CONTENT OF LIGNING AND ASH IN GRASS BIOMASS DEPENDING ON FERTILISER TYPE AND RATE

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Abstract. Plant biomass is one of ecological solutions for the future, since it allows compensating growing shortage of fossil resources. Hoverer, biomass production has to face problems related to cultivation of grass with particular chemical content. Ash is an important indicator used to characterise the quality of fuel, since higher ash content causes problems to automation of the combustion process, whereas lignin is natural astringent that holds a granule together. Productivity and chemical content of grass are largely influenced by fertilisers, namely their types and rates applied; therefore, the research aims at evaluating the ash and lignin content in reed canary grass (RCG) and tall fescue biomass depending on fertiliser types and rates, finding out biomass suitability for the production of biofuel, as well as studying correlations between the factors influencing the above indicators. The research helped discovering that the ash content in RCG dry matter comprises 7.02-8.88 % and lignin content varies between 4.46 % and 5.41 %; while the ash content in tall fescue biomass accounts for 7.93-8.29 %, and lignin content constitutes 4.82-6.06 %. RCG biomass indicated close linear correlation between the ash content and mineral fertiliser rate applied ($r = -0.88$). The grass biomass samples did not indicate correlation between the lignin and ash content. Since in comparison with wood fuel indicators, the ash content rates estimated in this study are higher, while lignin – lower, it is recommended to use tall fescue or RCG herbaceous biomass only as an additive to wood chips or pellets

Keywords: reed canary grass, tall fescue, fertilizers, lignin, ash.

Introduction

Biofuels may be a tool used to reduce carbon emissions, dependency upon fossil fuels, and provide jobs for the local economy. 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. Energy crops are an alternative heat source in many countries [1; 2]. However, compared to wood pellets, grass pellets have relatively high ash content and must be burned in a stove capable of handling ash (such as a corn stove) [3].

Energy crops are plants grown with the purpose of using their biomass for energy production. High contents of lignin and cellulose in grass biomass are desirable, especially when they are used as solid biofuels. They have high heating value due to the high content of carbon in lignin (about 64 %), and lignin crops can stand upright strongly at low water contents [4; 5]. Production of pellets for heating does not tolerate chemical adulterants (glue, varnish etc.), therefore lignin is of great significance, as it holds the pellet together. Lignin is used variously, e.g., in the production of materials (polymer, glue) and specific chemical substances (concrete additives, emulsifiers, binding materials) [6]. Compactness of the biofuel depends on the lignin content in energy crops [7]. Lignin improves efficiency of the thermo-chemical energy [8].

The ash content, along with varying levels of other elements such as chlorine or silica, can create problems for power or industrial users, contributing to fouling or slagging in boilers. One possible solution for getting better-quality pellets from agricultural biomass is to blend multiple feedstocks to get a consistent content in Btu, moisture and ash, and to keep undesirable components in acceptable concentrations. Including 10-20 % woody biomass in the blend can act as a binder, improving the durability of pellets [9]. Bearing in mind the low ash content of timber, it may be useful to mix it with biomass (with high ash content) directly before making pellets, since that would allow acquiring pellets with lower ash content; and thus use of biomass with high ash content for production of energy (biofuel and heat) may be facilitated.

Within the territory of Latvia, RCG biomass currently is considered to be one of the alternative sources for pellet production. This grass plant is characteristic with persistence to local climatic conditions and high biomass yield from 1 ha. Researches conducted in Latvia and all over the world have found out that all grass species are suitable for production of bioenergy, as they are perennial and highly productive [10].

Researchers have discovered that plant biomass may be one of the fuels used for the production of heat [1]; therefore, the research aims at evaluating correlations in ash and lignin content depending on fertiliser types and rates and studying suitability of this biomass for the production of biofuel.

Materials and methods

Research objects: RCG (*Phalaris arundinacea* L.) and tall fescue (*Festuca arundinacea* Schreb) are perennials yielding for 8-10 years, plant length up to 1.5 m, they are modest in terms of requirements for soil and may grow in marginal soils, moreover, they are suitable for cultivation in moisture meadows, with a strong root system and excel also with durability against draughts cold tolerance. Soil type: lesivated brown soil.

