THE AGROBIOLOGICAL FEATURES SOME NON-TRADITIONAL LEGUMINOUS FODDER PLANTS AND THE QUALITY OF THE HAY

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Abstract. *Food and energy supply is an acute problem of mankind in the context of depletion fossil fuels, climate change, degradation and reduction of agricultural lands. The efficient use of the biological potential of the local species of leguminous plants that are adapted to the specific climatic conditions becomes more and more relevant. We studied the agro biological features and the quality of the hay prepared from non-traditional plant species of fam. Fabaceae, local ecotype of the leguminous species Astragalus cicer, Lathyrus latifolius, Lathyrus sylvestris maintained in pure culture in Botanical Garden (Institute) of the Academy of Sciences of Moldova, control variant- alfalfa, Medicago sativa. The local ecotype of the non-traditional leguminous species have a slow growth and development rates in the first growing season, in the following years the vegetation period started 3-7 days later and the harvest period to make hay can start with 22-39 days later than alfalfa. The hay yield varied from 1.13 kg/m^2 to 1.33 kg/m^2. The Lathyrus species hay productivity exceeding Medicago sativa with 25 - 40 % and Astragalus cicer with 5-18 %. The Lathyrus species hay contains 0.71 nutritive units/kg, 194 g/kg digestible protein, 6.2 - 8.1 g/kg calcium and 1.5-2.2 g/kg phosphorus ; Astragalus cicer hay – respectively 0.69 units/kg, 94 g/kg 14.1 g/kg and 1.1 g/kg; alfalfa hay- 0. 67 units/kg , 148.4 g/kg, 14.2 g/kg and 2.0 g/kg. The preliminary investigation indicates the gas forming potential of the digestible organic matter of the hay made from non-traditional fodder legumes varied from 446 to 452 litre/kg VS. The best methane content 57% was achieved in hay Lathyrus species, the lowest 53.5% in the biomass of Astragalus cicer in comparison with 55.9 % Medicago sativa hay.*

Key words*: agro biological features, Astragalus cicer, biochemical composition, biogas, hay, Lathyrus latifolius, Lathyrus sylvestris, nutritive value*

INTRODUCTION

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

Grasslands, one of the largest habitat type in the world, has numerous functions and values regarding ecology, economy and society. Grassland are fodder sources for livestock production and can be promising feedstock for biogas production (PEETERS , 2009; BAHCIVANJI ET AL., 2012; BAUER ET AL., 2014).

Healthy animals are needed for profitable animal husbandry. The life of animals and the products of animal origin require constant and continuous exchange of substances between the body and the environment. The animal feed should have a nutritional value that meets the dietary needs of each species, breed and age or weight category. Other requirements are the absence of contaminants, the free access to food and water, depending on the type of feeding, the number of daily portions correlated with the growth and maintenance system. Therefore, the quality and quantity of food play an important role and influence directly the performance

and health of animals, as well as the quality and safety of animal products intended for human consumption.

Fodder plants are an important part of a balanced diet for animals. About 700 species of the wild flora of the Republic of Moldova can be used as fodder. Among them, there are 70 species of the family *Poaceae*, which contain high amounts of cellulose and minerals necessary for herbivorous animals, and 71 *Fabaceae* species, from which, animals receive large amounts of vegetal protein, vitamins and minerals, which raise the economical value of the fodder and the livestock production (TELEUȚĂ AND ȚÎȚEI, 2016).

