Scientific Papers. Series A. Agronomy, Vol. LIX, 2016
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

PROSPECTS FOR THE UTILIZATION OF THE *Miscanthus giganteus* AND *Polygonum sachalinense* FOR SOLID BIOFUEL PRODUCTION IN THE REPUBLIC OF MOLDOVA

Victor ŢÎŢEI[1], Andrei GUDÎMA[2], Alexandru MUNTEAN[2], Mihai GADIBADI[2], Aurelia LUPAN[1]

[1]Botanical Garden (Institute) of the Academy of Sciences of Moldova, Chişinău, 18 Padurii str., MD 2002 Republic of Moldova
[2]State Agrarian University of Moldova, Chişinău, 56 Mircesti str., MD 2049 Republic of Moldova

Corresponding author email: victitei@gmail.com

Abstract

Energy production from renewable sources plays an important role. To determine crops which are the most suitable for energy production, its thermophysical properties, ecological impact and production economy must be investigated thoroughly. The hybrid Miscanthus giganteus and the cultivar Gigant of Polygonum sachalinense, which were cultivated in the experimental plot of the Botanical Garden (Institute) of the ASM, served as object of study, control variant – wheat straw Triticum aestivum. It has been established that stems of Polygonum sachalinense stems defoliated and dehydrated faster than Miscanthus giganteus, the bulk density of the chopped material 181 kg/m^3 and 146 kg/m^3, respectively. Wheat straw is characterized by the lowest bulk density (83 kg/m^3). The specific density of briquettes made from milled chaffs (20 mm and 10 mm) of Polygonum sachalinense reaching values 799-841 kg/m^3, Miscanthus giganteus 869-882 kg/m^3, but Triticum aestivum 733-740 kg/m^3. The *Polygonum sachalinense and Miscanthus giganteus biomass were distinguished high gross calorific values (19.3-19.8 MJ/kg) and moderately ash content (2.23-2.51%), but wheat straw low calorific value (17.0 MJ/kg) and high content of ash (5.08%).*

Key words: *biomass, briquettes, Miscanthus giganteus,* Polygonum sachalinense, thermophysical properties.

Energy is one of the most important commodities in today's world to ensure socio-economic development of the country. Due to increasing energy demands and pollution problems caused by the use of fossil fuels, it has become necessary to introduce alternative energy sources into the global energy turnover. Energy production from renewable sources plays an important role in European energy policies. The biomass takes a priority among the energy fuels. High potential lies in herbaceous biomass, which has been on rise in recent years. To determine crops which are the most suitable for energy production, its thermo physical properties, ecological impact and production economy must be investigated thoroughly.

In recent years, the Moldovan Parliament adopted a series of legislative acts in the energy field, including the Energy Strategy of the Republic of Moldova (2013), the law on the use of renewable energy (2007), and the law on energy efficiency (2010). In 2009, Moldova became a member of the Energy Community, which extends the EU internal energy market to South-East Europe and beyond through a legally binding framework. In the period 2010-2014, the EU allocated €14 million for the production of renewable energy from local biomass (e.g. straw) as part of a EuropeAid project, helping to reduce dependence on imported natural gas.

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. The biomass research activities are relatively new (Ţîţei, Teleuţă, 2012; 2014; Marian et. al. 2014)

Some promising herbaceous perennial plant species belong to *Poaceae* Barnhar. and *Polygonaceae* Juss. families.

The giant knotweed or Sakhalin knotweed, *Polygonum sachalinense* F.Schmidt [*Fallopia sachalinense* (F. Schmidt ex Maxim.) Ronse Decr., *Reynoutria sachalinense* (F. Schmidt ex Maxim.) Nakai], *Polygonaceae* family, is a herbaceous perennial plant growing up to 2-4 m tall, with strong, extensively spreading rhizomes forming large clonal colonies, native to North-East Asia: the northern Japan and the Russian Far East. It appeared in Europe the second half of the 19^{th} century, being implemented in culture during the 20^{th} century due to its tolerance and stable productivity, serving as fodder from early spring until late autumn, but also as raw material for the different industries. This species has been investigated over more than 30 years in Moldova. Being selected adapted forms to local soil and climate conditions, the *Polygonum sachalinense* cultivar *Gigant* was created and registered in 2012 in the Catalogue of plant varieties of the Republic of Moldova, it reproduces by pieces of rhizomes and rooted cuttings, or seedling about 25 thousand/ha (Ţîţei, 2014). One of the most commonly used energy crops from *Poaceae* family is *Miscanthus giganteus* Greef et Deu., a sterile tetraploid hybrid, with parental forms *Miskanthus sinensis* Andersson and *Miscanthus sacchariflorus* (Maxim.) Franch., belonging to C_4 photosynthetic pathway plant group, native to tropical and subtropical regions of Africa, Southeast Asia. The hybrid *Miscanthus giganteus* is propagated asexually, usually by dividing the rhizomes and by tissue culture. It is characterized by a rapid growth and development, ultimate height 4.5 metres, is tolerant to soil and environmental conditions, being widely used for fuel production in Europe since the 80s of the last century (Lewandowski et. al., 2000).

