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SPANISH CANE PRODUCTION IN THE FUNCTION OF CIRCULAR ECONOMY AND RENEWABLE ENERGY SOURCES

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Abstract

In recent years many countries direct their researches to finding the best way for getting energy and reasonable using of renewable energy as part of circular economy. In research it was analyzed a significant source of all forms of energy, the Spanish cane. Spanish cane can be used on many ways: as biogas, vegetable coal, and as an alternative source of plant fibers. Its cellulose fiber is used for production of paper as well as in the textile industry (substitute for cotton, flax, and kenaf fibers). The Spanish cane can be established as perennial grass areas at degraded and unused land due to its ability to be cultivated in marginal agro-ecological conditions. By development of new technologies for the biological waste processing into energy, within the circular economy, there is increase in the alternative fuel use and, thanks to its low requirements for water and warmth Spanish cane is a desirable energy crop. Speaking of erosion, it has to be mentioned that Spanish cane is one of the best crops for soil protection against all types of erosion. It is also very good in phytoremediation and absorption of harmful gases from the atmosphere, valued in as an ornamental plant and in the construction industry.

Key words: *renewable energy sources, circular economy, Spanish cane as energy crop, biofuel and biogas, phytoremediation.*

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Introduction

Throughout its long history, European, African, and Asian peoples have used Spanish cane for various purposes. The growing interest of producers and processors was also influenced by the fact that above-ground biomass is an excellent source for obtaining biofuels. Spanish reed belongs to the group of plants of the C3 pathway of photosynthesis. Recently it is used as a raw material in numerous industrial branches, it is interesting for processing in small businesses and home crafts. Spanish reed is used for phytoremediation, and absorption of harmful gases from the atmosphere. It is among the best crops for soil protection against all types of erosion and valued as an ornamental plant Ahmed et al. (2011). Spanish cane is grown for above-ground biomass, which is used in further processing as fresh or dried trees. According to the method of use, the method and time of product collection are determined. When for the production of bio-ethanol is use above-ground biomass it is mowed in the phenological stage with silo harvesters. The mowed biomass, which was cut by the forage harvesters to a length of about 10 cm, is inserted by conveyor belts into the means of transport and taken directly to further industrial processing. Two swaths can be obtained during the year, only if the conditions of the external environment are very favorable (long growing season) Hardion et al. (2016).

In our agroecological conditions, Spanish cane for obtaining biofuel from fresh biomass would be cut once a year, in the second half of August. After mowing, the plants regenerate and, through photosynthetic activity, provide assimilates necessary for the life functions of underground trees and roots Janković et al. (2017).

In our agroecological conditions, Spanish cane for obtaining biofuel from fresh biomass would be cut once a year, in the second half of August. After mowing, plants regenerate and, through photosynthetic activity, provide assimilatives necessary for the vital functions of underground trees and roots. If the goal of production is dry above-ground trees, they are cut during the winter, usually in February. Mowing is done with rotary tractor mowers or machine aggregates that tie the mowed biomass into bundles. Winter mowing is the most favorable because the leaves have already fallen and the water content in the trees is about 30%. After a short drying in the field, the bundles are transported and stacked in covered rooms, canopies protected from precipitation. Further drying processes continue in dry rooms. Dry trees are used as solid biofuels in large boiler plants, for example in thermal power plants, then to obtain cellulose, as well as in other industrial branches Ball et al. (2006).

Finally, it should be noted that this is not a new and little-known plant species. Developing for centuries throughout the American continent, the Spanish reed showed an efficient way to synthesize a large amount of useful and usable organic substances from the available water and mineral salts from the soil through its metabolic C3 pathway.

A more modern way of using Spanish cane in construction is the use of woody mass, as an adhesive material for the production of chipboards and plywood, which are used for the production of numerous household appliances, and more recently, furniture. The world-famous company IKEA plans to reorient itself to “green technology” by 2030 and to replace wood with alternative building materials originating from annual cultivated plants Lambert et.al. (2010); Glamočlija et al. (2022).

Aim of this research was analyzing of the possibilities of using Spanish cane, which is grown for biomass, which is a raw material in numerous industrial branches and is interesting for processing in the small economy and at home. It is rich in carbohydrates, which can be used in many ways, including for obtaining biofuel. Due to these properties, as well as the fact that it has negligible nutritional value, today it is predominantly used to obtain biofuels and is considered one of the most important energy crops of the third generation. Of biomass are produced solid, liquid, and gaseous fuels in a realistic, efficient and clean way, and as such it presume a renewable source of energy. The term “biomass energy” means energy products obtained from organic matter (plant, animal, or microbial origin). Gao et al. (2012) said that for insurance of necessary energy sources supply, most countries in the world are, in their research, tried to find the most rational way of using renewable energy sources Gao et al. (2012).

Material and Method

The research analyzed the use of Spanish cane as a significant source of renewable energy, in the function of the circular economy: biofuel production; construction and pulp industry; home industry and soil remediation.

