INTRODUCTION AND AGRO ECONOMICAL VALUE OF *SORGHUM ALMUM* IN THE REPUBLIC OF MOLDOVA

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Abstract: *Taking into account the expansion of areas of degraded soils and the frequency of droughts in our country, it is necessary to mobilize and introduce new species that would ensure production in these severe conditions. The objective of this research was to evaluate the yield and fodder value, biomass calorific value of new species Sorghum almum Parodi in the conditions of Moldova. We have established that plants of Sorghum almum productivity after 2 harvests reached 43.6-44.2 t/ha of green mass or 9.2-11.8 t/ha dry matter. The green mass is used as natural forage and the preparation of silage. 100 kg of natural fodder contains 21-29 nutritive units and 216- 290 MJ/kg metabolizable energy for cattle. To produce solid bio fuel, biomass can be harvested with technical means of fodder collection and used to produce briquettes and pellets, with a gross calorific value of about 18.6 MJ/kg dry mass. The potential of energy production is 190-270 GJ/ha.*

Keywords: *Sorghum almum* Parodi, biological peculiarities, productivity, nutritional value, biomass calorific value

INTRODUCTION

Agriculture is a strategic branch of the national economy of the Republic of Moldova which aims at ensuring food security for population, the necessary raw materials for non-agricultural activities and an active and profitable export of agricultural products, increasing the landscape and rural areas, providing a decent standard of living (comparable to the average standard of living in Europe) and environmental protection. Agriculture remains an important sector generating almost half of export earnings. Arable land occupies over 70% of the territory. Agricultural land use in the Republic of Moldova favours crop production, representing 60-70% of the total agricultural production. Crop production, for example, seems to be particularly vulnerable to climate-related stresses: the excessive drought from 2003, 2007, 2009 and 2012 had a disastrous effect on most annual crops. The development of the livestock sector has been problematic in the past decade, being hampered by obstacles related to competitiveness and market. The livestock sector faces the scarcity of internal resources (low productivity of genotypes of breeds, limited feeding) and harsh pressures caused by imports of cheaper animal products. The provision of fodder is limited due to the low availability of high quality pastures and reduction of the agricultural land sown with fodder plants [BAHCIVANJI ET AL., 2012].

The energy crisis in recent decades and the need to reduce pollution create new problems that society has to face. Among the alternative energy sources, in the context of the fossil fuel crisis, which will deplete sooner or later, is the bioenergy crop production, thus agriculture acquires a new function: production of energy raw materials [EL BASSAM, 2010].

An important part in solving the above problems is played by herbaceous perennial plant species with intensive growth which can ensure animals with vegetable fodder, and on the other hand, can become a source for obtaining biomass for the production of renewable energy. 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.

Taking into account the expansion of areas of degraded soils and the frequency of droughts in our country, it is necessary to mobilize and introduce new species that would ensure production in these severe conditions. Plants of the genus *Sorghum* Moench, family *Poaceae* Barnhart, plant group C4, may have an essential role [ȚÎȚEI AND TELEUȚĂ, 1994; 2011].

The species *Sorghum almum* Parodi, columbus grass, is native to South America. It is a perennial rhizomatous grass with stout stems up to 3 m tall. The waxy leaf blades are flat and sandpapery. The blades are 1.3-3.8 cm wide and 45.7-81.3 cm long. Foliage occasionally has long hairs at the base of the upper leaf surface. The ligule is membranous and fringed along the top. The inflorescence is a 15.2-61 cm long panicle, with lax, spreading branches. Seeds are 0.6-1.0 cm long and smooth. *Sorghum almum* tolerates a wide range of soil types and temperatures and it is drought tolerant, reproduces by seed and rhizomes. Currently, the species *Sorghum almum* is studied in scientific centres and universities in different regions of the Earth [ELIZONDO, 2004; HEUZÉ ET AL., 2015; LANYASUNYA ET AL., 2007; RAKHMETOV AND RAKHMETOV, 2008; UTEUSH , 1990].

The objective of this research was to evaluate productivity, fodder and calorific value of new species *Sorghum almum* Parodi in Moldova's conditions.

MATERIALS AND METHODS

The species *Sorghum almum* Parodi, which was cultivated in the experimental land of the Botanical Garden (Institute) of the ASM, served as object of study, the forage crop *Festuca arundinacea* Schreb. - control variant. The experiments started in spring 2013 year. Scientific researches on agro biological peculiarities were performed according to the methodical indications [NOVOSELOV ET AL., 1983], biochemical composition and nutritional value of natural fodder [PETUKHOV ET AL., 1989], the evaluation of dry biomass – according to CEN/TC 335, the calorific value of dry biomass was determined by calorimetric method using the device LAGET MS 10A.

