AGROECONOMIC VALUE OF SOME PERENNIAL FORAGE LEGUMES

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Abstract

The results of the evaluation of the growth and development rates, the seed productivity, the green mass yield, the biochemical composition, the content of amino acids, macro and micro elements, the nutritive and energy value of the forage, as well as the biomethane productivity of native perennial leguminous species maintained in monoculture in the National Botanical Garden (Institute) from Moldova: Astragalus cicer L., Coronilla varia L., Glycyrrhiza glabra L., Vicia tenuifolia Roth., are presented in this scientific paper. Control variants – the traditional forage legumes: Medicago sativa and Onobrychis viciifolia. The local ecotypes of the studied leguminous species were characterised by different growth and development rates, their green mass yield varied from 3.05 to 4.08 kg/m^2, the nutritional and energy value reached amounts of 0.20-0.26 nutritive units/kg and 2.21-2.93 MJ/kg metabolizable energy, the content of digestible protein in fodder 129-161 g/nutritive unit and met the zootechnical standards. The species Astragalus cicer contained the highest amount of essential amino acids, Glycyrrhiza glabra was distinguished by a higher content of lysine, valine, leucine, Vicia tenuifolia and Coronilla varia – optimal content of methionine. The studied ecotypes can serve as starting material in improving and implementing new varieties of leguminous species in the production of protein rich forage, as well feedstock for biogas production.

Keywords: biochemical composition, biological peculiarities, economic value, perennial forage legumes

INTRODUCTION

Agriculture is challenged by an increasing demand for food and feed combined with a decreasing availability of resources.

Current agricultural production is highly N limited, while the provision of industrial N is largely based on fossil energy with its associated emission of greenhouse gases. Leguminous plants play an important role in forming and maintaining phytocoenoses, contribute to biological nitrogen accumulation in the soil, to the improvement of soil's physical and chemical characteristics, the reduction of erosion processes. Many legume crops are also excellent honey plants, other plants can be used as raw material in various branches of the economy, cosmetology, pharmaceutics and bioenergetics industry (Duke, 1981; Stoddard, 2013).

Forage legumes offer great potential to cope with a major challenge for modern agriculture: to produce more food and feed with less resources. Legumes from pastures and meadows contribute nitrogen to a complex and dynamic recycling system, organic matter containing legume proteins may be mineralized in soil, liberating N as nitrates (NO_3) and NH_4 that may be used by grasses and other species of plants.

The use of legumes in grassland livestock systems constitutes one of the pillars for sustainable and competitive ruminant production systems, because they have the potential to extend the grazing season, increase the quantity of grazed forage and hay, and reduce the amount of N fertilizer needed. Legume feed not only improves forage quality, but also increases the intake of the ration, hence, gives better performance in terms of livestock production. Several forage legumes possess plant secondary metabolites that include tannins and polyphenol oxidase. Tanniferous legumes such as sainfoin (*Onobrychis viciifolia*), crownvetch (*Coronilla varia*) and cicer milkvetch (*Astragalus cicer*) can prevent bloat of animals, have anthelmintic bioactivity (Acharya *et al.,* 2006; Lüscher *et al.,* 2016).

The flora of the Republic of Moldova is relatively rich and includes 5568 species of plants (superior plants – 2044 species, inferior plants – 3524 species), family *Fabaceae* Lindl. – 25 genera and 120 species. The spontaneous flora of the country includes over 700 species of fodder plants, about 71 species leguminous plants.

The grasslands from the Republic of Moldova cover about 14 % of the territory, they are in a deplorable condition and have very low productivity, with a share of leguminous plants decreasing from year to year (Bahcivanji *et al.,* 2012; Negru, 2007).

The collection of non-traditional forage plants of "Alexandru Ciubotaru" National Botanical Garden (Institute) totals nearly 339 botanical taxa (species, varieties), including 78 leguminous plants (Teleuta and Titei, 2012; 2016).

The objective of this research was to evaluate some biological peculiarities, the biochemical composition, the content of amino acids, macro and micro elements of the local ecotype of perennial leguminous plant species *Astragalus cicer, Coronilla varia, Glycyrrhiza glabra, Vicia tenuifolia* and the possibility to use them as forage for ruminant animals or as biogas substrate in the Republic of Moldova.

