Soybean Biomass as a Renewable Energy Resource

Darko KIŠ [1](✉)
Branko SUČIĆ [1]
Vlado GUBERAC [1]
Neven VOĆA [2]
Vlatka ROZMAN [1]
Luka ŠUMANOVAC [1]

Summary

A constant need for energy is necessary and permanent as far as modern society is concerned. The primary energy resource in today's world are fossil fuels. A serious problem is the fact that their amount is decreasing. Fossil fuels are not renewable. Their sources will disappear and new energy resources will have to be switched to, because the consequences of energy resources disappearance are inconceivable. Biomass as an energy resource is not properly used. There are many ways to generate energy from biomass. You can grow plants to get biomass for energy production or you can use plants' residues, which are the results of agricultural production. You can also use organic waste products and animal faeces. The oldest way of the production of energy or fuel from biomass is burning. Agricultural biomass including soybean straw is a very acceptable fuel from the point of view of environmental protection and especially greenhouse gases emission.

The use of biomass energy offers chances for the establishment of new jobs. This way it can have a positive influence on both the local and national economy. The knowledge and use of soybean growing has a great importance for the development of certain regions in Croatia, as well as on the employment rate and entrepreneur encouragement. It would be even more important to start using unused land areas. Soybean growing makes it possible to introduce "the third culture" (except for wheat and corn), which will result in additional and safer profit for farmers in Croatia, a more favourable use of agricultural machines, and the profitability of production.

Key words

biomass, soybean, renewable energy resource

[1] University J.J. Strossmayer of Osijek, Faculty of Agriculture,
Trg Sv. Trojstva 3, 31000 Osijek, Croatia
✉ e-mail: dkis@pfos.hr
[2] University of Zagreb, Faculty of Agriculture, Svetošimunska cesta 25, 10000 Zagreb, Croatia

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Introduction

The international acknowledgement of the need for the greenhouse gases control and decrease has given a new life chance to biomass, which is the oldest energy resource used by the mankind. The involvement of biological resources into the estimate of national emission of greenhouse gases (Kyoto Protocol, 1997) pointed out another role of biomass which is a reduction of the emission through a long-term absorption of carbon by plants. There are different estimates of the potential and role of biomass in the global energy policy for the future, but each scenario predicts its increase and a very important role (Grubler, 1998). By the year 2010 the biomass would participate with 73 % in energy production compared to other renewable energy resources (EC, the White Book, 1997). Croatian scientists and experts have conducted numerous researches and some technologies for energy production from biomass have been developed (Domac, 2000). Biomass residues are available almost in every area of agricultural production in Croatia. Up to now they have been only very rarely used for the production of thermal energy for own technological requirements. Danish experiences in the field of biomass (a power plant over 450 MW) show the real possibilities and ranges of energy generation from straw (Nikolaisen, 1998). In case when 30 % of oil seed rape straw is used the possibility for energy exploitation is about 89 to 96.88 GJ/ha, which is an equivalent of 2.362 t/ha of a liquid fuel (Kiš, 2004). A way of a rational management of straw is the production of briquettes and pellets. Burning briquettes does not cause any harm to the closed carbon dioxide cycle because like other biomass they are also considered a CO_2 neutral fuel (Kiš, 2007). In 2006, the EU was entering the second phase of the utilization of renewable energy sources. Concept BTL (Biomass-to-liquid) describes process of getting synthetic liquid fuel (Kricka et al., 2007). Based on the above mentioned the soybean straw can be used as an ideal substitute for expensive ensilage components in substances. It can decrease the price of biofuel generation and in this way the price of electric energy.

