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The yield and composition of reed canary grass biomass as raw material for combustion[1]

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Biomass has variable composition and properties which depend on fertilization intensity. Reed canary grass (*Phalaris arundinacea* L.) was investigated in small-plots experiment on light soil *Arenosols.* The biomass yield data on the average of two years of sward use showed that in this experiment biomass yield of reed canary grass without nitrogen was significantly lower than that fertilized with nitrogen, and ash content range depended on fertilization. In comparison with grass fertilized with N_{120} and N_0 the biomass with nitrogen fertilization N_{120} showed the lowest concentration of ash, which is a favourable feature for combustion process. Further research into the management of reed canary grass is needed.

Key words: *Phalaris arundinacea* L., biomass yield, bioenergy potential

INTRODUCTION

Biomass yield and quality are the indicators which determine possible energy yield of biomass per unit and an optional species of plants for energy conversion. In the past few years in Europe great focus is on bioenergy. Till now in Lithuania the most popular bioenergy source was wood, but increasing interest in bioenergy sector and new processing technologies suggest looking for alternative energy sources in all sectors. One of the most suitable sources for bioenergy in agriculture is perennial grasses [1, 2]. Perennials can be grown in one place without reseeding more than ten years; they do not require a lot of fertilizers

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and their quality can be managed by the cutting frequency, by fertilization or by choosing the most suitable variety of grasses [3, 4, 5, 6]. Different requirements of biomass quality are for biogas production and solid fuels, but there is one, which is common for all bioenergy sources, namely biomass yield [7].

In the regions of Northern Canada, Europe and Russia higher energy potential is achieved from the production of cold season (C3) perennial grasses, such as reed canary grass (*Phalaris arundinacea* L.) and tall fescue (*Festuca arundinacea* Schreb.) [8, 9]. Lewandowski et al. [10] in her experiments proved that C4 or warm season plants are more productive than C3 or cold season plants because of higher efficiency of photosynthesis, but in the northern regions reed canary grass and tall fescue grown on a higher yield than C4 plants because of lower ambient temperatures and shorter growing season, which significantly limits C4 type vegetation growth.

The selection of energy crops should be started from traditional crops as their growing for other purposes and overwintering abilities are already known. The main question for the researchers is how to get the highest biomass yield with the appropriate biomass quality for bioenergy.

In different soil and climatic conditions the biomass yield of the same crops is different. Kadžiulienė et al. [11] and Jasinskas, Kryževičienė [12] have reported that in favourable climatic conditions reed canary grass yields are 7–11 tons of dry matter per hectare. Reed canary grass can produce over 15 t ha^{-1} of dry biomass in Canada [13], from 6–11 tons of dry matter per hectare in Sweden [14]. One of the potential impacts on biomass quantity and quality is the use of nitrogen fertilizer. The response of reed canary grass to nitrogen fertilizer depends on the richness of the soil with nitrogen, as well as the fertilization rate [15, 16, 17]. However, because of the environmental consequences, nitrogen fertilization at high levels may not be desirable as nitrogen fertilizer contributes to groundwater pollution and depletion of the ozone layer, along with lowering the net energy balance of bioenergy crop production. To maximize net energy yield and land-use efficiency, reed canary grass had to be fertilized with not higher amount of N than 140 kg ha^{-1}. This led to nitrous oxide emissions and NO_3 leaching of more than 2 g N m^{-2} y^{-1}, compared with switchgrass, which lost only 0.5 g N m^{-2} y^{-1} [13]. Thus, the potential fertilization efficiency is closely related to local conditions and swards management.

If biomass is used for combustion, quantitative parameters are very important together with several indicators of the quality. The ash content of biomass is very important because when ash concentration is increased by 1%, the calorific value is reduced by 0.2 MJ kg^{-1} [18]. Because of poor quality of available biomass significantly lower energy value of biomass yield is available; it depends on worse conversion and lower calorific value [19, 20, 21]. Straw, grain, herbs and various other waste have relatively large amounts of N, Cl and S, which act to form a variety of pollution and corrosion promoting compounds [22, 23].

Fertilizing with nitrogen increases yields, but as far as it is in the control of reed canary grass biomass ash content tests are not very abundant. The aim of the research is to find ash flow differences dependence on fertilization of different rates of nitrogen in reed canary grass.

