YIELD PARAMETERS OF ENERGY GRASS SPECIES AND POSSIBILITIES OF THEIR UTILISATION

J. MOUDRÝ JR.[1], **M. KOBES**[1], **J. KUTIL**[1], **Jana FRIEBELOVA**[2]

[1] University of South Bohemia,
Faculty of Agriculture, České Budějovice
e-mail: JMoudry@zf.jcu.cz

[2] University of South Bohemia,
Faculty of Economy, České Budějovice

In connection with rise of global energy consumption use of alternative resources is more and more actual topic. Importance of renewable resources utilization has intensified with regard to decrease of fossil fuels, their price rise and consequent risk of eventual energy breakdown due to their shortage. Among others, plant biomass utilization is one of these renewable resources. Today in many countries large agricultural lands lie fallow and can not be used for food production in the long term. However, with respect to sustainable development this land needs to be agriculturally managed and biomass production might be just one of the suitable ways, whereas use of available energy grass species with adequate characteristics comes into question.

This work is focused on yield monitoring of selected grass species that are expected to be used for energy purposes. Species cocksfoot (Dactylis glomerata), tall oat grass (Arrhenatherum elatius) and reedgrass (Phalaroides arundinacea) were cultivated in three locations whereas aerial biomass yield and dry matter content was monitored in three harvests periods (before spiring phase, winter beginning – after first frosts, in spring). As additional cultivation requirements of selected grass species were assessed. Based on comparison of yield parameters in particular locations was chosen the most suitable species and overall efficiency of utilization for energy purposes. As far as the biomass production is concerned tall oat grass proved the best yields – 7,08 t/ha before spiring, 10 t/ha after freeze and 5,92 t/ha in spring harvest. However, dry matter content plays important role as well whereas the critical limit for burning is 80 %. This parameter was fulfilled only by reedgrass which also is cultivation less-demanding. Suitability of harvesting term is dependent on subsequent utilization of biomass, e.g. for biogas production is the most optimal harvest-time before spiring.

Key words**:** *energy grasses, biomass, dry matter, yield parameters*

In connection with rise of global energy consumption requirements and concurrent decrease of nonrenewable energy resources utilization of alternative resources is more and more important. This situation might be solved by massive utilization of renewable energy resources. Lenža et al. (2006) considers as renewable resources (OZE) such technologies that produce heat or electric power based on solar, water, wind, biomass, Earth geothermal energy and environment (heat) energy. Cenek (1994) defines also energy of sea waves, ocean currents and heat as renewable energy sources.

At the present time renewable resources cover 18% of the global energy consumption only. This share varies according to particular states. Similarly as for energy consumption where Libra, Poulek (2007) state that global population share of 20% in advanced countries consume 80% of global energy production. At present in the Czech Republic according to WEC - Czech energy industry report for 2007, overall energy production is covered by particular resources as follows: 64 % - coal, 30 % - nuclear, 1,3 % - natural gas, 3,7 % - water and 0,7 % - biomass. The share of renewable resources makes mere 4,5% (Weger, 2008). Current Czech energy policy outlines a goal to increase the share of renewable resources on primary energy resources consumption to 8,9 % in year 2010 and to 15.7 % in year 2030. Biomass resources are expected to cover approximately three quarters of this share, according to Havlíčková (2007) app. 80 -85 % in year 2030.

In addition to traditional kinds of biomass (wood, chips, forestry remains) based on fulfilment of energy policy there also is opportunity for use of a new biomass source - growths of so called energy plants, where can be involved various tree and herbage species, their varieties and natural and purposeful cross-breeds.

In condition of the Czech Republic there is no problem for cultivation of biomass expected. Moudrý (2007), Sroller (2001) state, that in lower altitudes of submontane regions (450-650 m above see level), there will be decreased farming intensity in environmentally sensitive areas predominantly. In these areas important share of plant production will fall on special plants cultivation with food and non-food (energy and industry) utilization. On the one hand this will contribute to agrobiodiverzity rise and maximal exploitation of natural potential on the other. Moudrý, Strašil (1998) mention as suitable lands for energy plants cultivation also various waste-lands with high air pollution load. Energy plants should be grown in every area, where commercial crops cannot be effectively grown and in places, where chemicals input needs to be reduced.