RESULTS AND DISCUSSIONS

Analyzing the biological peculiarities of the species *Sorghum almum* in the Republic of Moldova, we could mention that after sowing, during 5-7 days, the seedlings emerged at the soil surface. The first leaf of a sprout was wide and almost horizontally tilted away from the axis of the shoot (adaptation for absorption of the maximum amount of light energy). When the formation of the first leaf was completed in 2-4 days after the emergence of shoots, it was determined the depth of the zone of tillering. During this period, when the accumulation of dry matter was low, an intensive growth of roots and the highest share of their working surface from the overall were noted. With the transition of plants to the phenophase of the second, third and fourth leaf, the mass of plants significantly increased, mainly due to the growth of leaves; the isolation of a side budlet was noticeable at the base of an internode. The phase of the fifth leaf differed from the previous ones in more intensive (by 2-3 times) accumulation of dry matter in aboveground and underground parts.

With transition of plants to the phenophase of the sixth and seventh leaf, a further increase in the intensity of dry matter accumulation due to the increase of leaf area was noted. After the phase of the seventh leaf, the transition of plants to the phase of visible tillering was noted. Prior to stem elongation, plants had been rapidly moving to the formation of shoots not only of the second, but the third and even the fourth order. Until the seeds ripened, in the structure of a plant, shoots of the four-five orders had been formed, which led to a high tillering intensity – to 20.6 lateral shoots per plant. The diameter of the shoots at the base, depending on the density of grass, was 5-8 mm. The formation of rhizomes of *Sorghum almum* plants in the first year of vegetation began during the phenophase of stem elongation and their great bulk was located within the limits of the bush into the soil to a depth of 40 cm. Formation of rhizomes determined long-term cycle of development of this crop. Rhizomes play an important role in the life of *Sorghum almum*: they are the main organ that store up substances for an unfavourable period, they concentrate the bulk of dormant buds, which germinate in the spring, and the formed adventitious roots increase the absorption capacity of plants. During July, the growth and development of the aerial part intensified and, at the end of the month, the formation of the panicle started, the shoots reaching 235 cm high (Table 1). Mowing the plants for the first time in this period resulted in a yield of 3.84 kg/m^2 natural fodder. The harvested fodder had a moderate content of dry matter. After harvest, the *Sorghum almum* plants revived and by the end of September the shoots grew about 64 cm tall, were much thinner than those from the first mowing, but had a higher content of leaves (40%). The natural fodder yield at the second mowing was 0.52 kg/m^2, with decreased dry matter content (16%).

Table 1

Agro-biological peculiarities of the species *Sorghum almum*

Indices	*Sorghum almum*, 2013 y.	*Sorghum almum*, 2014 y.	*Festuca arundinacea*, 2014y.
First mowing:			
plant height, *cm*	235	287	125
natural fodder, *kg/m^2*	3.84	2.50	2.86
dry matter content,*%*	22.0	29.9	21.6
content of leaves in the fodder,*%*	35.9	31.9	29.7
Second mowing:			
plant height, *cm*	64	158	48
natural fodder , *kg/m^2*	0.52	1.92	0.63
dry matter content,*%*	16.0	23.0	23.0
content of leaves in the fodder,*%*	40.0	32.9	94.4
Annual productivity:			
natural fodder, *kg/m^2*	4.36	4.42	3.49
dry matter, *kg/m^2*	0.92	1.18	0.76

So, in the first year of vegetation, *Sorghum almum* productivity after 2 harvests reached 43.6 t/ha of natural fodder or 9.2 t/ha dry matter, while *Festuca arundinacea* provided only one harvest with a yield of 15.5 t/ha green mass.

In the second year of vegetation (2014 y.), shoots developed from the underground rhizomes formed in the previous year. To start the vegetation, *Sorghum almum* plants needed a sum of active temperatures higher than other perennial grasses; the revival of vegetation was observed in the second half of April. The growth and development rate of shoots increased after 25-30 days after revival of vegetation and, until the end of June, plants were in the panicle formation phase, growing 287 cm tall. We may mention that in the second year of vegetation the panicle formation occurred 25 days earlier in comparison with the previous year. The first mowing at this time allowed us to obtain 2.50 kg/m^2 natural fodder with a high content of dry matter (29.9%), but a lower content of leaves (31.9%)

compared with the previous year. It is known that the resumption of vegetation after harvest largely depends on weather conditions. In the first 20 days, growth and development were slow, then they intensified and until the end of September the shoots grew about 158 cm tall and 70% of plants were in the panicle formation phase. The yield of natural fodder at the second mowing was 1.92 kg/m^2 or 0.44 kg/m^2 dry matter. After the content of leaves, the harvested fodder during this period did not differ essentially as compared with the first mowing. In the second year of vegetation, the annual productivity of *Sorghum almum* plants could reach 44.2 t/ha natural fodder or 11.8 t/ha dry matter and *Festuca arundinacea* – 34.9 t/ha natural fodder or 7.6 t/ha, respectively.

