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EXPLORING THE POTENTIAL OF INVASIVE PLANT SOSNOWSKY'S HOGWEED FOR DENSIFIED BIOFUELS PRODUCTION

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Abstract. The study focuses on the determination of biofuel parameters of invasive Sosnowsky's hogweed (*Heracleum sosnowskyi*) biomass. Utilization of available waste biomass can be one of the most efficient ways to prevent spreading, so this approach does not promote controlled cultivation of Sosnowsky's hogweed biomass for profitable solid biofuels production. Laboratory determination of the main fuel-energy properties showed that the gross calorific value of studied biomass is 15.1 MJ/kg (as received) and 16.5 MJ/kg (dry basis). Ash content analysis resulted in 10.7% (dry basis) and 10.8% (as received with 10.1% moisture content of). Choosing the appropriate harvest time may most probably affect solid biofuels quality as well as biomass to biofuels processing pathway, thus more studies are required to find an optimal and feasible solution.

Key words: Invasive alien plant; *Heracleum sosnowskyi;* Biomass; Solid biofuels; Renewable energy.

INTRODUCTION

The rising energy consumption, depletion of fossil fuel reserves and associated environmental issues push the research and development of the renewable energy field. Biomass represents one of the most promising sources of renewable energy in many countries worldwide. Energy crops, algae and agricultural wastes are broadly applied for the production of modern biofuels. A particular interest for energy purposes and underutilized potential has a biomass of invasive weeds, which are, moreover, an increasing cause for concern (Čerevková, A. et al. 2020). The introduction and spread of invasive non-native species constitute one of the main drivers of global change in ecosystem services and biodiversity (Sala, O. et al. 2000). There is no single universal solution currently available to stop their spread, reduce the impact, or prevent future invasions.

According to L. Zihare et al. (2019), a significant amount of biomass is annually generated from various measures related to combating the spreading of Sosnowsky's hogweed. Sosnowsky's hogweed (Heracleum sosnowskyi) is herbaceous, perennial, monocarpic, a seed-propagated plant belonging to the genus Heracleum (family Apiaceae, synonym Umbelliferae) (Tkachenko, K. 1989; Jahodová, S. et al. 2007). Seed productivity, which is considered as high (10,000-20,000 seeds per plant) and germination percentage consisting of up to 90% in the first year increase the plant's competitive abilities crucial for successful dispersal (Mishyna, M. et al. 2015). The most vulnerable areas to invasion include abandoned grassland, fringes along watercourses, woodlands, roads and railways as well as nature conservation areas. The studies showed that Sosnowsky's hogweed was found in Serbia (Stojanović, V. et al. 2017), Lithuania (Gudžinskas, Z. et al. 2018), Bulgaria (Vladimirov, V. et al. 2019), etc. There is a serious threat to the human population due to photoallergic properties of the plant as a result of the intensely toxic furanocoumarin's presence in the plant's sap. Contact with the plant, followed by sun exposure, may lead to the development of large blisters and symptoms of burns (Jakubowicz, O. et al. 2012). Furocoumarins are plant's protective agents from fungi, bacteria, and plant growth regulators (Mishyna, M. et al. 2015). Scientific papers published so far are mainly mapping the spread and environmental impact of Sosnowsky's hogweed (e.g., growth rate, frost resistance, impact on soil and biodiversity (Renčo, M. et al. 2019, Čerevková, A. et al. 2020), human's health risks (Rzymski, P. et al. 2015). Also, properties of its essential oils were studied (Jakubska-Busse, A. et al. 2013, Synowiec, A. et al. 2015). According to P. Musihin et al. (2006) Sosnowsky's hogweed was found to be a promising material for cardboard production. Based on the European and Mediterranean Plant Protection Organization (2009), there are management techniques for the plant eradication. Depending on the size of the plant populations, the following techniques are usually implemented: black polythene cover, hand pulling of young seedlings, root cutting, removal of umbels, chemical techniques using the herbicides, mowing, intensive grazing and ploughing of the soil. However, the advantages and disadvantages of each technique exist.

MATERIALS AND METHODS

The present study aimed to determine the main solid biofuel parameters of Sosnowsky's hogweed biomass, that was performed at the Laboratory of Biofuels at the Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague. Representative sample of Sosnowsky's hogweed's stem was collected in the beginning of August 2021 in Leningrad Region, Russian Federation. Length of a stem was approximately 215 cm. The stem of the plant can be characterized as hollow and ridged, 20-40 mm in diameter. The harvested representative sample was pre-processed by chopping and dried (room temperature 15-25 ºC for about 4 weeks). Two types of analytical samples were prepared for analysis: analytical sample as received and dry matter. The determination of biomass properties was carried out in accordance with the methodology of the International and European standards for solid biofuels. Following basic biofuel parameters were measured (using the particular standard and laboratory equipment mentioned below).