More intensive utilisation of energy plants will be eased thanks to technologies for cultivation and harvesting of common culm crops that can also be effectively used for energy plants cultivation and harvesting (Petříková, 2006).

However, produced biomass should be used for heat production in small and middle size heating stations and plants. It can also be applied in larger heat plants in case of fuel base diversification but there is necessary to ensure long-term fuel supply from near sources preferably. With dependence on biomass price and transport costs this distance is currently 60 km, however, this factor is very unstable (Šafařík, 2009).

Selection of energy plant become an important step, which is predominantly made based on yield parameters. In the Czech Republic the most common are energy sorrel on area of 1 200 ha and fast-growing tree species (poplar trees and willow trees) on area of 150ha. For several regions there also come into question other perennial energy herbages, grasses for example. Potentially usable are for example reed canary grass (*Phalaroides arundinacea*), which under sufficient nutrition conditions provide a bumper yield (Šantrůček at al., 2001), oat grass (*Arrhenatherum elatius)* or cocksfoot grass (*Dactylis glomerata*).

MATERIAL AND METHOD

Within the MŠMT 2B06131 “Nonfood energy utilisation of biomass” project, in the section focused on grasses species were monitored reed canary grass (*Phalaroides arundinacea*), oat grass (*Arrhenatherum elatius)* or cocksfoot grass (*Dactylis glomerata*). All of these tree species are cultivated in three locations (Lukavec near to Pacov, České Budějovice and in Sokolov region) using small-area experiments.

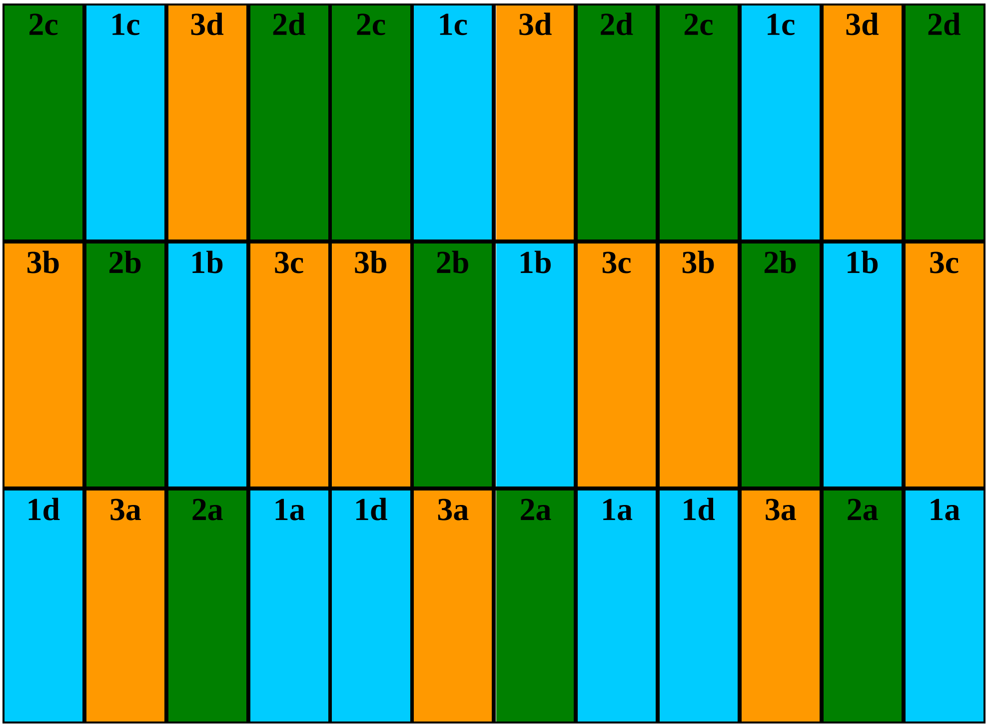
The grasses were sown and treated so that weeds were eliminated and the plants were grown ready for full production in following years. Monitored parameters were aerial biomass yield (t/ha), dry matter content (t/ha) and dry matter content percentage.

