INDICATORS CHARACTERISING CALORIFIC VALUE OF REED CANARY GRASS AND LAST YEAR'S GRASS

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Abstract. Recent trends towards environmentally friendly economies promote biofuels; moreover, many researchers suggest producing bioenergy from grass. However, suitability of various grasses for this particular purpose should be studied more in detail. Pellets require biomass with good calorific value indicators, therefore, this research aims at comparing them in last year's grass and reed canary grass (RCG) biomass harvested in spring and autumn of two different years (2010 and 2011) and determining the suitability thereof for the heat production in Latvia. The research resulted in finding the following: RCG dry matter harvested in spring has the lowest ash content (3.1 %); the most suitable moisture content of spring last year's grass and RCG constitutes 9.8 % and 9.9 %, respectively; the highest combustion ability was observed for last year's grass yielded in spring (19.0 $MJ \cdot kg^{-1}$); and ash melting temperature for spring RCG comprises 1170-1265 ºC and of last year's grass 1060-1140 ºC. The results acquired show that, as compared to RCG dry matter harvested in both, autumn and spring, last year's grass dry matter samples have better moisture and ash content as well as higher combustion ability; therefore last year's grass is very suitable for production of heat.

Keywords: last year's grass, reed canary grass, moisture, ash, calorific value, ash melting temperature.

Introduction

Higher interest in bio-energy production during the last decades has forced scientific researchers to estimate the biomass energy potential. Reed canary grass (RCG) has been estimated to be a potential bio-energy crop in northern Europe [1; 2]. It is generally agreed that sustainable bio-energy production requires multi-criteria evaluations. Therefore, economic analysis of production as well as further evaluation emphasizing an optimum resource usage should be carried out. Studies have evaluated the RCG yields, duration period, winter losses [3-5].

Previous research conducted by BERC, Cornell College of Agriculture, the EPA and others has shown that grass fuel is a true renewable fuel source with 80-90 % of the energy content of wood and 70% less greenhouse gas emissions than fossil fuels. There have also been a number of recent studies and combustion trials of heating equipment burning grass [6].

Perennial grasses are good candidates for biofuels since they do not have to be planted every year, nor do they require application of agricultural chemicals. Since the crop value for bioenergy use is carbohydrates, not protein, the grasses can be harvested after they die back in the fall, and thus after nitrogen and other nutrients have been translocated back into the roots and crowns. This late harvesting means that the nutrients stay in the perennial parts of the plants which, in turn, means that the crop does not need high levels of fertilization each year [7].

Over the past 15 years, growing of crops (both herbaceous and woody), especially of energy crops, has gained widespread appeal, and perennial grasses, such as switchgrass, miscanthus, and RCG, represent new and exciting renewable energy options. Perennial grasses have many benefits as a bioenergy crop. The simplest way to think of grass is as an efficient and fast growing solar energy collector that is relatively easy to grow, harvest and process. Grasses not only sequester and store vast amounts of carbon in the root systems and soil, but conveniently occur globally in a wide range of geographies, climates, and soil types [8].

Grasses have 95 % of the Btu value of wood, and several pioneering companies are beginning to produce high-quality grass pellets for heating. Historically, since biomass combustion systems were designed around wood, simply substituting grass for wood in the same combustion system will generally not produce satisfactory results.

Grasses have higher ash content and a different chemical composition, therefore, distinct combustion systems are needed to handle these differences. During combustion, higher chlorine and potassium levels in grasses vaporize and form salts on boiler walls. These salts can cause "clinkers" (incombustible residues) in systems not specifically designed to handle grasses, reducing performance markedly [8].

Calorific value is a measurement of heat or energy produced, and is measured either as gross calorific value or net calorific value. The difference is determined by the latent heat of condensation of the water vapour produced during the combustion process. Gross calorific value (GCV) assumes all vapour produced during the combustion process is fully condensed. Net calorific value (NCV) assumes the water leaves with the combustion products without fully being condensed. Fuels should be compared based on the net calorific value. The typical GCVs of some of the commonly used liquid fuels are the following: (kCal·kg^{-1}) kerosene – 11.100, diesel oil – 10.800, L.D.O – 10.700, furnace oil – 10.500 LSHS – 10.600 [9].