Hay is a valuable feed for farm animals, both in winter and throughout the year, rich source of nutrients, vitamins and minerals, especially for the young animals, pregnant females and breeding males. It helps the motor functions of the stomach, or the muscular activity of the digestive system, and promotes rumination, indispensable for proper digestion in ruminants. The nutritional value of the hay depends on the plants species, the age at which these plants have been harvested, the methods and duration of drying and storage. To produce the necessary quantity of hay, in addition to the natural hayfields, which by the way, in Moldova, occupy small areas – 382 000 ha and have low productivity – about 300 feed units/ha. 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. Considering the limited material and technical resources in the Republic of Moldova, the efficient use of the biological potential of the local species of leguminous plants that are adapted to the specific climatic conditions becomes more and more relevant (BAHCIVANJI ET AL., 2012, TELEUȚĂ AND ȚÎȚEI, 2016)

The genus *Astragalus* L. comprises approx. 2.500 species and is the largest genus of angiosperms (Lock and Schrire, 2005), in the spontaneous flora of the Republic of Moldova, there are 16 species, *Astragalus cicer* L. and *Astragalus ponticus* Pall possess a certain forage value (NEGRU, 2007). Cicer milkvetch, *Astragalus cicer* L. is a long-lived, perennial, non-bloat legume with vigorous creeping roots or rhizomes. Stems are large and hollow, upright when young and becoming decumbent and trailing. Leaves are with 10 to 13 pairs of leaflets, plus one terminal leaflet. Flowers are pale yellow to white with 15 to 60 flowers growing in a compact raceme. Pods do not shatter easily and may retain seeds through winter. Seeds are bright yellow or pale green, and are about twice as large as those of alfalfa. It is very good legume species with winter-hardy and drought-tolerant, high yield, excellent forage quality, high persistence and good nitrogen fixing ability. Additionally, it is a species that allows for wildlife and has potential for soil erosion control and reclamation of disturbed lands because of its aggressive rhizomatous growth habit. It is widely used in Europe and in America (DUKE, 1981; TOWNSEND, 1993; LOEPPKY ET AL.,1996; GERVAIS ,2000; ANISZEWSKI, 2004, ACHARYA ET AL., 2006;),

The genus *Lathyrus* L. include about 160 species, important agricultural crops and model organisms for genetic and ecological research (DUKE, 1981). In the spontaneous flora are 14 species (NEGRU, 2007). Flatpea, *Lathyrus sylvestris*, is a perennial vine with woody roots, suitable as 'pioneer plant' for the recultivation of slag heaps and mining areas for agricultural production (FLACHOWSKY ET AL., 1982; FOSTER, 1990; KUPORITSKAYA, 1978). Everlasting peavine, *Lathyrus latifolius* L., synonyms *Lathyrus megalanthus* Steud., is a vigorous climbing herbaceous perennial to 2m, with branched rhizome, leaves composed of one leaflet pair with a tendril, flowers 2-3 cm in width, vivid purplish-pink, in racemes of 5-11. The pod is elongate linear, glabrous, dark brown, with reticulate veins and 8—14 seeds. The seed is globose or oblong, weakly tuberculate. The species grows on meadows and forest clearings. Currently, the

species *Lathyrus latifolius* are studied in different academic centres and universities of the Earth (GABOREANU ET AL., 1998; ALEMAN AND WOTTO, 2003)

For the cultivation of these species, along with breeding program and development of technological elements of cultivation, it is necessary to study the quality of biomass (hay) and the possibility of its use as animal feed and feedstock for biogas production are necessary. This fact determined the choice of the subject of the study.

MATERIALS AND METHODS

The local ecotype of the leguminous species: cicer milkvetch *Astragalus cicer*, everlasting peavine *Lathyrus latifolius,* flatpea *Lathyrus sylvestris* maintained in pure culture, served as subject of study, the traditional fodder crops, alfalfa, *Medicago sativa* - control variant. Seed collected from the spontaneous flora and experiments were performed on experimental land in the Botanical Garden (Institute) of the Academy of Sciences of Moldova, latitude 46°58′25.7″ and longitude N28°52′57.8″E. The scientific researches on growth and development, yield and biochemical composition of the plants were carried out according to the methodical indications (NOVOSELOV ET AL.,,1983; PETUKHOV ET AL.,1989). The green mass of the studied species was harvested for the first cut, to produce hay in budding – flowering stage. The harvested mass was dried directly in the field.

