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THE MOBILIZATION OF ENERGY CROP RESOURCES IN MOLDOVA

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ABSTRACT

In the context of the current sharp rise in energy prices and frequent weather anomalies caused by climate change, humankind faces two major problems: food supply and energy security, which compels us to look for alternative ways of solving these problems, including the reduction of the dependence on fossil fuels and the development of new technological processes for renewable energy production. The main objectives of this study were to evaluate some agrobiological peculiarities and the quality of harvested biomass from local cultivars: 'Solar' *Helianthus tuberosus*, 'Ileana' *Inula helenium*, 'Vital' *Silphium perfoliatum*, 'Energo' *Sida hermaphrodita*, 'Vigor' *Astragalus galegiformis*, 'Titan' *Miscanthus giganteus*, 'Argentina' *Sorghum almum*, 'Gigant' *Polygonum sachalinense* and the prospects of using their biomass as feedstock for renewable energy production. It was found that the studied cultivars, in the second and following growing seasons, were characterised by optimal growth rate and moderate regenerative capacity after being mowed, making it possible to cut by 1-3 times per season, obtaining 4.61-14.25 kg/m^2 green mass, which may be used for anaerobic digestion in biogas plants, with biochemical methane potential of 297-336 litre/kg organic matter. Besides, digestate and fugate are believed to be good fertilizers, being rich in plant available nutrients such as nitrogen, phosphate and potash, and could serve as a replacement for fossil based mineral fertilizers in organic farming. The stems of the studied cultivars quickly dehydrate in the autumn-winter period, and can be chopped, milled and used as feedstock for the production by cellulosic ethanol and solid bio fuel. The analysis of lignocellulose composition showed that the dry matter contained 375-517 g/kg cellulose, 211-305 g/kg hemicellulose, 68-134 g/kg acid detergent lignin. The estimated theoretical ethanol yield from cell wall carbohydrates averaged 408-591 L/t. The gross calorific value of stem biomass was 18.63-19.50 MJ/kg. The specific density of densified solid fuel pellets and briquettes meet the quality standard requirements. The obtained results indicate the possibility of using the local cultivars for the creation of energy plantations in the Republic of Moldova. The cultivation and harvesting of these cultivars do not require sophisticated mechanisms and specific equipment like as in forest exploitations.

Keywords: biomethane, cellulosic ethanol, cultivars, plant resources for energy biomass, solid bio fuel.

INTRODUCTION

In the context of the current sharp rise in energy prices, diminishing supplies of fossil fuels, greenhouse gas emission and frequent weather anomalies caused by climate change, humankind faces two major problems: food supply and energy security, which compels us to look for alternative ways of solving these problems, including the reduction of the dependence on fossil fuels and the development of new technological processes for renewable energy production. Plant species are efficient users of solar energy for converting CO_2 into biomass. Over the last decades, biomass continues to be the most important type of renewable energy source (RES). The use biomass as feedstock for solid, liquid, and gaseous biofuels has been growing. In energy terms, biomass provides the major share (75%) of the bioenergy component (~60%) of the EU's renewable energy mix. These trends are expected to continue under The European Green Deal proposed by the current European Commission. The capacity of biomass to replace fossil fuels in existing infrastructure and the variety of end uses bioenergy provides (e.g., for electricity, heating, and fuel for transportation), makes biomass an attractive and convenient energy resource towards the decarbonisation transition. There are various types of biomass, including forest biomass, agricultural residues and energy crops, and waste biomass (NECPs, 2019; Andersen et al., 2021).