In all of the tree monitored locations sowing was carried out in March and April 2007, sowing rates for particular grasses were given as follows:

- cocksfoot grass 1,15 kg (360 m2, germinative activity 66%);
- oat grass 1.3 kg (360 m2, germinative activity 81%);
- reed canary grass 1.25 kg (360 m2, germinative activity 75%).

Parcel size is 20*6 m, three times repeated (method of long parcels). During the vegetation season three weed-reduction mowing were applied as well as the annual weed chemical treatment by the end of spring. Since the second year nitrogen fertilisation in the rate of 60 kg/ha of LAV (calcium ammonium nitrate) was applied after the first spring mowing and before the phase of new leaves germination.

Harvesting was carried out in three terms as follows: before spiring (L) - phytomass from this harvest from České Budějovice location is used for biogas production, after first frosts in the winter (P), in the spring (J) - phytomass from this harvest is used as a raw material for burning. Parcels were divided into quarters (20 x 1.25 m) using matrix table method, each of which was harvested in particular term. Harvested phytomass from each parcel was separately weighted and consequently the dry mater content was determined.



Reed canary grass Oat grass Cocksfoot grass

Figure 1 **Parcel disposition plan (České Budějovice location)**

(Phalaris arundinacea) (Arrhenatherum elatius) (Dactylis glomerata)

1) Harvest before spiring phase;
2) Harvest after first frost in the winter beginning;
3) Spring harvest (by the end of March).

Site conditions in particular locations are characterized in following table:

Table 1

Site conditions

	Lukavec	Budějovice	Sokolov
Elevation m. a. s. l.	620	380	570
Soil type	sandy loam	sandy loam	clay (overburden)
Great soil group	Cambisiol	Cambisiol gleyficated	anthropogeneous
Mean annual temperature (^{o}C)	6,8	7,8	7,1
Average rainfall (mm)	686	620	650
soil pH (KCl)	6,11	6,4	6,0

RESULTS AND DISCUSSIONS

In Sokolov location the plant stands were established on a mine dump which is quite a different environment compared to the other two locations. In addition to this in this location due to droughts in the beginning of the vegetation season the growths emerged very bad and were uneven and open, which caused yield decrease. Numbers reached in this location are not added into final records.

Yields of Reed canary grass (*Phalaris arundinacea*)

Reed canary grass dry biomass yields reached in both locations in all of the harvesting terms (Fig. 1) amount of 5 - 7 t/ha, which Procházka (1995) approves. Recorded numbers correspond to yields of 4,5 - 9,0 t/ha mentioned by Šnobl (2004) as well. By contrast to these numbers Havlíčková (2007) states the upper yield limit up to 12,6 t/ha that was never reached in any of the monitored location. After winter biomass deduction our results correspond to numbers mentioned by Petříková (2006) who states average yield 7,1 - 9,4 t/ha. In neighbour countries average yields reach between 4,5 - 9,0 t/ha.

