SOME BIOLOGICAL PECULIARITIES AND BIOCHEMICAL COMPOSITION OF THE SPECIES *Lupinus perennis* L. IN THE REPUBLIC OF MOLDOVA

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Abstract

Forage legumes have been suggested as important components of low input, sustainable systems for livestock production and are the basis of organic agriculture. We have studied some biological peculiarities, chemical composition and nutritional value of the species *Lupinus perennis* L., native to North America, which was cultivated in the experimental land of the Botanical Garden (Institute) of the ASM, the traditional forage crop alfalfa *Medicago sativa* L. and *Onobrychis viciifolia Scop.* served as control variant. It has been established that the species *L. perennis* in the first year of vegetation has a slow growth and development, develops only rosette-like radical leaves, but in the following years, it grows and develops more intensively, this species starts flowering 15-29 days earlier than the traditional forage crops. Chemical composition of dry substances of green mass of the species *Lupinus perennis* is represented as follows: 14.42% raw protein, 3.91 % raw fats, 25.44% raw cellulose, 10.56 % minerals, 45.67% nitrogen free extractive substances, but *Medicago sativa* – 16.16 % raw protein, 1.88 % raw fats, 34.74 % raw cellulose, 10.00 % minerals, 37.22 % nitrogen free extractive substances, respectively, and *Onobrychis viciifolia* – 15.88% raw protein, 3.57 % raw fats, 34.95% raw cellulose, 8.92 % minerals, 36.74% nitrogen free extractive substances. The fodder of *Lupinus perennis* is distinguished by a high content of alanine, histidine, tyrosine, arginine. Due to the earlier first harvest time, stable productivity and quality of fodder, the use of the plantation of the species *Lupinus perennis* for a long period of time can serve as initial breeding material for enriching the range of forage crops, recovery of degraded and polluted lands.

Key words: *Lupinus perennis,* biological peculiarities, chemical composition, nutritional value

The world population is projected to reach 9 billion people by 2050, with marked variations between developed and developing regions. Food supply is an acute problem of mankind in the context of climate change, degradation and reduction of agricultural lands.

Livestock production is an important source of protein and other nutrients for human diet.

The problem of forage with high protein content is still an actual one in livestock farming. In the context of acute shortage protein substances in forages, which influences negatively the revitalization of the livestock sector, the diversification of forage production by mobilization, acclimatization and implementation of new crops both from local flora and other floristic regions is necessary. The Botanical Garden (Institute) of A.S.M.'s collection of non traditional fodder plants counts near 300 species and varieties. Scientific investigations performed in the last 65 years have been focused on improving and implementing new species, new forms and varieties have been created, and cultivation technologies have been developed (Teleuță A. and Ţîţei V., 2012, 2014).

The legume family, *Fabaceae* Lindl., is one of the largest in the plant kingdom, leading to biological nitrogen fixation (Lewis G. et. al. 2005; Stoddard F.L., 2013.). Biological nitrogen fixation is a characteristic of pioneer plants and so gives rise to another potential use of legumes in the bioremediation or colonization of soils otherwise unsuited for agriculture (Aschenbach T.A. and Poling M., 2015; Oros, V., 2002). Forage legumes have been suggested as important components of low input, sustainable systems for livestock production and are the basis of organic agriculture (Lüscher A. et. al. 2013).

It is well known that the productivity of the grasslands from the Republic of Moldova is very low and the share of fodder leguminous plants is decreasing (Teleuță A. and Ţîţei V., 2012). The

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fodder leguminous species 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 (Lewis G. et. al. 2005; Lüscher A. et. al. 2013). In order to redress the situation regarding the increase of the productivity and the quality of fodder, it is necessary to extend the range of fodder leguminous species and to carry out reseeding works.