MATERIAL AND METHOD

The native perennial species of the family *Fabaceae* Lindl.: cicer milkvetch *Astragalus cicer* L., crown vetch *Coronilla varia* L., liquorice *Glycyrrhiza glabra* L., cow vetch *Vicia tenuifolia* Roth., (seeds collected from the wild flora of the Republic of Moldova), grown in monoculture on experimental land in "Alexandru Ciubotaru" National Botanical Garden (Institute), latitude 46°58′25.7″ and longitude N28°52′57.8″E, served as subjects of the research, and the traditional leguminous fodder crops alfalfa *Medicago sativa* L. and common sainfoin *Onobrychis viciifolia* Scop., were used as control. The experimental design was a randomised complete block design with four replications, and the experimental plots measured 10 m^2. The seeds were sown at a depth of 2.0-3.0 cm with soil compaction before and after sowing. The scientific research on growth, development and productivity of the plants was carried out according to the methodical indications (Novosiolov *et al.*, 1983). The green mass was harvested manually; the first cut was done in the budding-flowering stage. Green mass productivity was determined by weighing the yield obtained from a harvested area of 10 m^2, which was afterwards transformed per hectare. The leaves/stems ratio was determined by separating the leaves, buds and flowers from the stem, weighing them separately and establishing the ratios for these quantities (leaves/stems). The dry matter content was detected by drying samples up to constant weight at 105 °C; crude protein – by Kjeldahl method; crude fat – by Soxhlet method; crude cellulose – by Van Soest method; ash – in muffle furnace at 550 °C; nitrogen-free extract (NFE) was mathematically appreciated, as difference between organic matter values and analytically assessed organic compounds; organic dry matter, or volatile solids (VS), was calculated through differentiation, the crude ash being subtracted from dry matter. The carbon content of the substrates was obtained from data on volatile solids, using an empirical equation reported by (Badger *et. al.*, 1979). The amount of macro elements contained in biomass was determined using standardized methods. Amino acid analysis was performed with a T 339 Amino Acid Analyzer (INGOS Ltd., Prague, Czech Republic) after samples were hydrolysed in 6M HCl. The biogas production potential and the specific methane yields were evaluated by the parameter "content of fermentable organic matter" (Weissbach, 2008).

RESULTS AND DISCUSSION

We could mention, as a result of the phenological observations, that the studied perennial forage legumes are characterised by different growth and development rates, in the first growing season. Thus, it was determined that the plantlets of *Vicia tenuifolia* emerged non uniformly at the soil surface, 23 days after sowing, 16 days later as compared with the control, *Medicago sativa*, and 10 days later as compared with *Onobrychis viciifolia*.

The plantlets of the species: *Astragalus cicer* and *Glycyrrhiza glabra* emerged 11 days after *Vicia tenuifolia*, but the plantlets of *Coronilla varia* emerged massively the latest, that is, about 45 days after sowing.

The plants of *Glycyrrhiza glabra* and *Vicia tenuifolia* are distinguished by a very slow growth and development of the aerial part, by the end of the growing season, the rosette with leaves developed, while *Astragalus cicer* and *Coronilla varia* reached the budding stage and the beginning of the flowering stage. In the first growing season, the studied perennial leguminous species weren't mowed, but were suitable for grazing.

Peiffer *et al.* (1972), remarked that *Coronilla varia* was characterized by slow germination, seedling emergence and development as compared with red clover, bird's foot trefoil and alfalfa. In the following years, the leguminous species, studied by us, resumed their growth and development in spring, when temperatures above 5-17 °C were established.

The species *Astragalus cicer*, *Coronilla varia*, *Vicia tenuifolia*, resumed growth in the second half of March, like the traditional leguminous fodder crops *Medicago sativa* and *Onobrychis viciifolia,* but the *Glycyrrhiza glabra* buds from the basal part of last year's shoots started growing when the average air temperature was 15-17 °C, at the middle of April.

The species: *Coronilla varia* and *Vicia tenuifolia* are characterised by a faster grow and development rhythm. Thus, by the end of April (table 1), the plants of *Coronilla varia* and *Vicia tenuifolia* reached 47-54 cm high, while the control species – about 38-40 cm.

The plants of *Glycyrrhiza glabra*, in this period, reached a height of 4 cm. The budding stage of *Vicia tenuifolia* began 16 days earlier in comparison with controls.

