a structural component are significantly less dependent on yield (r = -0.39). A little higher is the correlation between crude fiber content and height (r = 0.41) and crude protein (r = 0.59). Crude fats are in a relatively high positive correlation with the crude protein content (r = 0.66) and negative in the quantity of stems (r = -0.11) and height (r = -0.20). NFE are in positive correlation with the generative organs (r = 0.64) and the crude fibers (r = 0.46). The positive correlation dependence observed between the crude fibers and the feed value - the number of feed units of milk (r = 0.45) and growth (r = 0.40) in the dry matter allows these two indicators, which determine the nutritional value of fodders to be determined with a relatively high accuracy through the crude fiber content.

The percentage share of bird's-foot-trefoil is in a good regression dependence with stem quantity R^2 = 0.90 (Figure 3), which confirms the good correlation between them. The theoretical regression line and the equation of regression dependence between these two components are represented by the equation y = 1.2167x-65.001 at a relatively high determination coefficient.

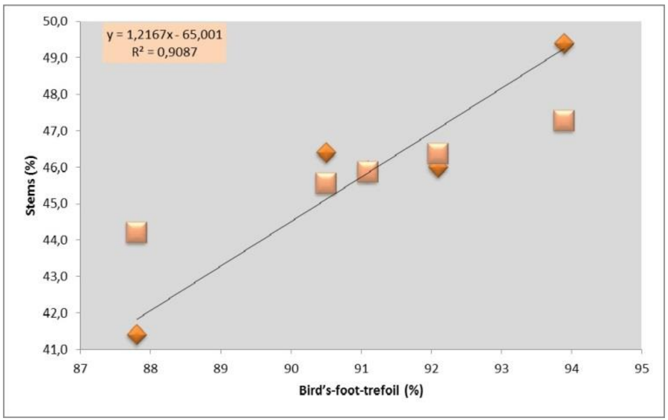

Figure 3. *Regression dependence between percentage share of bird's-foot-trefoil and the relative share of stems in the grassland after fertilizing with humate fertilizers.*

The established high correlation between the height and the quantity of the stems allows the equation y = 1.2682x-4.8335 to be derived at the determination coefficient R^2 = 0.64 (Figure 4).

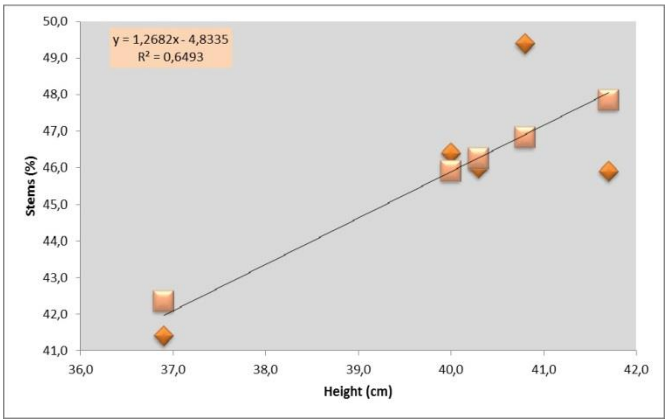

Figure 4. *Regression dependence between percentage share of stems and height of plants in the grassland after fertilizing with humate fertilizers.*

The results obtained are similar to the established regression equations for determining FUM and FUG content in meadow hays by other authors (Todorov et al., 2007) obtained from the study of many more samples of different origin and accepted for practical use in the development of nutrition rations of ruminants.

Conclusions

Fertilizing with humate fertilizers determines the high positive correlation dependence between the crude protein content and the percentage share of the leaves in the grassland (r = 0.8173) and the weight percent of bird's-foot-trefoil (r = 0.78).

There is a high correlation between the height of the plants and the relative share of the stems in the grassland (r = 0.80), as well as between FUM and FUG (r = 0.94).

The developed graphical regression models can determine the crude protein content by weight percentage of leaves in the dry biomass of bird's-foot-trefoil.

The feed value (FUM and FUG) can also be predicted and determined by developed graphical models based on the relative share of the leaves with sufficient accuracy for practical purposes.

There is good regression dependence between bird's-foot-trefoil percentage and stem quantity, which allows the development of a regression equation. The determination coefficient R^2 = 0.90 is high enough to represent the equation of regression dependence between these two components (y = 1.2167x-65,001).

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