THE PERSPECTIVE OF CULTIVATION AND UTILIZATION OF THE HYBRID *Rumex tianschanicus* × *Rumex patientia* IN MOLDOVA

Victor ȚÎȚEI[1], Alexandru TELEUȚĂ[1]

e-mail: vtitei@mail.ru, vic.titei@gmail.com

Abstract

The hybrid *Rumex tianschanicus* A. Los. × *Rumex patientia* L. created in Ukraine, known as the Sorrel of Uteush or schavnat was cultivated in the experimental land of the Botanical Garden (Institute) ASM. The objective of this research was to evaluate some biological peculiarities, productivity and fodder value, depending on the time of harvest, thermophysical properties of the dry mass of the hybrid *Rumex tianschanicus* × *Rumex patientia* in Moldova's conditions. It has been established that the hybrid in the 3rd- 4th years of vegetation has an accelerated growth and development rate. Branched stalks of this hybrid grow up to 2.5 m tall. In fourth year the hybrid *Rumex tianschanicus* × *Rumex patientia* was harvested in stem growth phase and we obtained 2.7 t/ha nutritive units with 600 kg/ha digestible protein; in the budding phase – 7.7 t/ha nutritive units with 1340 kg/ha digestible protein; at the end of flowering phase – 10.6 t/ha nutritive units with 913 kg/ha digestible protein. The fodder of this hybrid is distinguished by a high content of glutamine (235.2%), valine (22.4 %), proline (20.7%) and histidine (19.0 %), but a lower content of methionine (39.0%), lysine (36.0%), phenylalanine (20.0%) asparagine (37.2%), serine (13.5%) and tyrosine (318.0%) in comparison with alfalfa. For the production of solid biofuel, in seed maturation period hybrid *Rumex tianschanicus* × *Rumex patientia* can be harvested using equipment for harvesting grassy fodder, laid in swath for air-drying, chopped directly in the field or pressing in bales. The density of the briquettes made from biomass is 870 kg/m^3, ash content - 2.1% The potential of energy production reached 200 GJ/ha. The hybrid *Rumex tianschanicus* × *Rumex patientia* can be used as a multipurpose crop in Moldova's conditions.

Key words: hybrid *Rumex tianschanicus* × *Rumex patientia*, agro biological peculiarities, fodder value, biomass calorific value, multipurpose crop

Globally, agriculture plays a key role in improving livelihood, especially in rural communities. Livestock is the main stay of agricultural community, major problems of revitalization and development of animal husbandry is increasing and diversification of forage production which can provide a guaranteed flow of balanced fodder, in terms of quantity and quality, throughout the year, according to the physiological requirements of animals. 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 of biomass for various industries involved in the production of energy. Scientific research conducted in the Botanical Garden (Institute) of the ASM in the last 65 years aimed at mobilization, improvement and implementation of new non-traditional plant species with multiple uses, which use efficiently water, photosynthetic active radiation and land resources (Teleuță A. et al., 2008; Teleuță A. and Țîței V. , 2013; □î□ei V., 2015; □î□ei V. et al., 2013).

Some promising plant species belong to *Polygonaceae* Juss. family, it has about 50 genera and about 1100 species, including the species of *Rumex* L. genus, there are about 200 species of annual, biennial and perennial herbs (Vysochina G.I., 2011). The species *Rumex patientia* L. is widespread in Europe, used in Romania and Republic Moldova in spring broths. It is also used as feed for some animals (sheep, goat), but contains a high amount of organic acids, used in folk medicine (Teleuță A. et al., 2008).

Since the mid 30s of the twentieth century, research on plant improvement has been conducted by crossing with other species of the genus *Rumex*, including the species *Rumex tianschanicus*, native to Asia, highly tolerant to adverse environmental conditions. Substantial progress in the breeding of these species was achieved in Ukraine. The first hybrid *Rumex patientia* L. (maternal line) and *Rumex tianschanicus* A. Los. (paternal line) were created by multiannual selection, it is known as the Sorrel of Uteush or schavnat and was registered in

[1]Botanical Garden (Institute) of the Academy of Sciences of Moldova, Chişinău, Republic Moldova

former USSR by professor Yurii Uteush at the end of 1980s. (Uteush Y.A., 1990), currently, more hybrids are created for different purposes (Rakhmetov D.B., 2011).