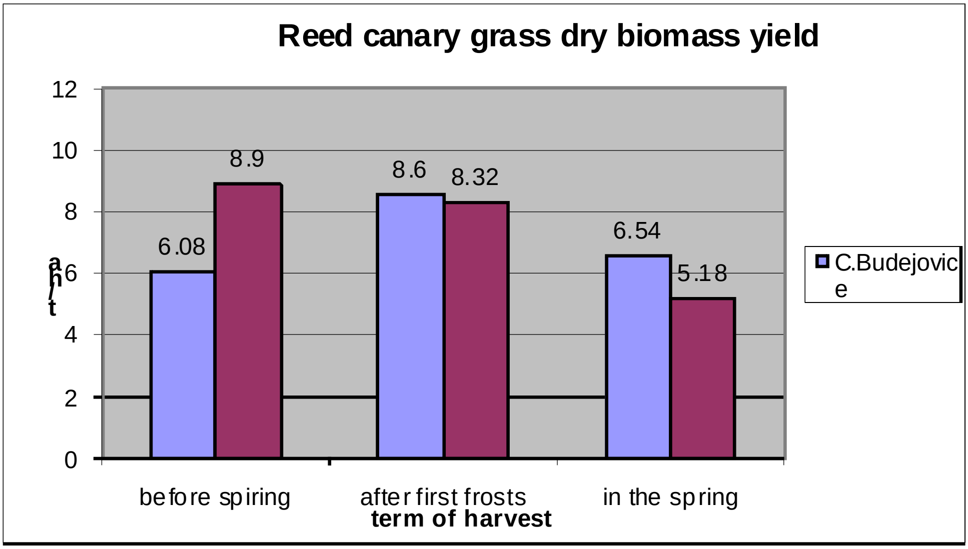


Figure 2 **Reed canary grass dry biomass yield**

Marked difference in dry matter yield within harvesting before spiring (30%) was probably caused due to less quality growth establishment and subsequent lower emergence. In Lukavec within the harvest after first frost yield actually decreased compared to the first harvest which was probably caused due to uneven rainfall that reed canary grass is sensitive to. Rainfall in June was strongly below average (50 %), on contrary in March rainfall reached 145 % of average numbers.

Yields of cocksfoot grass (*Dactylis glomerata*)

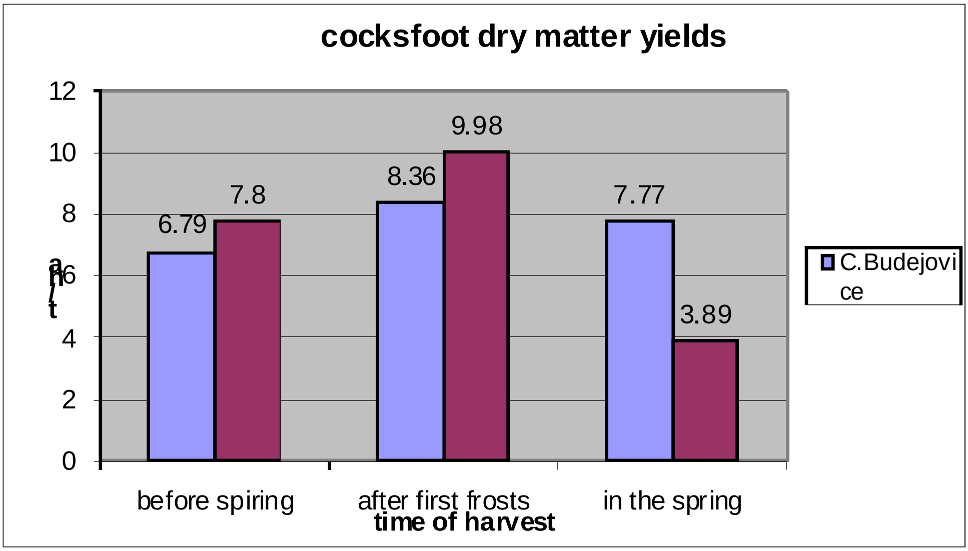


Figura 3 **Cocksfoot grass dry matter yields**

Cocksfoot yields (*Fig. 2*) conform to numbers found by Procházka (1995), who mentions yields about 8 t/ha. Providing good fertilisation these yields can be reached. In Kaplice Havlíčková (2005) reached yields of 11,64t with 15% water content. This difference was caused due to one half higher fertilizing rates and in addition to this, in Kaplice the experiments were carried out using one harvest only.