The field trial was carried out during 2011-2012 in the research and study farm “Peterlauki” (56º53’N, 23º71’E) of the Latvia University of Agriculture, in sod calcareous soils pHKCl 6.7, containing available for plants P 52 $mg\cdot kg^{-1}$, K 128 $mg\cdot kg^{-1}$, organic matter content 21 to 25 $g\cdot kg^{-1}$ in the soil. The field test fertiliser norms applied were the following ($kg\cdot ha^{-1}$): N0P0K0 (control) P_2O_5 – 80, K_2O – 120 (F – background), F+N30, F+N60, F+N90, F+N120 (60+60), F+N150 (75+75), F+N180 (90+90), vermicompost – 10 $t\cdot ha^{-1}$.

For the first time in Latvia influence of organic fertiliser – vermicompost and vermisil – on the productivity and chemical content of grass was researched. Vermicompost is organic fertiliser that is processed with organic agricultural waste earthworms (usually *Eisenia Foetida* L. and *Lumbricus Rubellus* L.) and bacteria or other organisms (vermin, fungi etc.). Vermisil is fertiliser containing humus substances acquired from vermicompost and is used to improve plant growth.

Total sowing norm in versions: 1000 germinant seeds per 1 m^2. Usage type: mowing two-three times. Fertiliser used until now was mineral (ammonium nitrate, complex N: P: K).

The ash content in various samples was found out in the agricultural scientific laboratory for agronomic analyses of the University of Latvia in compliance with the ISO 5984:2002/Cor1:2005 standard. The lignin content was determined in compliance with the LVS EN ISO 13906: 2008.

For each sample three parallel experiments were carried out, repeating each tested combination three times. The correlations were analysed as linear or polynomial regressions, and graphs were made using MS Office program Excel.

Results and discussion

The research helped discovering that the ash content in RCG dry matter comprises 7.02-8.88 % and lignin content varies between 4.46 % and 5.41 %; while the ash content in tall fescue biomass accounts for 7.93-8.29 %, and lignin content constitutes 4.82-6.06 % (Fig.1 and 2).

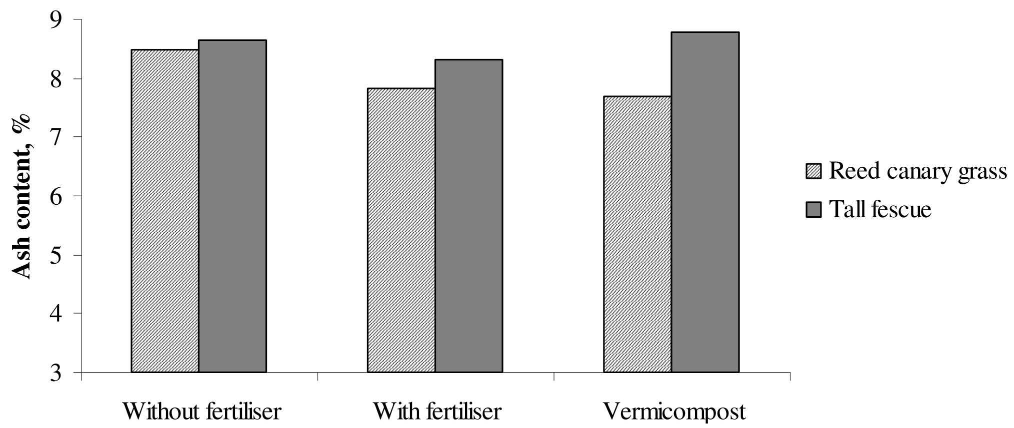

Fig. 1. **Average ash content in RCG and tall fescue biomass depending on fertiliser type**

