EFFECT OFFERTILIZATION ON THEYIELDS OF TALL WHEATGRASS HARVESTED ONCE A YEAR

Marek KOPECKÝ[1], Jan MOUDRÝ jr.[1], Jaroslav BERNAS[1], Zuzana JELÍNKOVÁ[1], Petr KONVALINA[1], Radka VÁCHALOVÁ[1], Jan MOUDRÝ[1], Ladislav KOLÁŘ[1]

e-mail: kopeckymarek@seznam.cz

Abstract

With the growing demand for energy, the requirements for energy sources have been growing too. In advanced countries, there has been a substantial development of renewable sources. In the conditions of Central Europe, biomass seems to be the most promising option. It is possible to utilize not only waste biomass but also the biomass grown on the purpose. Particularly in locations endangered by erosion, the growing of energy grasses is recommended since they not only provide protection against erosion but also perform a number of further ecosystem services. The methods of transformation of grassphytomass into thermal or electric energy include anaerobic digestion and direct incineration. This article presents the results of an experiment verifying the effect of various fertilization management schemes on the yields of the perennial energy grass called tall wheatgrass(*Elymus elongatus* subsp. ponticus cv. Szarvasi-1) harvested once a year. The experiment carried out on small parcels compared three levels of fertilization intensity. This involved mineral fertilization and fertilization with digestate;the control variant was not fertilized at all. The yield parameters were monitored for three years from spring 2013 when the experiment was commenced. The obtained results show a positive effect of fertilization of the grass on the grass yield. In the first two production years, the variant involving mineral fertilization showed, on average, a 22% increase in the dry matter yield than the variant without fertilization. The grass fertilized with digestate provided a 32% higher dry matter yield than the control variant.

Key words: fertilization, tall wheatgrass, yield

The world population has been growing fast (Schau E.M., Fet A.M., 2008). This demographic development also raises the worldwide demand for energies (Ho Y.Ch., Show K.Y., 2015). An important energy source is fossil fuels (SakuragiH. *et al,* 2011) including coal, oil and natural gas, in particular (Fergus J.W, 2015). The combustion of these fuels contributes to the general environmental pollution (Nicoletti G. *et al,* 2015) and to the release of greenhouse gas emissions (MoutinhoV. *et al,* 2015). In connection with the exhaustibility of fossil fuels (Gürdil G.A. *et al,* 2009) and the negative effects associated with their use, the attention has currently been increasingly paid to alternative renewable energy sources (Johnson T.S. *et al,* 2011).The most significant of them is biomass (JasinskasA., Šateikis I., 2009), which is used particularly for incineration or biogas production (JasinskasA. *et al,* 2008).

A secondary product of anaerobic digestion is theremaining indigestible matter called digestate (Jermář M.K., 2010). With the growing number of installed biogas stations, the digestate production will grow too (TlustošP. *et al,* 2013). Digestate contains the same quantity of nitrogen, phosphorus and potassium as the original materials, so it is used to fertilize fields (Moller K., Müller T., 2012). However, KolářL. *et al.* (2010) points out that the organic components of digestate are largely stable so they release nutrients slowly.

Some plant species are specially grown for the purposes of ecologic energy generation (Lewandowski I. *et al,* 2003). One of the most prevalent energy crops is maize, which is, however, often perceived as a plant burdening the environment (Keeney D.R., DeLuca T.H., 1992). In environmental terms, it is more appropriate to grow perennial plants (Kopecký M. *et al,* 2015a) that can also be recommended for locations endangered by erosion due to the better anti-erosion effects of such plants (Dumbrovský M. *et al,* 2014). In connection with the changing climate, emphasis is put on the resistance of plants to drought (Kopecký M. *et al,* 2015b). Drought is often regarded asa major threat in farming (KonvalinaP. *et al,* 2010), andfarmers need to adaptto this threat (Konvalina P. *et al,* 2014). Another advantage of such plants is their lower

[1] University of South Bohemia in České Budejovice, Faculty of Agriculture, Czech Republic

fertilization requirements as compared to annual plants (Lewandowski I. *et al,* 2003). Suitable energy plants resistant to drought include, e.g. tall wheatgrass (*Elymus elongatus subsp. ponticus cv. Szarvasi-1*) (Csete S. *et al,* 2011).

