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PRODUCTION POTENTIAL OF BIO-ENERGY CROPS IN MULTIFUNCTIONAL AGRICULTURE AND RURAL DEVELOPMENT

Ž.S. Dželetović[1], N.Lj. Mihailović[1], G.D. Dražić[2]

Abstract

Bio-energy crops are grown with the specific purpose of utilizing their parts or the whole plant mass for the production of liquid or solid fuels, as an alternative to fossil fuels. The use of traditional bioenergy crops (straw of cereals and wood mass) and common field crops (for ethanol and bio-diesel) are considered. Promising for such utilization are also various species of annual and perennial grasses, among which miscanthus (*Miscanthus×giganteus* Greef et Deu.*) is especially recognized as a source of good quality biomass. Only the intensive use of the existing and new energy crops could bring about a greater multi-functionality of agriculture, as well as comparative cost/benefit stability of agriculture and encourage the rural development.*

Key words*: *ethanol, biodiesel, wood mass, miscanthus

Introduction

Plant biomass represents a stored energy which may be utilized if necessary as fuel in power plants and in heating systems. It is a substitution for fossil fuels and it has a potential to decrease CO_2 emission and thus influence the decrease of global heating produced by the greenhouse effect. Utilization of this energy is favorable for the environment because it originates from continually renewable energy sources.

The main stimulant for the development and spreading of bio-energy crops is introduced through the ratification of the Kyoto protocol (1997) concerned with climate changes and the decrease of gas emission and the greenhouse effects. The great global interest in bio-fuels may me explained by the fact that they represent a potential

1 Phd. Željko S. Dželetović and Phd. Nevena Lj. Mihailović, INEP - Institute for the Application of Nuclear Energy, Banatska 31-b, Zemun, Serbia. (++387-11-261-8666, e-mail: zdzeletovic@inep.co.rs, nmihailovic@inep.co.rs)

2 Phd. Gordana D. Dražić, Faculty for Applied Ecology „Futura“, Lazarevački drum 13, Belgrade, Serbia. (++387-11-305-8987, e-mail: gdrazic@singidunum.ac.rs)

that decreases a country dependence on the import of oil derivatives, decreases CO_2 emission, contributes to the development of rural communities economy [15]. Ideal heating crop should have appropriate potential for taking up, keeping and conversion of available solar energy into the harvest biomass with maximal efficiency, minimal inputs and minimal unfavorable environmental impacts [7]. The systems for cultivation of the crops for biomass must have very favorable (positive) energy balance, i.e. low energy inputs in comparison with the output, considering that inputs imply utilization of fossil fuels and CO_2 emission into the atmosphere. Cultivation, harvest and especially nitrogen fertilization, represent high financial and fossil fuel inputs [7].

Traditional bio-energy sources

Traditional bio-energy sources are represented by the straw of various agricultural crops and the woody mass. Due to their high productivity (appropriate yield of the dry matter per the surface unit and per year) and due to their high potential for CO_2 substitution, the utilization of crops as solid fuels is interesting. The whole crop, as well as the individual fractions of grains and straw may be utilized for combustion. However, high concentrations of Cl, K and N in the crop biomass are serious drawbacks in their utilization as solid fuels [9]. On the other hand, big rolled bales of soybean straw, give very satisfactory combustion quality [14]. The quality of the biomass may be significantly improved by adding coal and other additives and it may be used as such for certain types of boilers with low level of pollutant emission, primarily of SO_2 emission [20].

About 7% households in Serbia utilize wood as heating fuel [15]. Forest plantations with great number of plants (short rotation coppices) which represent a uniform, locally available raw material of fast growing deciduous wood species, are widely promoted. The plantations consist mainly of densely planted willows or poplars, which are harvested usually each 3 years. The root remains in the soil after the harvest and next spring new sprigs emerge from it. By the direct combustion of the biomass, by shredding or chipping of the whole trunks, together with the bark and branches, a significant level of heating energy may be achieved.

