ASH CONTENT IN GRASS BIOMASS YIELDED IN 1ST AND 2ND CULTIVATION YEAR AND EVALUATION OF SUITABILITY THEREOF FOR PELLET PRODUCTION

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Abstract. One of the solutions for growing energy problems may be use of biomass; however heat production requires plants with particular characteristics. One of the biomass sources used for pellet production may be grass, nevertheless, it is a potential for high ash content leading to problems in the combustion process. Total ash content in grass biomass ranges between 2 % and 20 %. Research aims at measuring and characterising ash content in grass biomass yielded in 1st and 2nd cultivation year depending on the types and doses of fertilisers applied. It was found that the ash content in reed canary grass and tall fescue reduced (by 6.2 % and 6.7 %) and in festulolium, timothy and meadow fescue it increased (by 6.6 %, 6.7 % and 6.4 %). The data acquired show that grass biomass has high ash content; therefore it would be useful to produce pellets when mixing it with wood. High and high-quality grass yield requires application of nitrogen fertilisers, as they are among the key nutrients. In the research, average nitrogen content in tall fescue biomass dropped by 0.3 %, but it grew in biomass of reed canary grass (0.6 %), festulolium and timothy (0.5 %), meadow fescue (1.8 %).

Keywords: reed canary grass, tall fescue, festulolium, timothy, meadow fescue, ash content.

Introduction

In Latvia, biomass is the most perspective biofuel among all alternative energy sources. Moreover, there are various biomass types – straw, hay, grain, peat, chaff, etc. On the other hand, biomass pellets have high ash content, as compared to timber pellets, for example.

Currently grass is considered to be one of alternative sources for biomass production in the Baltics and Northern Europe, as it is suitable for local climatic conditions and produces high biomass yield [1; 2]. The main advantage of grass is the short growing period – biomass of several grass species may be yielded after 6-12 months [3].

Ash is one of the key biofuel quality indicators. Too high content of ash and non-combustible minerals causes problems to mechanization of the combustion process, resulting in lower useful fuel combustion coefficient. During the burning process, more fusions are formed. They are blocking the combustion chamber and the convective part of the boiler, thus more often mechanical cleaning is necessary. Usually biomass ash have lower melting temperature, therefore ash in the combustion chamber melt and obstruct air supply openings, moreover, non-combustible minerals ejected from the burner settle on the boiler furnace walls and melt there forming homogenous coating (glass) that reduces heat circulation. Main chemical elements forming ash are Al, Ca, Fe, K, Mg, Na, P, Si and Ti; they have effect on ach melting, formation of deposit and corrosion [4; 5].

Ash content in grass plants may vary between 1 and 20 %. It may be influenced by the plant species, soil texture, moisture, or mowing time (wood ash content should not exceed 1.5 %). Moreover, the heating capacity of such pellets is by 600-1000 $kJ \cdot kg^{-1}$ lower, e.g., one of bark briquettes with 14 % of ash heating value comprises 16554 $kJ \cdot kg^{-1}$ (in line with the standard DIN 51731, the heating capacity should reach at least 17500 $kJ \cdot kg^{-1}$). Heating value of fuel is an important quality indicator that largely depends on the moisture and ash content. With average moisture 6.7-7.8 % it ranges between 18400 and 17700 $kJ \cdot kg^{-1}$ [6]. Ash content in reed canary grass is much higher than in timber materials (0.5-3.0 %), but notably lower than in coal (approximately 25 %) [7].

Heat production and technological processes in Latvia in 2005 required 1.2 million tons of timber (relative moisture 50 %), that is 1.7 million tons of solid timber (cubic meter of dense timber, excluding air gaps among logs, branches, woodchip pieces. If not otherwise specified, when speaking about forestry and wood processing, usually the term cubic meter means solid timber). When burning such amount of wood, approximately 30 000 tons of ash are produced (assuming that the amount of ash and unburned timber comprises 5 %) [7]. Proportions of ash and specific inorganic components in grass biomass may differ notably among various plant parts. For example, in the research in the total ash and silicon dioxide content in various parts of rice straw (leaves, stems, knots, panicles) conducted by Samers and colleagues it was found that thec ash and silicon content in various parts differed significantly: the leaves contained 18-19 % of ash (76 % of which consisted of silicon dioxide), while the stems contained only 12 % of ash (with 42 % of silicon). Shares of inorganic components in various plant parts often were very specific; and this phenomenon directly influences the ways how biomass may be used. For example, rice husk (byproduct of rice grain processing) is considered to be good biomass fuel, but it has high ash and silicon content, therefore rice straw is considered to be complicated fuel. Rice straw has also high content of alkali metals that accumulate in ash [8]. Ash content in various biomass samples varies between 3 and 5.4 %, similarly as in straw, but it is higher than in timber [9].

