INFLUENCE OF NITROGEN FERTILIZERS ON CHEMICAL COMPOSITION OF ENERGY GRASS

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Abstract. Plant biomass is one of the ecological solutions that may be used in future due to the sustainability and availability thereof almost everywhere on earth. Today it is the second most commonly used energy source having 14 % contribution to the world energy consumption. However, production of biomass requires cultivation of grass having a particular chemical content, since grass biomass tends to produce high amounts of ash having negative influence on boilers. There are several indicators characterising the quality of fuel, the content of cellulose, lignocellulose, hemicellulose, and ash are among them. Cellulose and lignin are of a major significance, since they are the main combustible elements of biomass. The research covered the following grass species: reed canary grass, tall fescue, meadow fescue, festulolium, and timothy. The highest hemicellulose content was found in the samples treated with F+N90. The research also showed that, as the applied amount of the fertilizer P80K120 increases, the hemicellulose content in biomass grows, while the cellulose content as well as the ash content are not affected by the nitrogen fertilizer amounts. Analysis on application of various fertilizer norms on grass plants shows the most suitable lignin content in the samples not treated with nitrogen fertilizers. As energy grasses have a lower lignin content and high ash content, nitrogen fertilizer norms did not have notable influence on grass biomass, as compared to timber.

Keywords: energy grass, biomass, fertilizers, lignin, cellulose, hemicelluloses, ash.

Introduction

There are many crops or crop residues in agriculture that could be used for production of liquid, solid or gaseous fuels [1]. While the most promising crops utilised in the production of bioenergy (biofuel) are perennials since they can be harvested for several years in a row without reseeding and yield high biomass with satisfactory quality [2-4].

It is possible to control the biomass quality with various management methods. The growing conditions, grass specie, cutting frequency and fertilization leave the highest influence on the biomass production [5]. For this study we have chosen to observe nitrogen fertilizer influence on the yield. Nitrogen is an essential element for plant growth and development; it affects the yield capacity and quality. An optimal nitrogen fertilizer dosage is one that, when being increased, it does produce higher yield, but does not have negative influence on environment [6].

Plant biomass is the major energy source. A distinction is made between lignocellulosic biomass (wood, straw, green waste etc.), biomass with a high sugar and starch content (beetroot, sugar cane, wheat, maize etc.) and oleaginous biomass (rapeseed, soya, sunflower etc.). The mentioned biomass types are transformed into biofuels with the help of various methods [7].

Biomass is a general term used for all organic materials derived from plants. From the chemical viewpoint, it is a composite material, consisting of a mixture of hemicellulose, cellulose, lignin and extracts, and affected by the chemical structure of the species [8]. Today it is the second most commonly used energy source having 14 % contribution to the world energy consumption, as compared to 12 % of coal and 15 % of gas [9; 10].

The major combustible component of non-food energy crops is cellulose and the second one – lignin. Non-food energy crops are more efficient, as compared to the edible ones (having a great content of starch). Hemicellulose is a cellulose-related polysaccharide that comprises about 20 % of the biomass in most plants.

As biomass is primarily composed of hemicellulose, cellulose and lignin, it can be decomposed at temperature between 225-325 ºC, 305-375 ºC and 250-500 ºC, respectively [11]. It has been found that, the decomposition temperature of cellulose is much higher than that of lignin, which makes a larger amount of cellulose become more volatile [12]. This leads to the fact that the bigger the lignin composition, the greater the amount of char produced or carbonaceous residues, because of a lower thermal degradation.

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 a lower useful fuel combustion coefficient. They are blocking the combustion chamber and the convective part of the boiler, thus more often mechanical cleaning is necessary [13].

The research aims at evaluating some of the pellet quality parameters, namely cellulose,hemicellulose, andlignocelluloseindicators and the ash content in biomass from perennial grass and subjection of the parameters to nitrogen fertilizers.

