

BIOLOGICAL PECULIARITIES AND FORAGE VALUE OF THE SPECIES OF THE GENUS *ASTRAGALUS* L. IN THE REPUBLIC OF MOLDOVA

Alexandru TELEUȚĂ, Victor ȚÎȚEI

Botanical Garden (Institute) of the Academy of Sciences of Moldova
18 Padurii str., MD 2002, Chisinau, Republic of Moldova

Corresponding author email: director@gb.asm.md

Abstract

One of the major problems of the revitalization and the development of animal husbandry sector is increasing and diversification of the production of fodder, balanced in terms of quantity and quality throughout the year, according to the physiological requirements of animals. The leguminous plants play an important role in increasing the quality of fodder because they have a significant content of protein, vitamins and calcium raising the nutritional value of the fodder and livestock products. We have studied the biological peculiarities, productivity and nutritional value of fodder leguminous plant species of the collection of nontraditional fodder plants of the Botanical Garden (Institute) of the ASM: *Astragalus galegiformis* L., *Astragalus cicer* L., *Astragalus ponticus* Pall, *Astragalus sulcatus* L. The traditional forage crop alfalfa (*Medicago sativa* L.) served as control variant. It has been established that *Astragalus galegiformis* L. grows and develops more intensively than the other species studied, ensures a higher productivity with an increased fodder quality. The fodder of *Astragalus galegiformis* plants has a high content of essential amino acids, especially methionine and lysine. Due to the productivity and high and stable quality of fodder, use of the plantation for a long period of time, high capacity of fixing atmospheric nitrogen, ensuring of a good harvest for the bees, the species *Astragalus galegiformis* can serve as initial material for enriching the range of forage crops.

Key words: biological peculiarities, fodder leguminous plants, genus *Astragalus*, nutritional value, productivity.

INTRODUCTION

One of the major problems of the revitalization and development of the animal husbandry sector is increasing and diversification of the production of fodder, balanced in terms of quantity and quality throughout the year, according to the physiological requirements of animals. In the world flora, have been identified more than 50 000 species of plants that animals use as food, but, in culture, are used about 150 species. This enormous reserve allows the mobilization of new species, which would extend the range of agricultural crops, increase the productivity and improve the quality of fodder.

It is known that the plants of the family *Fabaceae* Lindl. are characterized by a high content of protein and essential amino acids, but, of the approximately 19 000 species, very few are used as crop plants.

In the context of climate changes and rising oil prices, the plants of the family *Fabaceae* Lindl., are of a particular interest, because, due to the assimilation and storage of nitrogen in the soil (up to 100 kg N/ha per year) they may

contribute to the reduction of the greenhouse gas emissions. This property of the species of the *Fabaceae* family contributes: to the reduction of the use of nitrogen fertilizers, which contain nitrogen protoxide with a heating potential which is 310 times higher than that of carbon dioxide; to a the better conservation of the nutrients by the reduction of the leakage into groundwater of nitrates and phosphates; to the reduction of the soil acidification and to the improvement of its structure (including the increase of the energy efficiency in soil treatment); to the improvement of the resistance to diseases and pests of crop plants in agrocoenoses; to the reduction of the use of herbicides and increase of biodiversity favourable for pollination. The fodder leguminous grasses play an important role in increasing the quality of feed, due to a significant contribution in protein, vitamins and minerals, which raise the nutritional value of the feed and the livestock production (Lüscher et al., 2013). The genus *Astragalus* L. comprises approx. 2,500 species and is the largest genus of angiosperms (Lock and Schrire, 2005). The most species of the genus

Astragalus are perennial and are spread in all the bio-geographical regions and are met more often in the cold, arid and continental zones of the Northern hemisphere and of South America. A lot of them are used as fodder, phyto-ameliorative, melliferous, medicinal or ornamental plants. On the territory of Eurasia, vegetate 849 species of the genus *Astragalus* L., 152 species of which are of interest as fodder plants (Laryn et al., 1951). Cicer milkvetch (*Astragalus cicer* L.), is widely used in Europe (Aniszewski, 2004; Belous et al., 2003) and in America (Davis, 1982; Townsend, 1993; Acharya et al., 2006;), because of their increased capacity to adapt to the soil and environmental conditions, the high ratio "leaf – stem", maintenance for a longer time of the leaves on the stem than alfalfa, clover or sainfoin, which equals to a greater digestibility *in vitro* of the dry matter (Loeppky et al., 1996).

