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Assessment of Conditions and Experience for Plantation of Agro-Energy Crops on Degraded Agricultural Land in Serbia

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Abstract**—**The potential of biomass as a renewable energy source leads Serbia to be the top of European countries by the amount of available but unused biomass. Technologies for its use are available and ecologically acceptable. Moreover, they are not expensive high-tech solutions even for the poor investment environment of Serbia, while other options seem to be less achievable. From the other point of view, Serbia has a huge percentage of unused agriculture land. Agricultural production in Serbia languishes: a large share of agricultural land therefore remains untreated, and there is a significant proportion of degraded land. From all the above, biomass intended for energy production is becoming an increasingly important factor in the stabilization of agricultural activities. Orientation towards the growing bioenergy crops versus conventional crop cultivation becomes an interesting option. The aim of this paper is to point out the possibility of growing energy crops in accordance with the conditions and cultural practice in rural areas of Serbia. First of all, the cultivation of energy crops on lower quality land is being discussed, in order to revitalize the rural areas of crops through their inclusion into potential energy sector. Next is the theme of throwing more light on the increase in the area under this competitive agricultural production to correct land use in terms of climate change in Serbia. The goal of this paper is to point out the contribution of the share of biomass in energy production and consumption, and the effect of reducing the negative environmental impact.

Keywords**—**Agro-energy crops, conditions for plantation, revitalization of rural areas, degraded and unused soils.

I. Introduction

ENERGY crops are increasingly gaining in importance around the world, in response to the need to reduce the amount of harmful gases in the atmosphere and mitigate the consequences of greenhouse effects [1]-[4]. Biomass as a source of energy, and it is similar to renewable energy sources such as water, solar energy, or wind. It is considered carbon-neutral because it does not release additional CO_2 [5], [6]. The main incentive for developing bioenergy crops was achieved through the adoption of the Kyoto protocol on climate change and reducing gas emissions and the greenhouse effects in 1997[7], [8]. Serbia has ratified this Agreement in 2008.

The current status of the sector of renewable energy sources in Serbia is referred to as a category of unused [1], [9], although Serbia has good potential for the development in this field [10]. One of the key moments in the development of renewable energy sources was the adoption of the action plan for biomass (2010) by the government of Serbia [11], which defines activities that will contribute to the use of biomass as a renewable energy source, followed by the national action plan for renewable energy of Republic of Serbia (2013), which sets targets for the use of renewable energy sources by 2020 [12].

Agriculture in Serbia is characterized by a large share of agricultural land which is not being cultivated. Also, the proportion of degraded agricultural land is not negligible. The production of energy crops may become an important factor in improving the socio-economic situation in rural areas. Although the rapid development and expansion of these crops is under harsh criticism and doubts in its validity and economic feasibility [2], the last two decades have been marked by establishing a large number of plantations in the Western European countries, while this trend has been increasingly expanding into the region of Eastern Europe and the Balkans [13].

The aim of this study is to evaluate the possibilities of growing agro-energy crops under the conditions and agro-technology in rural areas of Serbia. First of all, the cultivation of energy on lower quality land is being discussed, in order to revitalize rural areas through their inclusion in the energy sector.

II. Materials and Methods

This paper presents a general analysis of the Miscanthus plantations (*Miscanthus* × *giganteus*). They were selected because they have given good multifunctional results on the European continent.

For the purposes of the research, research was done on the plantation of 5 ha on degraded agricultural land in the village Noćaj (Sremska Mitrovica, Serbia), the experimental production of *Miscanthus* × *giganteus* in the experimental plot of 0.05 ha in Vršac (Serbia) in the framework of the Ministry of Education, Science and Technological Development, No TR 31078, and the production in the experimental plot in Pčinj (Serbia).

A comparative analysis of the experiences throughout the countries of Western Europe, according to available literature data, was used.

The potential of growing this crop in Serbia was assessed, compared to available less suitable farmland and climate factors.

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III. Results and Discussion

A. The Condition of Renewable Energy Sources Sector in Serbia

Hit by a delay in maintenance, investment and war activities throughout the last decade of the 20th century, the energy sector in Serbia is characterized by a high share of energy from non-renewable sources of energy and very high energy inefficiency. Manufacture of electrical and thermal energy takes place still in the high percentage of plants that are characterized by a relatively high level of emissions of greenhouse gasses [2].