The genus *Lupinus* L. comprises approx. 200 species, with centres of diversity in North and South America, there are some smaller centres in North Africa and the Mediterranean region (Zhukovsky P.M. 1929; Zaremba R. and Pickering M., 1994). In the spontaneous flora of the Republic of Moldova there is no species of the genus *Lupinus* L.

An important part in solving the above problems is played by herbaceous fodder leguminous perennial species with increased vegetative cover over longer growing periods leading to increased photosynthate assimilation, decreased planting costs and reduction of energy-intensive inputs. Expanded root system of perennial species could increase soil carbon sequestration, further decrease off-season soil erosion, increase temporal access to water and nutrients among many other benefits. The species *Lupinus perennis* L. has also great potential to be used in medicine and biological recultivation of degraded lands (Aschenbach T.A. and Poling M., 2015; Meyer R., 2006; Oros V., 2002; Stoddard F.L., 2013).

Lupinus perennis L., common names: wild lupine, blue lupine, sundial lupine, perennial lupine plants are 20-150 cm high. Stalks are numerous, erect, striated, slightly pubescent. Leaflets are obovate, with a blunted apex or pointed spear, naked from above, sparsely pubescent from below; their number is 7-11. Petioles are longer then leaflets; stipules are very small, almost missing. The inflorescence is long, sparsely flowered, sometimes almost verticilate. The calyx is silky, without bractlets; its upper labium with a protuberant basis, is integral or weakly emarginate, the lower one is integral, almost twice longer than upper. Floral bracts are styliform, shorter than the calyx, early falling. The corolla is purple or white, three times longer than the calyx. The vexillum is shorter than the wings. The carina is weakly ciliate. Pods are yellow-grayish-brown, with straight lines, necklace-shaped, short and closely hirsute, easy shattered, with 5-6 seeds. Seed is oval with a light hilum. It is widespread in the eastern part of the USA (from Florida to Canada), Canada (south of Ontario), and on the coasts of the Arctic Ocean (Halpern S. L., 2003; Meyer R.. 2006; Voronov A.T., 1974: Zaremba R . and Pickering M., 1994).

MATERIAL AND METHOD

The *Lupinus perennis* L. plants, from the collection of non traditional fodder plants of the Botanical Garden (Institute) of A.S.M, maintained in pure culture, served as object of study. The traditional fodder leguminous crops*:* alfalfa, *Medicago sativa* L. and sainfoin, *Onobrychis viciifolia Scop.* served as control variant. Experiments were performed with previously calibrated seeds of *Lupinus perennis,* on usual chernozem, in spring, when the soil had reached the physical maturity. The seeds were planted at a depth of 2.0 cm, with soil compaction before and after sowing. The evidence area of the plot constituted 10 m^2. The number of repetitions - 4. The scientific researches on growth and development, yield and nutritional value of the plants were carried out according to the methodical indications (Novoselov Y. K. et.al. 1983; Petukhov E.A. et. al. 1989.).

RESULTS AND DISCUSSIONS

We may mention that the *Lupinus perennis* seeds require for germination a longer period of time as compared with traditional leguminous fodder crops, this fact is linked to the capacity of absorption and penetration of the integument, the amount of water in the seedbed. It has been established that *Lupinus perennis* plantlets emerge at the soil surface 8-10 days later. Over the next 30-40 days, the growth and development of the aerial part of the plant is very slow, then it accelerates and, until the end of the growing season, the rosette develops (the plant develops only rosette-like radical leaves). The traditional leguminous fodder crops alfalfa and sainfoin go through all ontogenetic phases. Alfalfa can be harvested twice a year and sainfoin – once, the wild lupine can also be used for grazing.

It has been found that, in the following years, the studied species start vegetating when temperatures are above 5 ºC, *Lupinus perennis* plants grow and develop faster *(table1)*. Thus, on April 20, the plants of this species are about 37.2 cm tall, exceeding alfalfa with 9.1 cm and sainfoin with 13.9 cm.