In the spontaneous flora of the Republic of Moldova, there are 16 species (Negru, 2007), from these species, *Astragalus cicer* L. and *Astragalus ponticus* Pall possess a certain forage value. The plants are consumed by all the species of animals directly by grazing and as hay. The green mass of these species, used fresh, do not cause bloat at ruminant animals. The hay has a high content of leaves.

As promising forage species, were identified *Astragalus galegiformis* L. (native to the mountains Kaukaz) and *Astragalus sulcatus* L. (native to Eurasia and found on salty soils), which are studied in several scientific centres in USA, Russia, Ukraine, etc. (Davis, 1982; Ostapko and Shynkarenko, 2003; Belous, 2005; Chybys et al. 2011; Mandaeva, 2011. Voronyn et al. 2013)

It is well known that the productivity of the grasslands from the Republic of Moldova is very low, constituting 300 - 500 kg/ha of hay, and the share of fodder leguminous plants is decreasing. In order to redress the situation regarding the increase of the productivity and the quality of forage, it is necessary to extend the range of fodder leguminous species and to carry out reseeding works. One of the causes of the reduced use of the representatives of the genus *Astragalus* L. as feed for animals is the insufficient knowledge of the biological characteristics of these species, the biochemical

composition of these plants and their forage value. These aspects have determined the choice of the object of study.

MATERIALS AND METHODS

The species of the genus *Astragalus* L.: *Astragalus cicer* L., *Astragalus galegiformis* L., *Astragalus ponticus* Pall., *Astragalus sulcatus* L., which were cultivated in the collection of non-traditional forage plants of the Botanical Garden (Institute) of the ASM, served as object of study. Alfalfa served as control variant. Foundation of experiments was performed with previously scarified seeds on chernozem usual in spring when the soil had reached the physical maturity. The seeds were planted at a depth of 1.5-2.0 cm, with soil compaction before and after sowing. The evidence area of the plot constituted 10 m². The number of repetitions - 4. The scientific researches on growth and development, productivity and nutritional value of the plants were carried out according to the methodical indications (Novosiolov et al., 1983; Ivanov, 1985; Ermakov et al., 1987).

RESULTS AND DISCUSSIONS

As a result of the performed researches, it has been established that, in order to germinate abundantly, the seeds of the studied species of genus *Astragalus* L. need to be scarified. In the first year of vegetation, these species, in comparison with alfalfa, have a slow growth and development, reaching only the step of forming of the stem with leaves. *Astragalus cicer* L. reaches the flowering stage, and reaches a height of 55.0 cm.

In the following years, the species of genus *Astragalus* L. beginning their vegetation 2-5 days later than alfalfa. It has been found that *Astragalus galegiformis* L. has the most delayed beginning of the vegetation, but this species has a more rapid growth and development. After 20 days from the beginning of vegetation, the plant reaches 61.4 cm high versus 27.2 to 39.6 cm at the other species (Table 1). This rhythm is maintained until the flowering, when the plants reach a height of 191.4 cm and from 64.3 to 103.8 cm respectively at the other species genus

Astragalus L. (Figure 1). The flowering stage of *Astragalus galegiformis* L. begins 12 days earlier in comparison with alfalfa. A slower



Figure 1. General aspect of the *Astragalus galegiformis* L. in the Botanical Garden collection, 2013

development have the plants of *Astragalus cicer* L., which bloom 17 days later than alfalfa and 29 days later than the plants of *Astragalus galegiformis* L. The period of seed formation and ripening at the studied species of *Astragalus ponticus* Pall. and *Astragalus galegiformis* L. have a relatively short period of seed formation and ripening (with 22-28 days earlier than alfalfa). Analyzing the seed productivity, we can mention that the studied species of genus *Astragalus* L. have a higher seed yield in comparison with alfalfa. The plants of *Astragalus galegiformis* L. forms 60.4 g/m² or 7000 seeds/m², while the plants of *Astragalus sulcatus* L. formed 52.1 g/m² and the highest number of seeds - about 40 000 seeds/m².

The species of genus *Astragalus* L. have a different rate of accumulation of the aerial phytomass during the vegetation and content of dry matter. So, the plants of *Astragalus galegiformis* L. have the highest yield of natural fodder (6.42 kg/m²) and the plants of *Astragalus ponticus* Pall. – the lowest (1.48 kg/m²).

A higher dry matter content in the natural fodder is observed at the species *Astragalus sulcatus* L. and *Astragalus galegiformis* L.

Table 1. Biological peculiarities and fresh mass production of the species of the genus *Astragalus* L.