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The range of plant biomass can be increased by including new plant species, which grow in poor quality soil and produce large quantities of dry biomass (El Bassam, 2010). High potential lies in perennial species for biomass production, which has been on rise in recent years. Second-generation energy crops are an especially promising source for the future. These include selected clones or varieties of fast-growing trees (*Paulownia* sp., *Populus* sp., *Salix* sp., *Rosa* sp., *Robinia* sp. etc.), perennial and some annual grasses (*Arundo* sp., *Miscanthus* sp., *Phalaris* sp., *Pennisetum* sp., *Sorghum* sp., *Spartina* sp., *Panicum* sp. etc.), and other perennial plants (*Artemisia* sp., *Cynara* sp., *Helianthus* sp., *Silphium* sp., *Polygonum* sp., *Rumex* sp., *Sida* sp. etc.). These non-food and high yielding crops have a much better energy input/output ratio than first-generation crops like rape or cereals in regards to how much energy biomass is produced per hectare. The results of quality of biomass from the energy crops are given in the specialized literature (Alaru et al., 2011; Murphy et al., 2011; Kowalczyk-Jusko et al., 2012; Stolarski et al., 2014; Herrmann et al., 2016; Roman et al., 2016; Streikus et al., 2017; Bastidas-Oyanedel and Schmidt, 2019; Cumplido-Marin et al., 2020; Peni et al., 2020; Rakhmetov et al., 2020; Molas et al., 2021).

The Republic of Moldova has few fossil energy resources, so being forced to import near 95%, depending entirely on the supplying countries. Therefore, the issue of renewable energy sources is still relevant. According to the Energy Strategy of the Republic of Moldova, the total amount of energy produced from renewable sources should be increased to 20% by the year 2030 and ¾ of this amount will make energy from biomass. Forests in Moldova cover less than 13% of the territory, and it is necessary to study the feasibility of using different types of biomass as renewable energy sources.

To determine crops that are the most suitable for energy production, its agro-biological peculiarities, biochemical composition and thermo-physical properties, environmental impact and production economy must be investigated thoroughly (Țîței and Roșca, 2021).

Over 75 years of research on the mobilization, introduction and acclimatization of plants, collections and exhibitions of species with multiple uses, necessary for the development of the national economy, were founded in the “Alexandru Ciubotaru” National Botanical Garden (Institute). The use of the gene pool of local and introduced plant species as feedstock for renewable energy production is a new direction of research, initiated in 2009y. As a result of the research conducted, the collection of plants with energy biomass potential were created, which consists of 107 taxa from 13 families, annual and perennial, herbaceous and woody species. These taxa can be placed to use of marginal lands and poor quality soil (eroded, salinized etc.).

The main objectives of this study were to evaluate some agrobiological peculiarities and the quality of harvested biomass, fresh mass and stem dry matter, from local cultivars: ‘Solar’ *Helianthus tuberosus*, ‘Ileana’ *Inula helenium*, ‘Vital’ *Silphium perfoliatum*, ‘Energo’ *Sida hermaphrodita*, ‘Vigor’ *Astragalus galegiformis*, ‘Titan’ *Miscanthus giganteus*, ‘Argentina’ *Sorghum almum* and ‘Gigant’ *Polygonum sachalinense* and the prospects of using their biomass as feedstock for renewable energy production.

MATERIAL AND METHODS

The local cultivars of perennial energy crops: ‘Solar’ *Helianthus tuberosus*, ‘Ileana’ *Inula helenium*, ‘Vital’ *Silphium perfoliatum*, ‘Energo’ *Sida hermaphrodita*, ‘Vigor’ *Astragalus galegiformis*, ‘Titan’ *Miscanthus giganteus*, ‘Argentina’ *Sorghum almum* and ‘Gigant’ *Polygonum sachalinense* created in the “Alexandru Ciubotaru” National Botanical Garden (Institute), registered in the Catalogue of Plant Varieties**** and patented by the State Agency on Intellectual Property (BOPI, 2016, 2019, 2020) *-*** of the Republic of Moldova, maintained in monoculture in the experimental plot of the NBGI Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″ longitude, served as subjects of the research, and corn *Zea mays 'Porumbeni-458* MRf*'* was used as control.

The samples for evaluation were taken from plots with 3-5-year-old plants, except *Helianthus tuberosus*. The fresh mass of local cultivars of energy crops was cut in the flowering stage, but corn, *Zea mays* - in kernel milk-wax stage, in August. The harvested mass was chopped with a stationary forage chopping unit. For chemical analyses, green mass samples were dried in a forced air oven at 60°C, milled in a beater mill equipped with a sieve with diameter of holes of 1 mm and some assessments of the main parameters, such as crude protein (CP), crude fibre (CF), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL) and total soluble sugars (TSS), have been determined by near infrared spectroscopy (NIRS) technique using PERTEN DA 7200 NIR Analyzer. The concentrations of hemicellulose (HC) and cellulose (Cel) were calculated according to standard procedures. The carbon content of the substrates was obtained using an empirical equation according to Badger et al. (1979). The biochemical methane potential (Ym) were calculated according to the equations of Dandikas et al. (2015).