Under the environmental conditions in Serbia, the clones of eastern cottonwood (*Populus deltoides*) were found to be the best: they have a comparatively high volume mass and a high increment of wood mass, in comparison with the clones of Euro-American poplars [10]. In combination with appropriate planting densities, with necessary biological cultivation and protection measures, all necessary conditions may be fulfilled for the establishment of so-called energy plantations from renewable natural sources [10].

The remnants of fruit-trees or grapevine cuttings may also be utilized in original form, as a fuel. The quantity of the cut biomass is primarily dependent on the fruit/grapevine species and on the cultivar characteristics [23]. However, under the conditions in Serbia, the gathering, processing, preparation and utilization of the cut plant remnants did not find a wide application, because the cut remnants are characterized with substantial moisture, variable composition and voluminous form, and thus with low volume mass, which causes a low rationality of the transport as well as an impaired manipulation, storage and utilization in furnaces [23].

Utilization of agricultural crops as bio-energy fuels

Maize is the main raw material for the production of ethanol. Consumption of ethanol, as an alternative fuel, is constantly increasing. Our country, which is one of the big European maize producers, has very good predispositions for ethanol production [18]. With common agricultural crops, the most important quality feature is the starch content in the grain. It should be higher than 70% in order to obtain 37-40 l of pure ethanol per 100 kg of maize. Beside maize, commercial production of ethanol from potatoes and sugar beet is also possible. The price of the ethanol obtained by maize processing, for instance, varies between 30 and 60 USD, in dependence of maize price [1].

In Serbia, rapeseed represents the main raw material for bio-diesel production. In the global market, beside rapeseed, sunflower, soybean and palms are the most frequently represented bio-diesel sources. Germany is the country with the highest bio-diesel production [15]. Bio-diesel has better lubricity than sulfur-free mineral fuels. Two very important advantages of bio-diesel in comparison with mineral fuels are: quick biodegradation and a significantly lower emission of harmful particles and gases during motor combustion.

Promising new bio-energy crops

A great number of investigations have been carried out worldwide, mostly of grasses as potential energy crops. Various species of annual and perennial grasses, characterized with high biomass yield, high efficiency of nutrient and water utilization and good quality biomass combustion, turned out to be very promising for utilization. Perennial grasses that produce aboveground mass every year may have higher yield than cultivated forest plantations. Also, the existing forest economy machines may be used for their cultivation [7]. The species that are most convenient for cultivation and have the highest bio-energy yield are [5]:

- switchgrass (*Panicum virgatum* L.),
- reed (perennial) Canary-grass (*Phalaris arundinacea* L.),
- giant reed (*Arundo donax* L.) and
- miscanthus (*Miscanthus*×*giganteus* Greef et Deu.).

In Europe, the most frequently cultivated and widely spread is miscanthus, a very high C_4 grass, with a potentially high yield, but also with high requirements of nutrients and moisture. Miscanthus plantation is long-standing (15-20 years) and it is harvested each year since the end of December till the beginning of April. The caloric value of miscanthus biomass does not depend on irrigation or nitrogen fertilization. Energy production depends only on the yield biomass [6]. Miscanthus straw has good combustion quality, and because of the specific characteristics, it is convenient for briquetting [13]. With the current fuel prices, the miscanthus crop will be profitable if it is grown for 4 or more years, even without subsidies [7].

Contrary to annual species, perennial crops (primarily coppices with short rotation and perennial grasses) require only one cultivation activity, i.e. the preparations for planting. During the next 10-20 years, nitrogen inputs for perennial crops are minimal. After the harvesting of the plant material, it is combusted directly. The energy waste for the production of the crops is minimal. The input/output ratio in these systems may be even lower than 0,2 [12]. In fuel production from annual crops (ethanol from maize of bio-diesel from rape) the input/output ratio is ≥0,8 [12,22]. Thus, the prospect of the development and spreading of these bio-energy crops will depend primarily on the fluctuation of prices in the market (mostly of fuel prices, cereal prices and the level of governmental subsidies), as well on the specific technical requirements of the cultivation of these crops [5].