In another study on RCG biomass that was performed earlier (results of the year 2009) the ash content of different varieties averaged 15.4-19.0 %, while the 'Marathon'08 variety had an average ash content of 11.9 % [11]. The results acquired in both studies show that biomass of both RCG and tall fescue has high ash content compared to other fuels like wood fuels or pellets. Literature data show that the ash content in wood fuels does not exceed 1.4 % [12]. In peat pellets and briquettes it varies between 1.27 % and 5 %. It may be explained by the fact that the peat content varies rather greatly and may contain various mineral substances. The ash content in cereal straw among various species varies between 5 % and 8 % [12]. It is known that the plant species is one of the most important factors that influence the ash content in biomass. The ash content shown in other literature sources is rather different, e.g., the ash content resulted from usage of wood pellets is 0.50 %, from other fuels obtained from biomass, as switchgrass – 8.3 %, giant reed – 6.1 %, miscanthus – 2.3 %, cardoon – 17.4 % [13]. The difference in the ash content can also be problematic for ag-based pellets, particularly with residential heating where the higher ash content of herbaceous pellets is undesirable [3]. In our study (Fig. 1) among various fertiliser types the lowest ash content was found in the RCG samples treated with vermicompost (7.73 %) and without N fertiliser (8.48 %), while the tall fescue samples indicate the lowest ash content when treated with N fertiliser (8.34 %).

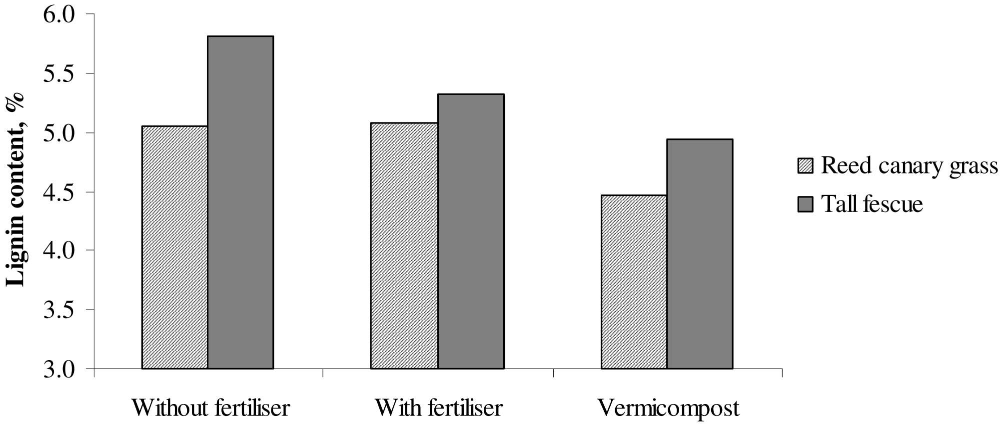

Fig. 2. **Average lignin content in RCG and tall fescue biomass depending on fertiliser type**

The results acquired show that the lignin content of both, RCG and tall fescue biomasses is lower compared to many other fuels. The lignin content in different crops varies from 27-42 % in hemps [14], 9.09 % in sunflowers [7] till 0.30 % in timber of coniferous trees [15]. Crop residues and perennial grasses typically range between 12 % and 14 % in lignin. That lower lignin content can require more energy to pelletize herbaceous feedstocks than woody biomass, unless binders are used [16].

In our study (Fig. 2) the highest lignin content was discovered in RCG biomass treated with N fertiliser (5.07 %) and in tall fescue biomass not fertilised (5.8 %).

It may be concluded that use of fertilisers did not leave significant influence on the ash or lignin content of TF ($p \geq 0.05$). However, the research allowed observing a tendency that the biomass samples treated with nitrogen fertiliser or vermicompost have lower average lignin content in tall fescue biomass ($p \geq 0.05$). In case of RCG biomass the research allowed observing a tendency that lower average lignin content was in the biomass samples treated with vermicompost.

Analysing the connection between the biomass ash content and N fertiliser dose we observed a close linear negative correlation in the RCG samples: $r = -0.88$ ($p < 0.05$) (Fig. 3).