Indicators	<i>Medicago sativa</i> L. (control)	<i>Astragalus cicer</i> L.	<i>Astragalus galegiformis</i> L.	<i>Astragalus ponticus</i> Pall.	<i>Astragalus sulcatus</i> L.
The period, days from the beginning of vegetation up to:					
- budding	70	79	61	66	73
- flowering	82	99	70	77	82
- seed ripening	143	145	121	117	145
Plant height, cm					
- at 20 days of vegetation	38.1	39.6	61.4	27.2	32.3
- at flowering	83.2	103.8	191.4	76.0	64.3
The yield:					
- fresh mass, kg/m ²	3.11	3.50	6.42	1.48	2.67
dry matter, kg/m ²	0.82	0.98	2.05	0.40	0.94
Seed production, g/m ²	27.14	34.3	60.40	40.90	52.1
The weight of 1000 seeds, g	2.67	3.10	8.66	8.44	1.31

The animal body, in order to maintain its vital functions and to give different production, needs permanently exogenous nutrients. Proteins are very important nutrients which provide assimilable nitrogen for the body. Analyzing the biochemical composition of the dry matter, from the plants of the genus

Astragalus L., (Table 2) we find that *Astragalus ponticus* Pall. is distinguished by a very high content of raw protein (23.40%). *Astragalus galegiformis* L. has the same amount of raw protein as alfalfa and the plants of *Astragalus sulcatus* L. have the lowest index of this component (14.60%). In the conditions

of Eastern Ukraine, it has been found a high content (25.0%) of raw protein at *Astragalus galegiformis* L. (Ostapko, Shynkarenko 2003). The forage of *Astragalus galegiformis* L. contains a high amount of fats (3.21%) and the forage of *Astragalus cicer* L. – of nitrogen-free extractive substances (56.48%). At all the studied species of the genus *Astragalus*, a high content of cellulose has been revealed - from 30.61 to 35.40%; *Astragalus galegiformis* L. has the highest index. We can mention that the natural forage of the plants of the genus *Astragalus* has a nutritional value of 0.21 - 0.27 nutritive units, at the species *Astragalus galegiformis* L., *Astragalus sulcatus* L. and *Astragalus cicer* L. it is superior to alfalfa. Regarding the amount of metabolizable energy for cattle, we find that the forage of the species of genus *Astragalus* L. exceed the forage of alfalfa. The natural forage of the species of genus *Astragalus* L. contains a normal amount

of protein which corresponds to the zootechnical standards, so, to a nutritional unit, correspond 129.62-225.09 grams of digestible protein and the highest content is found in the forage of *Astragalus ponticus* Pall. – 225.09 grams, that is, with 37% more in comparison with alfalfa.

The presence of minerals in animal nutrition is indispensable for their growth and health, because they are essential components of all tissues and organs that maintain osmotic pressure at a constant level, participate in the regulation of acid-base balance, activate a number of enzymes, moderate the neuromuscular activity, prevent the emergence and development of diseases of animals (Suttle, 2010). The plants of *Astragalus sulcatus* L. have a high content of calcium (5.06 g/kg), and the plants of *Astragalus ponticus* Pall. – a high content of phosphorus (1.23 g/kg) of natural forage.

Table 2. Biochemical composition of the dry matter and nutritional value of the natural forage of the genus *Astragalus* L.

Indicators	<i>Medicago sativa</i> L. (control)	<i>Astragalus cicer</i> L.	<i>Astragalus galegiformis</i> L.	<i>Astragalus ponticus</i> Pall.	<i>Astragalus sulcatus</i> L.
Biochemical composition of the dry matter:					
raw protein, %	17.03	16.30	16.63	23.40	14.60
raw fats, %	2.30	1.70	3.21	2.75	2.76
raw cellulose, %	33.31	30.61	35.40	31.90	33.10
nitrogen free extractive substances, %	39.41	56.48	38.32	32.35	40.74
mineral substances, %	8.01	7.91	6.46	9.60	8.80
1 kg of natural forage contains:					
nutritive units	0.21	0.26	0.27	0.21	0.27
metabolizable energy for cattle, MJ/kg	2.28	2.93	3.26	2.43	3.24
dry matter, g	263.70	280.00	320.00	272.40	354.00
raw protein, g	46.10	45.54	53.20	63.84	51.87
digestible protein, g	34.50	33.70	39.37	47.27	38.38
raw fats, g	6.20	4.84	10.18	7.90	9.83
raw cellulose, g	80.30	85.82	113.38	86.90	111.75
nitrogen free extractive substances, g	99.30	121.62	122.60	87.61	149.25
mineral substances, g	21.70	22.18	20.64	26.15	31.30
calcium, g	4.61	4.27	2.78	2.34	5.06
phosphorus, g	0.54	0.33	0.44	1.23	0.87
digestible protein, g/ nutritive unit	164.29	129.62	145.81	225.09	142.15