The plants of *Astragalus cicer* had a slower development rate. The flowering stage of *Vicia tenuifolia* and *Coronilla varia* started 74-77 days after the resumption of growth. The plants of *Astragalus cicer* and *Glycyrrhiza glabra* begin to bloom the last. During the flowering stage, the shoots of *Astragalus cicer*, *Coronilla varia*, *Vicia tenuifolia* reach 104-122 cm in lenght, *Glycyrrhiza glabra* – 165 cm, but the controls – 83-86 cm. The studied species need a different period of time from flowering until the full ripening of seeds.So, *Vicia tenuifolia* and *Glycyrrhiza glabra* need 30-39 days, *Astragalus cicer* and *Coronilla varia* – 46-64 days, while *Onobrychis viciifolia* needs 34 days and *Medicago sativa* – 61 days.

Table 1

Biological peculiarities of the studied species of the family *Fabaceae*

Indices	*Astragalus cicer*	*Coronilla varia*	*Glycyrrhiza glabra*	*Medicago sativa*	*Onobrychis viciifolia*	*Vicia tenuifolia*
Resumption of vegetation up to:						
- budding	79	70	63	75	75	59
- flowering	99	77	85	82	99	74
- seed ripening	145	141	124	143	133	104
Plant height, cm						
- at the end of April	39.60	47.20	3.70	38.10	35.90	53.96
- at flowering	103.80	122.10	165.50	83.20	85.50	105.70

Table 2

The agro-characteristic of the studied species of the family *Fabaceae*

Indices	*Astragalus cicer*	*Coronilla varia*	*Glycyrrhiza glabra*	*Medicago sativa*	*Onobrychis viciifolia*	*Vicia tenuifolia*
Seed production, g/m^2	34.33	19.00	62.30	27.14	112.22	140.00
Weight of 1000 seeds, g	3.10	3.54	11.05	2.67	14.09	22.19
Fresh mass yield , kg/m^2	3.50	3.92	4.38	3.11	3.95	3.05
Dry matter yield, kg/m^2	0.98	0.87	1.10	0.82	1.03	0.95
Leaf content, %	56	63	55	44	39	56

Seed production is a key pillar in the capacity of maintenance, expansion and cultivation of the species. Analysing the seed productivity (table 2), we conclude that the studied leguminous species differ from traditional leguminous fodder crops in the quantity of produced seeds and in the weight of 1000 seeds. All the studied species have bigger seeds as compared with *Medicago sativa,* but *Vicia tenuifolia* has bigger seeds than *Onobrychis viciifolia.* We have also found that *Astragalus cicer* produces approximately the same number of seeds as *Medicago sativa* The total yield, the quality and the seasonal distribution of forage may be of greater importance to the livestock producer. As mentioned above, the studied leguminous forage species have different growth and development rates that influence the productivity of natural forage and the dry matter yields. Thus, a higher yield of natural forage from the 1-st cut, was produced by *Glycyrrhiza glabra* (4.38 kg/m^2) and *Coronilla varia* (3.92 kg/m^2 kg/m^2), a lower one – by *Vicia tenuifolia* (3.05 kg/m^2). *Glycyrrhiza glabra, Astragalus cicer, Vicia tenuifolia* is distinguished by a higher productivity of dry matter as compared with *Onobrychis viciifolia*, but *Coronilla varia* – as compared with *Medicago sativa.*

It is well known that animals eat mainly leaves, due to their high content of nutrients, and the ratio leaves/stems influences the forage value. The forage of the studied leguminous species is characterized by a high content of leaves (55-63 %).

In some papers, the results of the research on the productivity of the studied leguminous forage species are given. It was mentioned that the productivity of *Coronilla varia* under the climatic conditions of Russia reached 65 t/ha green mass (Dronova *et al.*, 2009); in South Africa crown vetch yielded 10.6 t/ha of dry matter, but alfalfa – 7.1 t/ha (Le Roux *et al.,* 1988). The green mass productivity of liquorice, *Glycyrrhiza glabra,* under the climatic conditions of Lower Volga region, Russia, varied from 22 t/ha, on non irrigated land, up to 55 t/ha, on irrigated land (Astafyev *et al., 2016*); in India, the shoot biomass of liquorice, harvested on different alkali soils, varied from 5.63 to 7.95 t/ha, in the first year and 11.07-15.03 t/ha of dry matter in the next year, forage biomass production was better on soil with higher pH than normal soil (Dagar *et al.,* 2015).