The plant height of the hybrid *Rumex tianschanicus* × *Rumex patientia* reached, at flowering, 160-220 cm, in better soils – 200-260 cm, the individual plants grow up to a height of 300 cm. The root of the plants is huge, branched; some sectors of roots reach 1.5 to 2.0 meters deep. Stems are straight, at the bottom – round, without fuzz, juicy, the diameter at the basal portion (at 15 cm) – 15-24 mm, number of internodes – from 25 to 50. The plant produces on average 4-9 vegetative shoots. Lower leaves have a length of 45-60 cm. Upper stem leaves have a size of 24x9 cm to 30x12 cm. The shape of the leaves is ovate-lanceolate, margins – entire, leaf – smooth or slightly toothed. Petioles are 15-30 cm long. The leaves are succulent; on the plant, they are arranged in a spiral. Inflorescence – panicle, 90-130 cm long, consisting of 10 to 20 branches of the first order. The small flowers are androgynous, the male flowers are purple-red and the female flowers are yellow-green, both types are borne in bunch. The fruit is a small three-edge shaped nut. It is glossy and brown. The weight of 1000 seeds is 3-3.4 g (Uteush Y.A., 1990; Rakhmetov D.B., 2011).

The hybrid *Rumex tianschanicus* × *Rumex patientia* was investigated and implemented in Russia, Belarus, Kazakhstan, China, South Korea, North Korea, Czech Republic, Bulgaria, Germany, Norway. It is a very promising crop for production of high quality forage, biofuel, specialized food products and food additives (Rakhmetov D.B., 2011; Rachmetov D. et al., 2004; Stepanov A. F. and Kukusheva A. N. , 2012; Ust'ak S., 2012; Ust'ak S. and Ust'akova M. , 2004).

The values of the quality indices obtained from the peracetic acid pulp of the hybrid *Rumex tianschanicus* × *Rumex patientia* plants indicate their possible use in the pulp and paper industry, for the production of various kinds of paper and cardboard. (Barbash V. et al., 2011).

The objective of this research was to evaluate some biological peculiarities, productivity and fodder value, depending on the time of harvest, thermophysical properties of the dry mass of the hybrid *R. tianschanicus* × *R. patientia* in Moldova's conditions.

MATERIAL AND METHOD

The hybrid *Rumex tianschanicus* × *Rumex patientia (*hybrid *R. tianschanicus* × *R. patientia)*, served as object of study, as control variant – traditional fodder crop alfalfa *Medicago sativa*, which were cultivated in the experimental land of the Botanical Garden (Institute) ASM. The experiments started in the spring of 2012, with seeds that had been sent to us by Dzhamal Rachmetov, head of the Department of Alternative Crops, National Botanical Garden of the National Academy of Sciences of Ukraine. The seedbed was prepared the same manner as for fodder crops: ploughing at 25-27 cm, in autumn, harrowing and rolling with heavy roller in spring 2-3 days before sowing, seeds were sown at a depth of – 1-1.5 cm, 1.7-2 million germinative seeds per 1 ha. Scientific researches on agro-biological peculiarities were performed according to the methodical indications (Novoselov Y. *et al.,* 1983), biochemical composition and nutritional value of natural fodder (Petukhov Y. *et al.*, 1989).

The biomass of *Rumex tianschanicus* × *Rumex patientia* and *Medicago sativa* was mown using equipment for harvesting fodder in seed maturation phase, laid in swath for drying and chopped directly in the field. Scientific researches on the biomass for the production of solid biofuel were carried out: the moisture content of chopped material was determined by CEN/TS 15414 in an automatic hot air oven MEMMERT100-800; the content of ash was determined at 550◦C in a muffle furnace HT40AL according to CEN/TS 15403; automatic calorimeter LAGET MS-10A with accessories was used for the calorific value determination, according to CEN/TS 15400; the cylindrical containers were used for determination of bulk density, calculated by dividing the mass over the container volume; the briquetting was carried out by hydraulic piston briquetting press BrikStar model 50-12 (Briklis); the mean compressed (specific) density of the briquettes was determined immediately after removal from the mould as a ratio of measured mass over calculated volume.

RESULTS AND DISCUSSIONS

We could mention that, in the conditions of the Republic of Moldova, the seeds of the hybrid *R. tianschanicus* × *R. patientia* require higher temperatures of the seedbed, in order to germinate in soil, in comparison with alfalfa. Seedlings appeared on the soil surface after 11-14 days after sowing. After emergence, it was necessary to accomplish the soil loosening with weeding. The growth and development was slow, after 2-3 months of vegetation the plants developed roots and formed the aerial socket of 3-4 pairs of 13-15 cm long leaves. At the end of the growing season, the hybrid formed a strong rosette of leaves, ovate-lanceolate, 53-57 cm long, on long grooved petioles. In the first year of vegetation, it did not form generative shoots, but developed strong root which penetrated into the soil up to 1 m.