Miscanthus giganteus has produced more than double the biomass of another grass species. The objective of this research was to evaluate some thermophysical properties of the biomass and briquettes of the hybrid *Miscanthus giganteus* and the cultivar *Gigant* of *Polygonum sachalinense* in Moldova's conditions.

MATERIALS AND METHODS

The hybrid *Miscanthus giganteus* and the cultivar *Gigant* of *Polygonum sachalinense*, which were cultivated in the experimental plot of the Botanical Garden (Institute) of the ASM, the 4^{th} growing season, served as object of our study, having as control variant wheat straw *Triticum aestivum*.

Harvesting of the hybrid *Miscanthus giganteus* and *Polygonum sachalinense* was done manually in the first days of March. Harvestable stems of *Miscanthus giganteus* and *Polygonum sachalinense* and wheat straw bales were chopped into chaff with the use of stationary forage chopping unit. The obtained chaffs of mean dimension from 7 to 35 mm, were milled in a beater mill equipped with a sieve with diameter of openings of 20 mm and 10 mm. Scientific researches on the biomass for the production of solid biofuel were carried out: the moisture content of plant material was determined by CEN/TS 15414 in an automatic hot air oven MEMMERT100-800; the content of ash was determined at 550ºC 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; 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, in the first year of vegetation, *Miscanthus giganteus* developed, in the underground part, the root system and new rhizomes, and the 3-5 shoots can reach 152-183 cm tall, with high leaf content. It was established that during the first month, *Polygonum sachalinense* grew and developed slowly and formed 3-5 leaves in the aerial part, during the next month, the development of the stem with internodes began. So, at the end of August, the plants reached 164-170 cm, the first six internodes were already wooden; in the underground part of the stem, it was observed the appearance of dormant buds which next year would contribute to the formation of new shoots.

In the following years, the regrowing season for the species *Polygonum sachalinense* started in the first half of March and for the hybrid *Miscanthus giganteus* – in April, 12-25 shoots grew, which by the end of vegetation reached 3.0-4.5 m tall, the root system reached 2 m depth, the number of rhizomes increased considerably.

A more detailed research on biomass was carried out in the 4th year of vegetation. It is known that moisture and leaf contents in harvested biomass influence the costs of transport, storage, drying and processing, and the thermophysical properties of solid biofuel.

The moisture and leaf contents of plant material of the tested species varied significantly at the end of the growing season (Table 1). The highest moisture content was determined in the biomass of *Polygonum sachalinense* (about 72%), in comparison with *Miscanthus giganteus* (about 52%), but the leaf and panicle contents in the biomass of the latter was high (37.12%).

Over 35-40 days, *Polygonum sachalinense* stems were completely defoliated, while the *Miscanthus giganteus* leaves were kept for a long period of time (in March, the leaves constituted 0.93% of biomass). After the establishment of temperatures below 0ºC, the studied species were distinguished by the pace of dehydration of tissues, *Polygonum sachalinense* in field dehydrated faster than *Miscanthus giganteus*. At the end of December, the humidity of the stems of *Polygonum sachalinense* reduced to 26 %, in the middle of January – below 20%, and in early March – 14%, but in *Miscanthus giganteus* – 38%, 27% and 11%, respectively. Similar results were presented by other authors (Lisowski et. al., 2010; Sypula et. al., 2010; Stolarski et. al., 2014).

The low density of biomass materials poses a challenge for the handling, transportation, storage and combustion processes. These problems may be addressed through densification, a process that produces solid fuel with denser and more uniform properties than the raw biomass.

It has been established that the bulk density of the chopped material of *Miscanthus giganteus* constitutes 146 kg/m^3 and of *Polygonum sachalinense* is higher - 181 kg/m^3, while wheat straw is characterized by the lowest bulk density - 83 kg/ m^3 (Table 2).

Table 1. Plant material moisture and leaves contents of the *Miscanthus giganteus* and *Polygonum sachalinense*

Period	*Miscanthus giganteus*		*Polygonum sachalinense*	
	moisture content, %	leaves content, %	moisture content, %	leaves content, %
7 October	51.65	37.12	71.92	19.34
27 October	50.80	32.98	71.29	2.96
10 November	45.80	28.44	60.00	1.25
20 November	45.10	24.13	46.20	0
18 December	42.20	12.11	31.70	0
30 December	38.53	10.24	25.84	0
16 January	26.89	7.17	19.60	0
5 March	10.89	0.93	13.63	0

Table 2. Bulk density of biomass and briquettes of the studied species

Variants	*Triticum aestivum*		*Miscanthus giganteus*		*Polygonum sachalinense*	
	bulk density of biomass, kg/m^3	specific density of briquettes, kg/m^3	bulk density of biomass, kg/m^3	specific density of briquettes, kg/m^3	bulk density of biomass, kg/m^3	specific density of briquettes, kg/m^3
chopped chaffs 7 -35 mm	83	715	146	594	181	732
milled chaffs 20 mm	86	733	153	869	202	799
milled chaffs 10 mm	93	740	167	882	216	841

Distinct differences in bulk density between chopped and milled chaffs were found. These differences amounted to 7-21 kg/m^3 in *Miscanthus giganteus* and 21-35 kg/m^3 in *Polygonum sachalinense,* with 3-10 kg/m^3 in wheat straw.