The quality of the protein is determined by the content in certain amino acids, which ensure the biological value of the forage. The content of essential amino acids, (Table 3) ranges from 2.507 mg/100 g dry matter (*Astragalus sulcatus* L.) to 4.524 mg/100 g dry matter (*Astragalus galegiformis* L.). This index is of

4.103 mg/100 mg dry matter at the alfalfa control. Analyzing the content of each essential amino acid in the species mentioned above, we have found out that *Astragalus ponticus* Pall. has the highest content of threonine (0.678 mg/100 g dry matter.), exceeding alfalfa with 20%.

The valine content at the species mentioned above has similar values, being about 16% higher than alfalfa. The plants of the species of the genus *Astragalus* L. have a lower content of methionine (from 0.028 at *Astragalus sulcatus* L. to 0.098 mg/100 mg dry matter at *Astragalus galegiformis* L.), which also

reduces the biological value of the protein of these species. The plants of *Astragalus ponticus* Pall. are characterized by a high content of lysine and isoleucine, while the plants of *Astragalus galegiformis* L. – of leucine and phenylalanine.

Table 3. The content of amino acids in the natural forage (mg/100 mg dry matter) of the genus *Astragalus* L.

Amino acids	<i>Medicago sativa</i> L. (control)	<i>Astragalus cicer</i> L.	<i>Astragalus galegiformis</i> L.	<i>Astragalus ponticus</i> Pall.	<i>Astragalus sulcatus</i> L.
asparagine	1.711	2.024	2.039	3.110	0.936
threonine	0.564	0.604	0.579	0.678	0.340
serine	0.687	0.681	0.698	0.767	0.407
glutamine	1.360	1.507	1.518	1.953	0.878
proline	0.922	1.077	1.063	0.765	0.723
glycine	0.550	0.593	0.574	0.676	0.360
alanine	0.674	0.678	0.728	0.570	0.408
valine	0.559	0.657	0.650	0.649	0.344
methionine	0.139	0.088	0.096	0.058	0.028
isoleucine	0.459	0.480	0.498	0.510	0.262
leucine	0.913	0.983	1.004	0.914	0.544
tyrosine	0.458	0.509	0.484	0.458	0.314
phenylalanine	0.850	0.878	0.971	0.794	0.560
histidine	0.326	0.602	0.523	0.411	0.251
lysine	0.619	0.700	0.726	0.760	0.429
arginine	0.655	0.607	0.627	0.306	0.351
total essential amino acids	4.103	4.390	4.524	4.363	2.507
% of essential amino acids from the total amino acids	35.85	34.65	35.40	32.61	35.14

CONCLUSIONS

Both the species of the spontaneous flora of the Republic of Moldova (*Astragalus cicer* L., *Astragalus ponticus* Pall.) and those introduced from different floristic regions (*Astragalus galegiformis* L., *Astragalus sulcatus* L.) pass consecutively all the ontogenetic stages of development ensuring a satisfactory seed production for the necessities of the establishment of plantations.

The studied plant species of the genus *Astragalus* L. (*Astragalus cicer* L., *Astragalus galegiformis* L., *Astragalus ponticus* Pall., *Astragalus sulcatus* L.) grow and develop quite rapidly, and at these indices they are not inferior to the control (*Medicago sativa* L.). The harvest of fresh mass has reached maximum levels at *Astragalus galegiformis* L. and constitutes 6.42 kg/m² or 2.05 kg/m² dry matter.

The fodder obtained from the studied species is valuable: rich in protein, essential amino acids, fats and a high level of metabolizable energy

for cattle, exceeding the quality of the fodder from *Medicago sativa* L.

The fodder obtained from the studied species of the genus *Astragalus* L. contains an amount of protein which corresponds to the zootechnical standards.