For the growth, development, reproduction, as well as for the production of high quality milk or meat, cattle need many nutrients they receive from feed. Proteins are the most important and the largest group of natural macromolecular compounds, essential for life, are a source of nitrogen for the body and play a crucial role in the valorification of the genetic productive potential. The natural forage of *Vicia tenuifolia*, is characterised by a high content of raw protein, 18.44 % of dry matter (table 3), in comparison with *Medicago sativa* and *Onobrychis viciifolia*, while *Coronilla varia* and *Glycyrrhiza glabra* have moderately content of raw protein.

Fats are the main source of energy for animals because they are necessary for the organism in order to ensure the normal development of vital processes and transportation of soluble vitamins in fatty acids and it also contributes to the accumulation of fat in milk. The natural forage of *Vicia tenuifolia* and *Glycyrrhiza glabra* contains a high amount of raw fats (3.39-3.65 %), at the same level as *Onobrychis viciifolia*, greatly exceeding *Medicago sativa.* The forage of *Astragalus cicer* has a low content of raw fats (1.70 %).

The content of raw cellulose is quite low in the dry matter of the species *Vicia tenuifolia, Glycyrrhiza glabra, Astragalus cicer* and very high in *Coronilla varia.* We also mention that the optimal cellulose content has a beneficial effect on the synthesis of protein substances in the rumen of animals and on the reduction of the nitrate content.

The nitrogen-free extract (NFE), along with fats, provides the necessary energetic material for vital processes, contributing to the formation and storage of fats. The content of nitrogen-free extract varies from 39.74 % to 47.75 % dry matter, it is very high in the species *Glycyrrhiza glabra,* high in *Vicia tenuifolia* and *Astragalus cicer*, this fact influences the possibility of the forage to provide energy.

The vegetal forage contains minerals in variable quantities, regarding the type of the elements and the proportion between them and other chemical compounds. Minerals are essential components of all tissues and organs that maintain constant osmotic pressure, participate in the regulation of acid-base balance, activate a number of enzymes, moderate neuromuscular activities and prevent the emergence and development of diseases in animals. The presence of minerals in animal feed is indispensable for their growth and health. The forage of *Vicia tenuifolia, Astragalus cicer* and *Coronilla varia* is characterized by optimal content of minerals (6.83-7.90 %), higher as compared with that of *Onobrychis viciifolia,* but the forage of *Glycyrrhiza glabra* – by a lower one (5.40 %), in comparison with the control species.

Some authors mentioned various findings about the quality of fodder. ACAR *et al.,* 2001, remarked that C*oronilla varia* spp. *varia* in Pakistan contained 14.86 % protein and 9.99 % ash. According to Dronova *et al.*, 2009, the chemical composition of dry matter of crown vetch was: 25.2 % protein, 3.3 % fat, 25.5 % cellulose, 34.3 % nitrogen-free extractive, but alfalfa – 21.8 %, 2.3 %, 22.0 % and 35.0 %, respectively. Reynolds *et al.*, 1967, reported than crown vetch forage contained 21.7% protein and 22.2% fibre, the digestibility in sheep was 65.6 % protein and 46.2% fibre, but slightly less than the digestibility of alfalfa forage.

Alekseeva (2007) remarked that the biomass of *Glycyrrhiza glabra* ecotypes, in the conditions of Kalmykia, Russia, contained 6.80-11.50 % sugars, 15.67-25.67 % protein, 12.80-21.40 % cellulose, 5.67-17.40 % ash and 1.30-1.70 %

flavonoids. According to Toderich *et al.* (2014), in Kyzylkesek, Uzbekistan, the chemical composition and gross energy value of air dried matter of liquorice (fruit maturation stage) was: 20.7 % protein, 4.2 % fat, 33.4 % cellulose, 33.3 % nitrogen-free extract, 7.51 % ash and 18.4 MJ/kg, but alfalfa (flowering stage) – 16.1 %, 1.6 %, 11.6 %, 60.8 %, 9.1 % and 17.4 MJ/kg, respectively. Astafyev *et al.*, in 2016, reported that liquorice forage, in Lower Volga region, Russia, contained 8.2 % protein, 4.8 % fat, 25.4 % fibre, 53.3 % nitrogen-free extract and 33.94 mg/kg carotene.