MATERIALS AND METHODS

Reed canary grass was investigated in a small-plot experiment on sand with small stone and gravel admixture, *Eutri-Cambic Arenosol* (*ARb-eu*) near Dotnuva, in Lithuania (55° 24‘ N, 23° 52‘ E) and the results obtained over the first and second years of swards use. The soil chosen for the experiment is less suited for other crops. It is neutral, deeper alkaline, with a humus status of 2%, with moderate total nitrogen, available phosphorus and potassium contents. Soil pH was 8.0, organic carbon 12.7 g kg^{-1}, total nitrogen 1.44 g kg^{-1}, available P 36–48 mg kg^{-1} and K 128–142 mg kg^{-1}.The pre-crop was red clover of the third year of use. Early in spring, the clover field was ploughed; the soil was prepared by a cultivator and a harrow. Reed canary grass was sown by a drill with 15 cm inter-row spacing. Seed rate was 15 kg ha^{-1}. The experiment was designed as a randomized complete block with three replicates. Plot size was 10 × 10 m. Harvested plot size – 10 m^2.

Phosphorus and potassium fertilizers were applied at a rate of 60 kg ha^{-1}. Three nitrogen fertilization levels (0, 60 and 120 kg ha^{-1}) were explored from the first year of reed canary grass swards use. The plants were harvested 3 times throughout the growing season and the dry matter (DM) yield and the chemical composition of the biomass were determined. Total C, N and S content of samples was determined simultaneously by dry combustion (Dumas method) using Vario *EL* III *CNS*-auto-analyser (Elementar, Germany).

The results were processed by analysis of variance ($p < 0.05$).

RESULTS

The dry matter content of reed canary grass varied from 4 704,8 to 11 249,9 kg of dry matter per hectare. In our research the DM yield of unfertilized reed canary grass was 7 670,0 kg ha^{-1} in the first year of sward use and 4 704,8 kg ha^{-1} in the second year of sward use (Table 1). The fertilization with higher rate of nitrogen fertilizer increased the biomass yield, but nitrogen fertilization gave a significant dry matter increase not every year. When fertilized with an average N_{60}, in the first–second years of growth, the plants accumulated on average 9 472,0 kg of dry matter per hectare biomass; however, in the second year the biomass amount decreased to 7 792,1 kg of dry matter per hectare. The fertilization with a higher rate of nitrogen fertilizer had a significantly higher effect on biomass yield only in the second year of sward use. This confirmed the results of the research performed in Estonia, where DM yield of reed canary grass increased continuously with the increase in nitrogen fertilizer input [24]. Of course, the reduction of biomass yield in less fertilized sward could be influenced by weather conditions, therefore more research is needed to prove the tendency.

When estimating the feasibility of use of reed canary grass for energy needs, the plant quality is of not less importance than the productivity potential. The key energy indicator of solid fuel – calorific capacity is most adversely affected by too high ash concentration in the biomass. The least ash concentrations were noted for reed canary grass fertilized with higher rate of nitrogen fertilizer (Figure). It is possible to increase the total dry-matter production of reed canary grass by an average of 121% through the addition of nitrogen fertilizer amount of up to 336 kg N ha^{-1} [25, 26].

There had also been reported that nitrogen fertilization increased the amounts of N and S in plant tissues at harvest [27]. This lowers the biofuel quality of reed canary grass. Therefore, the amount of N used in the culture of reed canary grass for biofuel purposes should be lower than for the maximization of forage production [13]. In our study, however, only in the first year of usage concentration of S was higher in fertilization with higher amount of nitrogen fertilizers (Table 2). Each other year of fertilization at higher N fertilizer rates resulted in N and S element decrease.

The carbon content of biomass is around 45%, while coal contains 60% or greater [21]. A higher carbon content leads to a higher heating

Table 1. Biomass dry matter (DM) yield of reed canary grass, kg ha^{-1}

Grass	Fertilization	Year of sward use		Average
		First	Second	
Reed canary grass	N_0	7 670,0	4 704,8	6 187,4
	N_{60}	11 151,9	7 792,1	9 472,0
	N_{120}	10 878,3	11 249,9	11 064,1
LSD_{05}		3 863,8	861,97	