Results and discussion

The above-ground biomass of Spanish cane is of low nutritional value. The content of useful nutrients depends on the age of the plants. Determining the chemical composition of Spanish cane stems and leaves, it can be concluded that it has a

low nutritional value Ahmed et al. (2011). According to the data of a number of authors, the nutritional value of above-ground biomass as fodder is not significant, except for the higher content of phosphorus salts (table 1).

Table 1. Nutritional value of Spanish cane (%)

Nutritious substance	Young plants	Wandering	Ripe plants	
	Stem	The leaves	Stem	The leaves
Total proteins	8.13	12.25	5.94	8.88
Digestible proteins	1.50	1.96	0.63	1.10
Oil	2.2	1.9	3.0	2.2
Carbohydrates	20.0	20.7	23.2	21.7
Alpha-cellulose	54	52	54	53
Hemicellulose	32	28	36	35
Lignin	5.8	3.5	8.2	7.1
Mineral salts	3.80	4.55	3.30	3.82
Potassium	3.09	3.19	2.04	2.42
Calcium	0.30	0.43	0.52	0,67
Magnesium	0.12	0.19	0.25	0.32
Phosphorus	0.11	0.16	0.08	0.11

Source data: *Ahmed et al.* (2011)

Fuel consumption in the past decades is constantly increasing, as is the number of inhabitants on the planet. As sources of energy, we use solar energy, which manifests itself in the following ways: hydropower, electric and thermal energy, then energy from the biosphere. The fourth form of energy is called bioenergy. It is created in the processes of photosynthesis in plants and is released by burning biological material. Today, bioenergy is a very important source of energy, which according to its origin can be non-renewable (solid, liquid, and gaseous fossil fuels) and renewable (biomass of agricultural and forest species, their remains, as well as all agricultural and municipal waste (Ikanović et al. 2022; 2023). Thanks to the very high annual yields of above-ground biomass rich in cellulose and without a significant share of undesirable compounds, Spanish cane is today among the most important energy crops. The annual increase in biomass can be used for heating in the household, as well as for industrial energy needs because it can be used in several ways to convert into heat and electricity. Spanish reed achieves a dry weight yield of 50-80 tons per hectare. To these facts should be added the possibility of cultivation in a wide geographical area, in different agroecological conditions, and with minimal investment in production technology

(Janković et al. 2017). The simplest way of using biomass as an energy source is the burning of previously baled dry trees in large boiler plants of thermal power plants. For this method of use, dry biomass is cut with silo harvesters and pressed into round bales weighing 600-800 kg, which are stored next to the point of consumption Schmer et al. (2008). The fact that the Spanish reed, with minimal agrotechnical investments during the annual cycle, forms the highest yield of above-ground biomass attracted the special interest of scientists. It is rich in carbohydrates, which can be used in many ways, including for obtaining biofuel, Pictures 1-2. Due to these properties, as well as the fact that it has negligible nutritional value, today it is predominantly used to obtain biofuels and is considered one of the most important energy crops of the third generation.

Biodiesel is an alternative fuel available today which is prepared from vegetable oils and used in diesel engines. Diesel is clean, and efficient and is generated from renewable sources (Figure 1, Krstić et al. 2007).

Picture 1. Energy balance of biodiesel production (Krstić et al. 2007)

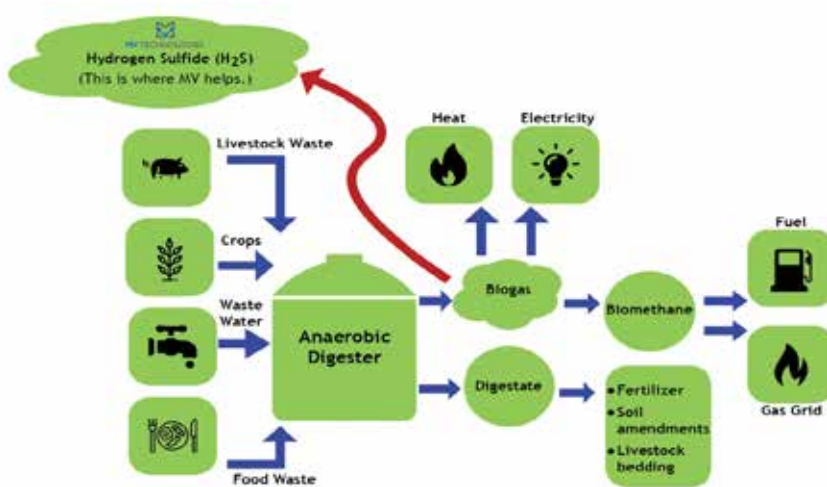


Picture 2. Spanish cane for biofuels,



Source: <https://www.facebook.com/photo/?fbid=440819259323489&set=trska-presovana-plocanad-preselt-tablavelicinameret-150m-x-080m>

Picture 3. The Environmental & Economic Benefits of Anaerobic Digestion - MV Technologies



One of important natural process is anaerobic respiration. Primitive organisms, including the oldest surviving bacteria use that process. Organic matter, by the anaerobic metabolism of bacteria release large amount of nitrogen, biogas methane, some of hydrogen-sulphide and organic solid and liquid residues. Hydrogen sulfide is toxic to humans and most other animals by inhibiting cellular respiration. (https://en.wikipedia.org/wiki/Hydrogen_sulfide). MV Technologies' systems help to remove the H₂S gas from the methane. Following this process, both the biogas and the remaining organic solids and liquids can be used in multiple ways, presenting both environmental and economic benefits (Picture 3, Dražić et al. 2019; Rakašćan et al. 2021; Popović et al. 2020;

2023; Rakić et al. 2023). Although this function is useful in microbiology and the oil industry, excessive production of methane is a problem because it is as large a greenhouse gas as carbon dioxide, linked to climate change.