The dry matter of *Astragalus galegiformis* and *Inula helenium* was collected in the stage of seed ripening, in July-August, the other crops were harvested in winter. The harvested stalks were chopped into chaff using a stationary forage chopping unit. The chopped biomass was milled in a beater mill equipped with a sieve with diameter of holes of 6 mm.

To perform the analyses, biomass samples were dried in an oven at 85°C and then milled (<1 mm) and homogenized. After that, the total carbon (C), hydrogen (H), nitrogen (N) and sulphur (S) amounts were determined by dry combustion in a Vario Macro CHNS analyzer (Elemental Analyzer, GmbH, Langenselbold, Germany), according to standard protocols at the State Agrarian University of Moldova. The pelleting was carried by the equipment developed at the Institute of Agricultural Technique "Mecagro", Chişinău. The physical and mechanical properties of dry biomass and pellets were determined according to the standards: the moisture content of the plant material was determined by SM EN ISO 18134 in an automatic hot air oven MEMMERT100-800; the content of ash was determined at 550ºC in a muffle furnace HT40AL according to SM EN ISO 18122; the automatic calorimeter LAGET MS-10A with accessories was used for the determination of the calorific value, according to SM EN ISO 18125; the particle size distribution was determined according to SM EN ISO 17827 using standard sieves, the collected particles in each sieve were weighed; the cylindrical containers were used for the determination of the bulk density, calculated by dividing the mass over the container volume according to SM EN ISO 17828, SM EN ISO 18847. The mean compressed (specific) density of the briquettes and pellets were determined immediately after removal from the mould as a ratio of measured mass over calculated volume (Marian, 2016).

To determine the cell wall fractions (NDF, ADF, ADL) in the dry mass of tested crops were assessed using the near infrared spectroscopy (NIRS) technique. The Theoretical Ethanol Potential (TEP) was calculated according to the equations of Goff et al. (2010) based on conversion of hexose (H) and pentose (P):

$$H = [\%Cel + (\%HC \times 0.07)] \times 172.82$$
$$P = (\%HC \times 0.93) \times 176.87$$
$$TEP = (H + P) \times 4.17$$

RESULTS AND DISCUSSION

Analysing the results of the assessment of agro-biological peculiarities of the studied local cultivars of energy crops, we have come to the conclusion that they are characterized by optimal growth and development rates.

It can be noted that cultivar 'Vigor' *Astragalus galegiformis,* fam. *Fabaceae,* propagates by seeds, and in the first year of vegetation, the growth and development rates of *Astragalus galegiformis* were low in comparison with *Medicago sativa*, *Lotus corniculatus* and *Onobrychis viciifolia*, the shoots were prostrate, thin, and about 47-91 cm long at the end of the growing season. In the second and the following years, the plants started growing at the end of March, from dormant buds, and were characterized by faster growth and development rates. In the flowering period, at the time of the first cut (late May - early June) the erect shoots of ‘Vigor’ *Astragalus galegiformis* reached 110-140 cm, the potential yields were 5.56-6.63 kg/m^2 green mass or 1.05-1.21 kg/m^2 dry matter with 51.0-53.5% leaves and flowers in the harvested mass. The capacity of plants for regeneration depends on the weather conditions. Thus, the plants can be cut another 1-2 times, with a productivity of 1.96-2.83 kg/m^2 green mass. At the time of seed maturation, the stems had few leaves, and the productive potential was 70-100 g/m^2 seeds and 1.05-1.42 kg/m^2 residual mass (stems).

