THE USABILITY OF GRASSES FOR ENERGY PURPOSES IN RELATION TO OTHER CROPS

Jan MOUDRÝ jr.[1], Petr KONVALINA [1], Jan MOUDRÝ[1], Markéta PROKEŠOVÁ [1]

[1] University Of South Bohemia In České Budějovice, Czech Republic

Abstract

Together with rising importance of renewable resources for the world energy industry the usability of energy crops has been more and more actual topic. Taking into consideration that the area for these crops has increased, it is necessary to concern many more factors and aspects related to their production. Beside the yield of dry matter, which is still considered the main criterion of production efficiency, it is necessary to take into account the environmental and some economic aspects. In this regard it seems suitable to use for energy purposes also other crops with yields under the profit break-even point of 12 t/ha that could not compete with established species. Energy grasses as reedgrass (*Phalaris arundinacea*), cocksfoot (*Dactylis glomerata*) or tall oat grass (*Arrhenatherum elatius*) with average yields of dry matter between 8 – 9,5 t/ha cannot be compared (as far as the yield is concerned) to maize (*Zea mays*) or miscanth (*Miscanthus sinensis Anderss*) for example, however these crops can be chosen to the crop rotation thanks to their environmental functions – soil protection and low site conditions requirements for example.

Key words: energy crops, grasses, renewable resources

According to Libra, Poulek (2007) the energy industry is a very important segment of state economy of each country in the world. The world energy consumption has been continuously rising which according to Pastorek at al. (2004) results from human population growth, that since the 17th century has risen 12 times (from 0,5 bil. to 6,1 bil.). Libra, Poulek (2007) find another important factor of rising energy the technical progress in the last century and this is why Andert at al. (2006) regard the alternative energy resources as a global issue. At present time the share of renewable resources energy has not even reached 20% of global consumption in fact.

Within the framework of renewable resources utilization biomass has become one of the crucial resources for the medium and long-term period (Havlíčková at al., 2008). Also Slavík (2006) states that biomass share in renewable energy resources plays the most important role not only in the Czech Republic but also in other states in the EU.

Biomass is an enormous source of raw material and energy and can be used for many purposes in special, technical and energy industry (Usťak, 2006). Agricultural crops, cereals and straw are materials with energy potential content similar to brown coal (Leština, Moudrý, 2001).

According to Váňa, Usťak (2006) utilization of biomass for energy purposes has been more actual because of the necessity of greenhouse gases reduction as well. Also Pastorek, at. al. (2004) mention that biomass utilization for energy purposes dramatically helps to reduce carbon dioxide emissions in the atmosphere.

According to Slavík (2006) wood has been the most common material used for this purpose worldwide and for its combustion have been developed many types of equipment. Another typical material utilised for energy purposes is cereal crops straw, which apply to wheat straw above all. Currently many more energy crops for energy production purposes have been grown according to Andert at al. (2006). Moudrý, Strašil (1999) state that for energy purposes plant residues can be effectively used as well . From this point of view the perennial crops are more potential because of lower operating cost of cultivation (Usťak, 2006), cost of stands establishment and seed material (Petříčková, 2006). However, for the choice of suitable energy crops it is necessary to take into account the environmental factors beside the technological and economical aspects only.

MATERIAL AND METHOD

Within the MŠMT n. 2B06131 project „Non-food utilization of biomass in the energy industry“, one section covers energy grasses as a potential resource of biomass for energy purposes. Among the suitable species were chosen: *Dactylis glomerata*, *Arrhenatherum elatius* and *Phalaris* *arundinacea*. These grasses are studied for green matter and dry matter yield (t/ha), percentage content of dry matter and water (%) and energetic usability for burning and biogas production.

The grasses above have been cultivated using small-parcel experiments. The stands were established in year 2007 in tree locations, four times repeated and three times harvested. The parcel dimensions were 1,2 x 18 meters (so-called long parcel method). Harvesting was carried out three times in following vegetation phases: before spiring (June), in the early winter after first frosts (November) and in the early spring (March). Time of harvest is the most important factor determining further biomass use (biogas production or combustion).