According to the research on woody biomass due to the methodology FAO, the estimated total potential of biomass in Serbia is 3,389,223 toe [10], of which around 1.1 Mtoe is already used while 2.3 Mtoe is unused [12]. The gross final energy consumption shares of thermal energy from biomass in 2009 was around 11.5%, while the planned growth by the year 2020 is at 17.5%. [12].

In terms of energy, the most exploited is woody biomass. It is an important source of energy for individual households, on the other hand, unplanned exploitation has produced a number of landslides and erosion areas. A very important source of biomass is plant biomass in agriculture, especially plant residues from plant, fruit and grape production, but the energy crops increasingly gain in importance, particularly on limitedly suitable or degraded agricultural land.

B. Energy Crops

According to the modern agronomic classification, energy crops represent a new group of field crops, which would be a response to the need to reduce a number of harmful gasses in the atmosphere [14] and mitigate the consequences of the greenhouse effects. Productive organs of these plants, usually above ground biomass, emit into the atmosphere, by burning, less harmful gasses than fossil fuels [15].

As energy crops are most commonly used wild or cultivated perennial grass family representatives, which during one-year and multi-year lifecycle form large aboveground biomass. Produced biomass is used for energy purposes in several ways, such as solid fuel, whole or in the form of briquettes [2], [8]. Since biomass is rich in nitrogen-free extractive substances (NFES), it is used for the production of bioethanol. Although these plant species grow as wild, most of them after the selection and breeding in accordance with certain procedures, are adapted for commercial production. In highly developed countries of the world, these kinds occupy larger and larger areas, exclusively on soils that are not suitable for intensive arable production. This type of crops requires minimal energy for its production and use [16]; systems of cultivating crops for biomass must have low energy inputs compared to the outputs.

According to the research in Western Europe for the production of bioenergy, the best results were given by the species Miscanthus (*Miscanthus* × *giganteus* Greef et Deu), a plant that is characterized by high photosynthetic activity. It comes from Asia, and in the 30s of the twentieth century [17], it was brought to Europe from Japan. A sterile hybrid, horticultural genotype *Miscanthus* × *giganteus* Greef et Deu, was singled out by Axel Olsen in 1935, noting its very strong growth [18].

Main characteristics: High yield potential per hectare (experiments conducted in Northern Europe since 1983 have shown the capacity for high yields of over 20 t of dry weight ha-1 per year) [8], the net energy yield ranges from 152 to 326 mg/ha per year [2], require only a cultivation activity - preparation for planting, during the term (10-20 years) the inputs of nitrogen (N) are minimal[19], [20], it can be grown on degraded soils [21] and soils below the power lines, after 2-3 years it can be replanted from rhizomes[2].

C. The Assessment of Conditions for the Development of Energy Crop Plantations

In terms of energy crops growing, views on expansion, i.e. the takeover of agricultural land for the production of energy crops, are divided, as this will reduce the surface area of food production so it is being increasingly worked on the research of this type of cultivation of field crops on less favorable or degraded agricultural land.

Land in the Republic of Serbia is very diverse as a result of the great heterogeneity of the geological structure, climate, vegetation, and micro-fauna. About 55% of agricultural land is made of the land which is generally not suitable for processing or can be processed with significant limitations.

As for the data on the quality of land in Serbia (excluding Vojvodina) degraded land can be considered as first class land and it includes about 29% of the territory, mainly agricultural land [22]. In Vojvodina, in recent decades, there has been a negative trend of humus content in the soil, but the most critical are the regions of Srem and South Bačka.

A large part of the arable land is acidified (more than a quarter of the surface), as a result of the uncontrolled use of chemicals, while in Vojvodina part of the surface is also salinized (14%).

According to the census of agriculture 2012 in the Republic of Serbia [23], the total agricultural land covers a total of about 5 million ha, of which less suitable farmland covers 242,000 ha. The estimated area of unused agricultural land is about 424,000 ha - of which about 7% of the arable land.