Oat grass yield (*Arrhenatherum elatius*)

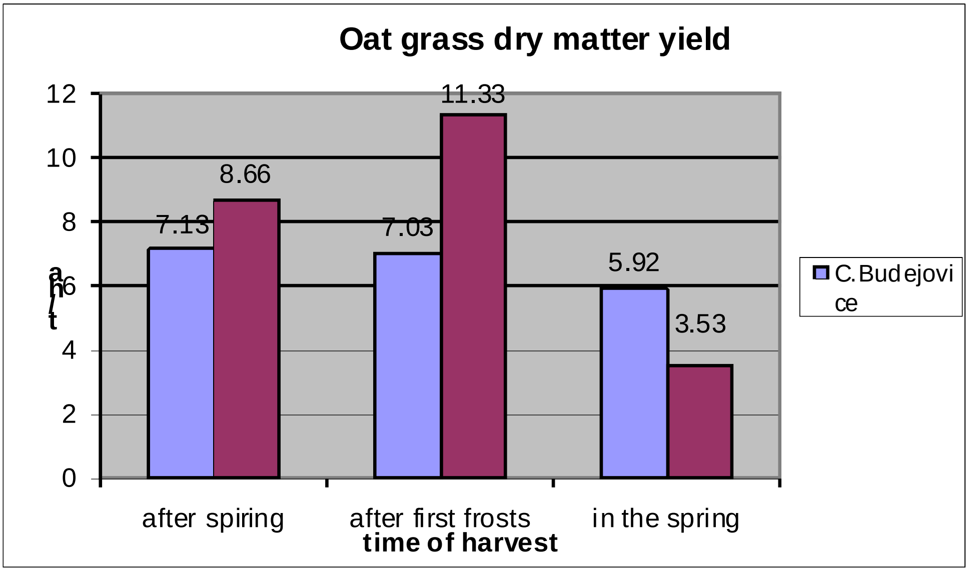


Figure 4 **Oat grass dry matter yield**

Oat grass yields (*Fig. 4*) exceed numbers found by Procházka (1995) - about 5 t/ha and by Demela (1976) - 6 t/ha. Oat grass yields correspond with numbers found by Petříková (2006), who mentions yields about 7 - 9 t/ha. Beside the spring harvest these values were always reached.

Differences between particular locations can be caused by soil and rainfall, which was higher in Lukavec compared to Č. Budějovice location.

Impact of time of harvest on yields

Time of harvest depends on method of biomass utilization. In particular harvest phases water content in plants is positively correlated with plant senility. It is true that the younger growth the higher water content and the less dry matter content is. *Figure 5*. presents dry matter yield totals reached in Č. Budějovice and Lukavec. It is evident that the highest yields were reached after first frost, which exceeded the harvest before spiring by 1,38 t/ha. This higher phytomass yield is associated with dry matter content percentage, however in the time of fall harvesting water content in energy grass growths still reaches relatively high number about 30 - 70% that does not allow to use the biomass for biogas production purposes. In addition to this in autumn season the after-drying without further inputs is unrealistic.