Materials and methods

The study covered the research of the following energy crops used for fuel (pellet) production: culmiferous plants – reed canary grass (RCG) (*Phalaris arundinacea* L.); tall fescue (*Festu caarundinacea* Schreb.); festulolium (×*Festulolium pabulare*); meadow fescue (*Festuca pratensis* Huds.); timothy (*Phleum pratense* L.).

The energy crops were grown in the Research and Study farm "Peterlauki" (56º53'N, 23º71'E) of the Latvia University of Agriculture, in sod calcareous soils pHK_{Cl} 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., using 5 grass species and treating them with 5 different fertilizers norms (kg·ha^{-1}): 1) N0P0K0; 2) P80K120 (F – background); 3) F+N30; 4) F+N60; 5) F+N90. Each of the combinations tested was repeated three times. The total seeding rate was 1000 germinant seeds per 1 m^2. Swards were cut two times during the vegetation season.

Grass plant biomass samples were tested for various chemical indicators – cellulose, hemicellulose, lignin and ash content.

The lignin content and ADF faction in energy crop pellets was determined in compliance with the LVS EN ISO 13906: 2008[14], NDF faction – with LVS EN ISO 16472: 2006 [15], the ash content in different composition samples with the ISO 5984:2002 [16] standard, cellulose and lignin was measured in the Agricultural Scientific Laboratory for Agronomic Analysis of the Latvia University of Agriculture.

For each sample three parallel experiments were carried out, repeating each tested combination three times.

Results and discussion

The research shows that the lowest average hemicellulose content is 23.2 %;whereas the highest value was recorded in festulolium biomass withfertilizerP_2O_5-80, K_2O-120 (F) – 26.5 % and in timothy biomass with fertilizer F+N30 – 27.02 % (Fig. 1). Also in the researches conducted by other scientists [13] energy grass contains 25–30 % of hemicellulose. As compared to the non-treated samples, rise in the fertilizer norm up to F+N90 leads to increase in hemicellulose on average of 5 %.

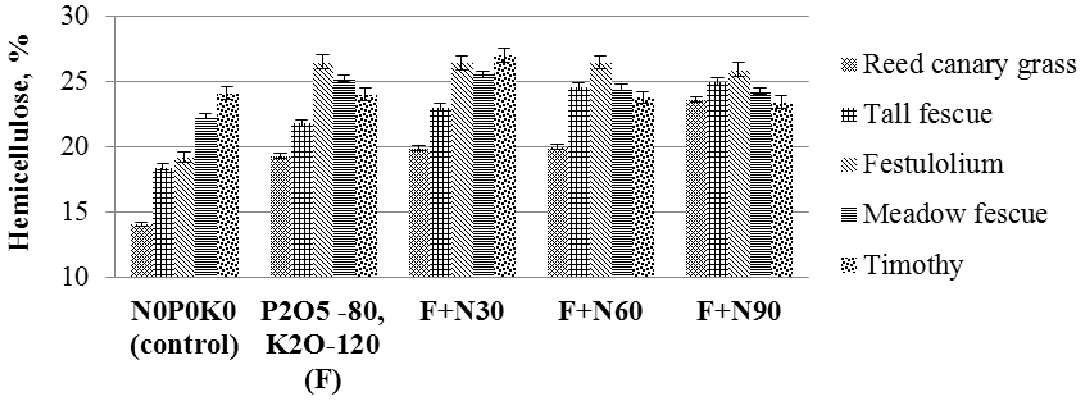

Fig. 1. **Influence of nitrogen fertilizers on hemicellulose content**

When the nitrogen fertilizer norm increases, the most notable changes in the cellulose content may be observed in reed canary grass biomass and infestulolium biomass – rise of 28.4 % and 33.7 %respectively. While in other biomass samples no notable influence was observed (Fig. 2). The

cellulose content in other researches varies between 24 % and 28 % [13], whereas in this research it is greater. Potential cellulose content in plants (by weight) accounts for approximately 33 % (in timber – about 50 %) [17].