The carbon content of the substrates was calculated using empirical equation reported by BADGER ET AL., 1979, the biogas and biomethane were calculated using the gas forming potential of nutrients according to BASERGA, 1998, corrected for the index of digestible nutrients.

RESULTS AND DISCUSSIONS

As a result of the performed researches, it has been established that, in order to germinate abundantly, the seeds of non-traditional fodder legumes studied species need to be scarified. In the first year these species, in comparison with alfalfa, have a slow growth and development, *Lathyrus latifolius* and *Lathyrus sylvestris* plants reached the flowering stage and grew 43-54 cm tall, *Astragalus cicer* - 55.0 cm.

We might mention that, the following years (Tab.1), the vegetation period of the studied legumes species started 3-7 days later in comparison with *Medicago sativa*, the most delayed start of vegetation period was characteristic of the species *Lathyrus latifolius*. The budding stage in comparison with alfalfa, of *Astragalus cicer* plants begins 9 days and flowering stage 17 days later. The *Lathyrus* species needed a 22-33 day longer period to reach budding period, a 25-50 day - flowering stage and a 22-39 day longer period – to reach seed maturation. A more delayed development during the growing season was characteristic of flatpea plants; we could also mention that everlasting peavine plants had a more rapid pace of development and were distinguished by a short flowering period. From the resumption of growth till the end of April, a more rapid growth rate was observed in cicer milkvetch plants (39.6 cm) about the same as in alfalfa and a slower one – in everlasting peavine plants (22.0 cm). At the time of the first harvest, flatpea plants reached 187.78 cm, everlasting peavine – 165.60 cm and cicer milkvetch – 103.8 cm while the control variant - 83.20 cm high. In other studies, it has been mentioned that flatpea *Lathyrus sylvestris* plants can reach 3.00 m (KUPORITSKAYA, 1978).

It was determined that the harvest period of *Astragalus cicer*, to make hay, can start in mid June, *Lathyrus latifolius* – in late June and *Lathyrus sylvestris* mid July. We might mention that flatpea and everlasting peavine provided a natural fodder yield of 4.58-4.71 kg/m^2 or 1.18-1.33 kg/m^2 hay, exceeding control variant with 25-40 % and cicer milkvetch with 5-18 %. The harvested green mass of the studied *Lathyrus* species was richer in leaves (48-55%).

In some papers, it has been mentioned that the green mass of flatpea reaches 92-125 t/ha (KUPORITSKAYA, 1978; FOSTER, 1990), everlasting peavine – 95.5 t/ha (ALEMAN AND WOTTO, 2003).

Table 1

Some biological peculiarities and productivity of non-traditional fodder legumes

Indices	*Medicago sativa*	*Astragalus cicer* L.	*Lathyrus latifolius*	*Lathyrus sylvestris*
Resumed development up to:				
- budding, days	70	79	92	103
- flowering, days	82	99	107	132
- seed ripening, days	143	145	165	184
Plant height, cm				
- at the end of April	38.1	39.6	22.0	26.4
- at flowering	83.2	103.8	165.6	187. 8
The yield, first cut:				
- green mass, kg/m^2	3.11	3.50	4.71	4.58
- hay, kg/m^2	0.94	1.13	1.18	1.33
The leaf share of the hay, %	33	39	52	52

Due to the organoleptic evaluation of the obtained hay, it was found that the *Lathyrus* species hay had a pleasant smell, was rich in leaves because they were retained better on the stems, the leaves were light dark green and the stems were yellow greenish, the stems were more flexible. The *Astragalus cicer* hay contained fewer leaves, as compared with *Lathyrus* species, had a pleasant smell, the leaves were dark green and the stems – light yellow.

Analysing the biochemical composition of the absolutely dry matter from hay, Tab. 2, we found that the crude protein content varied depending on the species and ranged from 16.81 % to 23.71 %. The *Lathyrus latifolius* and *Lathyrus sylvestris* hay contained very high amounts of crude protein.