Larin (1951) reported that the nutritive values of *Vicia tenuifolia* ranged from 18.7 to 22.3 % crude protein, 2.4 to 4.2 % fats, 24.2 to 32.6 % cellulose, 35.5 to 42.9 % nitrogen-free extract and 6.9 to 9.1 % ash, but *Astragalus cicer* respectively 24-27% crude protein, 3.5-3.6% fats, 21.0-22.4% cellulose, 39.1 to 41.8 % nitrogen-free extract and 8.1 to 8.2 % ash content. The nutritional and energy value is determined by the biochemical composition and the digestibility of the organic substances from the forage, which influence the health and the productivity of animals. We can mention that the natural forage of the studied species reaches amounts of 0.20-0.26 nutritive units/kg and 2.16-2.93 MJ/kg. The nutritional and energy value of the forage of *Vicia tenuifolia, Glycyrrhiza glabra* and *Coronilla varia* is at the same level as *Medicago sativa*, but is lower in comparison with *Onobrychis viciifolia*. The content of digestible protein in fodder is 129-161 g/nutritive unit and meets the zootechnical standards.

The production of animal protein has an essential function in livestock farming. The quality of protein supply is determined by its potential to cover the physiological requirements in terms of amino acids, for maintenance and performance (growth, reproduction, production of milk and meat).

The determination of the amino acid composition of proteins in forage is of great importance, the amino acid level is one of the indicators of the nutritional value of fodder.

The protein quality is determined by the ratio of certain amino acids, which provide the biological value of the feed. The efficiency of using protein crops in animal feed production strongly depends on the content of essential amino acids in various crops and the composition of compound feedstuffs. By analyzing the amino acid content (table 4), we have found that the forage obtained from the studied species contains different amounts of essential amino acids. The species *Astragalus cicer* contain the highest amount of essential amino acids, but *Coronilla varia* contain low amount. It has been found that all the studied species have a lower content of methionine than *Medicago sativa*, but the species *Vicia tenuifolia* and *Coronilla varia* are distinguished by a higher content of methionine in comparison with *Onobrychis viciifolia*.

The species *Glycyrrhiza glabra* and *Vicia tenuifolia* contain a higher amount of lysine than the traditional crops, but the species *Coronilla varia* – a lower one. In comparison with traditional forage crops, *Astragalus cicer* is characterized by a very high content of histidine, higher content of threonine, isoleucine and leucine; *Glycyrrhiza glabra* is very rich in valine and leucine; *Vicia tenuifolia* – very rich in leucine, isoleucine and poor in histidine and phenylalanine.

Table 3

Biochemical composition and nutritional value of the studied species of the family *Fabaceae*

Indices	*Astragalus cicer*	*Coronilla varia*	*Glycyrrhiza glabra*	*Medicago sativa*	*Onobrychis viciifolia*	*Vicia tenuifolia*
Raw protein, % d.m.	16.30	14.72	13.80	17.03	17.44	18.44
Raw fats, % d.m.	1.70	2.81	3.65	2.30	3.39	3.07
Raw cellulose, % d.m.	30.61	35.46	29.40	33.31	33.50	28.50
Nitrogen free extract, % d.m.	43.49	39.74	47.75	39.41	39.43	43.16
Minerals, % d.m. 8.35	7.90	7.27	5.40	8.01	6.24	6.83
Nutritive units/ kg f.m.	0.26	0.20	0.21	0.21	0.23	0.20
Metabolizable energy, MJ/kg	2.93	2.22	2.16	2.28	2.86	2.21
f.m.	225.09	224.20		263.7	274.00	218.0
Dry matter, g/kg f.m.	33.70	26.42	51.00	0	35.80	32.16
Digestible protein, g/kg f.m.	129.62	132.10	27.10	34.50	156.00	160.80
Digestible protein, g/ nutritive unit			129.00	164.29		

Table 4

The content of amino acids in fodder of the studied *Fabaceae* species (g/kg dry matter)

