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ENERGETIC PLANT SPECIES THAT NOT COMPETE WITH CONVENTIONAL AGRICULTURE

GATUNKI ROŚLIN ENERGETYCZNYCH, NIEKONKURUJĄCE Z ROLNICTWEM KONWENCJONALNYM

Abstract: The objective of this contribution is to evaluate such energetic plants that will not compete with conventional agriculture. Our analysis is based on definition of energetic plant - a plant grown as a low cost and low maintenance harvest used to make biofuels, or directly exploited for its energy content (heating or electric power production). It was emphasized that besides of woody plant species as energetic plants can be also used both crops and non-food plants. Besides switch grass (*Panicum virgatum* L), jatropha (*Jatropha curcas* L) or algae some species from family Euphorbiaceae and Asteraceae store high concentration of triacylglycerols and latex, that can be used for production of biocomponents into the fuels. Species *Amaranthus* sp., *Miscanthus sinensis* Anderss., *Euphorbia marginata* L, *Ambrosia artemisifolia* L, *Helianthus tuberosus* L, and *Solidago canadensis* L successfully grown under climatic conditions of Slovakia, are presented as a potentially used energetic plant species - herbs - that will not compete with the crops. However, it should be stressed that mentioned species are (like jatropha) invasive plants. Since production of biofuels from crops as well as from non-food plants is still actual, carbon dioxide emission and energy balance of biofuel production is presently intensively discussed. Life-cycle analysis (LCA) appeared as a useful tool to appreciate impact of biofuels on the environment. LCA is presented as a scientific method to record environmental impacts from fuel production to final disposal/recycling. This approach is also known as "well to wheel" for transport fuels or "field to wheel" for biofuels. In order to investigate the environmental impacts of bioenergy and biofuels it is necessary to account for several other problems such are acidification, nitrification, land occupation, water use or toxicological effects of fertilizers and pesticides.

Keywords: biofuels, biomass, conversion processes, energetic plants, invasive plants, life-cycle analysis (LCA), non-food plants

Current energetic plant species and agro-industrial biofuel production chains rely on utilization of agricultural resources that compete with traditional food production. The most important actual crops such are eg *Zea mays* L*, Brassica napus* L*, Glycine max* (L) Merr*, Triticum aestivum* L*, Helianthus annuus* L are thus used in both, food and technical industry. In our previous paper [1] we characterized energetic plants as the plants grown as a low cost and low maintenance harvest used to make biofuels, or directly exploited for its energy content (heating or electric power production). We mentioned that according to Weger [2] for the choice of suitable energetic plants following criteria could be considered: high biomass production, biomass suitability for biofuel production, manageability and economy of plant cultivation and environmental aspects. Besides crops some of non-food plants (herbs), such are *Panicum virgatum* L, *Jatropha curcas* L or some species from family Euphorbiaceae and Asteracea, store high concentration of sugars, triacylglycerols and latex, that can be used not only for production of biocomponents into the fuels, but these plants are introduced as a potentially utilized energetic plant species that will not compete with the crops. Recently was published that "life-cycle analysis" (LCA) is an useful tool to appreciate impact of biofuels on the environment. LCA could be

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characterized as a scientific method to record environmental impacts from fuel production to final disposal/recycling. This approach is also known as “well to wheel” for transport fuels or “field to wheel” for biofuels. In order to investigate the environmental impacts of bioenergy and biofuels it is necessary to account for several other problems such are acidification, nitrification, land occupation, water use or toxicological effects of fertilizers and pesticides [3, 4].

Energetic plants as a source of feedstock and renewable energy

Presented analysis is based on definition of energetic plant - a plant grown as a low cost and low maintenance harvest used to make biofuels, or directly exploited for its energy content (heating or electric power production). It is well known that for energetic purposes forest biomass (dendromass), energetic wastes from wood-processing industry as well as food industry and waste biomass from industrial and communal field are most frequently utilized. It is feedstock for production of second-generation biofuels. In general, besides of woody plant species as energetic plants can be also used both crops and non-food plants (eg [5-7]). We have already mentioned that from crops are exploited mainly maize, rapeseed, soybean, wheat and sunflower. From non-food plants in addition to switch grass (*Panicum virgatum* L), jatropha (*Jatropha curcas* L) or algae some species from family Euphorbiaceae and Asteraceae store high concentration of sugars, triacylglycerols and latex, that can be used for production of biocomponents into the fuels. Especially jatropha seems to be an attractive non-food plant. For example, a national mission to produce biodiesel from Jatropha (13 million tones annually by 2013), has been launched as an initiative of the Indian government to address socio-economic and environmental concerns [8].

