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CORRELATIVE DEPENDENCES BETWEEN FORAGE CHEMICAL COMPOSITION AND CRUDE PROTEIN PRODUCTIVITY OF GRASS–LEGUME MIXTURE UNDER VARIABLE MINERAL FERTILIZING

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Abstract. During the 2001–2003 period in RIMSA, Troyan the correlative relationships between forage chemical composition and crude protein productivity of grass mixture containing perennial ryegrass and birdsfoot trefoil under variable mineral fertilizing was investigated. The following variants in the experiment were included:

1. Unfertilized variant (standard);
2. Annual soil mineral fertilizing with $P_{80}K_{80}$;
3. Annual soil fertilizing with $N_{80}P_{80}K_{80}$;
4. 1st year–fertilizing with $P_{80}K_{80}$, 2nd year–fertilizing with $N_{80}P_{80}K_{80}$, 3rd year–fertilizing with $P_{80}K_{80}$;
5. 1st year and 2nd year–fertilizing with $P_{80}K_{80}$, 3rd year–fertilizing with $N_{80}P_{80}K_{80}$.

There were positive correlations during annual mineral fertilizing (var. 2 and var. 3) with crude protein productivity for only two of the chemical composition components–for var. 2 with regard to crude ash content (r=0.7695–strong) and calcium (0.8974–very strong), and for var. 3–weak correlation between crude ash (r=0.4179) and crude fibre (r=0.4731). There were positive correlations for var. 4 of variable mineral fertilizing regarding to crude ash content (r=0.2506–weak) and crude fibre (r=0.7178–middle). There were positive correlations for var. 5 with four of the indicators–calcium (r=0.4184–weak), crude ash (r=0.5319–middle), crude protein (r=0.2340–weak) and crude fat (r=0.0992–very weak correlation).

Key words*:* grass–legume mixture, variable mineral fertilizing, forage chemical composition, crude protein yields, correlative dependences.

Introduction

The annual fertilizer application of the same types of fertilizers or manure in either permanent or temporary grasslands will result in unfavourable changes in their botanical composition, and thus affect the quality of the forage produced from them, especially when they are mainly utilized for cutting.

When combinations of fertilizers are applied alternately in different years, this will have a favourable effect on the forage quantity and quality traits [NEVENS *et al.* 2002].

Interest of practical application has availability between some bioproductive and quantitative indices of forage.

There are hardly any studies concerning meadow forage plants for establishing correlative relationships between productivity and some biochemical and morphological indicators of forage , which have been conducted only by some legumes and grasses until now [PELIKAN, 2002; PETKOVA *et al.* 2006; CHURKOVA, 2007; LINGORSKI, 2011].

The objective of this study was to establish the correlative relationships between crude protein productivity and some components of forage chemical composition from grass mixture containing perennial ryegrass and birdsfoot trefoil cultivated in fore–mountainous regions of the Central Balkan Mountains under variable mineral fertilizing with PK and NPK.

Material and methods

The experiment was carried out during the 2001–2003 period in the experimental field of RIMSA, Troyan and the detailed description of its carrying–out was presented in a previous publication [LINGORSKI *et al.*, 2005].

The following variants were studied in the experiment: 1.

Unfertilized variant (standard); 2. Annual mineral fertilizing with $P_{80}K_{80}$; 3. Annual fertilizing with $N_{80}P_{80}K_{80}$; 4. 1st year–fertilizing with $P_{80}K_{80}$, 2nd year–fertilizing with $N_{80}P_{80}K_{80}$, 3rd year–fertilizing with $P_{80}K_{80}$; 5. 1st year and 2nd year–fertilizing with $P_{80}K_{80}$, 3rd year–fertilizing with $N_{80}P_{80}K_{80}$.

Samples for chemical analyses were taken at harvesting of the area, which was

conducted at the stage of pasture ripeness of the grass stand (in the end of the tillering of perennial ryegrass or at the beginning of flowering stage of birdsfoot trefoil).

In this research, the chemical composition of absolutely dry matter was studied, including: content of crude protein in % (after Kjeldahl), crude fibre in % (after Heteron and Jensen), crude ash in % (through dry ashing in a muffle oven at temperature of 550°C), crude fat in % (after Soxlet), calcium in % (after Stotz–complexometrically) and phosphorus in % (by the vanadium–molybdenum method of Gericke and Kurmis). The correlation coefficients between biochemical indicators of forage and yields of dry mass were calculated through the computer programme product Microsoft Excel.

Results and discussion

The factual data about the particular components of the chemical composition of dry mass presented in *Table 1* show that they vary in different fertilizing variants of the experiment. So, the crude protein ranged from 16.35% (var. 5)–16.80% (var. 4) under variable mineral fertilizing with PK and NPK to 17.57% (var. 3)–17.62% (var. 2) under the annual mineral fertilizing with $N_{80}P_{80}K_{80}$ and $P_{80}K_{80}$ against 15.85% in the standard.

Table 1.