MATERIAL AND METHOD

The small-size parcels of *Elymus elongatus* subsp. ponticus cv. Szarvasi-1 were established on 17th April 2013 on the experimental site of the University of South Bohemia in České Budějovice. The site is located in South Bohemia (48.9743008N, 14.4487503E). The average altitude of the experimental station is 400 m above sea level. Furthermore, the experimental site is characterized by a long-term average annual air temperature of 8.3°C and a long-term average annual precipitation of 520 mm.

Before sowing, the parcel was fertilized with mineral fertilizers dosed 70 kg of N, 50 kg of P and 30 kg of K per hectare. The size of individual parcels was 10 m^2 (8·1.25 m). A total of 12 parcels were sowed and divided into three groups (4 repetitions in each group) by the fertilization intensity. The control variant marked as "Extensive" was not fertilized at all. The parcels marked as "Intensive" were fertilized with mineral fertilizers dosed 100 kg of N (ammonium sulphate, ammonium nitrate with dolomite), 10 kg of P (triple superphosphate) and 30 kg of K (potassium salt) per hectare every year. The last third of parcels, marked as "Digestate", was fertilized with the annual dose of 28 $t{\cdot}ha^{-1}$of the digestate originating from an agricultural biogas station and containing approximately 100 kg of N. The fertilizers were always applied on a one-time basis after mowing. The list of agrotechnical operations is available below (*table 1*).

The harvests took place in spring. The grass was cut with a mower with a finger cutter bar at a height of around 6 cm. Afterwards, the harvested fresh matter yield was determined and processed for drying. Dry matter content was determined by drying the biomass at 60 °C until constant weight. Subsequently, the fresh matter yields were converted to dry matter (DM) yields per hectare.

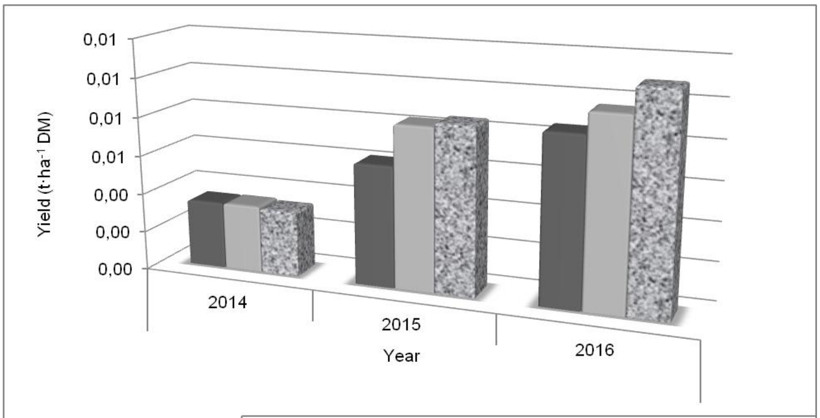
Table 1

Agrotechnical operations

Date	Intensive	Digestate	Extensive
15. 4. 2013	Fertilization before sowing	Fertilization before sowing	Fertilization before sowing
17. 4. 2013	Establishing the grass growth	Establishing the grass growth	Establishing the grass growth
14. 6. 2013	Weed clearance mowing	Weed clearance mowing	Weed clearance mowing
8. 4. 2014	Mowing	Mowing	Mowing
8. 4. 2014	Fertilizer application	Digestate application	
17. 4. 2014	Herbicide application (Starane 250 EC)	Herbicide application(Starane 250 EC)	Herbicide application(Starane 250 EC)
19. 5. 2014	Herbicide application(Starane 250 EC)	Herbicide application(Starane 250 EC)	Herbicide application(Starane 250 EC)
17. 3. 2015	Mowing	Mowing	Mowing
19. 3. 2015	Fertilizer application	Digestate application	
21. 3. 2016	Mowing	Mowing	Mowing

