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H. RACLAVSKÁ[*], D. JUCHELKOVÁ[**], H. ŠKROBÁNKOVÁ[***], M. VOLFOVÁ[****], J. FRYDRYCH[*****]

CHANGES IN BIOMASS ENERGY PARAMETERS DEPENDING ON THE HARVEST SEASON

ZMĚNY ENERGETICKÝ PARAMETRŮ BIOMASY V ZÁVISLOSTI NA OBDOBÍ SKLIZNĚ

Abstract

The harvested period of energy grasses can change considerably the problem parameters which influence the process of combustion (concentrations of alkalies, chlorine, nitrogen and ash). The highest losses of water-soluble potassium (> 80 %) were observed for *Agrostis gigantea* Roth. and *Phalaris arundinacea* L., the lowest losses were found for *Festuca arundinacea* Schreb. The losos of water-soluble sodium (36 – 57 %) were Loir than those of potassium. The concentration of chlorine remained almost constant during whole vegetation period.

Abstrakt

Doba sklizně energetických travin může výrazně ovlivnit problémové parametry ovlivňující průběh spalovacích procesů (obsah alkalických prvků, chloru, dusíku a popelovin). Nejvyšší ztráty vodorozpustného draslíku (> 80 %) vykazoval psineček veliký Rožnovský (*Agrostis gigantea* Roth.) a lesknice rákosovitá Chrastava (*Phalaris arundinacea* L.), nejnižší ztráty (<30 %) vykazovala kostřava rákosovitá KORA (*Festuca arundinacea* Schreb.). Ztráty vodorozpustného sodíku byly nižší, pouze 36 – 57 %. Obsah vodorozpustného chloru zůstal po celé vegetační období téměř konstantní.

1 INTRODUCTION

For the manufacturing of bio-briquettes, plants of herbaceous character that are grown specifically on arable land and that produce high dry matter yields are suitable. Some types are grown

[*] prof. Ing. H. RACLAVSKÁ, CSc., VŠB - Technical University of Ostrava, Faculty of Mining and Geology, Institute of Geological Engieneering, 17. listopadu 15/2172, 708 33 Ostrava-Poruba, Czech Republic, tel. (+420) 59 732 4365, e-mail helena.raclavska@vsb.cz

[**] prof. Ing. D. JUCHELKOVÁ, Ph.D., VŠB – Technical University of Ostrava, Faculty of Mechanical Engineering, Department of Energy Engineering, 17. Listopadu 15/2172, Ostrava, tel. (+420) 59 732 5175, e-mail dagmar.juchelkova@vsb.cz

[***] Ing. H. ŠKROBÁNKOVÁ, Ph.D., VŠB – Technical University of Ostrava, Faculty of Mining and Geology, Institute of Environmental Engineering, 17. Listopadu 15/2172, Ostrava, tel. (+420) 59 732 5483, e-mail hana.skrobankova@vsb.cz

[****] Ing. M. VOLFOVÁ, VŠB – Technical University of Ostrava, Faculty of Mining and Geology, Institute of Environmental Engineering, 17. Listopadu 15/2172, Ostrava, tel. (+420) 59 732 1111, e-mail martina.volfova.st@vsb.cz

[*****] Ing. J. FRYDRYCH, OSEVA PRO, s.r.o., Hamerská 698, 756 54 Zubří, e-mail zubri@oseva.cz

exclusively for energy – a group of grasses grown as energy crops (mountain brome, redtop, reed canary grass, tall fescue, false oat-grass and hybrid ryegrass varieties).

A factor of importance to the determination of optimum harvest time for grasses is the knowledge of behaviour of key parameters influencing energy characteristics of biofuels: calorific value, ash content, content of volatile matter, contents of fixed carbon and nitrogen and alkali content (Reed T.B. and Gaur S., 2009). In some parameters (nitrogen, alkali, ash) values change is depending on harvest time. A delay in the harvest leads to reduced concentrations of most elements that are undesirable in combustion, e.g. nitrogen, sulphur, chlorine or potassium. An exception is silica, the concentration of which increases during winter (Hadders G. and Olsson R. 1996). During the growing season, alkalies are leached from grasses. What is a key factor in the use of grass biomass as a fuel is ash melting behaviour. Paulrud S. et al. (2001) state that for low ash content fuels (3–4% d.m.), higher portions of melt occurred in the lower temperature range of less than 1200°C and for high ash content fuels (5–10%), more melting occurred in the higher temperature range of more than 1500°C. The leaching of alkali from grass also contributes to an increase in ash fusion temperature from 1070°C to 1400°C (Burvall J., 1997, Hadders G. and Olsson R., 1996, Miller S.F. and Miller B.G. 2007). However, Finell M. and Nilsson C. (2005) state for Reed Canary Grass (RCG) that the ash content of the stem fraction of RCG mainly depends on location and soil type. Similarly, Landström S. et al. (1996) state that the ash content in RCG was lower in the crop at spring harvest than in August but varied with the soil conditions.