Table 2

The biochemical composition of the absolutely dry matter of the hay made from non-traditional fodder legumes

Indices	*Medicago sativa*	*Astragalus cicer* L.	*Lathyrus latifolius*	*Lathyrus sylvestris*
Raw protein, %	16.00	16.81	23.66	23.71
Raw fats, %	1.87	1.69	3.04	2.85
Raw cellulose, %	34.66	29.36	30.40	34.00
Nitrogen free extractive substances, %	37.47	43.43	33.58	32.63
Mineral substances,%	10.00	7.71	9.32	6.76

The high content of crude protein in *Lathyrus* species has also been mentioned in other studies. FLACHOWSKY ET AL., 1982, found that *Lathyrus sylvestris* hay contained 20 - 30% crude protein in the dry matter, protein digestibility for hay and dried green fodder varied between 72.3 and 75.8%. In the conditions of Guatemala *Lathyrus latifolius* contained 4.64% nitrogen or 28.8% crude protein in the dry matter (ALEMAN AND WOTTO, 2003)

The fats from feed are the main source of energy for animals, as they are necessary for the normal course of vital processes and contribute to the accumulation of fat in milk. The quantity and quality of lipids from feed affect the organoleptic qualities of animal products, especially their smell and taste. It was found that the content of fats in the *Lathyrus sylvestris* and *Lathyrus latifolius* hay were 2.85-3.04 %, much more than in *Medicago sativa* and *Astragalus cicer*. A lower amount of crude cellulose and a high amount of nitrogen-free extract was found

in the *Astragalus cicer* hay, but *Lathyrus sylvestris* hay contained a low amount of nitrogen-free extract, as compared with alfalfa.

Mineral nutrition is vital to growth, health and animal performance. The *Lathyrus latifolius* hay was characterised by a high content of minerals, about the same as in alfalfa. The mineral content in the hay made from *Lathyrus* sylvestris was much lower.

The content of nutrients and its digestibility influences the fodder value of hay (Tab. 3.). Thus, 100 kg of hay made from non-traditional fodder legumes contained 69.2-71.2 nutritive units, and *Medicago sativa* hay – 67.1 nutritive units. The studied species are suitable to make hay for cattle and sheep, with high metabolizable energy: 7.2 and 8.8 MJ/kg – *Astragalus cicer* hay; and 7.7-9.4 MJ/kg *Lathyrus* species hay. The amount of digestible protein in the hay met the zootechnical standards and constituted 136 - 274 g/nutritive unit. The concentrations of Calcium in the hay varied from 6.2 to 14.2 g/ kg and of Phosphorus - from 1.1 to 2.2 g/ kg. Calcium dietary requirements for sheep and cattle are 3-4 g /kg (NRC, 1984). These results indicate that non-traditional fodder legumes in this study were above animal Ca dietary requirements. However, in regards to Ca forage concentration, ratio Ca:P is of importance. Only Ca:P range from 1:1 to 7:1 is satisfactory, otherwise growth and feed efficiency decreases (UNDERWOOD AND SUTTLE, 1999).The satisfactory ratio Ca:P in *Lathyrus* species hay, but in *Astragalus cicer* hay is very high. A high content of Calcium (10.3 g/ kg) and of Phosphorus (4.2 g/ kg) in *Lathyrus latifolius* biomass was also mentioned in other studies (ALEMAN AND WOTTO, 2003).