RESULTS AND DISCUSSIONS

The yield potential of the new sort of energy grass *Elymus elongatus* subsp. *ponticus* cv. *Szarvasi-1* was evaluated for three fertilization intensities. The harvest yields in 2014-2016 (*figure 1*) are the average values calculated based on the four repetitions. In the year of establishment, the same agrotechnical operations were carried out in all the variants, while fertilization was not differentiated at that time. This was reflected in the harvest yields in spring 2014when very similar values in all the variants were determined. The yields were relatively low (3.5 $t{\cdot}ha^{-1}$of DM). After the harvest in 2014, the grass was fertilized as described above. As expected, in the subsequent year the unfertilized grass provided the lowest yield – 6.23 $t{\cdot}ha^{-1}$of DM, which is in line with the statement (Griffin T. *et al*, 2002). The grass responded well to additional fertilization, and the yields of the variants "Intensive" and "Digestate" increased by3 4%and 37%, respectively. They were close to the values reported by Mast B. *et al* (2014), which present the yields in the experiment in Stuttgart, Germany, ranging from 8.9 $t{\cdot}ha^{-1}$ to 13.4 $t{\cdot}ha^{-1}$, depending on the time of the harvest.



	Year		
	2014	*2015*	*2016*
Elymus elongatus Extensive	*3,45*	*6,23*	*8,56*
Elymus elongatus Intensive	*3,46*	*8,34*	*9,64*
Elymus elongatus Digestate	*3,36*	*8,54*	*10,93*

Figure 1 **Dry phytomass yields**

The production potential of the perennial grass *Elymuselongatus* subsp. *ponticus* cv. *Szarvasi-1* is demonstrated from the second production year. However, the soil properties are very important. In clay soils,the yield might not achieve even 5 t·ha^{-1} (Csete S. *et al*, 2011).In our experiment, the harvest in spring 2016 had the highest yield, but did not achieve the values reported e.g. by Heinz M., Roth T. (2013) – 17 t·ha^{-1} in Triesdorf, Germany, or by Janowszky J., JanowszkyZ. (2009) – 20 t·ha^{-1}inSopron, Hungary. The yields in České Budějovice were probably considerably affected by the extraordinary drought in the course of the vegetation season 2015. Csete S. *et al* (2011) state that rainfall deficiency may reduce the yield by as much as half.

The higher yield in the variant "Digestate" than in the variant "Extensive" confirms the findings of Dubský M. *et al* (2012) that digestate contains nutrients in a form acceptable for plants. In the course of the experiment, a positive effect of fertilization by digestate on the production of grass biomass was observed and found to agree with the findings (MatsunakaT. *et al*, 2006).

CONCLUSIONS

From 2013 to 2016, the yield potential of the new energy grass *Elymus elongatus* subsp. *ponticus* cv. Szarvasi-1was monitored on the experimental site in České Budějovice. A positive effect of fertilization on the production of phytomass of this plant was confirmed. An increase in the development of biomass was observed not only after the application of mineral fertilizers but also after the application of digestate from a biogas station. Given the unfavourable climatic conditions in 2015 and the mowing once a year, the dry matter yield amounted to 8.56 t·ha^{-1}in the variant not involving fertilization, 9.64 t·ha^{-1}in the variant involving mineral fertilization and 10.93 t·ha^{-1}in the variant involving fertilization with digestate. In addition to the production function, perennial grasses also provide further environmentally important functions, including e.g. soil protection against erosion or a positive effect on the quality of surface and underground waters.

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