REFERENCES

- Acharya S.N., Kastelic J.P., Beauchemin K.A., Messenger D.F., 2006. A review of research progress on cicer milkvetch (*Astragalus cicer* L.). Canadian Journal of Plant Science, 86, p. 49-62.
- Aniszewski T., 2004. Legume species that have breeding potential for NE Europe. Science of Legumes, 6, p. 256-265.
- Belous V.N., 2005. Vydy roda *Astragalus* L. y ykh roli v rastytelinom pokrove Predkavkaziy *Astragalus* Avtoref. dys. kand. byol. nauk. Stavropoli. (in Russian) Belous V.N., Samsonova O.E., Avdeeva O. A., 2003. Astrahaly Stavropoliya - perspektivnye kormovye y lekarstvennye kulitury. Vestnyk Rosselikhhozademyy, 5, p. 35-37 (in Russian).
- Chybys S.P., Stepanov A.F., Chybys V.V., 2011. Pytatelnaya tsennosti astrahala halehovydnoho.

- Vestnyk Altayskoho hosudarstvennoho ahramoho unyversyteta, 1, p. 65-68 (in Russian).
- Davis A.M., 1982. Crude protein, crude fiber, tannin and oxalate concentrations of 33 *Astragalus* species. *Journal of range management*, 35(1), p. 32-34.
- Ermakov A.Y., Arasymovych V.V., Yarosh N.P., Peruansky YU.V., Lukovnykova H.A., Ykonnykova M.Y., 1987. *Metody byokhymycheskoho yssledovannya rastenyy. Ahropromyzdat, Leninigrad, (in Russian).*
- Ivanov A.I., 1985. *Izuchenie koleksii mnogoletnih kormovyh rastenii (metodicheskie ukazania). VIR, Leninigrad (in Russian).*
- Laryn Y.V., 1951. *Astragalus* L.- Astrahal. In: Laryn Y.V. (Red.) *Kormovye rastenyya senokosov y pastbyshch SSSR.. T.2. Dvudolinye (khlorantovye-bobovye). Selikhoziyz, Moskva, p. 687-722.*
- Lock J.M., and Schrire B.D., 2005. Galegeae. In: Lewis G., Schrire B., Mackinder B., Lock J. M. (Eds.). *Legumes of the World. Surrey, Richmond, p. 475-487.*
- Loeppky H.A., Bittman S., Hiltz M.R., Frick B., 1996. Seasonal changes in yield and nutritional quality of cicer milkvetch and alfalfa in northeastern Saskatchewan. *Canadian Journal of Plant Science*. 76, p. 441-446.
- Lüscher A., Mueller-Harvey I., Soussana J.F., Rees R.M., Peyraud J.L., 2013. Potential of legume-based grassland-livestock systems in Europe. *Grassland Science in Europe*, 18, p. 3-29.
- Mandaeva S.A., 2011. Osobennosti rosta y razvytiya nekotorykh vydiv roda *Astragalus* L. pry yntroduktsyy v uslovyakh Respublyky Altay. In: Aktualinye problemy seliskoho khozyaystva hornykh terrytory. RYO HAHU, Horno-Altaysk, p. 236-239 (in Russian).
- Maslova N.V., 1993. Astrahal borozdchatyy. In: Byolohyya y ékolohyya osnovnykh vydiv poleznykh rastenyy na Yuzhnom Urale. Nauka, Moskva, p. 127-130 (in Russian).
- Negru A., 2007. *Determinator de plante din flora Republicii Moldova. Universul, Chişinău.*
- Novoselov I.K., Kharikov G.D., Shevtsova N.S., 1983. Metodicheskie ukazania po provedeniu polevyh opytov s kormovymi kulturami. VNII kormov, Moskva (in Russian).
- Ostapko I.M., Shynkarenko O.V., 2003. Pozhyvna tsinnisti novykh kormovykh roslyn z rodyn Fabaceae Lindl. ta Asteraceae Dumort. v umovakh Donbasu. *Naukovi osnovy zberezhennya biotekhnoloyi riznomanitnosti*, 5, p. 122-127 (in Ukrainian).
- Suttle N.F., 2010. *Mineral nutrition of livestock. 4th Revised edition. CABI Publishing, United Kingdom.*
- Townsend C.E., 1993. Breeding, physiology, culture and utilization of cicer milkvetch (*Astragalus cicer* L.) *Advances in Agronomy*, 49, p. 253-308.
- Voronyn A.A., Safonova O.N., Voronyna V.S., 2013. Ékolohycheskye aspekty yntroduktsyy vydiv roda *Astragalus* v uslovyakh Tsentralinoho Chernozemiya. *Mezhdunarodnyy nauchno-yssledovateliskyy zhurnal*, 7 (14), 1, p. 72-73 (in Russian).