Compared to unfertilised (N0P0K0) grass species the hemicellulose content of the fertilized(P80K120) plants increased by 5 %, while the cellulose content is not affected by the nitrogen fertilizer amounts. In general, the cellulose content of grass species varies from 29 % to 34 %, and is not affected by the amount of nitrogen fertilizer.

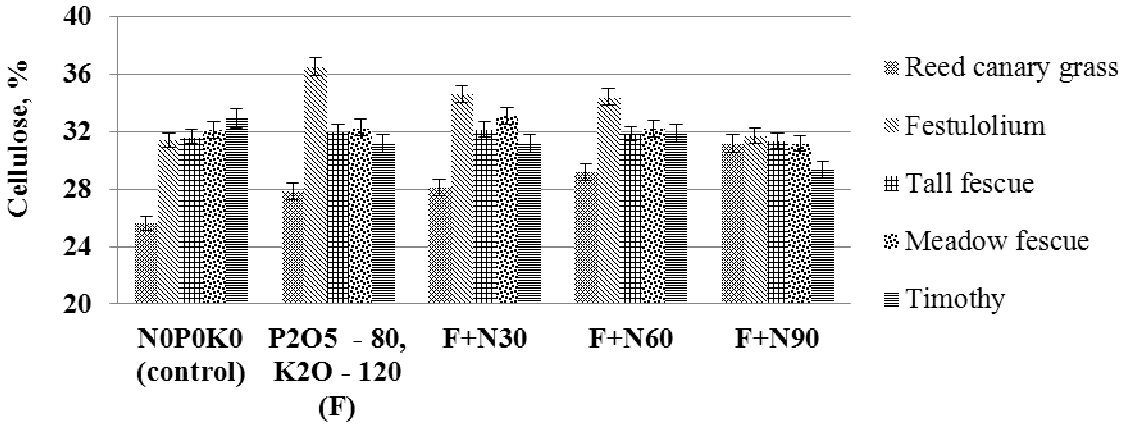

Fig. 2. **Influence of nitrogen fertilizers on cellulose content**

The fertilizer norms have rather insignificant effect on the lignin content in the biomass researched, except festulolium and timothy that indicated drop in the lignin content when fertilised with fertilizer F+N90 (Fig. 3). The energy grasses researched had a lower lignin content – 5.39-6.36 %. The highest lignin content was recorded in the samples with the nitrogen fertilizer N0P0K0 reaching on average 6 %, while the lowest lignin content was observed in biomass on which F+N90 was applied – reaching 5.2 %.

Compactness of solid fuel depends upon the lignin content in plants [17]. Lignin improves efficiency of transformation of thermo-chemical energy [18].

In another research [13], the lignin content varied between 7.6 % and 15 %, while in this research it was lower. To avoid problems with the biomass quality associated with summer harvests, it is recommended to harvest plants during winter or spring, after the growing season. Therefore, if energy grass is used for pellet production, it is advisable to mow the plants in the autumn, after first frosts, and to do it till spring, as well as to produce pellets from grass plant biomass that is mixed with wood (sawdust and woodchips).