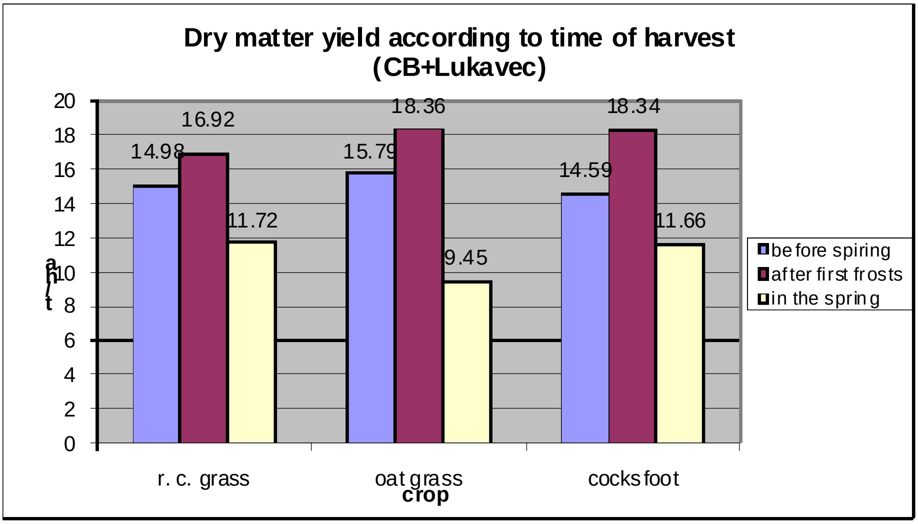


Figure 5 **Dry matter content according to time of harvest (Č. Budějovice)**

Figura 6 shows total yields of aerial biomass according to all monitored grass species and time of harvest. Greatest yield difference of 40% was recorded between harvest after first frosts and in spring, however this yield was negatively influenced by dry matter content percentage. Due to this utilisation limiting factor of late autumn harvest after first frost is preferred spring harvesting. The difference between harvest before spiring and late harvest after freeze makes 8,5 % only (app. 0,7 t/ha of dry biomass).However, spring harvest is not suitable for oat grass and mainly for cocksfoot because of relatively high harvest loss (20 - 25%). This loss is caused by growth logging, which does not happen to reed canary grass stands by contrast.

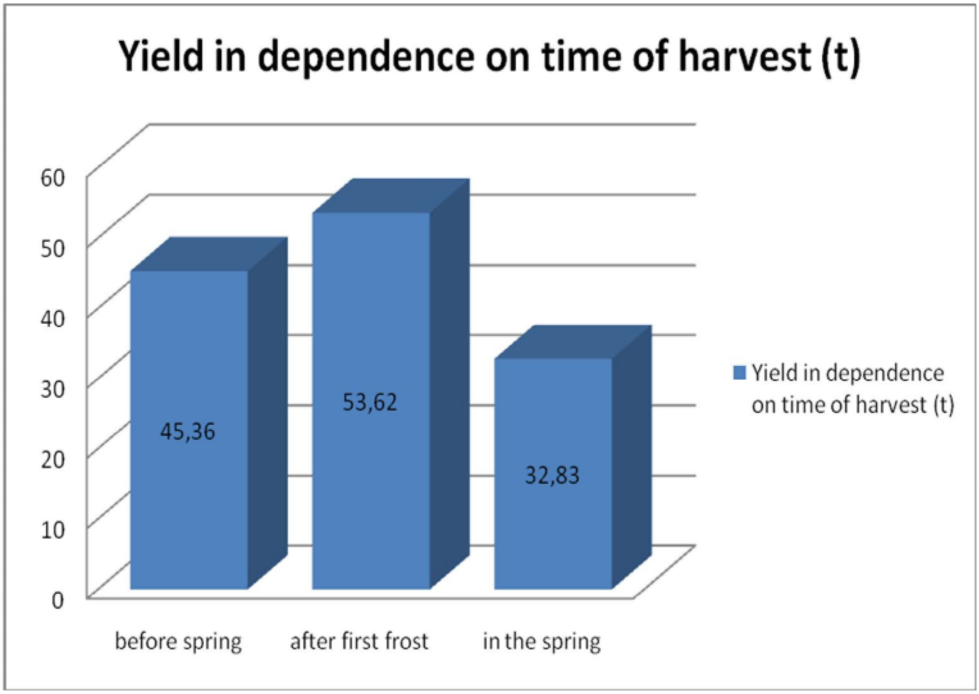


Figure 6 **Final yield according to time of harvest (ČB and Lukavec)**

Acknowledgement. This work was supported by MŠMT 2B06131 “Nonfood energy utilisation of biomass” project.