Budding and flowering phase of *Lupinus perennis* occurs very early, it needs 49 days and 64 days after the resumption of vegetation, respectively, while *Medicago sativa* needs 72 days and 83 days. It was noted that *Lupinus perennis* plants develop bigger inflorescences as compared with traditional crops. The big flowers of *Lupinus perennis* are “visited” by various insects including bees. The mentioned characteristics regarding the

stages of growth and development would allow the use of *Lupinus perennis* plants as an early source of food (nectar and pollen) for bees.

One of the main parameters that determine the degree of adaptation of introduced species is productivity *(table2)*. Taking into account the biological peculiarities of growth and development, the optimal time to harvest *Lupinus perennis* plants is in mid-May, the fresh mass productivity during this period reaches 3.18 kg/m^2 or 0.62 kg/m^2 dry matter with high leaf content (63%). It is well known that alfalfa and sainfoin reach optimal harvest time in late May.

Table 1

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

Indicators	*Lupinus perennis*	*Medicago sativa*	*Onobrychis viciifolia*
Days from the beginning of vegetation up to: -			
budding	49	72	64
- flowering	64	83	74
- seed ripening	101	145	117
Plant height, cm			
- at April 20	37.2	28.1	23.3
- at flowering	82.0	85.2	85.5

Table 2

The yield of the studied species of the family *Fabaceae*

Indicators	*Lupinus perennis*	*Medicago sativa*	*Onobrychis viciifolia*
The yield:			
- fresh mass 1-st cut, kg/m^2	3.18	2.48	4.15
- dry matter, kg/m^2	0.62	0.60	1.04
The leaf share of the fodder, %	63	44	39

The biochemical composition of the species *Lupinus perennis* is reported in *table 3*. Biochemical composition of the dry matter from fodder affects the digestibility and nutritional value, health and productivity of animals. Proteins are key nutrients that need to be taken into account in the diet of animals both in terms of quantity and quality. Cellular protein components of animal body are in constant renewal, ensuring optimal functioning of all physiological processes. It has been found that *Lupinus perennis* fodder contains 14.42% of protein, which is much lower in comparison with traditional fodder leguminous crops.

It is known that fats help to provide the organism with energy, determine the taste and quality of animal products. *Lupinus perennis* fodder is characterised by a very high fat content (3.91%), exceeding 2.2 times *Medicago sativa* fodder. We may mention that *Lupinus perennis* fodder has an optimal content of raw cellulose and high content of nitrogen free extractive substances (45.67%) and minerals (10.56%), which can contribute to a better assimilation of nutrients by animals. The high content of nitrogen free extractive substances influences positively the process of fodder conservation (hay, silage).

It has been determined that 100 kg of *Lupinus perennis* natural fodder contain 18.9 nutritive units, 19.4 MJ/kg metabolizable energy, digestible protein – 110.98 g/nutritive unit.

According to the mentioned indices, *Lupinus perennis* natural fodder has lower nutritional value in comparison with traditional crops, on the one hand, because of the low content of dry matter and raw protein, on the other hand, the very high content of fat and nitrogen free extractive substances influences positively the content of nutritive units and metabolizable energy.

Table 3

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

Indicators	*Lupinus perennis*	*Medicago sativa*	*Onobrychis viciifolia*
dry matter contains:			
raw protein, %	14.42	16.66	15.88
raw fats, %	3.91	1.88	3.57
raw cellulose, %	25.44	34.24	34.95
nitrogen free extractive substances, %	45.67	37.22	36.74
mineral substances,%	10.56	10.00	8.92
1 kg of natural fodder contains:			
nutritive units	0.19	0.20	0.22
metabolizable energy for cattle, MJ/kg	1.94	2.10	2.28
dry matter, g	196.00	243.00	250.00
digestible protein, g/ nutritive unit	110.98	154.07	134.36

Thus, if we compare the nutritional value of dry matter, 100 kg of dry matter of *Lupinus perennis* contain 96.28 nutritive units, 987.73 MJ/kg metabolizable energy and 10.53 kg digestible protein, while *Medicago sativa* contains 81.13 nutritive units, 866. 37 MJ/kg metabolizable energy and 12.50 kg digestible protein, *Onobrychis viciifolia* – 88.64 nutritive units, 912.83 MJ/kg metabolizable energy and 11.91 kg digestible protein, respectively.