Species *Amaranthus* sp., *Miscanthus sinensis* Anderss, *Euphorbia marginata* L, *Ambrosia artemisifolia* L, *Helianthus tuberosus* L and *Solidago canadensis* L successfully grown also under climatic conditions of Slovakia, are introduced as a potentially used energetic plant species that will not compete with the crops. However, it should be stressed that the most of mentioned species are (like jatropha) invasive plant species. These plants can be characterized as a non-indigenous or non-native species, that adversely (negatively) affect the habitats and bioregions, they invade environmentally, ecologically and economically. These plants disrupt by dominating a region, wilderness areas and wildland-urban innerface land from loss of natural controls. Some of them can adapt to the new environmental condition very fast, mainly in the case if there do not occur any adequate competitor. Under such conditions invasive plant species can form new vital and vigorous plant population and then can caused extinction of original species or even serious changes of whole ecosystem. Thus invasive plant species are one of the most important challenge for preservation of the environment. This actual topic was particularly published by Elias [9] and Cvachova and Gojdicova [10].

Very promising are results of Andrianov et al [11] with genetically modified (GM) tobacco plants (*Nicotiana tabacum* L). When grown for energy production instead for smoking, tobacco can generate a large amount of inexpensive biomass more efficiently than almost any other agricultural crop. Tobacco possesses potent oil biosynthesis machinery and can accumulate up to 40% of seed weight in oil. GM plants showed up to a 20-fold increase in triacylglycerol accumulation in tobacco leaves and about a twofold increase in

Life-cycle analysis (LCA)

Life cycle analyses look at the whole picture of how a fuel is made, from "cradle to grave". The life cycles begin with the extraction of all raw materials to make biofuel, and end with using the biofuels in engines. Understanding the benefits of biodiesel requires us to compare its life cycle emissions to those of petroleum diesel. This study examines biodiesel energy's balance, its effect on greenhouse gas emissions, and its effects on the generation of air, water, and solid waste pollutants for every operation needed to made biofuel. LCA is a scientific method to record environmental impacts "from cradle to grave", ie from production to final disposal/ recycling. Also known as "well to wheel" for transport fuels or "field to wheel" for biofuels (in detail see [15, 16]). Two of the most used types of life cycle assessment for bioenergy are those used to determine net-energy and net greenhouse gas emissions. In order to investigate the environmental impacts of bioenergy and biofuels it is absolutely necessary to account for several other problems as acidification, nitrification, land occupation, maintenance of biodiversity, water use or toxicological effects of fertilizers and pesticides (eg [3]). These authors summarized results of LCA of three liquid biofuels: FAME prepared from rapeseed and bioethanol prepared from both, wheat and sugarbeet. The analysis was based on the measurements of direct emissions from combustion of biofuels and blended fuels for the cars in Czech Republic. Comparing LCA of fossil fuels and biofuels it was found reduction of $CO_{2eqv.}$ in the case of biofuels, what corresponded with the other published foreign studies. It should be stressed that in the calculation of whole LCA of biofuel production the advanced processing technologies (including agricultural procedures) were applied. Moreover, during biofuels production some by-products originate which have to be also considered in actual calculation procedure. In another paper [17] was stressed that from the aspect of climate preservation as the most effective biofuel were found second-generation biofuels: synthetic motor fuel - BTL, bioethanol produced from lignocellulosic material - wood, straw. However, from the energy aspect these fuels have high energy cost. Based on LCA was found that production hydrogen as a motor fuel has both, high energy cost and high negative impact on the environment. These authors also compared outputs from the most important Well-to-Wheels analyses in European region focused on GHG (*Greenhouse gases*) emissions and energy production.

Conversion processes of non-food biomass to biofuels

Production process of second-generation biofuels utilize non-food plants (forest trees, energetic forest coppices, fast-growing trees and herbs), ligno-cellulosic residues and wastes (wood chips from forest thinning and harvest residues, surplus straw and plant residues from agriculture). Possible options for the conversion of these materials to biofuels include: thermal and catalytic cracking, hydrocracking, pyrolysis, carbonisation, catalytic and steam reforming, gasification and Fischer-Tropsch synthesis. In general, conversion of biomass to second-generation biofuels requires hard reaction conditions such are: high temperature, high pressure and presence of hydrogen. All these procedures were described in detail by Bajus [18, 19]. It should be stressed that cost of abovementioned procedures has to be also inclusive into the whole LCA.