RESULTS AND DISCUSSIONS

The choice of suitable crops for energy purposes depends in most cases on aerial biomass yields and resulting yield of dry matter. In this regard the selected grasses cannot be compared to crops with the ability of fast and massive aerial biomass production (*Miscanthus, Maize or Dock*). The limit value of profitable yield of dry matter is considered 12 t/ha, which grasses produce rather exceptionally

Table 1

Yields of dry matter produced by selected grass species published in literature

Species	Lowest yields of dry matter (t/ha)	Highest yields of dry matter (t/ha)	Average yields of dry matter (t/ha)
Miscanthus sinensis Anderss	2,53	30	16,27
Populus L.	7,6	20	13,8
Rumex patientia	7,5	20	13,75
Zea mays	8,5	17	12,75
Phalaris arundinacea	3,82	15	9,41
Dactylis glomerata	5	13,2	9,1
Arrhenatherum elatius	3,37	13,08	8,23

This fact is evident in the *table 1* above, where *Miscanthus sinensis Anderss* proves the most effecient species for energy purpose with average dry matter yield of 16,27 t/ha. As well as the other grasses under the study also Miscanthus belongs to the *Poaceae* family. Other grass species suitable for energy purposes would be *Populus L.* a *Rumex patientia* that reach similar yields (13,8 and 13,75 t/ha, but however this is still by 3 t/ha lower compared to *Miscanthus sinensis Anderss.* From the point of view of dry matter yield (12,75 t/ha) and related usability for energy purposes *Zea mays* could be used too. According to the average yields published in literature all the studied grasses cannot produce sufficient yield of dry matter content to reach profitability of production (*Arrhenatherum elatius* – 8.23 t/ha and (*Phalaris arundinacea*) 9,41 t/ha. Similar and a little lower yields proved the experimental stands where *Dactylis glomerata* reached 7,36 t/ha, *Arrhenatherum elatius* 7,53 t/ha and *Phalaris arundinacea* 8,85 t/ha (*table 2*).

The mentioned grasses prove suitable to be used for biogas production with twice repeated harvest management. Also Frydrych at al. (2001) approves that biomass produced by species *Dactylis glomerata* and *Arrhenatherum elatius* is suitable for biogas production.

Table 2

Overall yields of particular grasses harwested twice (t/ha)

Species	Yield - 1. First harwest (t/ha)	Yield - 2. Second harwest (t/ha)	Overall dry matter content in the vegetation season (t/ha)
Dactylis glomerata	6,36	app. 1	7,36
Arrhenatherum elatius	5,69	1,84	7,53
Phalaris arundinacea	5,95	2,88	8,85

Moudrý, Součková (2006) concluded that low costs of stand establishement, zero or minimal cost of herbicides or pesticides and other direct costs are another reason for energy grasses utilization. Furthermore *Arrhenatherum elatius* for example can be grown in arid locations from lowlands to submountain regions. *Dactylis glomerata* is suitable for arid to mesic locations in highlands and mountain regions. Such characteristics predestinates these grasses as suitable additional energy crops for conditions where other common energy crops cannot be succesfully cultivated.

Table 3

Specific heat (MJ/kg) of selected energy crops published in literature

Species	Lowest specific heat (MJ/kg)	Highest specific heat (MJ/kg)	Average specific heat (MJ/kg)
Miscanthus sinensis Anderss	17,9	19,7	18,8
Rumex patientia	16,77	19,17	17,97
Phalaris arundinacea	17,52	18,1	17,81
Dactylis glomerata	17,21	17,21	17,21
Arrhenatherum elatius	15,4	17,6	16,5
Zea mays	14,4	14,4	14,4
Populus L.	6,34	15,2	10,77

