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THE PERSPECTIVE OF CULTIVATION AND UTILIZATION OF THE NEW LEGUMINOUS GRASSES SPECIES IN MOLDOVA

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Abstract

The development and modernization of our country's agriculture is related to the revitalization of the animal breeding sector along with the implementation of new genotypes of animals and diversification of fodder production, balanced in terms of quantity and quality throughout the year, suitable for the physiological requirements of animals, and qualitative products as required in the market. Scientific research conducted in the Botanical Garden (Institute) of the ASM over decades was aimed at mobilization, improvement and implementation of new non-traditional plant species that use efficiently photosynthetic active radiation and land resources to obtain fodder with a high level of vegetable protein, the fodder leguminous grasses (fam. Fabaceae Lindl.) play an important role.
We have studied the biological peculiarities, productivity, chemical composition and nutritional value of new fodder leguminous plant species Astragalus galegiformis, Onobrychis inermis and Medicago tianschanica of the collection of non-traditional fodder plants of the Botanical Garden (Institute) of the ASM, the traditional forage crop alfalfa served as control variant. The nutritional value of fresh mass accounts: the Astragalus galegiformis - 0.27 nutritive units, 3.26 MJ metabolizable energy and 146g digestible protein/nutritive unit; Onobrychis inermis - 0.25 nutritive units, 2.56 MJ metabolizable energy and 154 g digestible protein/nutritive unit; Medicago tianschanica - 0.24 nutritive units, 2.86 MJ metabolizable energy and 173 g digestible protein/nutritive unit and alfalfa - 0.21 nutritive units, 2.28 MJ metabolizable energy and 164 g digestible protein/nutritive unit.
Due to the productivity and high and stable quality of fodder, use of the plantation for a long period of time, capacity of fixing atmospheric nitrogen, the new fodder leguminous species Astragalus galegiformis, Onobrychis inermis and Medicago tianschanica can serve as initial material for enriching the range of forage crops.

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

INTRODUCTION

The development and modernization of our country's agriculture is related to the revitalization of the animal breeding sector along with the implementation of new genotypes of animals and diversification of fodder production, balanced in terms of quantity and quality throughout the year, suitable for the physiological requirements of animals, and qualitative products as required in the market. The increase of fodder production in the context of climate change and increasing prices for energy resources will be based on more rational use of natural pastures and identification of new species that will expand the range of crops.
Recent literature has shown that systems based on forage legumes have the ability to positively impact on the environment (Lüscher et al., 2013). Forage legumes have been shown to increase efficiency of nitrogen use and decrease nitrogen transit from the soil. Moreover, global warming is projected to increase the yield of forage legumes, relative to grasses. Legumes are able to convert inorganic gaseous atmospheric nitrogen into bioavailable nitrogen compounds (ammonium) thanks to a symbiotic association with bacteria (the symbiont species of bacteria can be from several genera). Ammonium is then directly usable by the plants to produce proteins (Duke, 1981; Frame et al., 1998). A lot of them are used as fertilization of the degraded soil, honey, medicinal and ornamental plants.
Problem of forage with high protein content is still an actual one in livestock farming. Traditional legume crops, such as alfalfa and clover tend to exhaust with the lapse of time, and after 3-4 years

their productivity gets considerably lower. From the perspective of livestock nutrition, recent studies have demonstrated that forage legumes with moderate levels of secondary compounds, such as condensed tannins and flavonoids, are beneficial. In particular, some species of genus *Astragalus L.* and *Onobrychis* Mill. increased the efficiency of nitrogen utilisation in the digestive tract, reduced bloat hazard and decreased parasitism (Goplen et al. 1980; Lees, 1992).

For over six decades of scientific research on mobilization of plant resources, the collection of non-traditional fodder plants of the Botanical Garden (Institute) of the ASM was founded. It contains over 300 species and cultivars, including 70 leguminous fodder grasses, mobilized from different areas of Central and South Europe, Caucasus, Asia and America (Teleuță, 2010).