Conclusion

With regard to the well known fact, that already in 2009 the earth's population was estimated to be about 6.77 billion, and 850 million people is suffering from malnutrition, it is inevitable to secure primarily sufficient food for the population. Considering the increasing trend of biofuel use an important bioethical problem occurred - perplexity whether crops (eg maize, cereals, potatoes, rapeseed, and sunflower) could be used exclusively for alimentary purposes or also as an alternative energy source. Thus, energy conservation and biofuels that are not food-based are likely to be of far greater importance over the longer term. Biofuels such as synfuel hydrocarbons or cellulosic ethanol that can be produced on agriculturally marginal lands with minimal fertilizer, pesticide, and fossil energy inputs, or produced with agricultural residues have potential to provide fuel supplies with greater environmental benefits than either petroleum or current food-based biofuels [20]. The integration of plant science into energy industry research is crucial for the success and sustainability of biofuels. This integration will only be effective if the plant scientists and ecologists who work with biofuels can communicate new findings in a way that is useful to the larger interdisciplinary community. Ecological impacts associated with land conversion and the establishment of new plant species (especially non-food plants) for biofuel production are important determinates of the overall sustainability of biofuels as an energy source. Genetic modifications of plants grown for biofuel could reduce the ecological impact that biofuel agricultural systems currently incur. Inclusion of interactive climate, plant, soil and microbial controls over nutrient cycling in an LCA will provide a more realistic assessment of biofuel costs and benefits [21]. On 10 June 2010, the EC announced its scheme for certifying sustainable biofuels, part of a set of guidelines explaining how the Renewable Energy Directive, coming into effect in December 2010, should be implemented. Global-Bio-Pact, co-funded under FP7, aims to develop and harmonize global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts [22].

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GATUNKI ROŚLIN ENERGETYCZNYCH, NIEKONKURUJĄCE Z ROLNICTWEM KONWENCJONALNYM

Abstrakt: Celem pracy było wytypowanie takich roślin energetycznych, które nie będą konkurować z rolnictwem konwencjonalnym. Punktem wyjścia przedstawionej analizy jest definicja roślin energetycznych - roślin uprawianych przy niskich kosztach utrzymania i zbioru, stosowanych do produkcji biopaliw lub bezpośrednio wykorzystywanych do produkcji energii (ciepła lub wytwarzania energii elektrycznej). Podkreślono, że oprócz gatunków roślin drzewiastych roślinami energetycznymi mogą być również zboża i rośliny niebędące pożywieniem. Oprócz trawy (*Panicum virgatum* L) i jatrofy (*Jatropha curcas* L), niektóre gatunki glonów z rodziny *Asteraceae* i *Euphorbiaceae* zawierające duże stężenia triacylogliceroli i lateksu, mogą być wykorzystane do produkcji biokomponentów paliw. Gatunki *Amaranthus* sp., *Anderss Miscanthus sinensis*, *Euphorbia marginata* L, *Ambrosia artemisifolia* L, *Helianthus tuberosus* L, *Solidago canadensis* L mogą być pomyślnie uprawiane w warunkach klimatycznych Słowacji. Rośliny te przedstawiane są jako potencjalnie użyteczne gatunki roślin energetycznych, niekonkurujących z uprawami roślin spożywczych. Należy jednak podkreślić, że wymienione gatunki (np. jatrofa) należą do roślin inwazyjnych. Ponieważ produkcja biopaliw zarówno z roślin uprawnych, jak też z roślin nieżywnościowych jest nadal prowadzona, dlatego emisja ditlenku węgla i bilans energii z biopaliw obecnie są intensywnie dyskutowane. Analiza cyklu życia (LCA) to użyteczne narzędzie określania wpływu biopaliw na środowisko przyrodnicze. LCA jest przedstawiona jako metoda naukowa, pozwalająca na ocenę oddziaływania paliwa na środowisko od produkcji do ostatecznej jego likwidacji/recyklingu. Takie podejście jest również znane jako „szyb naftowy do koła“ dla paliw transportowych lub „pole do koła“ w odniesieniu do biopaliw. W celu zbadania wpływu bioenergii i biopaliw na środowisko należy uwzględnić kilka innych problemów, takich jak zakwaszenie, nitryfikacja, użytkowanie terenu, zużycie wody lub toksycznych nawozów i pestycydów.

Słowa kluczowe: biopaliwa, biomasa, procesy przetwarzania roślin energetycznych, rośliny inwazyjne, analizy cyklu życia (LCA), rośliny niespożywcze