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EVALUATION OF CHEMICAL CONTENT IN DIFFERENT ENERGY CROPS

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For energy crops (reed canary grass and timothy grass), it is important to evaluate the sulphur and carbon content, and the harvested dry matter dependency on the fertilizer norm. Sulphur and carbon are important elements of a combustible material, and carbon is directly important as it forms the burning component. On the other hand, sulphur is an unwelcome element in combustible materials as it promotes environmental pollution. The field trials were carried out in sod calcareous soils in 2011–2013. A research was conducted to investigate the chemical content of two grasses: reed canary grass *var.* 'Bamse' (*Phalaris arundinacea* L.), and timothy grass 'Jumis' (*Phleum pratense* L.). Fertiliser norms (kg ha^{-1}) applied in the research were: N0P0K0 (control), N30, N60, and N90. The harvest yield is one of the most important factors to obtain biocombustible materials; however, it does not mean that the amount of the harvest yield guarantees also a good quality of grasses. The research showed that the trial year had the most significant influence on both the sulphur yield and content in dry matter, the fertiliser norm essentially influenced the sulphur (η=30.1%) and carbon (η=6.5%) yield, but for the sulphur yield, a 6% interaction effect was established between the trial year and the nitrogen fertilizer norm.

Keywords: energy crops, fertilizer norms, carbon content, sulphur content.

INTRODUCTION

The chemical content is an important indicator, as the ash melting temperature is dependent on it (Bumane et. al., 2017). Any form of a hard biomass combustible material is basically formed from complex organic-origin compounds that consist of five chemical elements: carbon (C), hydrogen (H), sulphur (S), oxygen (O), and nitrogen (N) (Cars, 2008). The content of non-burning elements influences the production costs for heating, as these costs are incurred for transportation. If a combustible material contains more non-burning elements, the costs of a thermal unit increase. Therefore, for the material that is moist and with a large ash content, long-distance transportation is not advantageous. In Latvia, for this type of combustible materials, fire-wood and peat can be considered (Cars, 2008).

The nitrogen fertilizer is an important indicator to evaluate the factors that influence, for instance, the harvest yield (Rancane, Karklins, 2017; Adamovics et. al., 2015; Rancane et. al., 2015). Still, many investigations have shown that by increasing the nitrogen fertilizer, many quality indicators do not change (hemicellulose, ash content, lignin) (Adamovis et. al., 2016; Rancane et. al., 2015), or also an essential influence of nitrogen fertilizer has been established (Adamovics et. al., 2017; Poisa et. al., 2017).

The objectives of this study were to examine the effect of S and C content and harvest yield in the dry matter of reed canary grass and timothy grass depending on the fertilizer norm.

RESEARCH METHODS

The field trials were carried out in the Research and Study farm "Peterlauki" (56°53'N, 23°71'E) of the Latvia University of Agriculture (LLU) in 2011–2013. The soil was sod calcareous (pH_{KCl} 6.7, containing available P 52 mg kg^{-1} and K 128 mg kg^{-1}; organic matter content – 21–25 g kg^{-1}). The research was conducted on two grasses: reed canary grass *var.* 'Bamse' (*Phalaris arundinacea* L.) and timothy grass 'Jumis' (*Phleum pratense* L.). Fertiliser norms (kg ha^{-1}) used in the research: $N_0P_0K_0$ (control), N_{30}, N_{60}, and N_{90}. Seed sowing norm: 1000 germinating seeds per m^2. The first-cut herbage dry matter yield was analysed in the Analytical Laboratory for Agronomy Research (LLU) for carbon content (ISO 625, ISO 333) and sulphur content (ISO 334). The harvest yield for dry matter was established by drying a sample at 105 °C until the mass was unchangeable (ISO 6496). The obtained results were calculated for a hectare (t ha^{-1}).

From each fertilizer variant, three repeat samples of the green mass of reed canary grass and timothy grass were taken and weighed exactly ±0.01 kg. The samples were used to establish the dry matter content.

Establishing the hydrothermic value (HTC) for timothy grass and reed canary grass, it can be seen that on average in the growing season, it was from 1.0 to 2.00, but the period of April, June, July, and October of 2013 was insufficiently damp.

Excessively damp were June and July of 2011 and 2012, and August of 2011–2013. The increased dampness positively influenced the growth of reed canary grass and timothy grass, as herbaceous plants typically absorb large amounts of moisture.

The results were statistically processed using descriptive and variance statistics and dispersion analysis methods with *Microsoft Excel for Windows* (Arhipova, Bāliņa, 2006).

