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Herbage production and chemical characteristics for bioenergy production by plant functional groups from semi-natural grasslands

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ABSTRACT

The current paper is devoted to biomass yield and proportion, chemical composition and energy yield by functional groups in different semi-natural grassland types. The study was performed for three grassland types in Estonia which were represented by five NATURA 2000 meadows each. The highest yield was obtained from alluvial meadows followed by mesic and wooded meadows. Hence, the largest amount of other herbs was found from alluvial meadows, even if the proportion of this functional group was dominant in wooded meadows. The contribution of the sedges&rushes was the largest in alluvial meadows. The grasses were prevalent in mesic meadows. The legumes were growing in all studied grassland types in small amounts. Nitrogen content in legumes differed significantly from other studied functional groups, but no significant differences between functional groups in other chemical (Cl and S) contents were found. The other herbs had the highest ash content and the lowest calorific value contrary to the sedges&rushes with the lowest ash content and the highest calorific value. The highest area-specific energy potential was calculated for alluvial meadows followed by mesic and wooded meadows. The energy potential depends more on the amount of biomass than the calorific value of particular functional group. Improved knowledge about the functional groups and their chemical content enables to promote and optimise alternative usage of this late harvested mixed biomass from semi-natural grasslands for bioenergy production.

1. Introduction

Herbaceous biomass from extensively managed semi-natural grasslands, that is no longer needed for livestock feeding, has become a challenging option for bioenergy. Usage of this biomass for bioenergy production can reduce conservation management costs (e.g. Refs. [1,2]). Moreover, additional source of biomass from semi-natural grasslands can be a sustainable alternative to dedicated bioenergy crops and give the energy output that is similar with the energy profit from the local favourite herbaceous bioenergy crop [3–5].

The most problematic in herbaceous biomass usage is the large variability of its chemical content (e.g. Refs. [6,7]). However, all bioenergy conversion methods have certain requirements for substrate quality. In general, herbaceous

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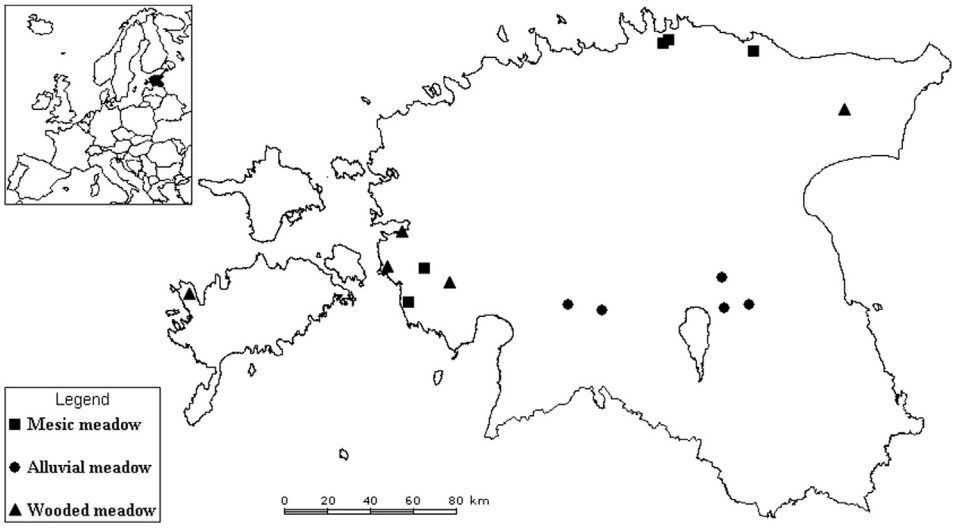

Fig. 1 – Location of the studied sites in Estonia.

biomass has higher ash content and lower carbon content than woody biomass [8]. If the combustion process is not regulated for burning herbaceous biomass, increased ash and alkali metal content can result in slagging, corrosion and fouling of the plant [9]. High concentrations of chlorine, nitrogen and sulphur in fuels can increase greenhouse gas emissions [10].

Recently numerous investigations have been conducted about the quality of several perennial grasses as dedicated bioenergy crops (e.g. Refs. [5,11]). However, based solely on this data we cannot predict the quality of herbaceous biomass from semi-natural grasslands consisting of large variety of species that may have different quality in terms of bioenergy production [11,12]. In general, grasses include less nitrogen than legumes and forbs in semi-natural grasslands [13,14]. Also the concentration of S, K, Ca, Mg and ash are found to be lower in graminoids (*Poaceae*, *Cyperaceae* and *Juncaceae*) than in forbs (both legumes and non-leguminous plants) [15]. The presence of legumes in a mixture is found to result in increased biomass yield, calorific value and therefore energy yield per area (e.g. Refs. [16,17]). However, more info is needed about the content of crucial chemical elements (e.g. non-metals that can cause greenhouse gas emissions) in natural species from semi-natural grasslands in boreal conditions. These data are difficult to achieve since the number of plant species in one square metre of semi-natural grassland may exceed 50. Therefore we limited the current study on estimating the biomass ratio, chemical composition and calorific value of different herbaceous plant functional groups, which distinguishing criteria took into account differences in plant species taxonomy and physiology.

The study hypotheses were the following:

- The proportion of functional group biomass will depend on grassland type;
- The chemical content of the biomass will vary by functional groups;
- The calorific value of the biomass from different functional groups will be different;
- The energy potential per area will depend on biomass yield and calorific value.

2. Materials and methods

2.1. Study sites

The fieldwork was carried out during the first half of July in 2008 in different locations of Estonia (Fig. 1), in the areas where the particular semi-natural grassland type was typical. The timing of the fieldwork was chosen to imitate the most common harvesting time for semi-natural grasslands in Estonia due to nature conservation restrictions. According to Estonian Meteorological and Hydrological Institute [18] the precipitation in the particular year was 38.2 mm, 17.0 mm and 87.8 mm (long-term (1971–2000) average 34 mm, 41 mm and 61 mm) and the average temperature was 6.4 °C, 10.3 °C and 14.4 °C (long-term average 3.9 °C, 10.1 °C and 14.5 °C) in April, May and June, respectively. Hence the particular biomass growing season was warmer (April) and drier (May) than usual.

For site selection, the database of semi-natural grasslands from the Estonian Seminatural Communities' Conservation Association was used. According to its data all the selected meadows had been managed without any seeding or additional fertilisation during last ten years through mowing once per year or grazing. The study sites represented semi-natural grassland types that are the most productive (flooded alluvial meadows on the river plains), the most common (dry to mesic boreo-nemoral meadows), or the priority habitats due to the highest biodiversity (wooded meadows). For fieldworks five meadows per each studied grassland type were selected. Further on in the current paper each grassland type is labelled by the underlined word and the details of all study sites by grassland type are gathered into Appendix A, B and C, respectively. The soil type of study sites was determined based on the digitised soil map of Estonian Land Board Web Map Server [19] and on the database of Digital Collection of Estonian Soils [20].