SOYBEAN BIOMASS AS FUEL AND FERTILIZER

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Scientific paper

Summary

Increase of world energy demands is in connection with world population grow. According to IIASA model it is predicted that the world energy consumption by the year 2030 will be 306,6 10^{12} kWh. Development of energy sector is the basis for development of society and demand for different sources of energy are constant and very urgent. Energy strategy of EU "20-20-20" has a long term goal of high energy production with low emission of glasshouse gases. Within this strategy EU countries have to reduce glasshouse gases emission for 20%, raise energy efficiency for 20% and, 20% of energy consumption should be from renewable resources. Biomass from agriculture is one of the renewable energy resources that is not enough exploited. Aim of this paper is to evaluate the possibility of soybean straw usage as a efficient energy resource and efficient fertilizer. Research results are pointing out validity of that usage.

Key words: *biomass, energy, fertilizers, renewable resources*

INTRODUCTION

The progress of the civilization has facilitated great discoveries and improvement of human life quality. At the same time it has caused strong dependence on energy sources, which ensure the maintenance of the achieved level of progress and further development. The consequences of the loss in energy supply are inconceivable. The aim of the long term EU development is to produce as much energy at the lowest level of greenhouse gases emission, the strategy which is simply called “20-20-20”. This document states that all the EU members should increase their energy efficiency and that they should consume 20% of the overall spent energy out of their own renewable sources. Biofuel is the most valuable sort of renewable energy sources. Biofuel as a renewable energy source is of special interest for Croatia because it can replace fossil fuels used for transport, which accounts for more than 30% in energy consumption. Furthermore, the production and use of biofuel supports two other goals, namely the safety of supply and regional development in the sense of economy improvement. There are different estimations considering the potential and role of biomass in the future global energy policy, but each of them anticipates its growth and important role (Grubler, A. 1998). Agricultural biomass is a very acceptable kind of fuel from the environmental point of view and especially when we consider the pollution of the atmosphere by so called greenhouse gases (Miller, 1992). The emission of SO_2 in case of straw burning is lower than in burning of coal and fuel oil but on the other side it is higher than in burning natural gas. Emission of NO_x when burning straw is significantly lower than in the other observed fuels. As well as the other biomasses straw is generally considered to be a neutral fuel (EC, 1997). $2 * 10^{11}$ tons of organic matter is produced annually on the Earth by photosynthesis. Soy straw as well as its oil, soybean meal, and glycerol have become important by-products convenient for energy production (about 17 MJ/kg). Soy straw has very similar characteristics and burning value as the other cereal residues so that the existent machinery can be used for its collection (Bugge J., 2001., Đolagić et all., 2002). The research aims at establishing the possibility of soy straw application as an efficient energy source and a possible source of organic fuel.

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 in the fields of Agricultural Institute Osijek. 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. 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. The fertilization value of soybean straw was determined using computer model for organic fertilization evaluation (Lončarić et al., 2009). The total nitrogen content, total organic carbon content, C/N ratio, total phosphorus and potassium content, as well as Fe, Mn, Zn and Cu concentrations in soybean straw were used as input data to calculate fertilization value. All the straw samples were

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prepared and analyzed according to TMECC methods (Thompson, 2001) using distillation (N), spectroscopy (P), and AAS (K, Fe, Mn, Zn, Cu) techniques.

RESULTS AND DISCUSSION

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 1) with the exploitation of 80% of the straw for the researched cultivars for the given years, the equivalent amount of natural gas and light liquid fuel per area unit i.e. per hectare were calculated. The data is shown in Table 2.