2 METHODS AND MATERIAL

Energy crops were grown and supplied by the company OSEVA PRO, Ltd. – Grassland Research Station at Rožnov – Zubří: redtop *(Agrostis gigantea* Roth.*)* Rožnovský, reed canary grass – Chrastava *(Phalaris arundinacea L.),* tall fescue – Kora *(Festuca arundinacea* Schreb.*)*, false oat-grass *(Arrhenatherum elatius* L.) J.Presl et C.Presl Rožnovský mountain brome – Tacit *(Bromus marginatus* Nees ex Steud.*)* white clover LOTR (*Trifolium repens L.*) and hybrid ryegrass varieties (*Festulolium*). Ryegrasses and hybrid ryegrass varieties belong to grasses having the highest water-soluble sugar contents (Kopecký D. et al. 2005). Water-soluble sugar contents (WSC) are a key factor influencing biogas yield in anaerobic digestion. The energy crops were harvested during the year 2011 in the months of May, July, August and September. Obtained samples were processed according to the method P CEN/TS 14780 Solid Biofuels - Methods of sample preparation.

The alkali content analysis was carried out according to the method ČSN P CEN/TS 15105 Solid biofuels – Method for determination of the water soluble content of chloride, sodium and potassium. The content of volatile matter and the ash content were determined according to CEN/TS 15402 Solid recovered fuels – Methods for the determination of the content of volatile matter and CEN/TS 15403:2006 Solid recovered fuels – Method for determination of ash content. The calorific value was determined in accordance with CEN/TS 15400:2006 Solid recovered fuels – Method for the determination of calorific value. The content of lignin was determined according to ČSN EN ISO 13906 Animal feeding stuffs – Determination of acid detergent fibre (ADF) and acid detergent lignin (ADL) contents.

3 RESULTS

For fuel production, otherwise non-recoverable waste materials, such as waste biomass, corn and rape straw, linen and cotton, maize, elephant grass and paper are used. These materials are equal in energy value to e.g. brown coal. The calorific value of wood briquettes moves in the range of 17-18 MJ/kg and that of straw briquettes moves in the range of 14-16 MJ/kg. In Figure No.1 there are gross calorific values of grasses harvested during the month of May. The gross calorific values of grasses grown specifically for energy move in the range of 16446 – 18279 kJ/kg. The highest gross calorific value was exhibited by *Trifolium repens L.* (18279 kJ/kg); the gross calorific values of reed-type grasses were also higher than those of hybrids (*Festulolium*).