The cultivar ‘Argentina’ *Sorghum almum,* fam. *Poaceae,* propagates by seeds. It is usually sown in the same period as maize. We could mention that after sowing, during 5-7 days, the seedlings emerged at the soil surface, it is highlighted by optimal growth and development rates ending with their formation and maturation in October. At the end of July, the formation of the panicle started, the shoots reaching 235 cm in height. Cutting the plants in this period resulted a yield of 3.84 kg/m^2 fresh mass, containing 22.0% dry matter and 35.9% leaves. In the second and the in further years, the plants resumed growth at the end of April; new shoots grew from the rhizomes formed in the underground part in the previous year, were cut for the first time in June, they were 196-235 cm tall, with a moderate leaf/stem ratio, and the productivity reached 3.27-3.72 kg/m^2 of green mass or 0.70-0.76 kg/m^2 dry matter. By the end of the growing season, another 1-2 harvests can be done, with a productivity of 1.90-2.41 kg/m^2 green mass. At the time of seed maturation (September-October), the stems were still leafy, the productive potential was 185-216 g/m^2 seeds and 0.81-1.12 kg/m^2 residual mass (stems).

The cultivar ‘Titan’ *Miscanthus giganteus,* fam. *Poaceae,* is propagated vegetatively, by rhizomes. In the first year of vegetation, the cultivar ‘Titan’ was characterized by optimal growth rate, developing shoots, which reached 152-183 cm in height. In the following years, the regrowing season started in the second half of April, when the temperature was above 10-12ºC, and the plants were characterized by faster growth and development rates, thus the developed shoots that reached a height of 157 cm in mid-June, 260 cm in mid-August and in the period when the panicle development started – middle September - first days of October – 380-415 cm, the potential productivity was 7.75-8.04 kg/m^2 green mass or 3.65-3.95 kg/m^2 dry matter with 28.6-31.7% leaves and panicles in the harvested mass. The annual productivity of dry matter stems was 1.92-3.00 kg/m^2.

The cultivar ‘Vital’ *Silphium perfoliatum,* fam. *Asteraceae* propagates generatively and vegetatively. In the first year, the plants passed 2 ontogenetic stages: development of plantlets and rosette with 16-18 dark green triangular leaves, but did not develop shoots. In the following years, the new plants started developing from generative buds in spring, when air temperature exceeded 6°C, at the end of March and in the first days of April, the plants were characterized by fast growth and development rates, which allowed obtaining up to 80.9-142.1 t/ha annual yield of green mass with 14-25% dry matter and 36-51% leaves. At the end of the growing season, when temperatures below 0°C were recorded, the tissues dehydrated very fast, while the leaves were kept on the stems longer (in March, dry leaves on the stems constituted 7-9% of biomass). The stem dry matter yields were 17.4-28.0 t/ha.

The cultivar ‘Ileana’ *Inula helenium,* fam. *Asteraceae,* is capable of both generative and vegetative propagation. In the first year, the plants developed a rosette of 6-8 oblong leaves of intense green colour and did not develop shoots. In the second year and the in further years, they resumed growth in the middle of April when temperature exceeded 12°C, the new shoots grew 200-220 cm tall, the potential yields in flowering period were 4.61-5.23 kg/m^2 green mass or 1.18-1.35 kg/m^2 dry matter with 54.3-57.5% leaves and flowers in the harvested mass. At the end of the growing season, the *Inula helenium* plants had only about 35% of the leaves still on the stems, the dry mass productivity was 0.8-1.01 kg/m^2.

The cultivar 'Solar' *Helianthus tuberosus,* fam. *Asteraceae,* is propagated vegetatively, by tubers, planted in soil in middle April at a depth of 7-10 cm (1.5-2.3 t/ha tubers). It was found that from the buds on the tubers, during 13-18 days after planting, 2-3 seedlings develop and appear on the soil surface. During the growing season they develop erect stems of green color with shades of anthocyanin, covered with a film of bluish-gray wax, 300-450 cm tall and with a diameter of 2-5 cm at the base, rough, porous, branched in upper part, with 50-70 leaves. The leaves are dark green, on the lower part of the stem they are opposite and on the upper part - alternate, petiolate, the leaf blades are ovate, medium sized with coarse toothed edge. Inflorescence is a solitary calathidium situated at the ends of branches, with a diameter of 4-6 cm at flowering. At the stage of flower buttons formation, the potential productivity was 14.4 kg/m^2 fresh mass or 3.7 kg/m^2 dry matter. On the underground part, at the end of May, stolons start forming, the stolons are 10-23 cm long and by thickening of the terminal part thereof, during July, first tubers are formed, the period of tuber formation and growth lasts until the end of September. The tubers are placed in the hole in a scattered way. The medium-sized tubers weigh 43-65 grams, are oval-oblong, with a thin peel of cherry color with a strong anthocyanin intensity and white core, the yield of tubers reached 44.0 t/ha. At the end of growing season and after frost, over 15-35 days, stems are completely defoliated.