RESEARCH RESULTS

Sulphur is an important element in the formation of plant proteins, amino acids, and some vitamins and ferments. In the same way, sulphur is involved in the photosynthesis process, joint energy metabolism, and carbohydrate production. The plants choose sulphates, which are found in mineral fertilizers, as also the sulphur dioxide is found in the atmosphere.

Still, many information sources reveal that in energy crops, the sulphur content preferably should be as small as possible (Komlajeva, Adamovičs…, 2012; Kakitis, Ancans.., 2014; Poisa, Bumane.., 2017), i. e., 0.1 % (Alakangas, 2010). An increased sulphur content in a combustible material produces sulphur dioxide emissions into the atmosphere.

The study found that increasing the fertilizer rate from N0 to N90 increases both the dry matter yield and the sulphur and carbon yield.

The sulphur yield of one hectare of reed canary grass (*Phalaris arundinacea* L.) was 282.87 kg ha^{-1} (N0) in 2012, and 596.22 kg ha^{-1} (N0) in 2013; but that of timothy (*Phleum pratense* L.) was 141.27 kg ha^{-1} (N0) in 2012, and 600.80 kg ha^{-1} (N0) in 2013. So large difference in the sulphur yield from one hectare is due to the different meteorological conditions in the years 2012 and 2013.

The research demonstrated that the increase in fertilizer norm does not essentially influence the sulphur content in the reed canary grass and timothy grass dry matter norms; therefore, the increase was evaluated for the influence of nitrogen fertilizer norm on the sulphur yield for one ha. For timothy grass and reed canary grass in both years of cultivation (2012–2013), the increase in fertilizer norm from N0 to N90 increased the sulphur yield by more than 100%. On the other hand, the sulphur yield increase from one kg of nitrogen decreased by 75% (from N30 to N90).

It was established that sulphur content in one kg dry matter was: for timothy – 0.04% in 2012 and 0.16% in 2013; for reed canary grass – 0.07% in 2012 and 0.16% in 2013; on average – 0.10%, not depending on the fertilizer norm used.

Carbon is the main burning element in a combustible material, with a high level of thermal energy (Cars, 2008). Carbon dioxide and water are formed in the process of burning carbohydrates; the energy from the sun is freed, which is a natural, sustainable battery for the accumulation of the energy of the sun. The carbon content obtained in one kg dry matter of timothy grass was 48% in 2012 and 43% in 2013, and that of reed canary grass was 47% in 2012 and 43% in 2013; on average – 45%.

The carbon yield of one hectare of reed canary grass (*Phalaris arundinacea* L.) was 1800.57 kg ha^{-1} (N0) in 2012 and 1937.39 kg ha^{-1} (N0) in 2013, and that of timothy grass (*Phleum pratense* L.) was 1535.42 kg ha^{-1} (N0) in 2012 and 1742.34 kg ha^{-1} (N0) in 2013 (Tables 1 and 2).

Table 1. Carbon yield from one hectare of reed canary grass and timothy at the Research farm "Pēterlauki" in 2012

Fertilizer norm N, kg ha^{-1}	Dry matter yield, t ha^{-1}	Carbon yield			Carbon yield from 1 kg N	Carbon yield increase from 1 kg N kg ha^{-1}
		kg ha^{-1}	±kg ha^{-1}	%		
reed canary grass (*Phalaris arundinacea* L.)						
N0	3.80	1800.57	–	100	–	3.80
N30	6.21	2933.72	1133.15	163	97.79	6.21
N60	6.27	2980.6	1180.03	166	49.68	6.27
N90	8.39	4006.88	2206.31	223	44.52	8.39
timothy (*Phleum pratense* L.)						
N0	3.15	1535.42	–	100	–	3.15
N30	6.48	3154.63	1619.2	205	105.15	6.48
N60	7.84	3767.08	2231.66	245	62.78	7.84
N90	8.04	3898.91	2363.49	254	43.32	8.04

The carbon yield from one kg nitrogen decreased by nearly 50% if the nitrogen fertilizer norm was increased from N0 to N90 (Tables 1 and 2). Carbon yield increase from one kg N decreased by increasing the nitrogen fertilizer norms. Such a large difference in the carbon yield from one hectare is due to the different meteorological conditions in the years 2012–2013.

The harvest yield stability indicators for some cultivated plants have been little researched, as two similar years are not possible in the countryside (Kroģere, Pelēce, 2004). However, in the scientific literature, no specific optimal values for reed canary grass and timothy grass for the countryside conditions in Latvia have been found. It can be noted that climatic changes, specifically increased rainfall and high temperatures, will show ever larger losses (ADAS, 2005).