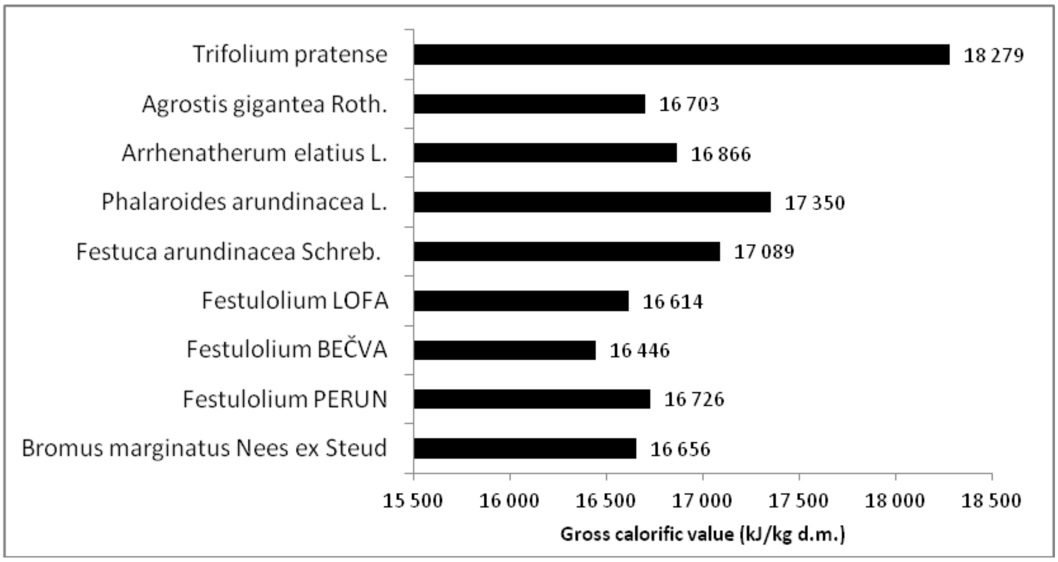

Fig.1 Gross calorific values of grasses from *OSEVA Research and Development Ltd.,* OSVEA Pro Zubří – May 2011.

From the point of view of course of fuel combustion and selection of combustion units, the proportions of volatile matter and fixed carbon are of high importance. In biomass, the content of volatile matter ranges from 70 to 80 %. In the studied set of 9 grasses, the content of volatile matter varied in a narrow range from 80.33 to 83.49 %. In the framework of the observed growing season (May, July, August and September) only minimum differences in the content of volatile matter were found as well. The ash content ranged from 5.45 to 7.47 %. Merely in the clover LOTR (*Trifolium repens L.*), the influence of harvest season on an increase in ash content from 6.30 % to 8.40 % manifested itself. The other "tall" grasses did not exhibit this increase.

The gross calorific value is also influenced significantly by the content of lignin in biomass. Telmo C. and Lousada J., (2011) founded highly significant correlation between the higher heating value and the Klason lignin and extractive contents. Also in our case, a significant linear dependence between the lignin content and the gross calorific value ($r = 0.77$) was proved. The dependence can be expressed by the following equation: Lignin (%) = $0.0012x – 12.879$, where x is the gross calorific value (kJ/kg). The contents of lignin increase during the growing season. In the course of harvesting in the month of May, the grasses contained 6.5 % of lignin and in September the lignin content was 17%. The greatest increase in lignin (133 %) was found in hybrids, the smallest increases were found in *Trifolium repens* (63 %) and in *Festuca arundinacea* Schreb. (57 %). Dermibas A. (2003) found a significant correlation dependence between the content of fixed carbon and the content of lignin. With reference to the relatively stable content of fixed carbon in the grasses, this dependence was not proved in our case.

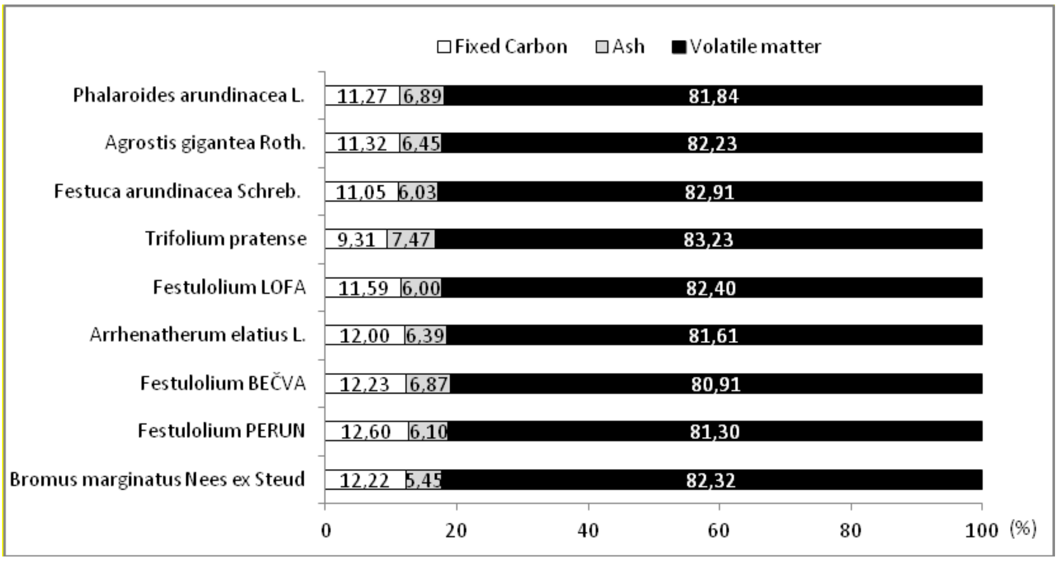

Fig.2 Distribution of volatile matter, fixed carbon and ash – arithmetic means for the year 2011.