The cultivar 'Energo' *Sida hermaphrodita,* fam. *Malvaceae,* can propagate generatively and vegetatively. The seedlings emerged at the soil surface unevenly, and over the following 2 months, they had a slow rate of growth and development of aerial parts, and then the rate was accelerating, the development of flower buds started in the middle of September, the stems grew about 171 cm tall and 6-13 mm thick at base. In the next years, plant growth and development started in spring, when the average temperatures were above 0°C, a high rate of growth of stems was observed during May (5-6 cm/day). The potential biomass yields in flowering period were 5.56-8.03 kg/m^2 green mass or 1.18-1.35 kg/m^2 dry matter with 54.3-57.5% leaves and flowers in the harvested mass. At the end of the growing season, when the average temperature was below 0°C, *Sida hermaphrodita* stems were completely defoliated. The stem dry matter yields were 16.2-25.0 t/ha dry matter.

The cultivar 'Gigant' *Polygonum sachalinense,* fam. *Polygonaceae* produces seeds but to create industrial plantations it is necessary to produce seedlings from roots or rooted cuttings. After planting, in the first 2 months of vegetation, the growth and development rates were optimal, having formed 5-7 internodes with 19-23 cm long and 8-11 cm wide leaves. During the next period, the branching of the central stem is observed, forming first degree shoots which continue to branch out until the end of the vegetation by developing five and four degree shoots, being formed a bush with a height of 164-170 cm. In the following years, in spring, when the air temperature exceeded 5°C, the cultivar 'Gigant' started the growth and development of the new shoots from the buds formed on the rhizomes, was characterized by faster growth and development rates, thus the developed shoots that exceeded 220 cm in end May, in flowering period, in mid-August, the plants reach 350-400 cm, the potential productivity was 7.75-8.04 kg/m^2 green mass or 3.65-3.95 kg/m^2 dry matter. After the establishment of temperatures below 0ºC stems were completely defoliated, the pace of dehydration of stems tissues accelerated, in the middle of January - below 20%. The annual productivity of stem dry matter was 18.2-28.5 t/ha.

Maize or corn *Zea mays,* fam. *Poaceae,* is known and appreciated as food, fodder and energy biomass widely used as a substrate for biogas plants in Europe and ethanol production in US, but frequent droughts, rising prices of seeds, agricultural equipment, fuel and fertilizers have a negative impact on the its productivity and the product cost of maize. The hybrid *'Porumbeni-458 MRf'* yielded 40-45 t/ha fresh mass with 28.0-35% dry matter.

The morphological structure of the whole plant has a significant impact on biochemical composition and quality of the substrate in the production of biogas via anaerobic digestion of the green mass. Analysing the results of the biochemical composition of dry matter (Table 1) we found that the dry matter of the studied whole plants of local cultivars contained 58-138 g/kg CP, 60-90 g/kg ash, 326-515 g/kg ADF, 497-808 g/kg NDF, 44-74 g/kg ADL, 279-453 g/kg Cel, 161-293 g/kg HC, C/N = 18-55, but corn substrate, respectively, with 88 g/kg CP, 60 g/kg ash, 310 g/kg ADF, 520 g/kg NDF, 31 g/kg ADL, 279 g/kg Cel, 210 g/kg HC, C/N = 35. The biochemical methane potential of energy crops substrates varied from 297 l/kg VS in *Miscanthus giganteus* substrate to 337 l/kg VS in *Astragalus galegiformis* substrate, compared to 349 l/kg VS in corn substrate.