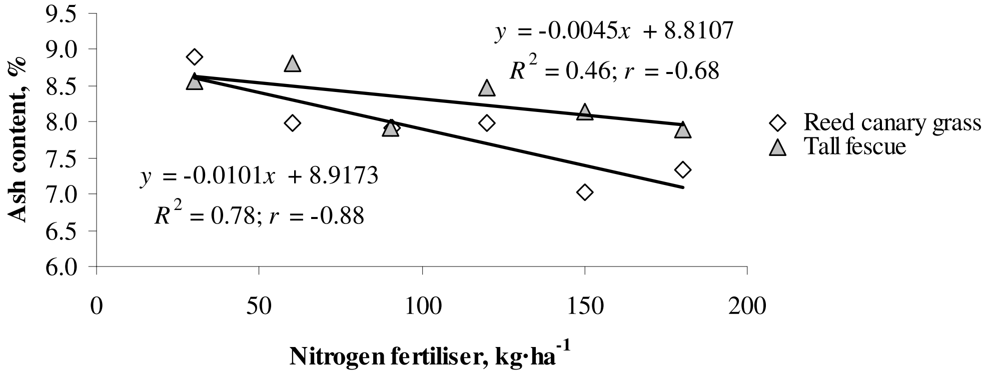

Fig. 3. **Ash content and mineral fertiliser rate correlations in RCG and tall fescue biomass**

In the tall fescue biomass samples correlation between ash content and N rate in fertiliser was not statistically significant ($p > 0.05$). It allows concluding that the higher N concentration in fertiliser, the smaller ash content in slag of RCG biomass. However, N rate in fertiliser did not influence the ash content in tall fescue biomass.

In its turn, the lignin content in both, RCG and tall fescue biomass samples did not have linear correlation with N rate in fertiliser, ($p > 0.05$) (Fig. 4).

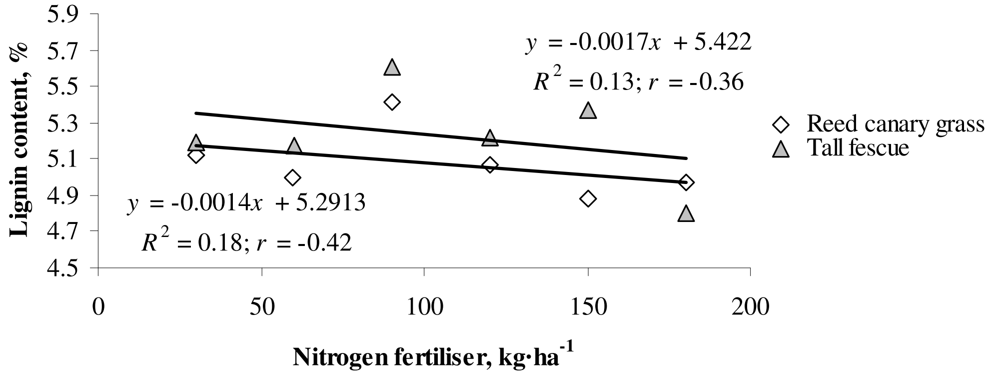

Fig. 4. **Lignin and ash content in RCG and tall fescue biomass depending on N fertiliser rate**

In order to find out relationships between the ash and lignin contents in tall fescue or RCG biomasses correlation and regression analysis was used. The results are shown in Fig. 5 and 6.