During the first harvest in the month of May, the contents of water-soluble sodium and potassium were the highest. The contents of water-soluble potassium varied in a range of 19 – 22.76 g/kg. *Trifolium pratense* LOTR exhibited the highest contents of 29.17 g/kg. The sodium contents are significantly lower (28.8 – 145.6 mg/kg). Also in this case, *Trifolium repens* LOTR showed a twofold higher content (279 mg/kg). In Figure No. 2 a loss of alkali during the growing season is expressed. The highest losses of potassium (> 80 %) were shown by *Agrostis gigantea* Roth. and *Phalaris arundinacea* L., the lowest losses (36 %) by *Festuca arundinacea* Schreb. Although both the elements exhibit similar behaviour, developments of the sodium and potassium losses during the growing season are not entirely identical. The dependence between the sodium loss and the potassium loss was observed by means of linear regression; a value of correlation coefficient r is 0.71 for the whole set, which fulfils the condition at the 0.005 level of significance for 36 samples. The highest value of correlation coefficient was found in the month of May (r = 0.88), in the months of August and September, the value was below the level of significance. Water-soluble chlorine exhibited a different behaviour. With the prolonged harvest season it was released only very little or even the content of it in the grasses grew by up to 30% of *Festulolium*. In the studied set of grasses, the content of water-soluble chlorine moved in the range of 3.2 – 4.8 g/kg. Between the content of water-soluble chlorine and the content of alkali, any significant statistical dependence was not proved.

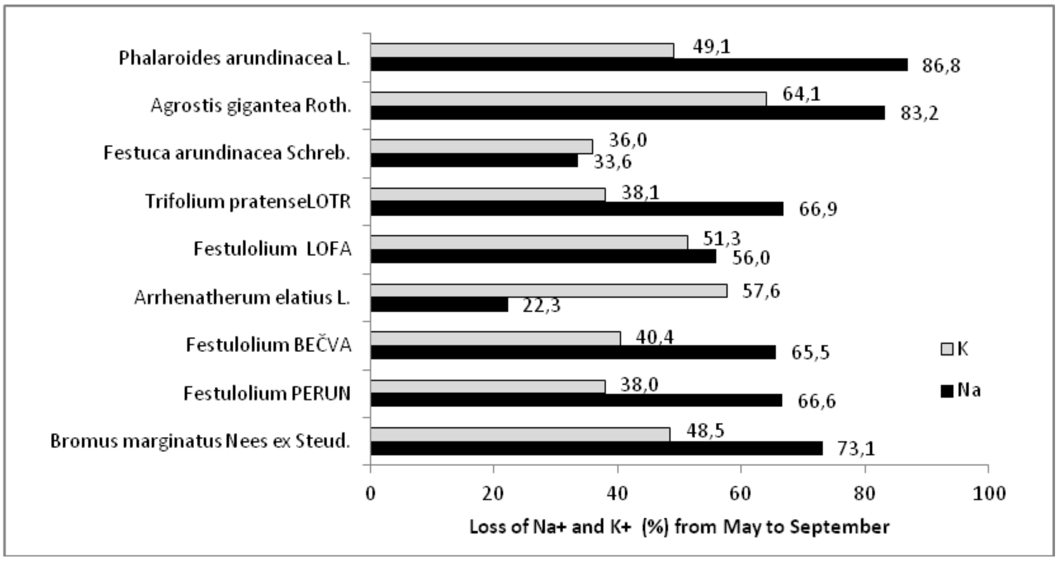

Fig.3 Losses of water-soluble sodium and potassium in the period May – September (%).

4 CONCLUSION

From the presented results, it is clear that, from the point of view of improving the energy parameters for grass combustion, late harvest can be recommended. Of the tested species, clover (*Trifolium repens*) is the least suitable; although it exhibited the highest gross calorific value (18279 kJ/kg), it has the highest content of alkali. In the studied set, the average content of water-soluble sodium at the end of the growing season is 27.5 mg/kg; *Trifolium repens* shows 92.5 mg/kg even in September. A similar situation exists in potassium. At the end of the growing season, the average *content* of water-soluble potassium amounts to 11.54 g/kg and the content in *Trifolium repens* is 18.05 g/kg. The content of volatile matter and the content of fixed carbon do not change significantly during the growing season and are quite similar to those of the observed grass species. A linear dependence between the lignin content and the gross calorific value was proved. The lignin content increases from 6.5 % (May) to about 17 % (September) during the growing season.

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