In the first year, the fresh mass yield reached 1.27 kg/m^2. Several researchers recommend not to harvest the hybrid *R. tianschanicus* × *R. patientia* in the first year of growing, because it is very important for the strengthening root collar.

The root collar formed three to five wintering buds, from which, the generative shoots grew in the second year of vegetation. In February-March, when the air temperature exceeded 0°C,

plant development from buds started. The plants went through all stages of ontogenetic development finishing with seed formation. The plant height reached 138-159 cm, the fresh mass yield reached 3.58 kg/m^2.

It has been established that the hybrid *R. tianschanicus* × *R. patientia*, in the 3rd year of vegetation, had an accelerated growth and development rate. In early May, the yield reached 4.72 kg/m^2 of natural forage. The fodder value of 1 kg fresh mass was of 0.14 nutritive units, 2.13 MJ metabolizable energy and 18 g digestible protein.

A more detailed research was carried out in the 4th year of vegetation (*table 1*). It was found that the hybrid plants *R. tianschanicus* × *R. patientia* resumed growth, in spring, 14 days earlier in comparison with alfalfa. The growth rate changed during April, thus, in mid-April, stems started forming, harvesting during this period made possible to obtain a yield of fresh mass of 2.94 kg/m^2, but the dry matter content was very low (10.75%) and such feed is given to animals in a mix with fibrous fodder. The growth and development rate was intensifying over the next 15-20 days, flower buds appeared and shoots reached a height of 137-167 cm, the productivity of aerial phytomass reached 5.08 kg/m^2 fresh mass or 0.80 kg/m^2 dry matter. The fodder harvested in the first days of May was characterized by very high leaf content. Harvesting the hybrid plants *R. tianschanicus* × *R. patientia* in full flowering phase made possible to obtain a yield of fresh mass of 5.89 kg/m^2 with a moderate content of dry matter. At the same time, the leaf content in the fodder was lower. In comparison with the traditional fodder crop alfalfa, which in this period reached the optimal harvest time, the fodder productivity of the hybrid *R. tianschanicus* × *R. patientia* was 2 times higher, but the harvested fodder had a lower content of leaves and dry matter.

A high yield of the hybrid plants *R. tianschanicus* × *R. patientia* is also mentioned in other studies Rakhmetov D.B., 2011; Rachmetov D. et al., 2004; Stepanov A. F. and Kukusheva A. N. , 2012; Ust'ak S., 2012; Ust'ak S. and Ust'akova M. , 2004). So, Rakhmetov, 2011, stated that in the conditions of Ukraine, it could have a productivity of 80-100 t/ha natural fodder depending on the genotype.

Table 1

The yield of the hybrid *Rumex tianschanicus* × *Rumex patientia*

Indicators	*R. tianschanicus* × *R. patientia*			*Medicago sativa* (*control)*
	stem growth period	budding period	end of flowering period	
The yield:				
- fresh mass 1-st harvest, kg/m^2	2.94	5.08	5.89	2.48
- dry matter, kg/m^2	0.31	0.80	1.22	0.60
The leaf share of the fodder, %	89	66	37	44

The forage yield and seasonal distribution may be of great importance to the livestock breeders. Sometimes the balance of nutrients in the forage will have positive or negative effects on animal health. Analyzing the biochemical composition of the dry matter of the hybrid *R. tianschanicus* × *R. patientia* (*table 2*) we found that nutrient content changed depending on the harvesting period. The fodder harvested in the stem growth phase was distinguished by very high raw protein content (24.88%) and mineral substances (15.67%), high content in budding phase (20.12% and 13.99%) and low content – at the end of flowering phase (9.71% and 6.28%), at the same time, the cellulose content increased from 15.03% to 44.43%, probably due to the report leaves/stems of harvested fodder. Fat content reached moderate values (2.76-2.86 %) in the stem growth phase and at the end of flowering phase, and low content in budding period (1.03 %). We may mention that the dry matter from the natural fodder of *R. tianschanicus* × *R. patientia* contained 36.82-41.56% nitrogen free extractive substances.

As mentioned above, the yield and biochemical composition of the dry matter influences the nutritive value and the efficiency of fodder production. So, the hybrid *R. tianschanicus* × *R. patientia* was harvested in stem growth phase and we obtained 2.7 t/ha nutritive units, 600 kg/ha digestible protein; in the budding phase – 7.7 t/ha nutritive units with 1340 kg/ha digestible protein; at the end of flowering phase – 10.6 t/ha nutritive units with 913 kg/ha digestible protein. *Medicago sativa* (at fist harvest) contains 4.90 t/ha nutritive units with 750 kg/ha digestible protein.