Amino acids	*Astragalus cicer*	*Coronilla varia*	*Glycyrrhiza glabra*	*Medicago sativa*	*Onobrychis viciifolia*	*Vicia tenuifolia*
Asparagine	20.24	18.57	15.52	17.11	17.51	20.71
Threonine	6.04	5.51	5.20	5.64	5.65	6.45
Serine	6.81	6.78	5.50	6.87	6.85	8.94
Glutamine	15.07	14.18	16.72	13.60	13.98	13.94
Proline	10.77	14.80	9.06	9.22	11.54	13.74
Glycine	5.93	8.52	6.76	5.50	5.57	4.70
Alanine	6.78	7.12	5.64	6.74	6.72	4.41
Valine	6.57	4.59	8.40	5.59	6.54	5.48
Methionine	0.88	1.01	0.82	1.39	0.91	1.37
Isoleucine	4.80	3.44	4.57	4.59	4.59	5.19
Leucine	9.83	8.98	12.49	9.13	9.20	11.43
Tyrosine	5.09	4.42	3.24	4.58	4.91	4.02
Phenylalanine	8.78	6.47	5.24	8.50	9.37	5.61
Histidine	6.02	2.39	2.76	3.26	3.71	1.18
Lysine	7.00	5.24	7.62	6.19	7.06	7.67
Arginine	6.07	5.17	4.68	6.55	5.87	6.39
The sum of essential amino acids	49.92	37.63	47.11	44.29	47.03	44.38

Table 5

The content of minerals of the studied species of the family *Fabaceae* per kg dry matter

Minerals	*Astragalus cicer*	*Coronilla varia*	*Glycyrrhiza glabra*	*Medicago sativa*	*Onobrychis viciifolia*	*Vicia tenuifolia*
Calcium, g	13.61	12.90	9.05	16.94	11.20	11.80
Phosphorus, g	5.16	5.67	6.16	4.42	7.53	6.43
Magnesium, g	3.06	2.31	1.08	2.71	3.28	2.27
Potassium, g	13.93	21.45	15.67	15.38	15.17	19.17
Sodium, mg	153.60	52.85	121.41	349.5	366.20	82.16
Iron, mg	190.60	389.8	221.5	250.83	343.20	262.90
Manganese, mg	72.47	63.39	60.21	50.90	91.55	61.34
Zink, mg	68.00	26.96	28.03	22.37	26.15	23.55
Copper, mg	6.41	5.35	11.15	7.00	6.75	5.75
Strontium, mg	39.59	35.41	22.57	49.77	34.53	26.02

Table 6

Gas-producing potential of the fermentable organic matter (FOM) from the studied *Fabaceae* species

Indices	*Astragalus cicer*	*Coronilla varia*	*Glycyrrhiza glabra*	*Medicago sativa*	*Onobrychis viciifolia*	*Vicia tenuifolia*
Ratio carbon/nitrogen	20	22	25	19	19	18
FOM, g/kg VS	672	626	709	642	658	708
Biogas, litre/kg VS	537	501	567	514	526	563
Methane, litre/kg VS	282	263	298	270	276	296
Methane productivity, m^3/ha	2764	2311	3274	2214	2843	2812

Comparing each macro- and micro- element separately with traditional fodder leguminous crops (table 5), we could mention that the content varies from species to species. The dry matter of the studied species *Vicia tenuifolia, Astragalus cicer* and *Coronilla varia* in comparison with *Medicago sativa* is distinguished by low content of calcium (11.80-13.61 g/kg) and higher content of phosphorus (5.16-6.43 g/kg), but inversely proportional to *Onobrychis viciifolia* fodder. *Glycyrrhiza glabra* has an optimal ratio of calcium and phosphorus, contains a high amount of copper, zinc and very low – of magnesium (1.08 g/kg), low – of sodium, iron, manganese and strontium in comparison with *Onobrychis viciifolia.* The fodder of *Coronilla varia* and *Vicia tenuifolia* is characterized by high level of potassium (19.17-21.54 g/kg), but lower – of magnesium (2.27-2.31 g/kg), sodium (52.85-82.16 mg/kg) and copper (5.35-5.75 mg/kg). *Astragalus cicer* fodder contained large amounts of magnesium, manganese, zinc and poor – of iron, in comparison with *Medicago sativa.*