Animals need for growth, development, reproduction and realization of some products, numerous nutrients they receive from feed. It is known that forage plants of the fam. *Poaceae* are rich in glucides and poor in protein substances in comparison with the fam. *Fabaceae* Lindl. Analyzing the results of determination of the biochemical composition of dry substances of *Sorghum almum* natural fodder from the first harvest, Table 2, we can mention that the protein content reached 6.8-8.00 %, fats – 2.03-2.62%, cellulose – 37.50- 39.44 %, nitrogen free extractive substances – 44.23-44.72 % and minerals – 7.16-7.50%. A higher content of protein, fat and nitrogen free extractive substances and a lower content of cellulose and minerals were found in the fodder harvested in the first year of vegetation.

Table 2

Biochemical composition and nutritional value of the fodder of *Sorghum almum*, first mowing

Indices	*Sorghum almum*, natural fodder 2013 y.	*Sorghum almum*, natural fodder 2014 y.	*Sorghum almum*, silage 2014 y.	*Festuca arundinacea*, natural fodder 2014y.
Biochemical composition dry matter:				
raw protein, %	8.00	6.80	6.42	6.73
raw fats, %.	2.62	2.03	2.61	1.64
raw cellulose, %.	37.50	39.44	34.84	40.02
nitrogen free extractive substances, %.	44.72	44.23	46.08	42.06
mineral substances, %	7.16	7.50	10.05	9.55
1 kg forage contains:				
dry matter, g	220	299	230.0	216
nutritive units	0.21	0.29	0.22	0.19
metabolizable energy for cattle, MJ/kg	2.16	2.90	2.19	1.86
digestible protein, g	12.3	13.8	10.3	9.3
digestible protein, g/nutritive unit	59	48	48	50

The content of organic substances and their biochemical composition influence the nutritional and energy value of fodder. Thus, in the first year, 100 kg of natural fodder contains 21 nutritive units, 216 MJ/kg metabolizable energy and, in the second year, 29 nutritive units and 290 MJ/kg, respectively. The natural fodder of *Sorghum almum* is richer in nutritive units and metabolizable energy than the natural fodder of *Festuca arundinacea*. The digestible protein content of a nutritive unit is below the zootechnical standards and constitutes 48-59 g.

Sorghum almum silage at the first mowing 2014 y. is characterized by a fairly good quality; it has a pleasant smell like pickled apples, greenish gold colour, and perfect consistency at conservation. It was found that the content of dry matter in the silage constitute 23.0%. The dry matter of the silage contains 6.42% raw protein, 2.61% raw fat, 34.84% raw cellulose, 46.08% nitrogenous free extractive substances and 10.05% mineral substances. The nutritive value in this period is 0.22 nutritive units and 2.19 MJ of metabolizable energy per 1 kg of conserved fodder. Our results are in concordance with those obtained by other researchers [COŞMAN, 2014; RAKHMETOV AND RAKHMETOV, 2008].

Sorghum almum has a high capacity of protection against soil erosion due to the development of a strong root system, regeneration after harvest and is characterized by high resistance to drought. These qualities allow this species to be used in exploitation of degraded lands by establishing industrial plantations in order to obtain biomass for the production of renewable energy.

Table 3

Characteristics of the dry biomass of *Sorghum almum* (direct grinding)

Indices	
Humidity of the harvested biomass, %	10
Content of leaves in the dry biomass,%	28
Bulk density of the chopped biomass, kg/ m^3	118-133
Gross calorific value, MJ / kg	18.6
Density of briquettes, kg/ m^3	700
Ash of briquettes, %	3.7
Potential of energy production, GJ/ha	190-270

To produce solid bio fuel, the *Sorghum almum* plants can be harvested in August-September by mowing, drying in swaths and pressing in bales or grinding; in November-December by direct grinding when the humidity is reduced to 10%. The dry biomass can be harvested with technical means of harvesting fodder. The biomass yield, depending on age and manner of exploitation of the plantation, is about 11-15 t/ha. The bulk density of the direct grinding biomass is of 118-133 kg/m^3, the gross calorific value reaches 18.6 MJ/kg, the ash content - 3.7% (Table 3). Briquettes' density is 700 kg/m^3.

CONCLUSION

The species *Sorghum almum* represents a promising crop in Moldova's conditions.

The yield of *Sorghum almum* reached 43.6-44.2 t/ha of green mass or 9.2-11.8 t/ha dry matter.

The green mass is used as natural forage and the preparation of silage.

100 kg of natural fodder contains 21-29 nutritive units and 216- 290 MJ/kg metabolizable energy for cattle.

The dry matter of the silage contains 6.42% raw protein, 2.61% raw fat, 34.84% raw cellulose, 46.08% nitrogenous free extractive substances and 10.05% mineral substances. The nutritive value is 0.22 nutritive units and 2.19 MJ of metabolizable energy per 1 kg silage.

Dry biomass can be harvested with technical means of fodder collection and used to produce briquettes and pellets, with a gross calorific value of about 18.6 MJ/kg dry mass. The potential of energy production is 190-270 GJ/ha.

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