The trial year as a totality of agrometeorological factors had the greatest influence on the sulphur yield and content in the dry matter (Table 3). Also Finnish scientists K. Hakala, M. Kontturi un K. Pahkala (2009) have found that the harvest yield potential is influenced by the local climatic conditions. The fertilizer norm (factor C) essentially influenced

the sulphur (η=30.1%) and carbon (η=6.5%) yield. For the sulphur yield, a 6% interaction between the trial year and the nitrogen fertilizer norm was established, which confirms that nutrient accessibility depends on soil fertility, fertilizer resources, and agrometeorological conditions (Hiltunen, Barišić..., 2008).

Table 2. Carbon yield from one hectare of reed canary grass and timothy at the Research farm "Pēterlauki" in 2013

Fertilizer norm N, kg ha^{-1}	Dry matter yield, t ha^{-1}	Carbon yield			Carbon yield from 1 kg N	Carbon yield increase from 1 kg N kg ha^{-1}
		kg ha^{-1}	±kg ha^{-1}	%		
reed canary grass (*Phalaris arundinacea* L.)						
N0	4.55	1937.39	–	100	–	–
N30	5.66	2421.08	483.69	125	80.7	16.12
N60	7.20	3060.74	1123.35	158	51.01	18.72
N90	8.77	3743.04	1805.65	193	41.59	20.06
timothy (*Phleum pratense* L.)						
N0	4.09	1742.34	–	100	–	–
N30	5.68	2426.22	683.88	139	80.87	22.8
N60	5.66	2414.83	672.49	139	40.25	11.21
N90	8.95	3782.78	2040.44	217	42.03	22.67

Table 3. Proportional influence of various factors on the sulphur (S) and carbon (C) content and yield, η, %

Factors	S, kg ha^{-1}	S, %	C, kg ha^{-1}	C, %
Repeats	0	0	0	0
Trial year (A)	41.3*	14.6*	0.2	0.3
Species (B)	0.5	66.9*	82.6*	99.3*
N fertilizer norm (C)	30.1*	ns	6.5*	ns
Interaction (A × B)	11.9*	16.8*	0.2	0.3
Interaction (A × C)	6.0*	0.3	0.3	ns
Interaction (B × C)	3.0	0.5	6.6*	ns
Interaction (A × B × C)	3.8*	0.5	1.0	ns
Effect of unexplored factors	3.4	0.1	2.6	0
Total	100	100	100	100

* significant at the 0.05 level ($F_{fakc} > F_{0.05}$)
ns – not significant ($F_{fakc} < F_{0.05}$)

The fertiliser utilisation effectiveness depends on the specific growth circumstances in a particular year. Inclusive of the rainfall amount and temperature (Fig. 1), the most effective are the dry years (Kasal, Ruzek ..., 2011). With a higher fertiliser norm, the nitrogen fertiliser utilisation coefficient reduces. This creates a risk that the unused nitrogen compounds can pollute the environment or with rainfall enter the reservoirs (Lyons, 1998; Štikāns, 1996; Evans,1997; Scholz, Kern ..., 2010; Skrabule, Vaivode, Ruža, 2012); therefore, special attention should be paid how to use them on plants that grow in damp conditions.

An increased nitrogen fertiliser norm for the harvest yield can decrease the energy indicators, for instance, for potatoes as regards starch content (Vucāns, 1996). Therefore, the question becomes urgent about the economic effectiveness of fertilizers, which is determined by the cost of the mineral fertilizers and the purchase cost of the harvest.

This is important because cultivated plants with the highest yield have the lowest prime costs. However, it should not be forgotten that record yields may not be economically profitable in certain circumstances and require optimalisation in specific conditions (Štikāns, 1996; Wrobel, Coulman, Smith, 2009; Scholz, Kern..., 2010).

CONCLUSIONS

Ecological and agrotechnical factors influenced the yield of reed canary grass (*Phalaris arundinacea* L.) and timothy grass (*Phleum pratense* L.), which is one of the most important factors characterizing the quality of energy crops.

The increase in fertilizer rate did not significantly affect the sulphur content in the dry matter of reed canary grass (*Phalaris arundinacea* L.) and timothy grass (*Phleum pratense* L.).

The increase in fertilizer rates from N0 to N90 significantly affected the amount of sulphur and carbon yield per one hectare of reed canary grass (*Phalaris arundinacea* L.) and timothy grass (*Phleum pratense* L.).

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