Animals rely on a permanent protein supply throughout life for maintenance, growth and reproduction. Amino acids are the building block of protein, each protein consisting of a chain made up of amino acids in a unique sequence. The specific deficiency, by insufficiency of some essential amino acids, has, besides losing weight of animals, various morphofunctional aspects, dependent on the action of the deficient amino acid (Pârvu G., 1992).

Table 2

Biochemical composition and nutritional value of the hybrid *Rumex tianschanicus* × *Rumex patientia*

Indicators	*R. tianschanicus* × *R. patientia*			*Medicago sativa* (*control)*
	stem growth period	budding period	end of flowering period	
dry matter contains:	10.75	15.75	20.67	24.30
raw protein, %	24.88	20.12	9.71	16.66
raw fats, %	2.86	1.03	2.76	1.88
raw cellulose, %	15.03	25.03	44.43	34.24
nitrogen free extractive substances, %	41.56	40.00	36.82	37.22
mineral substances,%	15.67	13.99	6.28	10.00

The determination of the amino acid composition of the proteins in fodder is of great importance. Analyzing the amino acid content, we could mention that in the natural fodder of the hybrid *R. tianschanicus* × *R. patientia*, there are the same essential amino acids that are found in alfalfa, but there are differences in their quantity (*table 3*). The fodder of this hybrid is distinguished by a high content of glutamine (235.2%), valine (22.4 %), proline (20.7%) and histidine (19.0 %), but a lower content of methionine (39.0%), lysine (36.0%), phenylalanine (20.0%) asparagine (37.2%), serine (13.5%) and tyrosine (318.0%) in comparison with alfalfa.

Table 3

The content of amino acids (mg/100mg d.m.) of the hybrid *Rumex tianschanicus* × *Rumex patientia*

Amino acids	*R. tianschanicus* × *R. patientia* (budding period)	*Medicago sativa* (*control)*
asparagine	0.1247	1.711
threonine	0.554	0.564
serine	0.605	0.687
glutamine	3.199	1.360
proline	1.113	0.922
glycine	0.660	0.550
alanine	0.638	0.674
valine	0.684	0.559
methionine	0.100	0.139
isoleucine	0.438	0.459
leucine	0.860	0.913
tyrosine	0.144	0.458
phenylalanine	0.708	0.850
histidine	0.388	0.326
lysine	0.462	0.619
arginine	0.614	0.655

Table 4

Thermophysical properties of the dry mass of the hybrid *Rumex tianschanicus* × *Rumex patientia*

Indices	*R. tianschanicus* × *R. patientia*	*Medicago sativa*
Bulk density of the chopped stems, kg/ m^3	173.2	121.4
Gross calorific value, MJ / kg	18.9	16.9
Density of briquettes, kg/ m^3	870	695
Ash of briquettes, %	2.1	6.4
Potential of energy production, GJ/ha	200	140
- equivalent coal, t	7.5	5.2
- equivalent to conventional oil, t	5.0	3.5

The rational use of natural resources is crucial for environmental protection. The demand for clean and environmentally-friendly fuels stimulates the search for new energy sources and the development of new production technologies designed to replace conventional fuel with a range of biofuels. It is most important to evaluate the thermophysical properties of biomass derived from energy crops (Blyum Ya. B. et al., 2014). For the production of solid biofuel, in seed maturation phase, the biomass was mown using equipment for harvesting grassy fodder, laid in swath for air-drying and chopped directly in the field. The productivity of the harvested biomass of studies crops constituted 0.83-1.06 kg/m^2 dry matter. The bulk density of the chopped biomass was 121.4-173.2 kg/m^3 (*table 4*). The ash content of briquettes was 2.1-6.4 %. The heating value reached 16.9-18.9 MJ/kg dry matter. The density of the briquettes made from biomass was 695-870 kg/m^3.

The potential of energy production of the hybrid *R. tianschanicus* × *R. patientia* reached 200 GJ/ha with moderate ash content of briquettes.

CONCLUSIONS

In the conditions of the Republic of Moldova the fresh mass yield the hybrid *Rumex tianschanicus* × *Rumex patientia* in first year reached 1.27 kg/m^2, second year - 3.58 kg/m^2 and third year - 4.72 kg/m^2.

