EVALUATION OF FACTORS INFLUENCING CALORIFIC VALUE OF REED CANARY GRASS SPRING AND AUTUMN YIELD

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Abstract. Production of pellets requires herbaceous biomass with low moisture and ash content, good combustion ability and ash melting temperature ensuring high-quality performance of the boiler. The research aims at analysing various parameters of reed canary grass (*Phalaris arundinacea* L.) biomass depending on the harvest (spring and autumn) and determining their suitability for the heat production in Latvia. Moisture and ash content was found out, as well as the highest and the lowest calorific values and ash melting temperatures within various phases. The average moisture indicators of reed canary grass spring harvest comprised 9.85 % and 17 % of fall harvest. Spring-harvest reed canary grass biomass ash content accounted for 3.10 %, whereas in the autumn harvest – 4.65 %. The highest and the lowest calorific value of spring-harvest reed canary grass biomass constituted 18.42 $MJ \cdot kg^{-1}$ and 15.27 $MJ \cdot kg^{-1}$, respectively, while of the fall harvest - 15.24 $MJ \cdot kg^{-1}$ and 13.82 $MJ \cdot kg^{-1}$, correspondingly. Ash melting temperature at the beginning of the deformation phase on average reaches 1170 ºC for the spring-harvest reed canary grass biomass and 1295 ºC for the autumn biomass. Acquired results show that reed canary grass biomass harvested in spring is more suitable for the heat production, as compared to autumn samples. Whereas ash melting temperatures are slightly higher for fall-harvest samples, still samples harvested in spring are suitable for heat production.

Keywords: *Phalaris arundinacea* L., calorific value, ash melting temperature, moisture.

Introduction

In 2008, the European Union ambitiously committed to increase the proportion of renewable energy up to 20 % of total energy consumption by 2020 [1]. The necessary growth of bioenergy will mainly come from forestry, but field crops will also be needed to reach the target. Biomass harvested from fields consists of residues (straw, tops etc.) and specifically cultivated crops (e.g., miscanthus, poplar, willow, reed canary grass (henceforth RCG), rapeseed, maize) [2-5].

Due to the changing climate and population living conditions and habits, agriculture remains one of the most important sectors of the economy in many countries; however, the approach to farming and plant use is undergoing changes as well. It is believed that sustainable plant use is one of the ways to develop bioenergy production [5].

Lemus and Lal [6] review states that bioenergy production from energy crops will result in a reduction of greenhouse gas emissions. Perennials have several environmental and energy advantages as compared to annual plants: lower fertilizer and pesticide requirements, nutrients are used more efficiently, soil carbon is better protected, concentration of greenhouse gases is reduced, and biodiversity is increased. Perennial grasses are one of the most perspective plants for bioenergy production; though, their development and growth differ between the various climates, therefore the feasibility of their cultivation in the Northern part of middle latitudes is still not clear. The main aspect that should be focused in respect to the growing of energy crops is the biomass productivity.

One of the most topical agricultural problems in Latvia is harvesting of high-quality perennial grass plants having particular chemical content that would allow using them as solid fuel (pellets, briquettes).

Various scientists [7-13] suggest growing perennial herbaceous energy crop – RCG as potential energy source.

Within the territory of Latvia, RCG biomass is regarded as one of the alternative sources for the production of pellets. This grass plant is characteristic with its stability under local climatic conditions and high biomass yield. Several researches [2; 8; 14-17] conducted prior show that RCG is suitable for growing under the climatic conditions of Northern Europe, as well as it is perennial (8-15 years).

The research aims at analysing various parameters of RCG biomass depending on the harvest (spring and autumn) and determining their suitability for heat production in Latvia. When evaluating the use of RCG biomass for the heat production we should characterise the main problems arising during combustion process that are related with moisture content, thermal capacity and ash melting temperature of both autumn and spring yield.

To ensure that dry matter of the RCG biomass meets the production requirements, researchers [18-20] suggest mowing RCG in early spring (March – May), because biomass obtained during this time period does not have to be dried, as it has low moisture content 10-15 %, lower ash content, as well as chemicals, which reduce fuel combustion and ash melting temperatures as well as cause corrosion, are leached during the winter.