Chemical composition (%) of grass mixture dry mass average for the 2001–2003 periods

Variants	Crude protein, %	Crude fat, %	Crude fibre, %	Crude ash,%	Calcium, %	Phosphorus, %
1(standard)	15.85	2.94	22.56	9.82	1.323	0.444
2	17.62	2.86	23.16	9.52	1.332	0.451
3	17.57	3.09	23.49	9.60	1.094	0.455
4	16.80	2.90	22.71	10.53	1.171	0.443
5	16.35	3.03	22.56	10.06	1.257	0.413

In spite of the fertilizing modes the values of crude fat reached comparatively small limits–from 2.86% (var. 2) to 3.09% (var. 3), and the other variants occupied intermediate values.

In regard to crude fibre index all five variants of the research there were no considerable differences and values variability was in very small limits–from 22.56% (standard) to 23.49% (var. 3).

The most important content of crude ash in the forage was established in the following fertilizing variants (var. 5 and var. 4–10.06 and 10.53%, respectively, followed by var. 1, var. 3 and var. 2–9.82, 9.60 and 9.52%). Calcium content varied in comparatively largest limits and the biggest value was in var. 2 (1.332%), followed by unfertilized standard–1.323% and the least values were in var. 3 and var. 4–1.094% and 1.171%. respectively.

Despite the fertilizing modes the phosphorus content in dry mass there were comparatively similar values and varied from 0.413% (var. 5) to 0.455% (var. 3).

It is evident from *Table 2* that the average content of crude protein in the unfertilized variant was 16.07% and varied within the limits from 14.14% (min) to 18.00% (max) at average degree of variation (CV)–8.66%. A similar variation was established with regard to crude fibre index–8.07%, and their content reached 20, 49% (min)–25.46% (max).

Comparatively big variability (medial stage) was established in reference to crude fat and crude ash–15.88% and 16.08%, and average contents in forage reached 2.88% and 9.92% respectively.

Low and medial stage of variation (4.66% and 7.39%) was established in relation to calcium and phosphorus contents. The standard deviation (SD) for them was the least–0.06% and 0.03% respectively.

The annual mineral fertilizing with $P_{80}K_{80}$ (var. 2) and $N_{80}P_{80}K_{80}$ (var. 3) increased the crude protein content in forage in comparison with the unfertilized standard–15.96% (min) and 19.17% (max) with average values 17.56% and 15.64% (min) against 18.59% (max)–average 17.11% respectively.

As far as the crude fat and calcium contents are concerned, the biggest coefficient of variation (middle stage) was established

after the PK–fertilizing–14.72 and 16.45% and also low standard deviation–0.42% and 0.22% respectively.

The variation coefficients of the other biochemical indicators were low in values and reached to 7.59% for crude protein, 7.89% for crude ash, 9.34% for fibre and 9.42% for phosphorus content.

The biggest values of the standard deviation for the crude protein (1.33%) and crude fibre (2.13%) were established.

Considering *Table 2* again, it becomes obvious that after the complete annual mineral fertilization (var. 3) the level of variation (6.47%) of phosphorus is lower than the level of crude protein and fibre (7.07% and 9.12%).

The maximum variation (middle level) for the crude ash, crude fat and calcium contents was established–13.23%, 15.68% and 17.72%. The standard deviation of the crude protein, crude ash and crude fibre was higher–1.21%, 1.27% and 2.13%.

Table 2.

Variation in some biochemical indicators of grass mixture dry mass average for the 2001–2003 periods

Chemical composition of dry mass, %	min	max	$x_{average}$	SD	CV, %
Var.1 (standard)					
Crude protein	14.14	18.00	16.07	1.39	8.66
Crude fat	2.26	3.51	2.88	0.46	15.88
Crude fibre	20.49	25.46	22.97	1.85	8.07
Crude ash	7.83	12.02	9.92	1.59	16.08
Calcium	1.230	1.375	1.302	0.06	4.66
Phosphorus	0.392	0.474	0.433	0.03	7.39
Var.2					
Crude protein	15.96	19.17	17.56	1.33	7.59
Crude fat	2.33	3.37	2.85	0.42	14.72
Crude fibre	19.91	25.77	22.84	2.13	9.34
Crude ash	8.36	10.37	9.36	0.74	7.89
Calcium	1.025	1.626	1.325	0.22	16.45
Phosphorus	0.387	0.489	0.438	0.04	9.42
Var.3					
Crude protein	15.64	18.59	17.11	1.21	7.07
Crude fat	2.54	3.73	3.13	0.49	15.68
Crude fibre	20.59	26.26	23.42	2.13	9.12
Crude ash	7.85	11.43	9.64	1.27	13.23
Calcium	0.927	1.414	1.170	0.21	17.72
Phosphorus	0.432	0.494	0.463	0.03	6.47
Var.4					
Crude protein	14.58	20.62	17.60	2.45	13.94
Crude fat	2.59	3.16	2.87	0.21	7.50
Crude fibre	20.24	25.92	23.08	2.07	8.97
Crude ash	8.29	12.64	10.46	1.69	16.12
Calcium	1.003	1.459	1.231	0.18	14.81
Phosphorus	0.393	0.489	0.441	0.03	7.85
Var.5					
Crude protein	13.34	19.04	16.19	8.87	54.79
Crude fat	2.47	3.66	3.06	2.04	66.57
Crude fibre	20.56	24.02	22.29	11.30	50.72
Crude ash	9.06	10.65	9.85	4.57	46.42
Calcium	1.135	1.330	1.232	0.17	13.61
Phosphorus	0.354	0.499	0.426	0,64	15.02