High and high-quality grass yield needs application of nitrogen fertilisers. Nitrogen is one the most important plant nutrients since it has influence on formation of frontispiece, grass yield and the quality of yield [10]. Therefore, the research aims at measuring and characterising the ash content in grass biomass yielded in the 1st and 2nd cultivation years depending on the types and doses of fertilisers applied.

Materials and methods

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 pH KCl 6.7, containing available for plants P 52 mg·kg $^{-1}$, K 128 mg·kg $^{-1}$, organic matter content 21 to 25 g·kg $^{-1}$ in the soil. The field test fertiliser doses applied were the following (kg ha^{-1}): N0P0K0 (control) P_2O_5 – 80, K_20 – 120 (F – background), F + N30, F + N60, F + N90, F + N120 (60 + 60), F + N150 (75 + 75), F + N180 (90 + 90), vermicompost – 10 t·ha^{-1}. Main fertiliser: background P_2O_5 – 80; K_20- 120 kg·ha^{-1}; sowing norm – 1000 germinant seeds per 1 m^2; usage type: mowing two-three times.

The study covers research in the following energy crops to be used for fuel (pellet) production: reed canary grass *cv.* “Marathon”, tall fescue *cv.* “Feline”), timothy *cv.* “Varis”, meadow fescue *cv.* “Patra”, and festulolium *cv* . “Punia”.

Ash content in samples with different component compositions was found in the agricultural scientific laboratory for agronomic analyses of the University of Latvia in compliance with the ISO 5984:2002/Cor1:2005 standard. 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

With the aim to find the effect left by various fertiliser types and doses on the ash and nitrogen content and to see whether similar correlations may be observed for several (two) years, the rank correlation analysis was conducted. It showed that generally there is relation between the ash and nitrogen content and the fertiliser type and dose.

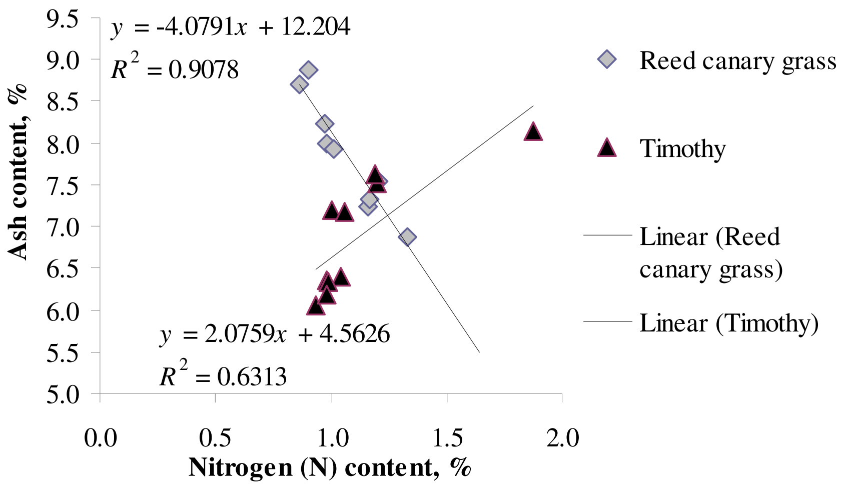

Fig. 1. **Correlation between ash content and nitrogen content in reed canary grass and timothy biomass in 2012 and 2013**

The figure depicting mutual correlations between ash and nitrogen contents (Fig. 1) shows that for several species, like timothy, the values of both parameters are increasing proportionally, while, e.g., for reed canary grass the ash content is reducing as the nitrogen content increases.

Moreover, for timothy and reed canary grass such correlation was observed in both years, while for the other grass species studied only one year indicated statistically significant correlation. It means that ash and nitrogen contents in the researched grass biomasses are influenced not only by the fertiliser type and dose, but also by other factors, that should be studied more deeply.