Combustion ability is the main parameter of fuel determining its efficiency [21]. The combustion process generates water vapour, and certain techniques may be used to recover the quantity of heat contained in this water vapour by condensing it. Moisture affects the combustion efficiency negatively [22], and the moisture content should be as low as possible. Agricultural residues typically have high moisture content and calorific values different from wood [23]. The moisture content of chipped wood that has been air dried for several weeks varies between 10 % and 20 %, whereas in agricultural biomass, depending on the type of feedstock, it ranges between 50 % and 85 % [24]. A moisture content of about 12 % is acceptable in biomass fuels used for combustion, which means that most biomass has to be dried before it can be processed. Typical energy contents differ from 0.5 $MJ\cdot kg^{-1}$ to 17 $MJ\cdot kg^{-1}$ at 10-15 % moisture content, depending on the type biomass feedstock [25-26].

An additional consideration with regards to the biomass fuel choice is the ash content. This is the inorganic matter that cannot be combusted and will remain in the form of ash and has to be discarded after combustion. Wood fuels normally have low ash contents (around 0.5 %), whereas many other agricultural residues can have ash contents as high as 20 % or even more. The amount of inorganic matter in biomass also affects its ultimate calorific value [24; 26-28].

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. [29]. Slagging of biomass ash during gasification is therefore a major problem [30].

The initial deformation temperature is the most important indicator of problems for conversion processes. The temperature at which ash starts to soften should be well above the maximum temperature of the process. The variable composition of biomass fuels and variable moisture and ash contents could cause combustion and ignition problems. There are numerous ways of addressing these problems, such as blending different biomass fuels, which could enhance flame stability, as well as decrease corrosion effects.

Materials and methods

With an aim to determine RCG suitability for thermal energy production the research analyzes different RCG biomass parameters depending on the harvest times (spring 2011 and fall 2011). Selected parameters of grass biomass quality were evaluated in the second year of vegetation.

In compliance with the 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 1050C, *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). These parameters were found out in waste, fuel investigation and testing laboratory SIA "Virsma".

Results and discussion

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 shows that average humidity indicators of reed canary grass spring harvest comprise 9.85 %, while of fall harvest – 17 % (Fig. 1).

Acquired results indicate that spring RCG biomass samples have the lowest ash content (3.10 %), while fall samples show 4.65 %. Ash content of the RCG harvested in summer and not treated with fertilisers reaches 8.24 %, while ash content of RCG treated with P80K120 accounts for 8.71 %, with N – on average 7.83 %. When analyzing the RCG varieties suitable for the production of heat it must be noted that their burning capacity is similar to wood, while burning biomass produces more ash, therefore when producing pellets the biomass should be mixed with sawdust and chips.

Also the highest combustion ability was recorded for spring samples - 18.42 MJ·kg^{-1}, whereas for fall samples it reduces – 15.24 MJ·kg^{-1}. The lowest combustion ability for spring samples reached 15.27 MJ·kg^{-1} and for autumn samples – 13.82 MJ·kg^{-1}.