An essential component of protein characteristics is its amino acid composition, which is its main structural characteristic, irrespective of the kind, origin and physiological function. Determining the amino acid composition of vegetal fodder of different species and the proportions of the respective amino acids facilitates the evaluation of its potential nutritional value, especially creating the possibility of not applying synthetic amino acids to enhance the nutritive value of animal feed mixtures.Analyzing the results on the amino acid content in the fodder *(table4)*, it has been found that the species *Lupinus perennis* is distinguished by an optimal content of both essential and nonessential amino acids.

Comparing each amino acid separately, we could mention that the content varies in comparison with traditional forage crops.

The role of the first deficient essential amino acid, limiting the nutritive value of protein, was played by methionine. We could mention that the methionine content of the species *Lupinus perennis* and of the species *Onobrychis viciifolia* is at the same level, but it is lower as compared with *Medicago sativa.* The second limiting amino acid for protein biosynthesis is lysine. *Lupinus perennis* is at the same level as *Medicago sativa* regarding the lysine content, but it is much lower as compared with *Onobrychis viciifolia.* Regarding the phenylalanine content, the species *Lupinus perennis* exceeds by far *Medicago sativa*, but it is inferior to *Onobrychis viciifolia.*

It has been found that *Lupinus perennis* fodder is richer in alanine, arginine, histidine, tyrosine, but has lower content of asparagine, threonine, serine, glutamine, glycine, valine, isoleucine, leucine, proline in comparison with traditional forage crops.

Table 4

The content of amino acids in the fodder (mg/100mg dry matter) of the studied species of the family *Fabaceae*

Amino acids	*Lupinus perennis*	*Medicago sativa*	*Onobrychis viciifolia*
asparagine	0.1388	1.711	1.751
threonine	0.488	0.564	0.565
serine	0.584	0.687	0.685
glutamine	1.100	1.360	1.398
proline	0.519	0.922	1.154
glycine	0.501	0.550	0.557
alanine	0.698	0.674	0.672
valine	0.527	0.559	0.654
methionine	0.089	0.139	0.091
isoleucine	0.400	0.459	0.459
leucine	0.830	0.913	0.920
tyrosine	0.528	0.458	0.491
phenylalanine	0.918	0.850	0.937
histidine	0.388	0.326	0.371
lysine	0.617	0.619	0.706
arginine	0.695	0.655	0.587

CONCLUSIONS

The species *Lupinus perennis* in the first year of vegetation has a slow growth and development, develops only rosette-like radical leaves, but in the following years, it grows and develops more intensively, the flowering starts 15-29 days earlier than the traditional forage crops. The fresh mass productivity (1-st cut) reaches 3.18 kg/m^2 or 0.62 kg/m^2 dry matter with high leaf content (63%). The dry matter has an optimal content raw protein (14.42%) and raw cellulose (25.44 %), high content of fat content (3.91%), nitrogen free extractive substances (45.67%) and minerals (10.56%). 100 kg of dry matter of *Lupinus perennis* contain 96.28 nutritive units, 987.73 MJ/kg metabolizable energy and 10.53 kg digestible protein. The methionine content of the *Lupinus perennis* and of the *Onobrychis viciifolia* is at the same level, but it is lower as compared with *Medicago sativa.* The lysine content is at the same level as *Medicago sativa.*

Due to the earlier first harvest time, stable productivity and optimal quality of fodder, the use of the plantation of the species *Lupinus perennis* for a long period of time can serve as initial breeding material for enriching the range of forage crops, recovery of degraded and polluted lands.

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