CONCLUSIONS

According to reached results it is true that non of monitored grass species is suitable as a main energy crop. The reason consist in insufficient phytomass production potential without reaching the rentability limit of 12 t dry biomass yield. Currently this yield deficit converted to an economic short is covered by grants, however their level is annually varying.

Highest yields provide oat grass with average harvest of 7,08 t/ha before spiring and 10 t/ha after first frosts and 5,92 t/ha wihtin spring harvest

When the biomass is supposed to be used for burning purposes, the most suitable appears spring harvest term because of dry matter content. An important role plays also site conditions. In České Budějovice location oat grass and cocksfoot reached about 68% dry matter content, which does not fulfil requirements for burning (80%), only reed canary grass approximated to this limit by 78%. On contrary to these findings, production from Lukavec reached for all of monitored species about 90% dry matter content, which is more than sufficient for burning purposes.

Harvesting loss due to oat grass and cocksfoot growth logging is another factor for time of harvest and can make up to 25%. This factor does not apply to reed canary grass which stands do not even lodge over winter season thanks to higher share of stems.

Meanwhile based on monitored production parameters grasses cannot be recommended as a main energy crop, however their use as supplementary biomass source appears realistic.

BIBLIOGRAPHY

1. Cenek, M., a kol., 1994 - *Obnovitelné zdroje energie*, Praha: FCC Public, 174 s. ISBN 80-901985-8-9.
2. Demela, J., 1976 -*Travní semenářství*. Praha : MZV SZN, 1976, 186 s.
3. Havlíčková, K., 2005 - *Biomasa jako obnovitelný zdroj energie : ekonomické a energetické aspekty*. Průhonice: VÚKOZ, 86 s. ISBN 80-85116-38-3.
4. Havlíčková, K., 2007 - *Zhodnocení ekonomických aspektů pěstování a využití energetických rostlin.* 1.vyd. České Budějovice, JU ZF. 92 s.ISBN 978-80-85116-00-7.
5. Lenža, L., 2006 - *Průvodce energetickými úsporami a obnovitelnými zdroji energie, Valašské Meziříčí,* 88s. ISBN 80-903680-1-8.
6. Libra, M., Poulek, V., 2007 - *Zdroje a využití energie*, Praha: Česká zemědělská univerzita, 141 s. ISBN 978-80-213-1647-8.
7. Moudrý, J.jr., Moudrý, J.,sr., Rozsypal, R., 2007 - *Analýza ekologického hospodaření na orné půdě*, ZF JU, Č.Budějovice, 30 s. ISBN 978-80-7394-053-9.
8. Moudrý, J., Strašil, Z., 1998 - *Energetické plodiny v ekologickém zemědělství.* Hradec Králové : VH press, 56 s.
9. Petříková, V., a kol., 2006 - *Energetické plodiny*. 1. vyd. Praha: Profi Press, 2006. 127 s. ISBN 80-86726-13-4.
10. Procházka, I., 1996 - *Kapesní atlas jetelovin a trav. 2. vyd*. Brno, Oseva, 44 s. ISBN 80-901789-2-8.
11. Šafařík, M., 2009 - *Pevná a kapalná biopaliva v souvislostech*. Energie 21. č. 1 s.6 – 7.
12. Šantrůček, J., 2001 - *Základy pícninářství.* Praha : ČZU v Praze, 1, 139 s. ISBN 80-213-0764-1.
13. Šnobl, J., a kol., 2004 - *Rostlinná výroba IV*, Chmel, len, konopí, využití biomasy k energetickým účelům. 1. vyd. Praha: ČZU v Praze, 119 s. ISBN 80-213-1153-3.
14. Šroller, J., 2001 - *Pěstitelské soustavy v marginálních oblastech, zemědělské informace*, ÚZPI, Praha, 6, 45s.
15. Weger, J.. Přírodní, 2000 - *Legislativní a ekonomické podmínky pěstování rychle rostoucích rostlin,* In Energetické a průmyslové rostliny VI. – Sborník referátů z odborné konference, Chomutov, ISBN 80-238-5287-6.