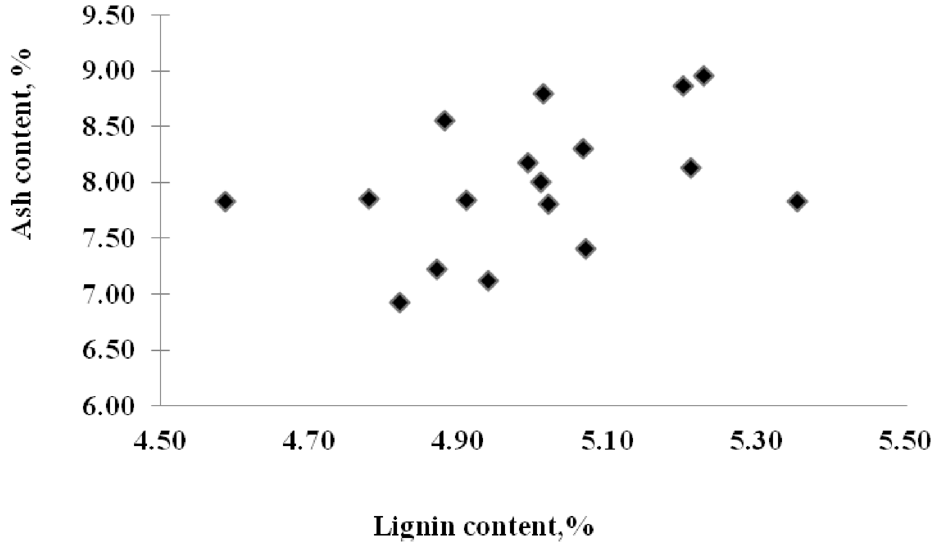

Fig. 5. **Lignin and ash content correlation in RCG biomass**

The RCG biomass samples did not indicate significant correlation between the lignin and ash contents ($p > 0.05$). Also there was no correlation between the lignin and ash content in tall fescue biomass.

Thus, in our study correlation between the ash and lignin content of grass biomass was not observed. However, the regression analysis conducted in 2009 with biomass samples obtained from RCG varieties grown in Latvia allowed concluding that the ash and lignin content are related. The research allowed observing significant ($p < 0.05$) and close negative linear correlation between the lignin and ash content ($r = -0.7864$, $n = 24$) [11].

Since in comparison with the wood fuel indicators, the ash content rates estimated within the framework of in this study are higher and the lignin content indicators are lower, it is advisable using tall fescue or RCG herbaceous biomass only as additive to wood chips or pellets.

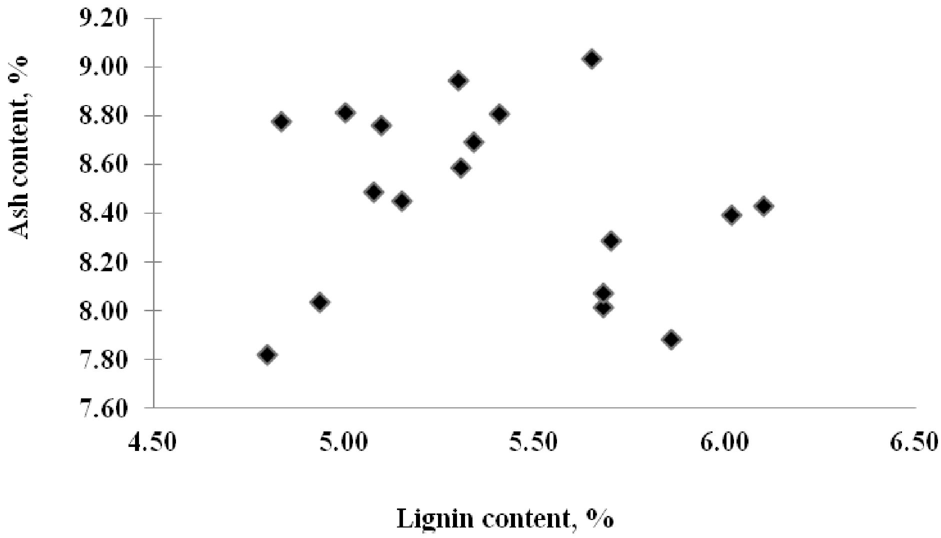

Fig. 6. **Lignin and ash content correlation in tall fescue biomass**

Conclusions

1. The reed canary biomass samples indicated close negative correlation between the ash content and nitrogen mineral fertilizer rate, $r = -0.88$. Thus, the higher nitrogen concentration in fertiliser, the smaller ash content in slag. The rate of nitrogen fertilizer applied did not influence the ash content in tall fescue biomass.
2. The research helped discovering that the ash content in grass dry matter comprises 7.02-8.88 % and the lignin content varies between 4.46 % and 6.06 % (low lignin content and high ash content), therefore, it would be useful to produce pellets from grass biomass mixing it with wood.

Acknowledgements

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