In addition to biogas production energy grasses can be used for direct burning. In Table 3 are presented specific heat values of selected energy crops. The specific heat means such quantity of heat that is released when a unit of fuel material is perfectly burned. Water released during the burning process is calculated to condense and the energy of chemical reaction does not need to be reduced by the latent heat. This makes the value of specific heat different from the calorific power value which includes water in gaseous state in the end of the reaction. Because of this the specific heat value always is equal to or higher than the calorific power. For burning purposes the most suitable species of the monitored ones is *Miscanthus sinensis Anderss*, the specific heat of which reaches 18,8 MJ/kg. According to the Diagram 1 the second best crops for burning purposes are both *Rumex patientia* (17,97 MJ/kg) and *Phalaris arundinacea* with similar value of the specific heat (17,81 MJ/kg). Other monitored energy grasses seem suitable for burning as well. The specific heat of *Dactylis glomerata* (17,2 MJ/kg) was recorded no more than 3,43 % lower compared to previous *Phalaris arundinacea.* The last studied species – *Arrhenatherum elatius* (16,5 MJ/kg) is utilisable for burning too. All of the mentioned grass species reached higher values compared to *Zea mays* with average value of 14,4 MJ/kg. Lower values are typical for tree species, *Populus L.* (10,77 MJ/kg) for example.

Within production of energy crops their demand for and influence of the environment has often been neglected so far. According to the Diagram 1 these values markedly differs and therefore in areas with higher environmental sensitivity (e. c. erosion hazard) species friendly to the environment should be preferred in spite of lower biomass yield.

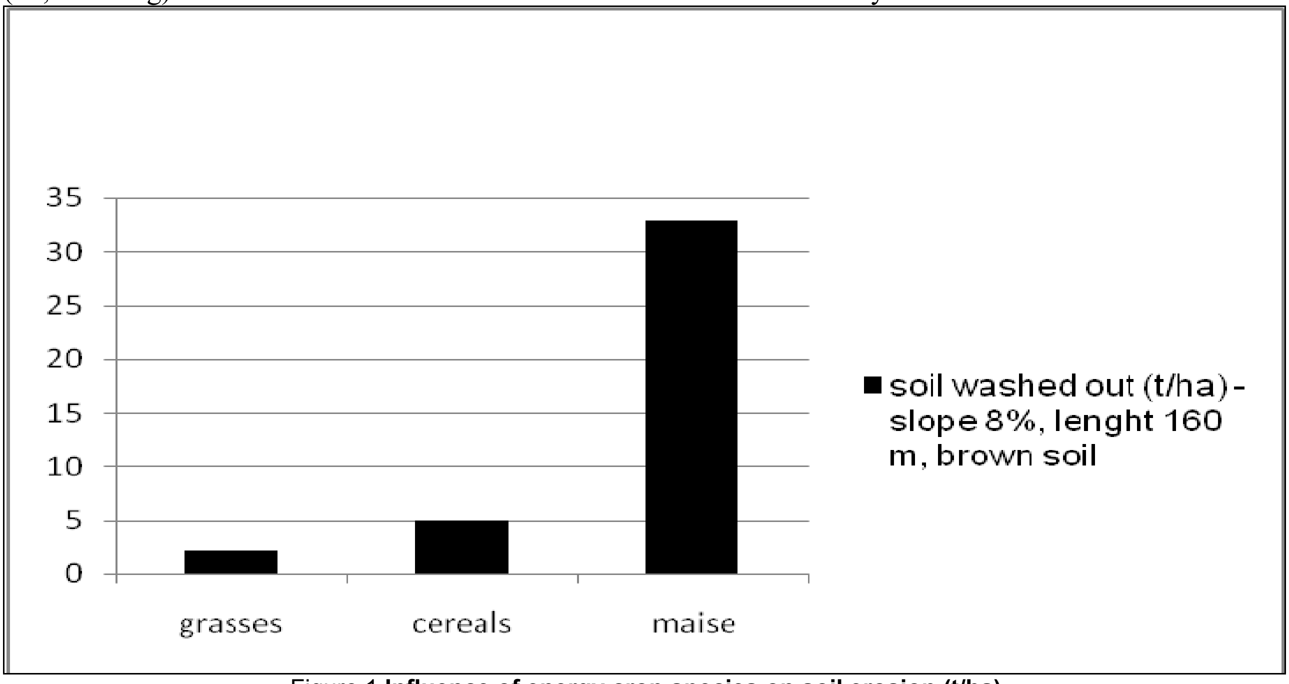

Figure 1 **Influence of energy crop species on soil erosion (t/ha)**

Grasses develop a robust and close turf that is best resistant to both livestock grazing and heavy machinery action. Furthermore grasses positively influence soil fertility, thanks to the robust root system they prevent soil erosion, depletion of nutrients (nitrates above all) into groundwater and help to enrich top soil. For example, the effect of soil protection factor of grasslands is ten times higher compared to maize, which makes them more suitable for slopping grounds.