Materials and methods

The research included five soybean cultivars, namely 'Ika', 'Neoplanta', 'Tisa', 'Podravka' and 'Vita' produced in the breeding company Agricultural Institute Osijek. It was conducted during a one-year period in the fields of Agricultural Institute Osijek. The experiment was established on brown soil. The crop preceding the experiment was wheat. The sampling was conducted during the harvesting operation in five repetitions with the following values being measured: the whole plant length and mass, the mass of the central branch and the mass of the side branches. The humidity of the central and side branches was measured for three hours in a drying-room at 105 °C by the conventional method. In this way the real amount of available straw per hectare was determined and the lower heating value of the biomass was calculated ie the influence of the biomass humidity on the amount needed. In other words, during the process of burning biomass spends its own energy for the water evaporation that has a large influence on the energy balance of the co-generational plants. Laboratory data processing was carried out on the stalk samples of the researched cultures in the laboratory "Kreka" Tuzla, and the basic energy data important for the biomass use as a fuel was calculated. The lower heating value was determined by a calorimeter C 4000 whereas the other elements were determined by the process of combustion in ceramic mugs at 900 C.

Results and discussion

Weather condition in 2007 for Osječko-Caranjska County is shown in Table 1.

The humidity values of the central and side branches were measured by a standard procedure in a drying room at 105 °C for three hours. In this way the real amount of the available straw per hectare was determined. Based on the data mentioned, the soybean biomass value as a fuel (Table 2) with the exploitation of 30 % of the straw for the researched cultivars for the given years, the equivalent amount of *natural gas*, light liquid fuel and mazut per area unit ie per hectare were calculated. The data is shown in Table 3.

A comparison of the results with those of former researches (Domac, 2000; Krička et al., 2000) validated the obtained values.

Conclusions

Based on one-year research (2007) of the soybean cultivars: 'Ika', 'Neoplanta', 'Tisa', 'Podravka' and 'Vita' as energy resources in biofuel production the following conclusions can be made:

1. Weather conditions for soybean growing were very bad in year 2007. Amount of rainfall was considerably lower then average (up to 50 % and more). Therefore amount of biomass for 'Ika' was 2571.10 kg/ha, and for Tisa 3374.70 kg/ha.

Table 1. Monthly amounts of rainfall (mm) and average air temperature (°C) during soybean vegetation in 2007 and averages for period 1979-2007 for location Osijek

Period		I	II	III	IV	V	VI	VII	VIII	IX	X
2007	mm	25,3	46,5	76,0	2,9	56,1	33,3	27,4	45,0	65,2	92,5
	°C	5,8	6,1	8,5	13,3	18,3	22,3	23,8	22,2	14,5	10,3
1979-2007	mm	44,8	37,3	44,1	53,8	62,1	81,6	59,2	67,4	59,4	52,6
	°C	-0,3	1,5	6,5	11,5	17,0	20,1	21,7	21,1	16,6	11,6

Table 2. The value of biomass soybean as a fuel

Analytical data		Ika	Neoplanta	Tisa	Podravka	Vita
Coarse humidity	%	20,10	20,13	20,07	20,10	20,15
Humidity test piece		8,63	8,48	8,34	8,35	8,45
Ashes	%	3,16	2,08	2,60	3,43	2,75
Volatile matters	%	71,17	73,46	71,73	70,69	71,95
Combustible matters	%	88,21	89,44	89,06	88,22	88,80
C – fix	%	17,04	15,98	17,33	17,53	16,85
Cokes	%	20,20	18,06	19,93	20,96	19,60
Sulphur combustible	%	0	0	0	0	0
Sulphur bound	%	0	0	0	0	0
Lower heating value	kJ/kg	16 993	16 856	17 070	16 785	16 644
Volatile matters (volatiles) without humidity and ashes	%	80,68	82,13	80,54	80,13	81,02

Table 3. An average value for the biomass and for the equivalents of other fuels for the cultivars 'Ika', 'Neoplanta', 'Tisa', 'Podravka' and 'Vita' in 2007