The following species have been identified as promising leguminous fodder crops:

Onobrychis inermis Stev. (syn. *Onobrychis sativa* Lam. var. *subinermis* Boiss.) - unarmed sainfoin, a Crimean and Caucasian endemic perennial herbaceous plant. The species is mainly distributed in the Caucasus. Stems 30-60 cm tall, subglabrous, branched in upper part. Stipules fused, ovate, ciliate. Lower leaves 6-8-paired, with oblong-elliptic leaflets; upper leaves 4-5-paired with linear-oblong leaflets. Racemes twice as long as leaves. Calyx 5-6 mm long, its teeth linear-subulate. Corolla 7-9 mm, pink. Pod 4-6 mm long, semicircular, without teeth. Flowering - in July, fructification - in August. Self-incompatible, cross-pollinated plant. 2n=16. (Dzyubenko and Dzyubenko, 2009**)**

Medicago tianschanica Vass. (syn. *Medicago* lavrenkoi *Vass*.; *Medicago ochroleuca* Kult.; *Medicago tianschanica* var. *lavrenko*i (Vass.) Khassan.; *Medicago tianschanica* var. *ochroleuca* (Kult.) Khassan.) Tian-Shan alfalfa is perennial herbaceous plant native to central Asia. Stems 40 to 120 cm high, numerous, branched, erect, more rarely ascending, together with the leaves sometimes appressed-pubescent. Stipules lanceolate in the free portion, with three to five acute teeth along the margin. Leaflets green, usually 15 to 30 mm. long, 3 to 4 (or up to 9) mm wide, elongate-obovate or oblanceolate, toothed in the upper portion. Inflorescence ovoid, dense, many-flowered. Bracteoles subulate, equalling or slightly shorter than the bracts. Calyx on the upper half of the tube sometimes hirsute, with subulate teeth longer than the tube. Flowers of various colours, white, yellow, lavender, pink, blue, green, purple, magenta, etc., but not red. Pod forming one to one-and-a-half twists, 4 to 5 mm in diameter, finely appressed-pubescent. 2n=32. (Bolton, 1962)

Astragalus galegiformis L. (syn. *Tragacantha galegiformis* L.) is native to Caucasus. The species is herbaceous perennial, up to 1.2-2.5 m in height. Leaves up to 20 cm long, with 13-16 pairs of leaflets, oblong-ovate, 12-25 mm long, rounded. Inflorescence up to 30 cm long brush with flowers. Calyx 5-6 mm long, weak and short with linear-subulate teeth. Corolla yellow or yellowish-white flag, 14 to 15 mm in length. Pods 10-16 mm long, pointed at both ends, glabrous, curved, 4-6 seeds. 2n = 16 (Sytin, 2009).

MATERIALS AND METHODS

The new fodder leguminous plant species *Astragalus galegiformis*, *Onobrychis inermis* and *Medicago tianschanica* of the collection of non-traditional fodder plants of the Botanical Garden (Institute) of the ASM served as object of study, the traditional forage crop alfalfa (*Medicago sativa* L.) served as control variant. The experiments started in spring; they were performed on chernozem, when the soil had reached physical readiness. The seeds were sown at a depth of 1.5-2.0 cm, with soil compaction before and after sowing. The plot area was of 10 m^2, 4 repetitions were done. The scientific research on growth and development, productivity and nutritional value of plants was performed according to methodical indications (Novosiolov et al. 1983; Ermakov et al., 1987).