Anaerobic digestion is a naturally occurring process. In the absence of oxygen, bacteria break down organic materials and produce biogas. The process reduces - or digests - the amount of material, producing biogas as a byproduct. This biogas can then be used as an energy source. The anaerobic digestion process occurs in three steps. First, plant or animal matter is decomposed by bacteria into molecules, such as sugar. The decomposed matter is then converted to organic acids, which are then converted to methane gas (biogas). The by-products of the process include methane gas and organic solids and liquids and small amounts of hydrogen sulfide (H₂S) gas. MV Technologies' systems help to remove the H₂S gas from the methane. Following this process, both the biogas and the remaining organic solids and liquids can be used in multiple ways, presenting both environmental and economic benefits (Picture 3, Dražić et al. 2019; Rakašćan et al. 2021; Popović et al. 2020; 2023; Rakić et al. 2023).

If the wood mass is used for combustion in smaller plants (boilers for floor heating of residential and commercial spaces), it is first chopped and then briquettes are made from it, for larger boilers or pellets. The thermal power of these energy sources is similar to the same wood products. Pellets have a high absorbent power and can be used as a mat in barns and boxes for pets.

A more modern way of using Spanish cane in construction is the use of woody mass, as an adhesive material for the production of chipboards and plywood, which are used for the production of numerous household appliances, and more recently, furniture. The world-famous company IKEA plans to reorient itself to “green technology” by 2030 and to replace wood with alternative building materials originating from annual cultivated plants Lambert et al. (2010), Picture 4.

Picture 4. Spanish cane furniture



Source: <https://indizajn.rtl.hr/inspiracija/noviteti/povratak-trske-ali-spanjolske-imamo-ide-je-koje-ce-vas-osvojiti/>

In the modern industry of musical instruments such as bass, clarinet, oboe, saxophone, bassoon, bagpipes, flute and other instruments with wooden parts, Spanish reed trees are used for their manufacture today. The best raw material is obtained from plants from the area of Attica.

The Romans used trees to make writing pens. In addition, it was used to make fishing rods, then as a support for annual and perennial climbing plants (legumes, decorative plants, vines and the like).

The plantings (crops) based on the sloping sides of watercourses form a strong stand with powerful roots and rhizomes, which provide a solid ice, preventing soil particles from being washed away during periods of bank flooding. In areas with pronounced periodic air currents during the summer and autumn, the density of Spanish reeds softens wind blows and prevents fine soil particles from being carried away. After studying vertical wind gusts in the plant's natural habitat in southern France, Speck et al. (2003) concluded that Spanish reed can withstand strong wind gusts without major mechanical damage.

According to soil conditions, it is very tolerant, it also succeeds in conditions of increased concentration of arsenic, cadmium and lead. By absorbing these elements and depositing them in the underground organs of the rhizome, the Spanish reed exhibits a significant potential for phytoremediation and is recommended for cultivation in conditions of increased soil and groundwater

contamination. This method of remediation is recommended on forbidden surfaces, in canals with waste water, as well as in hydroponic production if the water is contaminated with heavy metals Spencer et al. (2006).

Conclusion

Spanish cane as an autochthonous species in the wide Mediterranean and hinterland, is one of the most promising crops for the production of bio-fuels of this area, where it has already shown its production values. Based on the fact that growing Spanish cane yields much higher raw material yields per hectare than corn, it provides 1.5 times more of this energy source and excludes the use of this important food grain for energy purposes. It should also be noted that the production costs of Spanish cane are about 50% lower than maize.

Spanish cane provides opportunities that, on degraded and unused lands establish perennial grass areas, thanks to its low need in water and warmth. Therefore, it is recommended to establish grass areas next to roads, industrial and livestock buildings, i.e. areas that are major polluters of the atmosphere.

Beside its important role in erosion protection, Spanish cane is one of the best crops for phytoremediation, absorption of harmful gases from the atmosphere, and valued as an ornamental plant. It is rich in carbohydrates, which can be used in many ways, including for obtaining biofuel. Due to these properties, as well as the fact that it has negligible nutritional value, today it is predominantly used to obtain biofuels and is considered one of the most important energy crops of the third generation. Biomass is a renewable source of energy that is used to produce solid, liquid and gaseous fuels in a realistic, efficient and clean way.

In our agro-ecological conditions, the production of Spanish cane can be profitable because it can be grown on lands that are less fertile. Serbia is at the very top of European countries as per amount of available and unused biomass which represents largest renewable source of energy. Technologies for its use are available and environmentally acceptable. This fact could possibly serve as a practical recommendation for the cultivation of Spanish cane for energy production and phytoremediation on poor soils.

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