Cultivar	Mass, kg/ha w_1=15%	Energy value, kJ/kg w_2=15%	Energy value, MJ/ha w_2=15%	MJ/ha η = 80%	Natural gas equivalent, m^3/ha	Liquid light fuel equivalent, kg/ha	Mazut equivalent kg/ha
Ika	2571,10	15 509	39875,2	31 900	896,36	757,94	778,36
Neoplanta	3194,80	15 206	48580,0	38 864	1092,04	923,41	948,28
Tisa	3374,70	15 527	52399,0	41 919	1177,89	996,00	1022,82
Podravka	2820,72	15 019	42365.0	33 892	952,33	805,27	826,97
Vita	2683,10	14 815	39750,0	31 800	893,54	755,57	775,92

2. When 80 % of soybean straw was used the best results based on a one-year average value were achieved by Tisa cultivar with 41.92 GJ/ha or the equivalent of 1177.89 Nm^3 of natural gas or 1.02 t/ha mazut; the result for the Neoplanta cultivar with the exploitation of 80 % of straw was 38.86 GJ/ha, which is an equivalent value of 1092.04 Nm^3 of natural gas or 0.95 t/ha of mazut; the Podravka cultivar had an energy value of 33.892 GJ/ha, which is an equivalent value of 0.95 Nm^3 of methane or 0.81 t/ha of liquid light fuel, the Ika cultivar has an energy value of 31.90 GJ/ha, which is an equivalent value for 0.90 Nm^3 of methane or 0.76 t/ha of liquid light fuel, and the Vita cultivar had an energy value of 31.80 GJ/ha, which is an equivalent value for 0.89 Nm^3 of methane or 0.76 t/ha of liquid light fuel. These values represent large amounts of energy that can be used for soybean seed drying at the humidity of 13 % and they can also fulfil other demands for energy.
3. The following fire-boxes for the researched soybean cultivars can be used taking into account the coke content, C fix, the ash content, and the content of volatile matter. The appropriate fire-boxes were as follows: a biomass fire-box with grates, a fire-box with a manhole, a fire-box with a bottom biomass inflow, a combined fire-box, a fire-box with a whirl chamber, and a fire-box for combustion of baled biomass.
4. Soybean straw is a good basis for the production of the second generation of biofuels from renewable resources by Biomass-to-liquid procedure.
5. Based on the above said the researched soybean cultivars with their characteristics validate the sowing and can be used as a raw material in biofuels production.

References

BIOEN (1998): Program korištenja biomase i otpada I. Energetski institut "Hrvoje Požar", Zagreb.

Domac, J. (2000): Hrvatski sustav korištenja biomase. Magistarski rad, Fakultet elektrotehnike i računarstva Sveučilišta u Zagrebu, Zagreb.

EC (1997): White paper for a Community Stretegy and Action plan. Energy for the Future, Document (95), Luxemburg, 682.

Grubler, A (1998): Technology and Global Change, Cambridge University Press, Cembridge, 455 pp.

Kiš, D. (2004): Iskoristivost uljane repice kao bioenergenta u proizvodnji biodizelskoga goriva, Doktorska disertacija, Poljoprivredni fakultet Osijek

Kiš, D., Guberac, V., Jurić, T. And Arežina, M. (2007): Biomass from rape seed as renewable energy source. Proceedings Agriculture and Forestry as the producers of the renewable energy sources, 89-97.

Krička, Tajana; Voća, N.; Jukić, Ž.; Hrsto, D. (2000). Biodizel gorivo kao prekretnica u hrvatskoj poljoprivrednoj proizvodnji. 16 Hrvatsko savjetovanje tehnologa sušenja i skladištenja, Stubičke Toplice, 1 - 16.

Krička Tajana, Tomić, F., Voća, N., Jukić, Ž., Vanja Janušić (2007): The production of the renewable energy sources in the EU. Proceedings Agriculture and Forestry as the producers of the renewable energy sources, 9-16.

Miller, G. T. (1992): Living in the enviroment. 7th ed Wadsworth, Belmont, 233.

Nikolaisen, L., Nielsen, C., Larsen, M.G., Niesen, V., Zielke, U., Kristian Kristensen, J., Holm Christensen, B., (1998.): Stroh als Energieträger: Technik-Umwelt-Ökonomie, Trojborg Bogtryk.

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