RESULTS AND DISCUSSIONS

As a result of phenological observations, it has been found that in the first year of vegetation the examined species of forage legumes differ essentially by growth rate and development. It has been established that at the species *Medicago tianschanica* seedlings appear evenly on the soil surface after 7 days from sowing, four days earlier compared to the control *Medicago sativa*, at the species *Onobrychis inermis* seedlings appear after 17 days, and *Astragalus galegiformis* is characterized by the latest emergence of plantlets - after 24 days from sowing, or 13 days later than the control. The aerial part of

Astragalus galegiformis grows and develops slowly, reaching by the end of growing season only the phase when the stem with leaves are formed, but the plant develops a strong tap root system. The species *Medicago tianschanica, Onobrychis inermis* as well as *Medicago sativa* go through all ontogenetic stages. The *Onobrychis inermis* plants are characterized by a faster development, formation and ripening of seeds occurring 11 days earlier as compared with *Medicago sativa*, and 22 days earlier as compared with *Medicago tianschanica.*

In the following years, the studied species of forage legumes resume their vegetation in spring, when temperatures are above 6 ºC. It has been established that the species *Onobrychis inermis* resumes vegetation 5 days earlier than *Medicago sativa* and *Medicago tianschanica*, and *Astragalus galegiformis* is characterized by a later start of vegetation season, but this species grows and develops faster during the whole growing season. So, at the end of April (Table 1) the height of *Astragalus galegiformis* plants exceeds 61 cm, compared to 40 cm at the other studied species. This fast growth rate is maintained until flowering, when *Astragalus galegiformis* plants reach a height of 191.4 cm as compared to 83.2 cm - of *Medicago sativa* plants. During this period *Onobrychis inermis* plants are 108.3 cm tall.

It has been established that the flowering period of *Astragalus galegiformis* occurs 12 days earlier than *Medicago sativa* and - of *Onobrychis inermis* - 6 days earlier. *Medicago tianschanica* plants blossom 18 days later than those of *Medicago sativa* and 30 days later than *Astragalus galegiformis*.

The studied species require a different period of time from the beginning of vegetation until the full seed ripening. Thus, for the species *Onobrychis inermis,* this period of time is 117 days, for *Astragalus galegiformis* - 121 days and for *Medicago tianschanica* - 161 days. It also can be mentioned that the *Medicago tianschanica* plants need a longer period of time until flowering in comparison with the control, however, from flowering until full seed ripening any differences weren't found.

Analyzing the seed productivity, we can mention that the studied new species of forage legumes have a higher yield of seeds than *Medicago sativa*. The *Onobrychis inermis* and *Astragalus galegiformis* plants are distinguished by high seed productivity with a yield of 71.44 g/m^2 and 60.40 g/m^2, respectively. *Medicago tianschanica* plants have a higher seed productivity compared to the control and develop the highest number of seeds - about 14000 seeds/m^2.

As previously mentioned, the studied species of forage legumes have a different rate of growth and development during the growing season, which influence the natural forage harvest and dry matter accumulation. So, a higher yield of natural forage and dry matter is obtained from *Astragalus galegiformis* (6.42 kg/m^2 or 2.05 kg/m^2) and *Onobrychis inermis* (4.25 kg/m^2 or 1.25 kg/m^2), which by far exceeds the control.

It is known that animals eat leaves firstly due to the increased nutrient content and the proportion leaves/stem influences the forage value. The forage of *Astragalus galegiformis* and *Medicago tianschanica* is characterized by a higher content of leaves and dry matter in comparison with the control *Medicago sativa.*

Table 1. Agro-biological peculiarities of new species of fodder legumes in the 2nd year of vegetation

Indices	*Medicago sativa* L. (control)	*Astragalus galegiformis* L.	*Onobrychis inermis* Stev.	*Medicago tianschanica* Vass.
Period, days since the beginning of vegetation, until:				
- budding				
- flowering	70	61	66	82
- seed ripening	82	70	76	100
Plant height, cm	143	121	117	161
- at the end of April				
- during flowering	38.1	61.4	40.3	39.8
Annual yield:	83.2	191.4	108.3	81.5
- natural forage, kg/m^2				
- dry matter, kg/m^2	3.11	6.42	5.17	3.36
- leaf content in the forage,%	0.82	2.05	1.52	1.03
Seed production, g/m^2	35.4	48.0	35.8	44.5
Weight of 1000 seeds, g	27.14	60.40	71.44	32.10
	2.67	8.66	8.44	2.31

Animals need for growth, development, reproduction and realization of some products, numerous nutrients they receive from feed. Proteins are the most important and largest group of natural macromolecular compounds essential for life, which provide a source of assimilable nitrogen for the body and play a crucial role in exploitation of the genetic production potential. The natural forage of the studied species (Table 2) is characterized by a high content of raw protein (53.20-56.05 g/kg) as compared with *Medicago sativa* (46.10 g/kg); the forage of *Onobrychis inermis* has the highest protein content.