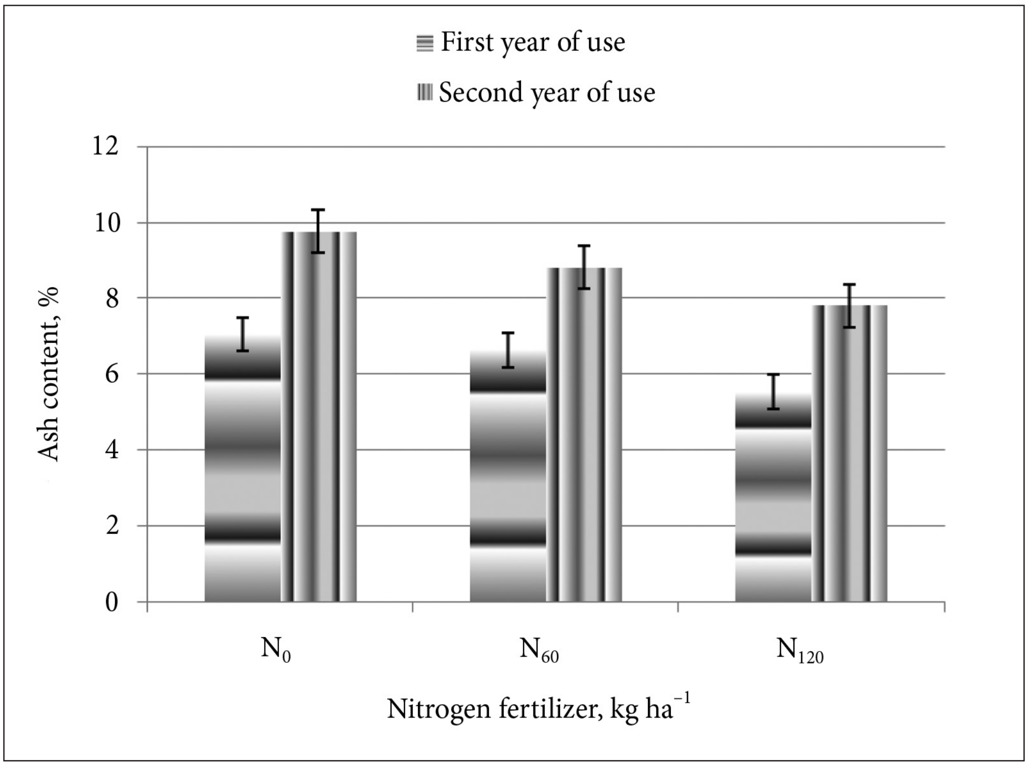

Figure. The ash content dependence on fertilization in the first and second year of reed canary grass use

Table 2. Chemical composition of reed canary grass, % in the first and second year of use

Grass	Fertili-zation	Chemical composition of DM (%)					
		First year of use			Second year of use		
		N	S	C	N	S	C
Reed canary grass	N_0	1.13	0.203	45.2	0.974	0.249	44.4
	N_{60}	0.946	0.210	45.0	0.964	0.230	45.3
	N_{120}	1.01	0.142	45.6	0.891	0.273	45.9

value [28]. Due to the poor quality of available biomass lower heating value is available [20, 21, 29]. In our study higher nitrogen fertilization means higher carbon content in the first and second year of reed canary grass swards use (Table 2).

CONCLUSIONS

The biomass yield of reed canary grass was influenced by nitrogen fertilizer. In two years of the experiment the fertilization with higher amount of N fertilizers shows a decrease of ash quantity. The average dry matter biomass yield of reed canary grass fertilized with 60 kg ha^{-1} of mineral nitrogen fertilizer was 9 472,0 kg ha^{-1}, fertilized with 120 kg ha^{-1} – 11 064,1 kg ha^{-1}, ash content 7.72% and 6.68%, respectively. Chemical composition of reed canary grass biomass shows that from swards fertilized at higher rates, we can expect a higher calorific value.

The selected reed canary grass for combustion showed the promising results of their productivity and chemical composition in the first and second year of swards use. Consequently, further research into reed canary grass management is needed.

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NENDRINIO DRYŽUČIO BIOMASĖS NAUDOJIMAS KIETAJAM BIOKURUI

Santrauka

Biomasės sudėtis ir savybės kinta priklausomai nuo tręšimo intensyvumo. Nendrinis dryžutis (*Phalaris arundinacea* L.) buvo tirtas eksperimentiniuose laukeliuose lengvos granuliometrinės sudėties dirvožemyje – smėlžemyje. Dviejų metų biomasės tyrimų duomenys atskleidė, kad azotu netręštas nendrinis dryžutis užaugino kur kas mažesnį biomasės derlių nei tręštasis. Pelenų kiekis biomasėje taip pat priklausė nuo tręšimo intensyvumo. Palyginus N_{120} tręštą ir visiškai netręštą (N_0) žolynus, nustatyta, kad tręštajame azoto trąšomis (N_{120}) buvo gerokai mažiau pelenų nei netręštajame, o tai labai svarbu deginant žolę. Nendrinio dryžučio auginimo ir naudojimo klausimais reikalingi tolesni tyrimai.

Raktažodžiai: *Phalaris arundinacea* L., biomasės derlius, bioenergijos potencialas