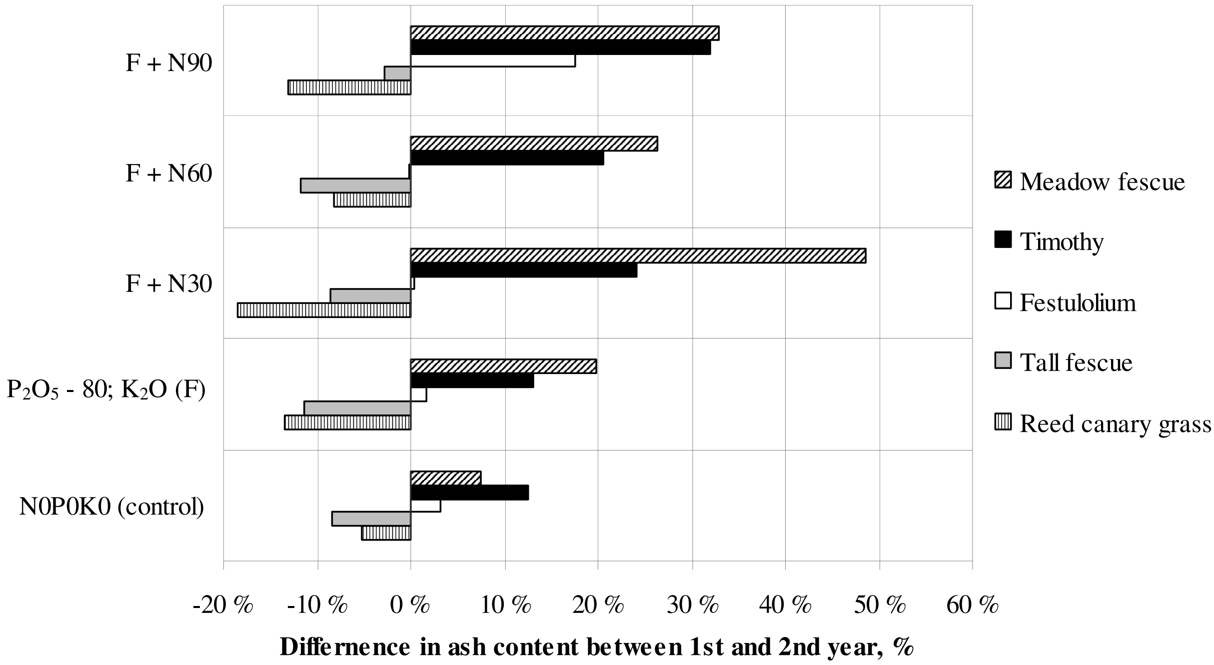

Fig. 2. **Difference in ash content (reduction/growth) in 2012 and 2013 depending on grass species and fertiliser type and dose**

The changes in the ash content by grass species in both years are shown in Figure 2, it allows concluding that average ash content in reed canary grass and tall fescue biomass reduced by 6.22-6.7 %, whereas in festulolium, timothy and meadow fescue biomass it grew by 6.62-7.32 %. The most notable ash content drop in reed canary grass biomass was when applying F + N30 and P_2O_5 – 80; K_20 – 120 (background) – (18 % and 14 %), for tall fescue when treating plants with F + N60 and P_2O_5 - 80; K_20 – 120 (background) – (12 % and 11 %). The ash content in festulolium biomass did not increase when applying F + N30 and F + N60 (0 %), but with F + N30 ash content went up by 18 %. The lowest ash content in timothy biomass was with fertiliser N0P0K0 (control) and P_2O_5 – 80; K_20 – 120 (background) – 13 %, whereas with F + N90 it reached 32 %, in meadow fescue biomass treated with N0P0K0 (control) it comprised 7 % and with F + N30 it grew by 49 %.

The nitrogen content in biomass yielded in both years has been depicted in Figure 3. Average nitrogen content in both years (depending on the fertiliser type and dose) reduced only in tall fescue biomass (by 0.3 %). The lowest nitrogen content in tall fescue biomass was recorded in the samples treated with F + N90 (0.74 %), while the highest when applying N0P0K0 (control) (1.01 %). Nitrogen content in reed canary grass biomass in the 2^{nd} cultivation year went up by 0.6 %. The highest nitrogen content was observed with N0P0K0 (control) – 1.34 %, but the lowest with F + N30 – 1.01 %. Average nitrogen content in two year yields rose also in timothy and festulolium biomasses – by 0.5 % and in meadow fescue biomass by 18 %.