The determination of moisture content. The moisture content of the biomass was determined by using the oven drying method (BS EN ISO 18134-3:2015) in the oven Memmert (model 100-800), where the analytical samples were dried out at 105 ºC to a constant weight. The weighting was done by use of a digital laboratory scale KERN (model ABJ 120-4NM) with a precision of 0.1 mg. Moisture content was calculated by the following equation:

$$MC_{ad} = \frac{(m_2 - m_3)}{(m_2 - m_1)} \times 100$$

where: MC_{ad} – moisture content as analysed, %; m1 – mass of an empty dish and lid, g; m2 – mass of a dish and lid with a sample before drying, g; m3 – mass of a dish and lid with a sample after drying, g.

Gross calorific value. The determination of the calorific value of the studied biomass was carried out by the bomb calorimeter LAGET (model MS–10A) following the standard EN ISO 18125:2017. The tested samples of biomass were placed into a calorimeter and burned in the high-pressure combustion bomb (in an oxygen environment). A laboratory-scale KERN with a precision of 0.1 mg was used for weighting. The gross calorific value was calculated as:

$$Q_{v.gr} = \frac{\varepsilon \times \theta - (m_{ign} \times Q_{ign} + m_b \times Q_b)}{(m_s)}$$

where: Qv.gr – gross calorific value of a biofuel sample, J.g-1; ε – effective heat capacity of calorimeter, J.°C-1; θ – corrected temperature rise, °C; mign – mass of an ignition wire, g; Qign – gross calorific value of an ignition wire (6,000 J.g-1 for nickel-chromium), J.g-1; mcb – mass of a combustion bag/paper, g; Qcb – gross calorific value of a combustion bag (16, 279 J.g-1 for paper), J.g-1; ms – mass of a biofuel sample, g.

The determination of ash content. Determination of the ash content was performed by burning analytical samples in the muffle furnace LAC (model LH 06/13) at the temperature 550 ºC in accordance with BS EN ISO 18122:2015. The samples' weighting was realised using a laboratory-scale KERN with a precision of 0.1 mg. The result was calculated as follows:

$$A = \frac{(m_3 - m_1)}{(m_2 - m_1)} \times 100 \times \frac{100}{100 - Mad}$$

where: A – ash content, %; m_1 – mass of an empty dish, g; m_2 – mass of dish with a sample, g; m_3 – mass of dish with an ash, g; M_{ad} – moisture content of the test portion used for a determination of ash content, w-%.

RESULTS AND DISCUSSIONS

Until the present, the application of Sosnowsky's hogweed biomass for energy purposes was studied superficially. For example, according to K. Tkachenko et al. (2018), this plant can be used to produce bioethanol. In the study of L. Zihare et al. (2018) investigation of pellets production from Sosnowsky's hogweed using different binders was performed. Nevertheless, the information related to the topic is very limited.

The moisture content of biomass has a significant impact on many properties of solid biofuels as well as production process. The resulting moisture content of tested Sosnowsky's hogweed biomass was 10.1%, which is suitable value for further processing, i.e., mechanical compression. The moisture content determination directly after biomass harvesting is needed for planning of the pre-treatment before solid biofuels production. In general, according to S. Akhmedov et al. (2019), the moisture content of biomass feedstock for solid biofuels production should not exceed 20%.

Calorific value of biomass plays a key role in its application for energy purposes. Gross calorific value of biomass sample as received was 15.1 MJ/kg and for dry matter material - 16.5 MJ/kg. Findings of L. Zihare et al. (2018) showed higher gross calorific value of Sosnowsky's hogweed - 19.4 MJ/kg (dry matter), however, in that case the biomass was collected in October.This variation can be explained by the different seasons of biomass harvesting and possibly different regions. In comparison, the calorific value of a potential energy crop *Miscanthus x giganteus* cultivated in various marginal soils ranges between 14.1 and 18.8 MJ/kg (Nebeská, D. et al. 2019).

Other important parameter of solid biofuels is ash content. Ash content of dried tested material was 10.7%, and 10.8% for the material as received. L. Zihare et al. (2018) also measured the ash content of Sosnowsky's hogweed biomass and found 3.4%. According to the standard BS EN ISO 17225-7:2014, dry basis ash content up to 10% is stated for the case of graded non-woody briquettes class B.

CONCLUSIONS

The biofuel parameters (related to densified biofuels) of *Heracleum sosnowskyi* biomass were determined. The methodology that has been created allows testing of basic biofuel parameters. Further comprehensive research work focused on the investigation of Sosnowsky's hogweed biomass as raw material for the production of densified solid biofuel is required. Analysis of biomass collected at different development stages of plant is needed in order to find an optimal harvesting period for the subsequent (quality) solid biofuels production. Pellets and briquettes as well as torrefied biofuels produced from invasive Sosnowsky's hogweed can be an attractive biofuel. The assessment of an optimal solid biofuel production technology can be based on the measurements of parameters such as mechanical durability as well. This approach to waste biomass processing can be one of the most efficient ways to prevent the plant's spreading.

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