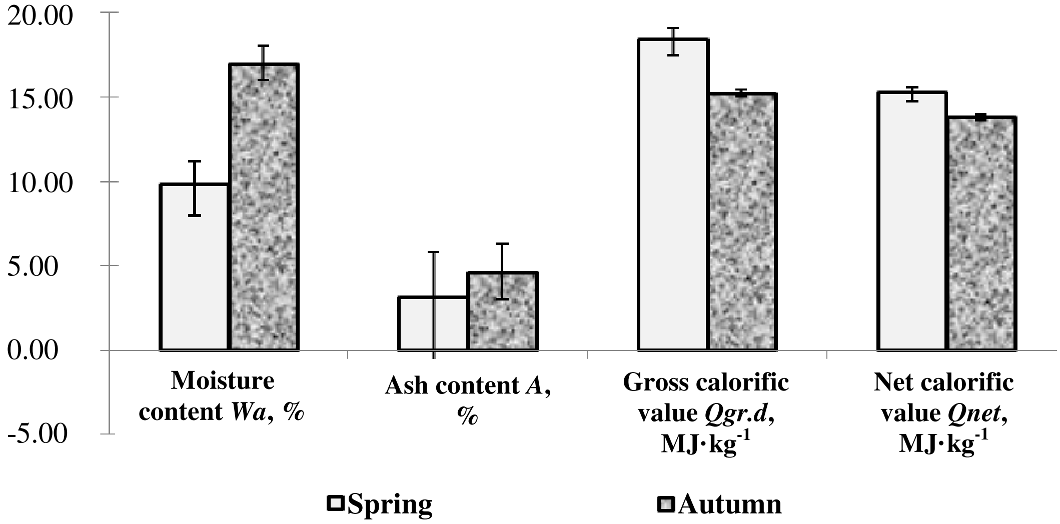

Fig. 1. **Energy quality indicators of reed canary grass spring and autumn yield dry matter**

When using RCG for the heat production the ash melting temperature of biomass is of a great significance. The most suitable RCG ash melting temperatures within all phases were recorded for the samples harvested in autumn.

Higher ash melting temperature was observed for the autumn RCG biomass (Figure 2.) Indicators of autumn-yield samples at the beginning of the deformation phase are higher (1295 ºC), while final discharge temperature reaches 1380 ºC. Whereas in spring RCG samples ash melting temperature is slightly lower – 1170 ºC at the beginning of the deformation phase and indicator reaches 1265 ºC at the final discharge.

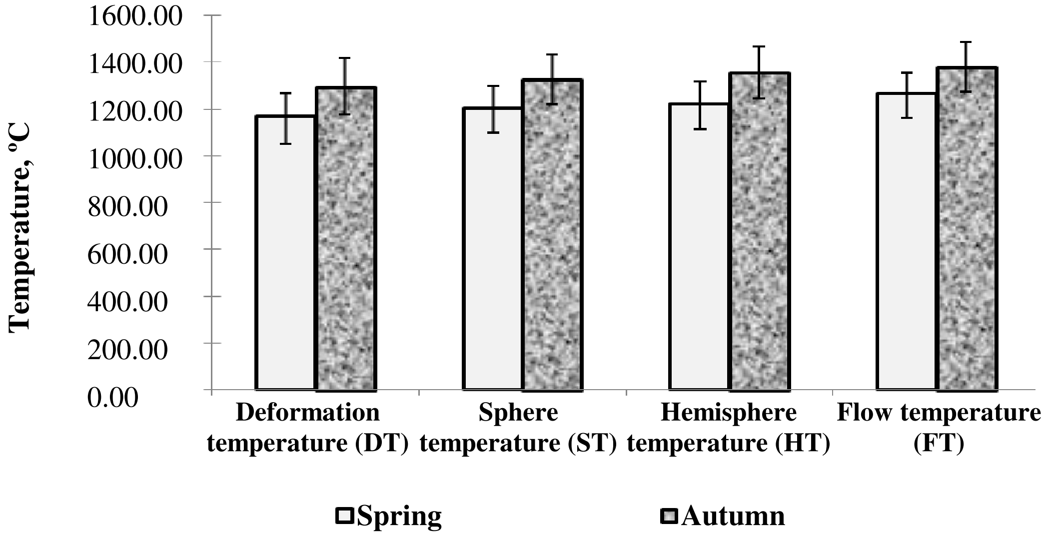

Fig. 2. **Ash melting temperatures of reed canary grass spring and autumn yield dry matter**

The results obtained show that RCG biomass ash melting temperature is suitable to ensure high-quality operation of the boiler.

Conclusions

1. Reed canary grass biomass samples harvested in both spring and autumn show high ash content. Slightly lower indicators were recorded for the spring-harvest reed canary grass – 3.10 %, therefore it is recommended to produce pellets from reed canary grass biomass mixing it with wood (sawdust and woodchips).
2. The highest combustion ability of reed canary grass biomass samples harvested in spring reached 18.42 MJ·kg^{-1}, whereas the lowest - 15.27 MJ·kg^{-1}.
3. Higher ash melting temperatures were observed for fall-harvest reed canary grass samples – 1250 ºC at the beginning of the deformation phase and 1380 ºC at the final discharge. It means that ash melting indicators are normal and will not cause problems during the combustion process in heating systems.
4. Ash content and moisture content of reed canary grass harvested in spring is lower and combustion ability is higher, therefore it is recommended to harvest reed canary grass for the production of pellets during the time period from late autumn till spring.

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