The higher protein content of the studied species in comparison with *Medicago sativa* is mentioned in researches carried out in several scientific centers from abroad. Thus, the protein content in proportion to dry matter of *Astragalus galegiformis* constitutes 18.77% under the conditions of Russia (Borayeva and Bekuzarova, 2010; Chibis et al., 2011), in Ukraine - 25.00% (Ostapko and Shynkarenko 2003). The raw protein content of the *Medicago tianschanica* plants in the region Penza, Russia reaches 20.88% (Kshnikatkina et al., 2005).

It is known that fats are the main source of energy for the animal organism and are necessary for the normal course of vital processes and transportation of soluble vitamins in fatty acids, contribute to the accumulation of fat in milk. The natural forage of *Onobrychis inermis* and *Astragalus galegiformis* contains a high amount of fat exceeding the control by approximately 64-69%, at *Medicago tianschanica* it is by 10% lower.

In all studied species, it was found a higher cellulose content in the natural forage in comparison with *Medicago sativa*, the highest being in *Astragalus galegiformis* (113.38 g/kg) and *Medicago tianschanica* (97.32 g/kg). 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 nitrate content.

The nitrogen-free extractive substances (NFE), along with fats provide the necessary energy for vital processes of animals, contributing to the formation and storage of fats. The content of nitrogen-free extractive substances is by 18-23% higher in the new species of forage legumes, which influences positively the possibility of the natural forage to provide energy.

The vegetal forage contains minerals in variable quantities regarding the type of the elements and their proportion to other chemical components. Minerals are essential components of all tissues and organs that maintain a constant osmotic pressure, participate in regulation of acid-base balance, activate a number of enzymes, moderate neuromuscular activities and prevent the emergence and development of animal diseases. The presence of minerals in animal feed is indispensable for growth and health. The forage of *Medicago tianschanica* and *Onobrychis inermis* is characterized by a high content of minerals and the forage of *Astragalus galegiformis* - by a lower one in comparison with the control.

Calcium is the mineral element that is found in the highest amount in the animal organism, it is a structural component of bones and teeth; it plays an essential role in blood coagulation, muscle contraction, activity of enzyme systems, at cellular level. The normal assimilation of calcium by organism depends also on the quantity of phosphor in the feed. Phosphor plays multiple roles in the vital processes in the body, being a constituent of nucleic acids it participates in protein synthesis, cell proliferation and transmission of hereditary characters; is a component of ATP (adenosine triphosphate) the main deposit of energy required by muscular activity, nerve activity, vital processes of the body; as phospholipids, it enters the structure of cells and cell membranes regulating the transportation of solutions through them; participates in the metabolization of glucides, fatty acids and amino acids etc. (Suttle, 2010).

A high content of calcium (5.26 g/kg) and phosphorous (0.58 g/kg) was found in the forage of *Medicago tianschanica*. The forage of *Astragalus galegiformis* has a low content of calcium and that of *Onobrychis inermis* contains these mineral elements approximately in the same amount as the control.

The nutritional and energy value is determined by the content and biochemical composition of the organic substances from the feed that influence the health and productivity of

animals. We can mention that the natural forage of the new species of forage legumes reaches 0.24-0.27 nutritive units and 2.76-3.26 MJ/kg metabolizable energy, by far exceeding the control *Medicago sativa*. The amount of digestible protein in a nutritive unit 145.81-173.29 grams) meets the zootechnical standards.