We could mention that the specific density of briquettes made from chopped material of *Miscanthus giganteus* was low, of 594 kg/m^3, but it increased significantly if milled chaffs where processed into briquettes, reaching values of 869-882 kg/m^3.

The specific density of briquettes made from milled chaffs of *Polygonum sachalinense* was 799-841 kg/m^3, but of *Triticum aestivum* was 733-740 kg/m^3.

The ash content of different types of biomass is an indicator of slagging behaviour of the biomass. The greatest level of this component was contained in *Triticum aestivum* - 5.08%, while the lowest – in *Miscanthus giganteus* - 2.23% (Table 3). Ash content of wheat straw pellets reach 6.33 % and negatively influences the combustion efficiency (Ivanova et. al. 2015).

Table 3. Ash content and calorific value of biomass

Indices	*Triticum aestivum*	*Miscanthus giganteus*	*Polygonum sachalinense*
ash content,%	5.08	2.23	2.51
calorific value, MJ /kg	17.0	19.8	19.3

The investigation showed that *Miscanthus giganteus* and *Polygonum sachalinense* had high gross calorific values between 19.8 MJ/kg and 19.3 MJ/kg respectively, but wheat straw had very low ones (17.0 MJ/kg), probably because of the high content of ash.

For Poland, the respective gross calorific values of *Miscanthus giganteus* and *Polygonum sachalinense* were 19.09 MJ/kg and 19.00 MJ/kg (Stolarski et. al., 2014). According to Havrland et al. (2013), in Czech Republic the energy yield of *Miscanthus giganteus* is around 531.9 GJ/ha and of *Reynoutria x bohemica* 387.7 GJ /ha.

CONCLUSIONS

The studied species *Miscanthus giganteus* and *Polygonum sachalinense* were varied significantly by the moisture and leaf contents of plant material at the end of the growing season, rhythm stems defoliation and dehydration after the establishment of temperatures below 0ºC. *Polygonum sachalinense* stems defoliated and dehydrated faster than *Miscanthus giganteus*.

The specific density of briquettes made from chopped material (7-35 mm) of *Miscanthus giganteus* was low - 594 kg/m^3.

The specific density of briquettes made from milled chaffs (20 mm and 10 mm) of *Polygonum sachalinense* reaching values 799-841 kg/m^3, *Miscanthus giganteus* – 869-882 kg/m^3, but *Triticum aestivum* – 733-740 kg/m^3.

Polygonum sachalinense and *Miscanthus giganteus* were distinguished high gross calorific values 19.3 -19.8 MJ/kg, but wheat straw low - 17.0 MJ/kg, probably because of the high content of ash (5.08%).

Miscanthus giganteus and *Polygonum sachalinense* are very promising crops for the production of high quality bio-fuel in Moldova's conditions.

REFERENCES

Havrland B., Ivanova T., Lapczynska-Kordon B., Kolarikova M., 2013. Comparative analysis of bio-raw materials and biofuels. Engineering for Rural Development. Jelgava, 541-544.

Ivanova T., Kavalek M., Havrland B., Kolaríkova M., Skopec P., 2015. Comparison of technologic parameters of pellets and other solid fuels produced from various raw materials. Agronomy Research, 13(2): 303-310.

Lewandowski I., Clifton-Brown J.C., Scurlock J.M.O., Huisman W., 2000. Miscanthus: European experience with a novel energy crop. Biomass and Bioenergy, 19: 209-227.

Lisowski A., Klonowski J., Sypula M., 2010. Comminution properties of biomass in forage harvester and beater mill and its particle size characterization. Agronomy Research 8 (Special Issue II): 459-464.

Marian Gr., Muntean Al., Gudîma A., Ţîţei V., Pavlenco A., 2014. Analiza comparativă a biomasei obţinute din culturi energetice. Ştiinţa agricolă, 2: 70-75.

Stolarski M.J., Krzyżaniak M., Śnieg M., Słomińska E., Piórkowski M., Filipkowski R., 2014. Thermophysical and chemical properties of perennial energy crops depending on harvest period. International Agrophysic, 28: 201-211.

Sypula M., Lisowski A., Chlebowski J., Nowakowski T., Struzyk A., 2010. Bulk density of chopped material of energetic plants. Annals of Warsaw University of Life Sciences – SGGWAgriculture, 56: 29-37.

Ţîţei V., 2014. Particularităţile agrobiologice şi posibilitatea utilizării speciei hrişca de sahalin în R. Moldova. Lucrări ştiinţifice. Agronomie şi ecologie. UASM Chişinău, 41: 306-309.

Ţîţei V., Teleuţă A., 2012. Perspectiva fondării plantaţiilor energetice în Republica Moldova. In. Edificarea societăţii durabile.Chişinău, 251-255.

Ţîţei V., Teleuţă A., 2014. Specii perene şi soiuri de plante pentru fondarea plantaţiilor energetice în Republica Moldova. Intellectus, 4: 88-94.