The most common densification method used for solid fuel production is briquetting and pelleting. Some physical and mechanical properties of biomass and solid biofuels is presented in Table 2. Particle size distribution of chopped mass influenced the costs of transport. To enhance packing density of biomass and produce pellets and briquettes, for instance, biomass feedstock has to be ground into 3-8 mm particles before compacting the material into a denser product (Mani et al., 2006).

Table 1. The biochemical composition and the biomethane production potential of substrates from the studied crops

Indices	*Helianthus tuberosus*	*Inula helenium*	*Silphium perfoliatum*	*Sida hermaphrodita*	*Astragalus galegiformis*	*Miscanthus giganteus*	*Sorghum almum*	*Polygonum sachalinense*	*Zea mays*
Crude protein, g/kg DM	81	98	96	144	171	58	112	138	88
Acid detergent fibre, g/kg DM	341	409	382	377	326	515	425	444	310
Neutral detergent fibre, g/kg DM	528	634	612	546	497	808	697	662	520
Acid detergent lignin, g/kg DM	60	63	56	62	48	62	44	74	31
Cellulose, g/kg DM	281	346	326	315	279	453	381	370	279
Hemicellulose, g/kg DM	187	225	230	169	171	293	272	218	210
Minerals, g/kg DM	67	76	72	60	90	67	87	90	60
Carbon, g/kg	518.0	513.3	515.6	521.1	505.6	518.1	507.2	505.6	522.2
Nitrogen, g/kg	13.0	15.7	15.4	23.0	27.4	9.4	17.9	22.1	14.1
Ratio carbon/nitrogen	40	32	34	23	18	55	28	23	35
Biomethane potential, L/kg	300	300	312	308	337	297	336	291	349

Table 2. Some physical and mechanical properties of biomass and solid biofuels from the studied crops

Indices	*Helianthus tuberosus*	*Inula helenium*	*Silphium perfoliatum*	*Sida hermaphrodita*	*Astragalus galegiformis*	*Miscanthus giganteus*	*Sorghum almum*	*Polygonum sachalinense*	*Zea mays*
Particle size distribution, %									
<5 mm	3.3	1.1	0	3.8	0	1.9	2.2	0.2	1.5
4-5 mm	11.7	14.2	0.2	8.2	2.3	5.3	4.4	1.4	1.4
3-4 mm	25.4	20.9	18.2	18.6	16.4	11.8	13.3	18.6	10.4
2-3 mm	27.4	25.7	29.2	34.2	31.8	24.7	26.4	35.8	34.5
1-2 mm	23.4	27.7	29.0	21.9	33.1	30.4	31.3	27.4	30.8
1 mm	8.8	12.4	23.4	13.3	16.4	25.9	22.4	16.6	21.4
Elemental composition, %									
Carbon	45.75	44.74	45.07	46.38	46.50	46.34	45.23	45.18	44.87
Hydrogen	5.92	5.82	5.96	6.01	5.55	5.95	5.76	5.44	5.65
Nitrogen	0.20	0.41	0.21	0.20	1.47	0.33	0.25	0.28	0.83
Sulphur	0.04	0.08	0.03	0.09	0.11	0.05	0.08	0.07	0.24
Ash content of biomass, %	2.42	3.14	3.83	2.03	3.31	1.75	3.04	2.38	4.04
Gross calorific value of biomass, MJ/kg	18.63	18.46	18.65	19.50	18.80	19.50	18.99	19.00	18.34
Bulk density of milled chaffs 6 mm, kg/m^3	230	218	235	204	260	208	170	260	160
Specific density of briquettes, kg/m^3	880	860	996	854	870	889	800	890	910
Bulk density of briquettes, kg/m^3	448	460	490	467	475	490	425	475	490
Specific density of pellets, kg/m^3	903	936	1048	918	1000	1200	1030	1020	1150
Bulk density of pellets, kg/m^3	600	612	660	570	630	690	685	640	694

Table 3. The cell walls composition and theoretical ethanol potential of substrates from the studied crops