Thus, in the conditions of the Republic of Moldova, the productive potential of *Astragalus galegiformis* plants reaches 17.3 thousand nutritive units/ha and 2.5 thousand kg/ha of digestible protein; *Onobrychis inermis* - 12.9 thousand nutritive units/ha and 2.2 thousand kg/ha of digestible protein, respectively; *Medicago tianschanica* - 8.1 thousand nutritive units/ha and 1.4 thousand kg/ha of digestible protein, respectively, and *Medicago sativa* - 6.6 thousand nutritive units/ha and 1.1 thousand kg/ha of digestible protein.

Table 2. Biochemical composition and nutritive value of the natural forage of leguminous plants

	Medicago sativa L. (control)	*Astragalus galegiformis* L.	*Onobrychis inermis* Stev	*Medicago tianschanica* Vass.
1 kg of natural forage contains:				
dry matter, g	263.70	320.00	295.00	307.00
raw protein, g	46.10	53.20	56.05	55.45
digestible protein, g	34.50	39.37	42.04	41.59
raw fat, g	6.20	10.18	10.50	5.53
raw cellulose, g	80.30	113.38	87.61	97.32
nitrogen-free extractive substances, g	99.30	122.60	117.54	122.73
minerals, g	21.70	20. 64	23.30	25.97
calcium, g	4.61	2.78	4.34	5.25
phosphor, g	0.54	0.44	0.56	0.58
nutritive units	0.21	0.27	0.25	0.24
metabolizable energy for cattle, MJ/kg	2.28	3.26	2.76	2.86
Digestible protein, *grams/nutritive unit*	164.29	145. 81	169.16	173.29

The amino acid composition is the most important factor in defining food protein quality, followed by the digestibility of the protein and the bioavailability of its amino acids. The protein quality is determined by the content of certain amino acids, which ensure biological value of the feed. Analyzing the amino acid content (Table 3), we have found out that the forage of the studied species contains a high amount of aspargine, threonine, serine, glutamine, proline, glycine, alanine, leucine, tyrosine, histidine, lysine and a small amount of methionine as compared to *Medicago sativa*.

Analysing the amino acid content, we have found out that the forage of *Medicago tianschanica* and *Onobrychis inermis* has the highest content of threonine and lysine and a very low content of valine, methionine, isoleucine and phenylalanine.

Table 3. Amino acid content of the natural forage (mg/100 g dry matter) of leguminous plants

	Medicago sativa L. (control)	*Astragalus galegiformis* L.	*Onobrychis inermis* Stev.	*Medicago tianschanica* Vass.
asparagine	1.711	2.039	2.498	2.714
threonine	0.564	0.579	0.596	0.749
serine	0.687	0.698	0.911	1.073
glutamine	1.360	1.518	1.942	1.902
proline	0.922	1.063	2.073	0.941
glycine	0.550	0.574	0.619	0.565
alanine	0.674	0.728	1.078	0.881
valine	0.559	0.650	0.276	0.228
methionine	0.139	0.096	0.054	0.090
isoleucine	0.459	0.498	0.285	0.249
leucine	0.913	1.004	1.253	0.988
tyrosine	0.458	0.484	0.705	0.490
phenylalanine	0.850	0.971	0.796	0.603
histidine	0.326	0.523	0.386	0.337
lysine	0.619	0.726	0.796	0.792
arginine	0.655	0.627	0.733	0.545

CONCLUSIONS

The species *Astragalus galegiformis, Onobrychis inermis* reach the natural forage harvesting period at the first mowing 10 days earlier, and *Medicago tianschanica* - 10 days later as compared to *Medicago sativa*, a fact which will help ensure a regular provision with natural forage.

The productive potential of *Astragalus galegiformis* plants is about 17300 nutritive units/ha and 2500 kg/ha of digestible protein; *Onobrychis inermis* - 12900 nutritive units/ha and 2200 kg/ha of digestible protein; *Medicago tianschanica* - 8100 nutritive units/ha and 14 000 kg/ha of digestible protein in comparison with 6600 units/ha and 1100 kg/ha of digestible protein at *Medicago sativa*.

These species can serve as starting material in crop improvement and implementation of new leguminous species for fodder production.

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