Total utilized agricultural land in Serbia is 3,355,859 ha (1,598,065 ha in Vojvodina) of which 2,816,424 ha is owned by family holdings (1,174,142 ha in Vojvodina). The largest share is of the fragmented agricultural holdings (47% and 2 ha), holdings of 2-5 ha account for 29% and more than 5 ha to 34%. On the territory of Vojvodina is conducted intensive agricultural production with the dominant sowing areas under maize and wheat (1.5 million ha). In Central Serbia, maize is also a present sowing unit; however, unlike the territory of Vojvodina, in central Serbia, there is a large share of abandoned agricultural areas that are potentially interesting areas for planting energy crops [10]. Most abandoned or unused agricultural land is in Districts Pčinja and Pirot, but limitations could be due to the altitude and climatic factors.

In the last decade, there has been a significant increase in plantation establishment of agro-energy crop *Miscanthus* × *giganteus*: about 8,000 ha in Poland, about 6,000 ha in Austria, in Germany 40,000 ha, 20,000 ha in France, in Romania over 10 plantations have been established since 2007. In the UK, according to available reports, 12700 ha is planted with this plant [8].

In the Republic of Serbia, the plantations are established on degraded agricultural land (5 ha) in Noćaj (Sremska Mitrovica) [2], [24] and 2 ha in Paraćin [2], non-degraded agricultural land in Vršac (0.5 ha) [25].

D.Economic Viability

Costs are in function of local and individual operating conditions, but production technology and items that produce costs are known and exact.

The establishment of 1 ha of Miscanthus crop is about 2,500 € in the first year [2]. The crop lasts up to 20 years [26], of which 15-18 years of utilization. The main phase of biomass exploitation is 15 years of the vegetative period [1-2], [4], [27]; a highest yield of biomass achieved at the age of 6-8 years [28].

Regarding the yield per hectare for Miscanthus, according to literature data the maximum yield in the fall is from 10-30 t/ha per year [29]. On the plantation in Noćaj (Sremska Mitrovica), established on degraded agricultural land (5 ha), the biomass yields in the fourth year amounted to 16.83 t/ha. Savings are reflected in the cost of replanting. The purchase price of biomass in the current market conditions is about 60 €/t.

In addition to the above parameters relating to the planting and purchase of biomass, we should not neglect the production of planting materials (rhizomes). Calculations carried out in the case of Miscanthus show that one of planted middle-class rhizome, after the third year, on average, develops to 50 new rhizomes (on degraded land with less available moisture to 30-40, on non-degraded land with enough available moisture to 60-70 quality rhizomes). Prices range of rhizomes goes from 0.15 to 0.17 €.

E. Climatic Conditions for the Optimal Development of Miscanthus

In terms of the optimal conditions, late spring frosts are not appropriate for this plant, the optimum temperature at which growth begins is 6 °C [30] that means the annual temperature which does not exceed below 7 °C.

Serbia has a moderate continental climate. There are three climate areas: continental, moderate continental and altered Mediterranean. The average annual temperature for the area with the altitude up to 300 m is 10.9 °C, and for areas with an altitude of 300 m to 500 m around 10.0 °C.

Establishing plantations on an area of over 700 m above sea level and areas with a large number of snow days is not recommended for the optimal growth and yield.

IV. Possibilities for Rural Areas

On a significant number of abandoned and degraded agricultural areas that are fragmented and held by households it is possible to establish energy crops, which will improve the socioeconomic status of local farmers.

Rural areas in a large percentage are characterized by a reduction in population and the increasing proportion of uncultivated land, i.e. drastically reduced agricultural activity. Orientation towards bioenergy crops growing versus conventional crop cultivation becomes an interesting option.

For fragmented farms (up to 2 ha) - the previously derived indicators may be an uninteresting option if the household dominantly chooses only the cultivation of energy crops without an extensive network of purchase, and dominantly only in this segment. However, as a supplementary activity for agricultural farms, on reduced fertility soil, limited suitable or abandoned possessions of up to 500 m above sea level, the depopulation of the area could be stopped and agricultural farms could be revitalized. In addition to using it as an energy source, *Miscanthus* × *giganteus* can be used to obtain a wide range of products such as paper pulp, building materials, geotextiles, fiberboard, cellulose derivatives, and others [1].