In Canada it was determined that *Coronilla varia* fodder contained: 17.9-18.4 g/kg calcium, 2.2-2.8 g/kg phosphorus, 27.2-31.1 g/kg potassium, 1.7-1.6 g/kg magnesium, 0.15-0.16 g/kg sodium, 8.0-9.3 mg/kg copper, 34-40 mg/kg zinc, 36-40 mg/kg manganese, 169-179 mg/kg iron (Gervais, 2000); in Russia crown vetch forage harvested in the budding period contained 40 g/kg calcium, 8 g/kg phosphorus, 0.6 g/kg magnesium, 2.48 mg/kg copper, 14 mg/kg zinc, 49 mg/kg manganese, 105 mg/kg iron (Kshnikatkina *et al.,* 2005); in Pakistan 22.2 g/kg calcium, 22.4 g/kg potassium, 1.88 g/kg magnesium, 14.46 mg/kg copper, 67.35 mg/kg zinc, 40.37 mg/kg manganese, 482.6 mg/kg iron (ACAR *et al.,* 2001); under the conditions of Kalmykia, Russia, depending on the ecotypes of *Glycyrrhiza glabra*, the biomass contained 9.61-16.30 g/kg calcium, 0.14-0.43 g/kg phosphorus, 5.27-9.05 g/kg magnesium, 3.20-15.25 mg/kg copper, 18.90-50.62 mg/kg zinc, 22.80-104.10 mg/kg manganese and 112-486 mg/kg iron (Alekseeva, 2007).

Biorefining offers a way for combining feed and bioenergy production. The use of forage legumes as biogas substrate contributes to an increase in the potential of bioenergy and can help reduce the greenhouse gas emissions. Through symbiotic nitrogen fixation, they compensate inorganic N fertilizer in conventional farms, if the digestate is applied as a fertilizer to the non-legume crops (Stoddard, 2013; Stinner, 2015; Toderich *et al.*, 2015).

The stability and productivity of anaerobic digestion is mostly influenced by the content of organic matter, biochemical composition, biodegradability and ratio of carbon and nitrogen (C/N). The biomass of the crops investigated in the present study revealed C/N ratios in a wide range, on average 18-25 (table.6). In general, a C/N ratio of 20/1 to 30/1 is regarded as optimal for methanogenesis. Fermentable organic matter (FOM) represents the proportion of organic matter that can be biologically degraded under anaerobic conditions and, thus, can be potentially used in biogas facilities (Weissbach, 2008). The calculated content of fermentable organic matter and the gas-producing potential of investigated perennial forage legumes biomass varied from 626 to 709 g/kg VS or 501- 567 L/kg VS, *Coronilla varia* – lower than *Medicago sativa*, but *Glycyrrhiza glabra, Astragalus cicer* and *Vicia tenuifolia* – exceeding *Onobrychis viciifolia*. The potential methane yield per ha of *Glycyrrhiza glabra, Astragalus cicer* and *Vicia tenuifolia* (first mowing) ranged from 2774 to 3274 m^3/ha, exceeding *Medicago sativa.*

CONCLUSIONS

1. The studied *Fabaceae* species need to be scarified, differ in the rates of growth and development, productivity and chemical composition of the harvested mass, this fact can help provide fresh diversified fodder for livestock during a long period.
2. The species *Coronilla varia* and *Glycyrrhiza glabra* have a productivity of 3.92-4.38 kg/m^2 green mass, at the same level as *Onobrychis viciifolia*, but by 26-31 % higher than *Medicago sativa*.
3. The nutritional and energy value of the studied *Fabaceae* species reached amounts of 0.20-0.26 nutritive units/kg and 2.21-2.93 MJ/kg metabolizable energy, the content of digestible protein in

fodder 129-161 g/nutritive unit and met the zootechnical standards.

4. The species *Astragalus cicer* contained the highest amount of essential amino acids, *Glycyrrhiza glabra* was distinguished by a higher content of lysine, valine, leucine, *Vicia tenuifolia* and *Coronilla varia* – optimal content of methionine, indicates that these crops could be can establish reasonable nutrient levels for livestock feeds, demising used chemical produced amino acids.

5. The species *Astragalus cicer* and *Coronilla varia* could be used for reseeding pastures and could also be used as forage because they don't cause bloating in ruminant animals, during earlier grazing.

6.
The potential methane yield per ha of *Glycyrrhiza glabra, Astragalus cicer* and *Vicia tenuifolia* ranged from 2774 to 3274 m^3/ha, exceeding *Medicago sativa.*

The studied ecotypes of perennial forage legumes can serve as starting material in improving and implementing new varieties of leguminous species in the production of protein rich forage, as well feedstock for biogas production.

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