The ash value is related to the inorganic material or salts in the fuel oil. The ash levels in distillate fuels are negligible. Residual fuels have higher ash levels. These salts may be compounds of sodium, vanadium, calcium, magnesium, silicon, iron, aluminium, nickel, etc. Typically, ash value varies within the range 0.03-0.07 %. Excessive ash in liquid fuels can cause fouling deposits in the combustion equipment [9].

Ash has an erosive effect on the burner tips, causes damage to the refractories at high temperatures and gives rise to high temperature corrosion and fouling of equipment. In terms of the content thereof, ash is impurity that will not burn. Typical range is from 5 % to 40 %. Ash reduces handling and burning capacity, increases handling costs, affects combustion efficiency and boiler efficiency, and causes clinkering and slagging. Ash melting behaviour in oxidizing atmosphere for the biomass ash is lower, thus ash melts in the combustion chamber, obstructing air vents, and incombustible minerals emitted from the torch settle on boiler furnace walls and form homogenous coating (glass) that reduces heat exchange. [9]. Slagging of biomass ash during gasification is therefore a major problem [11].

The research aims at evaluating and comparing the calorific value indicators – moisture content, ash content, combustion ability, ash melting temperature – of RCG and last year's grass biomass. The results acquired show that, as compared to RCG dry matter harvested in both autumn and spring, last year's grass dry matter samples have better moisture and ash content as well as higher combustion ability; therefore, last year's grass is very suitable for production of heat.

Materials and methods

With an aim to determine RCG and last year's grass suitability for thermal energy production the research covered analysis of various grass biomass parameters depending on the harvest times (RCG – spring 2011 and fall 2011, 2010; and last year's grass – spring 2011).

The selected parameters of grass biomass were evaluated in the second year of vegetation. In compliance with pre-determined standards, the following parameters were measured: moisture content – *Wa* (LVS CEN/TS 14774-2), ash content for dry matter – *A* (ISO 1171-81), Gross Calorific Value at *V* = const. for dried fuel at 1050 ºC, *Qgr.d* and Net Calorific Value at *V* = const. *Qnet* (LVS CEN/TS 14918), as well as ash melting behaviour at oxidizing atmosphere (in compliance with the ISO 540). The parameters were found out in waste, fuel investigation and testing laboratory SIA "Virsma". And correlations were analysed as linear or polynomial regressions, and graphs were made using MS Office program Excel.

Results and discussion

The moisture and ash content were established, as well as the highest and the lowest calorific value, and ash melting at different phase temperatures in oxidizing atmosphere.

The research indicates that spring last year's grass 2011 has the lowest moisture content – 9.8 %, while in spring RCG 2011 it comprises 9.85 %, and in autumn RCG of 2011 – 17 %. The highest moisture content, in turn, was recorded for autumn RCG 2010 – 31.3 % (Fig. 1.).

Burning fuel with lower ash content ensures more qualitative and economic performance of the heating system. The ash content in Latvian wood pellets and briquettes varies between 0.25 % and 1.0 %. The results acquired show that spring last year's grass 2011 has a slightly higher ash content (4.3 %) than spring RCG 2011 (3.10 %), while in autumn RCG biomass it constitutes 4.65-6.9 %.

Calorific value of fuel is a significant quality indicator that largely depends on the moisture and ash content. With mean moisture 6.7-7.8 % it varies between 18400 and 17700 kJ·kg^{-1} [12].

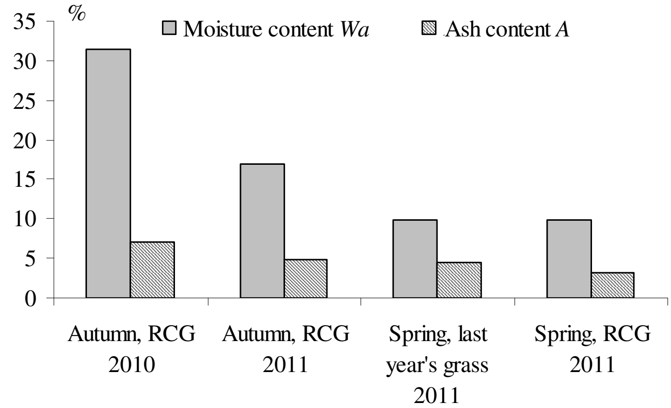

Fig. 1. **Evaluation of moisture and ash content in last year's grass and RCG biomass**

The most suitable combustion ability indicators among all biomass samples (of 2010 and 2011, spring and autumn) were recorded for spring last year's grass 2011, reaching the highest combustion ability 19.0 $MJ \cdot kg^{-1}$ and the lowest 15.8 $MJ \cdot kg^{-1}$ (Figure 2.). While the highest combustion ability of autumn RCG 2011 constituted 18.42 $MJ \cdot kg^{-1}$ and RCG 2010 – 17.8 $MJ \cdot kg^{-1}$.