In fourth year the hybrid *Rumex tianschanicus* × *Rumex patientia* was harvested in stem growth phase and we obtained 2.7 t/ha nutritive units with 600 kg/ha digestible protein; in the budding phase – 7.7 t/ha nutritive units with 1340 kg/ha digestible protein; at the end of flowering phase – 10.6 t/ha nutritive units with 913 kg/ha digestible protein.

The fodder of this hybrid is distinguished by a high content of glutamine (235.2%), valine (22.4 %), proline (20.7%) and histidine (19.0 %), but a lower content of methionine (39.0%), lysine (36.0%), phenylalanine (20.0%) asparagine (37.2%), serine (13.5%) and tyrosine (318.0%) in comparison with alfalfa.

For the production of solid biofuel, in seed maturation hybrid *Rumex tianschanicus* × *Rumex patientia* can be harvested using equipment for harvesting grassy fodder, laid in swath for air-drying, chopped directly in the field or pressing in bales. The density of the briquettes made from biomass is 870 kg/m^3, ash content - 2.1% The potential of energy production reached 200 GJ/ha.

The hybrid *Rumex tianschanicus* × *Rumex patientia* can be used as a multipurpose crop in Moldova's conditions.

REFERENCES

Barbash, V., Poyda, V., Deykun, I. 2011.- *Peracetic acid pulp from annual plants.* Cellulose Chemistry and Technology, ***45*** *(9-10):613-618*

Blyum, Ya.B., Grigoryuk, I.P., Dmitruk, K.V., Dubrovin, V.O. Yemec. A.I., Kaletnik, G.M., Melnichuk. M.D.,Mironenko, V.G., Rakhmetov, D.B., Sibirnij, A.A., Cigankov, S.P., 2014.- *System of bioresources usage and modern biotechnology in production of alternatives fuels*. Ed. Agrar Media Grup, Kyiv, 360 p. [in Ukrainian].

Novoselov, Y. K. , Kharkov, G.D., Shekhovtsova, N.S., 1983.- *Methodical instructions for conducting field experiments with forage crops.* Ed.VNNIK, Moscow. [in Russian].

Pârvu, G., 1992. - *Supravegherea nutriţional metabolică a animalelor*. Ed. Ceres, Bucureşti. 395 p.

Petukhov, E.A., Bessarabova, R.F., Holeneva, L.D., Antonova. O.A., 1989. - *Zoo technical analysis of the feed.* Ed. Agropromizdat, Moskva. [in Russian].

Rakhmetov, D.B., 2011.- *Theoretical and practical aspects of plant introduction in Ukraine*. Ed. Agrar Media Grup, Kyiv, 398 p. [in Ukrainian].

Rachmetov, D., Ust'ak. S., Ust'aková, M., 2004.- *Perennial spinach-sorrel hybrid– schavnat as a new perspective multipurpose crop.* VIII ESA Congress, Copenhagen. p. 86-94

Stepanov, A. F., Kukusheva, A. N. , 2012. -*The fodder sorrel productivity in different herbage use conditions.* [inRussian]. www.kgau.ru/vestnik/content/2012/11.12e.pdf

Teleuţă, A., Colţun, M., Mihăilescu, C., Ciocârlan N., 2008.- *Plante medicinale*. Ed. Litera. Internaţional, Chişinău, 336 p.

Teleuţă, A., Ţîţei, V. , 2013.- *Biological peculiarities and utilization possibilities of the cultivar "Solar" of Helianthus tuberosus L.* Revista Botanica, 2(7): 42-48.

Titei, V., 2015.- *Plant species for renewable energy production in the Republic of Moldova*. www.agronomyjournal.usamv.ro/pdf/2015/vol.LVIII/art77.pdf

Titei, V., Teleuta , A., Cosman, S., Cosman, V., 2013.- *Productivity and feeding value of giant knotweed in the Republic of Moldova*. [inRussian]. www.nbgnsc.com/en/content/bulletin-state-nikitsky-botanical-gardens

Ust'ak, S., 2012. - *Cultivation of fodder sorrel for biogas production*. Ed. VÚRV Praha. [in Czech]

Ust'ak S., Ust'akova, M. , 2004. - *Potential for agricultural biomass to produce bioenergy in the Czech Republic*. Sustainability, Markets and Policies. OECD Publishing Vienna. p. 229-239

Uteush, Y.A., 1990.- *New promising forage crops*. Edit. Naukovo dumka, Kyiv. 192. [in Russian]

Vysochina, G.I. 2011.- ***Phenolic compounds in systematics and phylogeny of the family Polygonaceae Juss. IV. Genus Rumex L.*** **Turczaninowia 14(1) : 120–126.**