CONCLUSIONS

Based on recorded results is evident, that energy grasses under study do not reach such high yields of dry mater when compared to other energy crops. On the experimental sites the yields did not reach the profitability level of 12 t/ha. Even according to the sources available grasses are able to close to or exceed the mentioned yield very rarely. However, some grass species is possible to use for energy purposes as additional crops, especially in regions where conventional crops cultivation is difficult or improper from the environmental point of view. Lower yields can be partially compensated for by higher values of specific heat that approximately range 17 MJ/kg, which exceeds values of maize (14,4 MJ/kg) or some tree species (10,77 MJ/kg). From the economic point of view grass stands do not need to be established every year and thus the costs of seed material and related operations decrease. In addition to this grasses are more environmentally friendly, here is necessary to mention the function of soil erosion prevention and biodiversity maintenance.

Acknowledgement

This work was supported by the MŠMT n. 2B06131 project „Non-food utilization of biomass in the energy industry“.

BIBLIOGRAPHY

Andert, D., Gerndtová, I., Hanzlíková, I., Andertová, J., Frydrych, J., 2006 - *Využití trav při produkci bioplynu*, In: Energetické a průmyslové rostliny XI. - Sborník referátů CZ Biom, Chomutov, p. 85-90.

Frydrych, J., ET AL., 2001 - *Energetické využití některých travních druhů*, ÚZPI, Praha, p. 34-35.

Havlíčková, K., Weger, J., Boháč, J., Štěrba, Z., Hutla, P., Knapek, J., Vašíček, J., Strašil, Z., Kajan, M., Lhotský, M., 2008 - *Rostlinná biomasa jako zdroj energie*. VÚKOZ, Průhonice, 82 p.

Leština, J., Moudrý, J., 2001 - *Fytoenergetika a otázky rostlinné výroby*, In. EKOTREND 2001 – trvale udržitelný rozvoj. Sborník z mezinárodní konference 28.-29.3.2001, JU ZF, České Budějovice, p. 223-224.

Libra, M., Poulek, V., 2007 - *Zdroje a využití energie*, ČZU v Praze (Kamýcká 129, 165 21 Praha 6), 140 p.

Moudrý, J., Součková, H., 2006 - *Nepotravinářské využití fytomasy*, VÚZE v Praze a ZF JU v Č. Budějovicích, 95 p.

Moudrý, J., Strašil, Z., 1999 - *Pěstování alternativních plodin,* JU ZF v Českých Budějovicích, 165 p.

Pastorek, Z., Kára, J., Jevič, P., 2004 - *Biomasa – obnovitelný zdroj energie*, FCC Public, Praha, 286 p.

Petříková, V., 2006 - *Nové zkušenosti s pěstováním energetických plodin a podmínky pro rozvoj fytoenergetiky v ČR*, In: Energetické a průmyslové rostliny XI. - Sborník referátů CZ Biom, Chomutov, p. 17-28.

Slavík, J., 2006 - *Vliv uhelných aditiv na mechanické vlastnosti lisovaných paliv z obilné slámy,* In: „energetické a průmyslové rostliny XI.“ 15.6.2006 Chomutov, Envi Bio, 75-84.

Usťak, S., 2006 - *Rozvoj pěstování a využití biomasy pro energetické a průmyslové účely v ČR: technické a ekonomické aspekty a základní překážky,* In: Energetické a průmyslové rostliny XI. - Sborník referátů CZ Biom, Chomutov: p. 118-133.

Váňa, J., Usťak, S., 2006 - *Možnosti zajištění trvale udržitelné výroby bioetanolu*, In: Sborník referátů z odborné konference „Energetické a průmyslové rostliny IX.“ CZ Biom a VÚRV, 15.6.2006, Chomutov, p. 7-16.