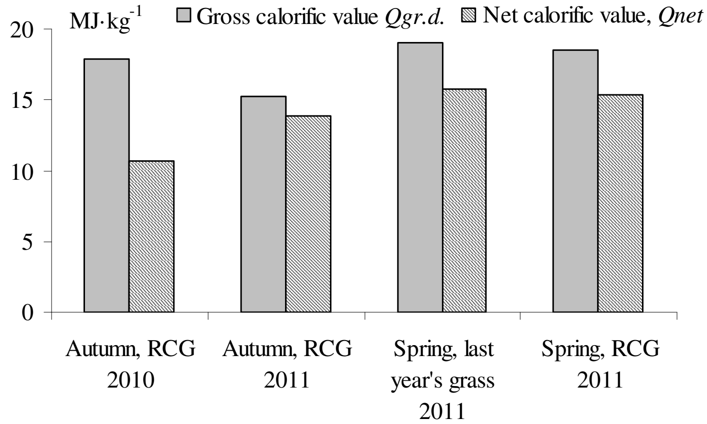

Fig. 2. **Calorific value of spring last year's grass and RCG**

The way ashes stick together depends on the ash melting temperature. The ash melting temperature above 1500 ºC does not show ash melting or formation of pieces. On the other hand, lower (<1300 ºC) melting temperature means that burning of these materials requires correct burning procedures to ensure that the grating mechanism is not damaged [13].

Ash melting temperature indicates the following: spring RCG 1170-1265 ºC, and last year's grass 1060-1140 ºC (Fig 3).

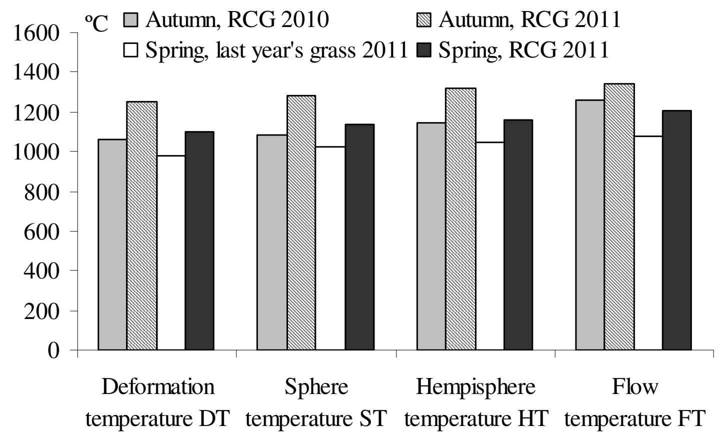

Fig. 3. **Ash melting temperatures of last year's grass and RCG biomass**

The data acquired show that spring last year's grass and RCG biomass are suitable as fuel for heat production. However, it should be noted that the combustion capacity thereof is similar to wood biomass, but such biomass produces more ash as well as it has lower ash melting temperature (one of the key problems in the burning process damaging heating systems); therefore, grass biomass for pellet production should be mixed with sawdust or woodchips. Thus economic cultivation of RCG and use thereof for heat production may be developed.

Conclusions

1. Analysis of the experiment results shows that spring last year's grass 2011 has the most suitable calorific value (highest and lowest) indicators, reaching the highest calorific value 19.0 $MJ \cdot kg^{-1}$ and the lowest – 15.8 $MJ \cdot kg^{-1}$.
2. As compared to the reed canary grass samples, spring last year's grass biomass has lower ash melting indicators: 1060-1140 ºC. It means that the results are too low and fuel will cause problems for the heating systems.
3. The research indicated that both biomasses – last year's grass and reed canary grass – have too high ash content; therefore, it is advisable to mix grass biomass with wood (sawdust, woodchips).
4. The information found out allowed concluding that last year's grass has similar characteristics as reed canary grass, thus both of them may be used for pellet production.

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