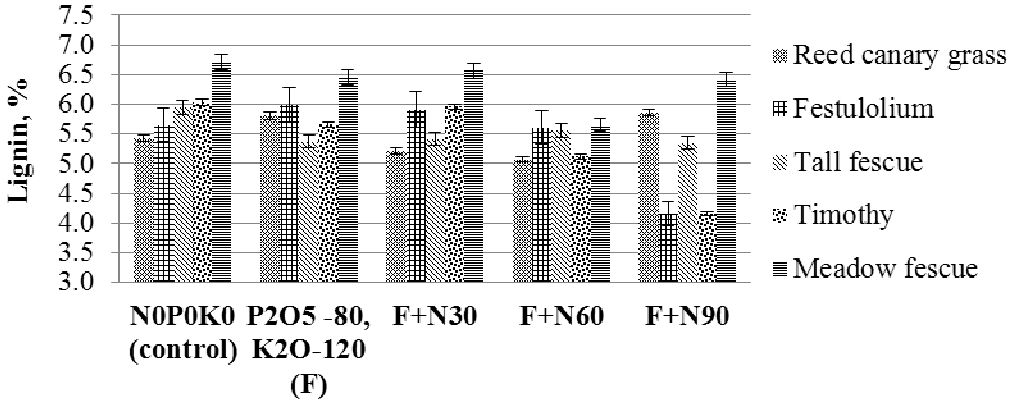

Fig. 3. **Influence of nitrogen fertilizerson lignin content**

Ash is one of the key indicators characterising the fuel quality. Too high content of ash and non-combustible minerals (also of sand) causes problems with automation of the combustion process

resulting in reduction of effective fuel combustion ratio [19]. The ash content in grass biomass is notably higher than in timber [20; 21].

In this research, the ash content in the studied energy grasses is high, reaching on average 7.7 %; moreover, nitrogen fertilizers do not have major impact on it. The highest ash content was found in meadow fescue treated with the fertilizer F+N30 – 8.6 % and in tall fescue treated withP80K120 (F– background) – 7.9 %.The research indicated a slight decrease in the reed canary grass ash content (from7.81 % to 6.88 %) and increase in the timothy ash content (from 7.20 % to 8.15 %).

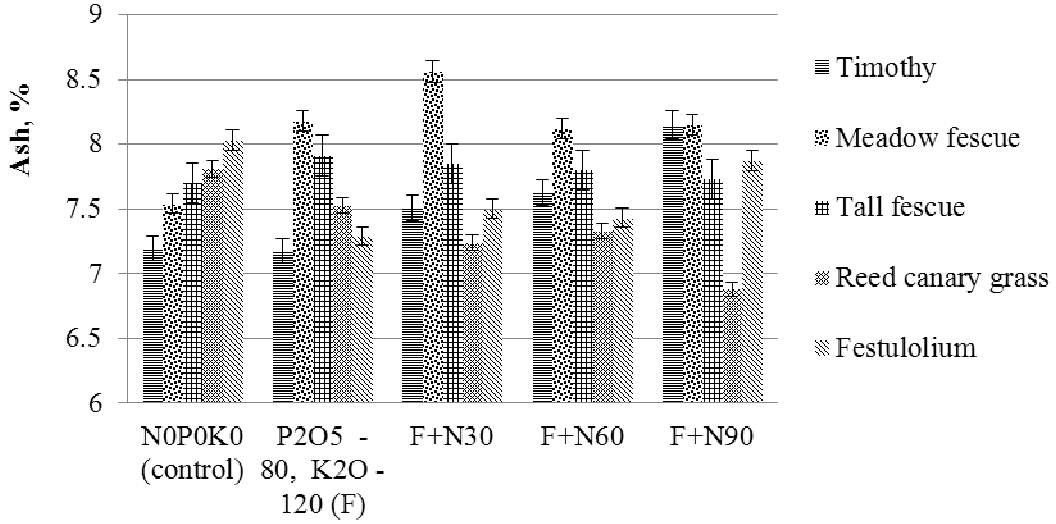

Fig. 4. **Ash content in energy grass influence of nitrogen fertilizer**

The 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 (ash content in wood should not exceed 1.5 %) [11]. The ash content in the grass samples studied is rather high – from 6.88 % to 8.56 %, which means that grass biomass should be mixed with wood biomass (sawdust or woodchips) to reduce the ash content in biofuel.

Conclusions

1. Our research indicates slight increase in the hemicellulose content by 5 % of fertilized (P80K120) grasses compared to unfertilized (N0P0K0), while the cellulose content is not affected by the nitrogen fertilizer amounts.
2. The cellulose content of the grass species varies from 29 % to 34 %, and is not affected by the nitrogen fertilizer amount.
3. Energy grasses have a low lignin content (average 5.76 %) and high ash content (average 7.7 %). The ash and lignin content of energy grass biomass is not influenced by application of nitrogen fertilizers.

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