Ecological problems and the profitability of bio-energy crop cultivation

Although the contribution of bio-energy to the total energy balance is still negligible, an advanced development and bio-energy crop spreading are obvious [5]. In connection with the "boom" of bio-fuel production and consumption, the critics stress potential social problems and costs connected with the environment including the consequences of food price increases [15]. In the beginning, it was recommended to cultivate biomass crops on the plots unfavorable for food crop growth [16]. According to official statistics, Serbia has enough abandoned and unexploited land, which could be used for cultivation of those crops, without decreasing the existing arable areas [15]. However, it is already evident that, for instance, miscanthus could be profitable if grown on some highly productive land plots convenient for wheat production, too [3].

Because of this, the advanced development and spreading of bio-energy crops are exposed to severe criticism and doubts as to their validity and commercial justification. The basic problem is the identification of the most convenient biomass and the construction of the process for energy extraction from it. Actually, the process of energy production will probably not be profitable with some biomass types, which are potentially energetically available, because energy consumption for their cultivation will not be compensated [1]. Not to mention that the total bio-fuel price is still high. Obstacle for the successful production is also the problem of competition with conventional crops, due to a high production cost and the need to occupy the arable land plots for a long time interval.

In the countries of EU zone, bio-energy cost/benefit depends on financial subsidies for all crops, except for the crops grown for direct combustion of biomass for heat production [4]. The utilization of energy plants in EU will not decrease substantially the food crop production, but it could induce higher prices of agriculture products [4]. An increase in income from agriculture could be expected in the future, because agriculture is increasingly connected with the development of primary energy cost, i.e. the increase of energy cost must increase the prices of agriculture products [4]. Also, energy production that is occupying the place of agriculture production does not open new jobs.

For large-scale commercial bio-fuels to contribute to sustainable development will require agriculturally sustainable methods and markets that provide enhanced livelihood opportunities and equitable terms of trade [19] . On the other hand, the results indicate that the application of highly efficient agriculture systems, in combination with geographic optimization of land utilization, may decrease the area necessary for the global food production till 2050 to almost 72% of the existing area [21].

Bio-energy crops and multifunctional agriculture

The main function of agriculture is food production. Multifunctional agriculture implies performing of other, primarily commercially justified functions useful for the community. Actually, the production of energy by cultivation of appropriate bio-energy crops may contribute significantly to the building of multifunctional agriculture in the countries like Serbia. The current comparatively marginal impact of bio-energy crop is being gradually surpassed by a continual growth of bio-fuel production and thus by increasing of the participation of the areas under bio-energy crops in the total area under agricultural crops.

The interests concerning bio-fuel production are contradictory. Besides, external factors may exert the crucial influence on the development of national bio-fuel programs [11]. Bio-energy may yield a positive contribution to climate issues and to rural revitalization. However, if not implemented successfully it may worsen the soil and water degradation, as well as ecosystem degradation. It may also reduce food production safety and increase the emission of greenhouse gases [19]. Because of this, the aim of energy management policy must be focused on the decrease of energy consumption, introduction of new energy sources, increase of the extent and the quality of agriculture production and the lower environmental pollution; i.e. lower production costs [8].

Stimulation measures of the Government focused on the production and application of bio-fuels in Serbia must be well calculated, because they bring the advantages: decrease of oil import, decrease of the emission of greenhouse gases, opening of new jobs, increase of good quality forage supply, cultivation on currently abandoned plots. Pejčinović and Delić [17] mention the following support mechanisms, which are of significance for utilization of renewable energy sources: stimulation fees, obligatory quotas, tender system, invested subsidies, tax reductions and a so-called “green price system”.

It may be concluded that only intensive utilization of the existing and new bio-energy crops, their great potential may be materialized and the multifunctional agriculture may be advanced, as well as a comparative price stability, which will stimulate a long-term rural development. However, the benefits that bio-energy crops contribute to rural development will probably depend on the region involved. Namely, the variations of potential yields and production costs may be great, both at the national level, and within individual regions [2].

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