Large areas in Srem and Bačka are in the category of degraded agricultural land, but farmers increasingly only maintain the existing balance in the atmosphere of general economic crisis and the inability to cope with all the problems of modernization and competition in the market. Considering the fact that perennial plantings require minimal maintenance and investment, it is absolutely justified to consider the repurposing of certain areas or crops on a limited suitable land.

The evident climatic changes should be taken into consideration. On average, temperature in Serbia has increased from 1951 to the present day about 1.4 °C. According to climate scenarios for Southeast Europe by 2070, the increase of the average temperature is about 2.4-2.8 °C [31], and changes in the distribution of precipitation are expected [32]. The increase in temperature is not a limiting factor for the development of this energy crops, but the re-arrangement of rainfall may affect the need for additional irrigation.

V. Conclusion

Bearing in mind the objective to increase the share of energy use from biomass, especially in the heating and cooling sector, the development agro-energy crops plantations would provide a significant contribution.

On a significant number of abandoned and degraded agricultural areas that are fragmented and in the private possessions, it is possible to establish energy crops, which will improve the socioeconomic status of local farmers, the revitalization of rural areas and their integration in the energy sector.

One of the important functions of growing cultures of this type, except the production of biomass as a renewable and environmentally friendly energy source, is that these are alternative "agricultural" cultures, which allow putting into

function the available land on which cannot be grown food, or where food is not grown. Also, opportunities for soil remediation are being opened, and significant contribution is in binding the increased amounts of atmospheric CO_2 and the reduction of greenhouse gas emissions.