Table 3

The nutritional value of the hay made from non-traditional fodder legumes

Indices	*Medicago sativa*	*Astragalus cicer*	*Lathyrus latifolius*	*Lathyrus sylvestris*
Nutritive units, kg	0.67	0.69	0.71	0.71
Metabolizable energy for cattle, Mj/ kg	7.10	7.23	7.68	7.71
Metabolizable energy for sheep, Mj/ kg	8.68	8.77	9.37	9.44
Digestible protein, g/kg	148.4	94.1	194.0	194.4
Calcium, g/kg	14.2	14.0	8.10	6.20
Phosphorus, g/kg	2.0	1.1	1.50	2.20
Digestible protein, g/ nutritive unit	221.2	136.0	274.4	273.0

The utilization of energy produced from renewable resources such as grasslands is an important factor to reduce fossil energy consumption. Processing technology and logistics for the cultivation of grassland as well as its harvesting and storage are technically well-engineered processes and have been successfully used for decades. Besides their use as animal fodder, hay can be also for biogas production (PEETERS, 2009: BAUER ET AL., 2014. The composition of the organic matter added to a digestion system has an important role on the growth rate of the anaerobic bacteria and the production of biogas. Bacteria need a suitable ratio of carbon to nitrogen for their metabolic processes. The carbon and nitrogen ratio (C/N) of the feedstock is essential parameter in evaluating these effects, and in providing optimal nitrogen levels.

Table 4

Gas forming potential of the digestible organic matter of the hay made from non-traditional fodder legumes

Indices	*Medicago sativa*	*Astragalus cicer* L.	*Lathyrus latifolius*	*Lathyrus sylvestris*
Ratio of content carbon and nitrogen (C/N)	20	19	13	13
Digestible organic matter, g/kg VS	540.1	571.8	575.6	583.7
Biogas, liter /kg VS	422	448	446	452
Biomethane, liter /kg VS	236	240	255	257

The C/N ratio in substrate of the studied species varied from 13 (*Lathyrus* species) to 19 (*Astragalus cicer* hay), and *Medicago sativa* – 20 (Tab. 4). The optimal C/N ratio is expected to be in the range 15-25, when the anaerobic digestion process is carried out in a single stage, and for the situation when the process develops in two steps, the optimal C/N ratio will range: for step I: 10-45; for step II: 20-30 (DOBRE ET AL.,2014). The gas forming potential of the digestible organic matter of the hay made from non-traditional fodder legumes varied from 446 to 452 litre/kg VS (Tab. 4). The best methane content 57% was achieved in hay *Lathyrus* species, the lowest 53.5% in the biomass of *Astragalus cicer* in comparison with alfalfa hay.

CONCLUSIONS

The local ecotype of the leguminous species *Astragalus cicer*, *Lathyrus latifolius, Lathyrus sylvestris* have a slow growth and development rates in the first growing season, in the following years the vegetation period started 3-7 days later and the harvest period to make hay can start with 22-39 days later than alfalfa.

The hay yield varied from 1.13 kg/m^2 to 1.33 kg/m^2. The *Lathyrus* species hay productivity exceeding *Medicago sativa* with 25-40 % and *Astragalus cicer* with 5-18 %.
The content of crude protein and fats in the *Lathyrus* species hay were much more than in *Medicago sativa* and *Astragalus cicer*. A lower amount of crude cellulose and a high amount of nitrogen-free extract was found in the *Astragalus cicer* hay.

The hay made from *Lathyrus* species contains 0.71 nutritive units/kg, 194 g/kg digestible protein, 6.2 - 8.1 g/kg Calcium and 1.5-2.2 g/kg Phosphorus ; *Astragalus cicer* hay – respectively 0.69 units/kg, 94 g/kg 14.1 g/kg and 1.1 g/kg; alfalfa hay- 0. 67 units/kg , 148.4 g/kg 14.2 g/kg and 2.0 g/kg.

The gas forming potential of the digestible organic matter of the hay made from non-traditional fodder legumes varied from 446 to 452 litre/kg VS. The best methane content 57% was achieved in hay made from *Lathyrus* species, the lowest 53.5% in the biomass of *Astragalus cicer* in comparison with *Medicago sativa*.

Preliminary scientific researches allow mentioning that the species of fodder legumes *Astragalus cicer, Lathyrus latifolius, Lathyrus sylvestris* can be used to produce quality hay and possibility of its use as animal feed and feedstock for biogas production.

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