Indices	*Helianthus tuberosus*	*Inula helenium*	*Silphium perfoliatum*	*Sida hermaphrodita*	*Astragalus galegiformis*	*Miscanthus giganteus*	*Sorghum almum*	*Polygonum sachalinense*	*Zea mays*
Acid detergent fibre, g/kg	631	584	631	687	443	585	583	633	499
Neutral detergent fibre, g/kg	889	834	899	928	654	890	875	889	749
Acid detergent lignin, g/kg	134	107	114	131	68	77	101	122	87
Cellulose, g/kg	497	477	517	556	375	508	482	511	417
Hemicellulose, g/kg	258	250	268	241	211	305	292	256	250
Hexose sugars, g/kg	89.01	85.46	92.59	99.0	63.38	91.48	86.83	91.4	75.1
Pentose sugars, g/kg	42.44	41.12	44.08	39.6	34.47	50.17	48.03	42.1	41.1
Theoretical ethanol potential, L/t	548	527	570	578	408	591	562	568	485

Particle size reduction and its distribution is an important parameter used for handling, storage, conversion, dust control systems and the combustion behaviour of biomass solid fuels. In the case of *Sida hermaphrodita, Helianthus tuberosus, Inula helenium* milled chaffs, we obtained the highest percentage of particles larger than 3 mm (30.6-40.4%), and the lowest values for the particles of 1 mm (8.8-13.3%). Moreover, the fractions 1-3 mm were relatively high, in the case of milled *Silphium perfoliatum, Astragalus galegiformis, Miscanthus giganteus, Sorghum almum*, *Polygonum sachalinense* and corn milled chaffs (Table 2). This is probably an effect of the specific anatomical structure of plant species, the high level of pith microstructures and the fibre content in biomass, influences the passage of particles through the sieve meshes.

The elemental composition of biomass is a significant asset that defines the amount of energy and evaluates the clean and efficient use of biomass materials, provides significant parameters used in the design of almost all energy conversion systems and projects, for the assessment of the complete process of any thermochemical conversion techniques (Lawal et al., 2021). Carbon is obviously representing foremost contributions to overall heating value. Furthermore, higher hydrogen content determines and leads to a higher net caloric value. Nitrogen (N), sulphur (S) and chlorine (Cl) contents are some of the main causes of air pollution from biomass combustion. A higher percentage of these elements generally results in a higher level of air contaminants being released. We found that tested biomass (Table 2), are characterized by an optimal content of carbon and hydrogen. Very higher content of nitrogen and sulphur were in *Astragalus galegiformis* and *Zea mays* biomass. Ash content is one of the main factors of biomass quality, since higher amounts of ash diminishes the quality of fuels, especially solid ones. The *Miscanthus giganteus, Sida hermaphrodita, Helianthus tuberosus, Polygonum sachalinense* biomass are distinguished by low ash content and excellent gross calorific value than corn stalks mass. The bulk density of the tested milled chaffs biomass varied from 170 to 260 kg/m^3, in corn milled chaffs 160 kg/m^3. The specific density of densified solid fuel pellets and briquettes meet the quality standard requirements.

Second generation bioethanol produced from lignocellulosic biomass is attracting attention as an alternative transport fuels, is currently an area of great research interest around the world. From the compositional point of view, lignocellulose is basically composed of secondary cell walls of structural plant tissues. The structure of lignocellulose consists of cellulose, the skeleton of which is surrounded by hemicellulose and lignin. The contents of these components vary significantly depending on the plant species, type of biomass, harvesting period. The effective decomposition of lignocellulose biomass should be preceded by conversions of these polysaccharides into monosaccharides. Analyzing the cell wall composition of dehydrated stems (Table 3) we could mention that the concentrations of structural carbohydrates in local cultivars substrates were: 375-517 g/kg Cel, 211-305 g/kg HC, 68-134 g/kg ADL, but in corn substrate, respectively, 417 g/kg Cel, 250 g/kg HC, 87 g/kg ADL. The estimated theoretical ethanol yield from cell walls carbohydrates averaged 408-591 L/t in local cultivars energy crops substrates, as compared to 485 L/t in corn substrates.

CONCLUSIONS

The obtained results indicate the possibility of using the local cultivars for the establishment of industrial biomass energy plantations.

The cultivation and harvesting of these cultivars do not require sophisticated mechanisms and specific equipment as forest exploitations do.

The harvested phytomass may be used as multi-purpose feedstock: for biomethane production, to prepare solid fuel, for bioethanol production.

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