Both variable fertilizing conditions (var. 4 and var. 5) of the crude protein content reached average 17.60% (min–14.58%, max–20.62%) and 16.19% (min–13.34%, max–19.04%) with middle and very high level of variation of this index–13.94 and 54.79%.

The variation coefficient for var. 4 had high values with regard to crude ash and calcium content in dry mass–16.12% and 14.81% respectively.

It is obvious that comparatively low level of variation (7.50%, 7.85% and 8.97%) had in reference to crude fat, phosphorus and crude fibre contents.

The lowest standard deviation of the crude fat, calcium and phosphorus content was established, whereas the other biochemical indices (crude ash, crude fibre and crude protein) reached 1.69%, 2.07% and 2.45%. The variation coefficient of var. 5 for crude ash, crude fibre, crude protein and crude fat–46.42%, 50.72%, 54.79% and 66.57% had very high values.

In relation to calcium and phosphorus contents the variation coefficient had the lowest values (13.61% and 15.02%) and the lowest standard deviation–0.17% and 0.64%.

For other researched fertilizing variants the standard deviation varied from 2.04% for crude fat and 4.57% for crude ash to 8.87% for crude protein and 11.30% for crude fibre.

The performed correlation analysis (*Table 3*) of the experimental data showed that in the unfertilized variant there were very strong positive correlations between yields and crude protein content (r=0.8270), and middle level regarding crude fat content (r=0.6018). The correlation was positive regarding calcium and phosphorus content, but it was weak–r=0.2699 and r=0.1718.

In relation to crude protein yields there were negative correlations between crude fibre and crude ash contents only.

Table 3

Correlations between some basic components of forage chemical composition and crude protein yields of grass mixture average for the experimental period (2001–2003).

Variants	Crude protein %	Crude fat, %	Crude fibre, %	Crude ash, %	Calcium %	Phosphorus %
1(standard)	0.8270	0.6018	–0.0023	–0.8352	0.2699	0.1718
2	–0.2452	–0.2940	–0.3707	0.7695	0.8974	–0.1984
3	–0.8791	–0.8444	0.4731	0.4179	–0.0665	–0.7113
4	–0.8331	–0.9825	0.7178	0.2506	–0.1678	–0.3205
5	0.2340	0.0992	–0.9812	0.5319	0.4184	–0.0222

During the annual mineral fertilizing (var. 2 and var. 3) there was a positive correlation of crude protein productivity between two of the chemical composition components–for var. 2 regarding crude ash content (r=0.7695–strong) and calcium (0.8974–very strong), and for var. 3–weak correlation between crude ash (r=0.4179) and crude fibre (r=0.4731).

Different by level and at the same time negative correlations for other biochemical indicators were established during the annual mineral fertilizing.

Positive correlations between crude ash content (r=0.2506–weak) and crude fibre (r=0.7178–medial) are available for var. 4 of variable mineral fertilizing.

Similar positive correlations are available for var.5 regarding four of the indicators–calcium–weak (r=0.4184), crude ash–middle (r=0.5319), crude protein (r=0.2340)–weak, aand crude fat–very weak correlation (r=0.0992).

In the same variant the other two indicators (crude fibre and phosphorus are in negative correlations regarding crude protein productivity.

Conclusions

The study of a grass mixture containing perennial ryegrass and birdsfoot trefoil in the fore–mountainous regions of the Central Balkan Mountains showed that the greatest quantities of crude protein and crude fat in the dry mass were accumulated under variable soil mineral fertilizing with $P_{80}K_{80}$ and $N_{80}P_{80}K_{80}$.

In the unfertilized variant there was a very strong and positive correlation between yields and crude protein content (r=0.8270), and middle level in reference to crude fat content (r=0.6018).

There was a positive correlation between calcium and phosphorus content, but it was weak (r=0.2699 and r=0.1718

respectively).

There were positive correlations during annual mineral fertilizing (var. 2 and var. 3) with crude protein productivity for only two of the chemical composition components–for var. 2 with regard to crude ash content (r=0.7695–strong) and calcium (0.8974–very strong), and for var. 3–weak correlation between crude ash (r=0.4179) and crude fibre (r=0.4731).

There were positive correlations for var. 4 of variable mineral fertilizing regarding to crude ash content (r=0.2506–eak) and crude fibre (r=0.7178–middle).

There were positive correlations for var. 5 with four of the indicators–calcium (r=0.4184–weak), crude ash (r=0.5319–middle), crude protein (r=0.2340–weak) and crude fat (r=0.0992–very weak correlation).

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