In the research conducted in the Czech Republic [7] it was found that the ash content is influenced by several factors. One of the factors is the age of the frontispiece; the younger the frontispiece, the lower the ash content. Another factor having effect is the agro-climatic conditions, e.g., the soil type. When growing reed canary grass in clay, the ash content comprises 10.1 %, while when growing it in humus, it constitutes only 2.2 %. In the study it was discovered that the ash content is lowered by application of nitrogen fertilisers – on average by 8.6 %. On the other hand, the research [11] allows concluding that application of fertilisers does not leave significant influence on the ash content.

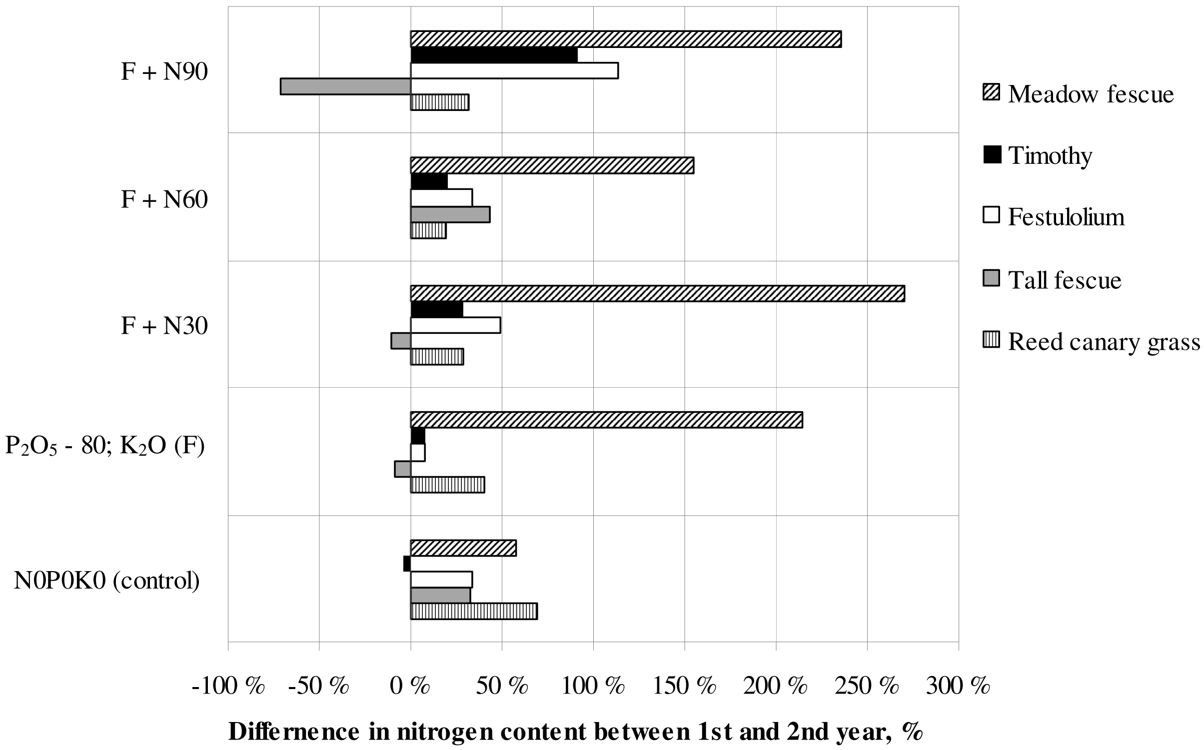

Fig. 3. **Difference in nitrogen content in 2012 and 2013 depending on grass species and fertiliser type and dose**

Conclusions

1. The results of two-year researches about the ash and nitrogen content show that the value of indicators in timothy biomass is increasing proportionally, whereas in reed canary grass biomass the ash content is reducing as the nitrogen content is growing.
2. It may be concluded that the ash and nitrogen content in the grass biomasses researched is influenced not only by the fertiliser type and dose, but also by other factors (e.g., soil), and this phenomenon should be researched more deeply.
3. Average ash content in reed canary grass and tall fescue biomass reduced by 6.22-6.7 %, whereas in festulolium, timothy and meadow fescue biomass it grew by 6.62-7.32 %.
4. Average nitrogen content in both years reduced only in tall fescue biomass – by 0.3 %. In reed canary grass biomass in the 2nd cultivation year it went up by 0.6 %, moreover, it rose by 0.5 % also in timothy and festulolium biomasses of both years and in meadow fescue biomass it increased by 18 %.

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