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REFERENCES

[1] N. Babović, G. Dražić, A. Đorđević, Possibilities of using biomass originating from Miscanthus×giganteus, *Hem. ind*. 66 (2) 223–233 (2012).
[2] S. Djordjevic, D. Cvetkovic, I. Radanović, J. Ikanović, B. Pavlović, Perspectives of development and spreading of bioenergy crops, *Ecologica*, 20 (2013) pp 400-104.
[3] J. P. McCalmontT et al., Environmental costs and benefits of growing Miscanthus for bioenergy in the UK, *GCB Bioenergy* (2015), aviable on http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12294/pdf
[4] P. McKendry, Energy production from biomass (part 1): overview of bio mass , *Bioresource Technology* 83 (2002), pp 37–46.
[5] G. Hoffmann, D. Schingnitz, A. Schnapke, B. Bilitewski, Reduction of CO(2)-emissions by using biomass in combustion and digestion plants, *Waste Management,* Volume 30, Issue 5 (2010), pages 893–901
[6] L. Gustavsson, P. Börjesson, B. Johansson, P. Svenningsson, Reducing CO2 emissions by substituting biomass for fossil fuels, *Energy* 20(11) (1995), pp 1097-1113.
[7] Z. Dzeletovic, G. Drazic, Dj. Glamoclija, N. Mihajlovic, Miscanthus – European Experience with a Novel Energy Crop, *PTEP 1450-5029* (2007) 11; 1-2, pp 66-70.
[8] Ž. Dželetović., Dj. Glamočlija, The economic importance of growing Miscanthus, *Agricultural Engineering* (2011/2), 61-68.
[9] M. Golusin, Z. Tesic, A. Ostojic, The analysis of the renewable energy production sector in Serbia. *Renewable and Sustainable Energy Reviews,* Vol. 14(5) (2010), pp 1477-1483.
[10] B. Jovanović, M. Parović, "*Status and development of biomass in Serbia*", Jefferson Institute, 2009.
[11] Conclusion for Biomass Action Plan 2010-2012 Adoption, *Official Gazette of Republic of Serbia* No 56/2010.
[12] National Action Plan for the use of Renewable Energy Sources in Serbia, 2013, The Ministry of energy, development and environment
[13] Ž. Dzeletovic et al, Prospects of using plants as bioenergy crops, *Aagricultural engineering*, Year XXXII, (2007/3), pages. 59-67.
[14] Ž. Dzeletovic, G. Drazic, S. Blagojevic, N. Mihajlovic, Specific agro-technical conditions of growing Miscanthus, *Agricultural Engineering,* Year XXXI, Volume 4, December, 2006.
[15] I. Lewandowski, "*Produktion von Energiegräsern und-getreiden: Möglichkeiten und Grenzen der Produktion von biogenen Festbrennstoffen am Beispiel von Miscanthus*", Rohrglanzgras und Wintergetreide. Habilitation Institut fuer Pflanzenbau und Gruenland, Universität Hohenheim, 200, 162 pp.
[16] S. Nonhebel, Energy yields in intensive and extensive biomass production systems. *Biomass and Bioenergy*, 2002, vol. 22, No. 3, pp 159–167.
[17] I. Lewandowski, J. Clifton-Brown, M.O. Scurlock, W. Huisman, Miscanthus: European experience with a novel energy crop, *Biomass Bioenerg*. 19(2000), pp 209–227.
[18] L. Laursen Cytogenetic analysis of Miscanthus 'Giganteus', an interspecific hybrid, (1993) *Hereditas* 119:297–300.
[19] D. Christian, A. Riche, A Nitrate leaching losses under Miscanthus grass planted on a silty clay loam soil. *Soil Use and management*, 14(1998), pp 131–135.
[20] S. Jankovic, Dj. Glamoclija, S. Prodanovic, Energetski usevi - Tehnologija proizvodnje i prerade, *Institut za primenu nauke u poljoprivredi* (2015).
[21] G. Drazic, Agro-energy Crop, in Ecoremediation Of Degraded Areas through Miscanthus Plantation Establishment, Singidunum University, Faculty of applied Ecology Futura, (2014), pp 16-31
[22] G. Dražić, Degraded land resources of the Republic of Serbia, in Degraded areas of the Republic of Serbia, Faculty of applied ecology Futura, Belgrade, 2010, pp.35-48.
[23] Statistical Office of the Republic of Serbia, 2013, Census of Agriculture 2012 in the Republic of Serbia, First report.
[24] A. Vitas, Experimental field trial with the type of *Miscanthus* × *giganteus* on location Zasavica, in Ecoremediation of Degraded Areas through Miscanthus Plantation Establishment, Singidunum University, Faculty of applied Ecology Futura, (2014), pp 118-138
[25] M. Arandjelovic, Impact of abiotic and biotic factors on morphological characteristics of the experimental field of miscanthus in Vrsac, in Ecoremediation of Degraded Areas through Miscanthus Plantation Establishment, Singidunum University, Faculty of applied Ecology Futura, (2014), pp 94-117
[26] Ž. Dželetović, J. Maksimović, I. Živanović, Yield of Miscanthus×giganteus During Crop Establishment at two Locations in Serbia, Journal on Processing and Energy in Agriculture 18 (2014) 2 1821-4487; p 62-64
[27] M. Jakovljevic, et al., Biomass Production as Renewable Energy Resource, Thermal Scinence Vol. 19, No. 3, (2015), pp. 823-835
[28] G. Dražić, N. Mihailović, Ž. Dželetović, B. Stevanović, J. Šinžar, *Miscanthus Giganteus – The Basis of New Bioenergetic Fuel, in 2007 Book of paper. 13th Symposium on Thermal Science and Engineering of Serbia*, pp 131-134
[29] J.C. Clifton-Brown, B. Neilson, I. Lewandowski, M.B. Jones, The modelled productivity of *Miscanthus* × *giganteus* (GREEF et DEU) in Ireland, *Industrial Crops and Products*, vol. 12, Issue 2, August 2000, pp 97–109.
[30] DEFRA, "*Planting and growing Miscanthus*". Best Practice Guidelines (for Applicants to Defra's Energy Crops Scheme), Rural development programme, England, 2007. http://adlib.everysite.co.uk/resources/000/023/838/miscanthus- guide.pdf (online Oct 2012).
[31] S. Đorđević et al., *Adaptation of agricultural land based on Regional climate models*", *in 2013 Conference proceedings, Scientific-technical Conference Environmental protection between Science and Practice - Status and perspectives*, pp 413-422.
[32] T. Popović et al., "Climate changes in Serbia and expected impacts", *in 2009 Proc. V Regional Conference "EnE09 – Environment to Europe"*,pp 12-18.