The total nitrogen concentrations were in range 3.1 (cultivar Tisa) to 4.8 g/kg (cultivar Vita), but in the straw of cultivar Vita were determined the lowest phosphorus (1.0 g/kg) and potassium (2.8 g/kg) concentrations. At the same time, the highest phosphorus concentration was in cultivar Ika (4.9 g/kg) and highest potassium in cultivar Podravka (6.2 g/kg). This data resulted in highest basic fertilization value (2.57; 2.53 and 2.47) for cultivars Podravka, Ika and Tisa (respectively). However, among mentioned cultivars weren't significant differences in basic fertilization values. Significantly lower basic fertilization values were determined for cultivars Neoplanta (2.00) and Vita (1.40), mainly because of very low phosphorus concentrations (Table 3). Analysed straws could have some additional basic value in case of favourable C/N ration and/or high micronutrient content. But, there weren't determined any additional values connected to C/N ration since it ranged from very high 81 (Vita) to even higher 133 (cultivar Tisa). The C/N ratios were too high considering foreseeable biological nitrogen fixation during straw decomposting, but these would be presumably neutralized by mineral nitrogen in soil fixed by symbiotic bacteria during soybean vegetation. Relatively high concentrations of analysed micronutrients (Fe, Mn, Zn and Cu) in soybean straw of all the cultivars resulted in addditional fertilization value (2.0). Finally, total fertilization index was calculated by adding additional fertilization values (2.0) to basic fertilization value (in range 1.40 to 2.57) resulting in fertilisation indexes in range 3.40 (Vita cultivar) to 4.57 (Podravka cultivar), out of possible value 10. Determined basic fertilization values were in average 10-60 % lower than fertilization value of fresh cattle or horse manure, and additional fertilization value were 10% lower to 100% higher than fresh cattle or horse manure. However, average fertilization values of soybean straws were at the level of fresh cattle manure (cultivar Vita), or 25-35% higher (other cultivars). The fertilization values of soybean straw were up to 40% of fertilization value of composted pig manure.

Tab.1: 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
Ashes	%	3,16	2,08	2,60	3,43	2,75
Volatile matters	%	71,17	73,46	71,73	70,69	71,95
Combustibile 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 combustibile	%	0	0	0	0	0
Sulphur bound	%	0	0	0	0	0
Lower heating value	MJ/kg	16,99	16,85	17,07	16,785	16,64
Volatile matters without humidity and ashes	%	80,68	82,13	80,54	80,13	81,02

Tab. 2: An average value for the biomass and for the equivalents other fuels for the soybean cultivars

Cultivar	Mass kg/ha w_1=20%	Energy value MJ/ha w_2=20%	MJ/ha η= 80%	Natural gas equivalent Nm^3/ha	Liquid light fuel equivalent kg/ha
Ika	2731,794	46421,37	37137,10	1043,00	882,60
Neoplanta	3394,475	57217,27	45773,82	1285,56	1087,86
Tisa	3585,619	61206,51	48965,21	1375,19	1163,71
Podravka	2997,015	50304,90	40243,92	1130,25	956,44
Vita	2850,794	47448,61	37958,89	1066,08	902,13

Tab. 3: Average value of nutrient concentrations, C/N ration and fertilization indexes for the straw biomass of soybean cultivars

Cultivar	N (g/kg)	C/N	P (g/kg)	K (g/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Fert. Index
Ika	4,1	100	4,9	4,3	155	6,2	5,7	3,6	4,53/10
Neoplanta	3,2	128	1,5	4,2	180	6,7	4,2	2,6	4,00/10
Tisa	3,1	133	2,0	5,4	224	7,2	7,4	4,4	4,47/10
Podravka	3,8	109	2,9	6,2	109	5,9	6,5	5,5	4,57/10
Vita	4,8	81	1,0	2,8	147	6,5	3,8	3,5	3,40/10

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.When 80% of soybean straw was used the best results based on a one-year average value were achieved by Tisa cultivar with 48.97 GJ/ha or the equivalent of 1375,19 Nm^3 of Natural gas or 1.16 t/ha light liquid fuel; the result for the Neoplanta cultivar with the exploitation of 80% of straw was 45,77 GJ/ha, which is an equivalent value of 1285.56 Nm^3 of natural gas or 0.87 t/ha of light liquid fuel; the Podravka cultivar had an energy value of 40.243 GJ/ha, which is an equivalent value of 1130.25 Nm^3 of methane or 0.96 t/ha of liquid light fuel, the Ika cultivar has an energy value of 37.137 GJ/ha, which is an equivalent value for 1043.00 Nm^3 of methane or 0.882 t/ha of liquid light fuel, and the Vita cultivar had an energy value of 37.96GJ/ha, which is an equivalent value for 1066.08 Nm^3 of methane or 0.902 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.

2. 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 firebox 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.

3. The fertilization value of analysed soybean straw were on the range of fresh cattle or horse manure, or up to 40% of fertilization value of composted manures. The positive properties of straws were micronutrients and nitrogen contents, potassium and phosphorus were depended on cultivar and not favourable properties was C/N ratio.

4. 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 and efficient fertilizer.

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