VETIVER GRASS AS RECULTIVATION POSSIBILITY AND A NEW POTENTIAL ENERGY PLANT IN SERBIA

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Abstract: *Vetiver grass (Chrysopogon zizanioides), native to southern India, is a sterile, non-invasive plant that is propagated vegetatively by dividing the sod into smaller pieces. It is used in more than 100 countries for soil and water protection, infrastructure stabilization, pollution control, wastewater treatment, erosion protection, slope stabilization, weather damage prevention, and other environmental applications (through bioengineering and phytoremediation). The possibility of using this grass as a renewable energy source in Serbia is the main focus of the project, which was implemented in the period from 21.04.2021. until 29.12.2023. on test fields in Belgrade and internal landfill PK Drmno. This paper will present the results of the initial trials of growing vetiver grass in the changing climatic conditions of Serbia at locations with less valuable soil quality.*

Key words: VETIVER GRASS, BIOFUEL, EROSION, RECULTIVATION.

INTRODUCTION

Vetiver grass native to southern India, it is a barren, non-invasive plant. Propagated vegetatively by dividing the plant into smaller parts with about 3 shoots. It is used in more than 100 countries for soil and water conservation (Figure 1), infrastructure stabilization, pollution control, wastewater treatment, sediment mitigation and remediation, prevention of weather damage, and other environmental applications (through bioengineering and phytoremediation).

Figure 1, Worldwide distribution of active programs for vetiver grass [1]

The vetiver plant (Chrysopogon zizanioides), although classified as a grass, behaves more like a fast-growing tree or shrub for soil stabilization purposes. It has an extremely deep and massive finely structured root system that can reach a depth of 2 m to 3 m in the first year and 7 m in the second. Foreign experience has shown that vetiver reaches its maximum size in the third year from planting and can be up to 100 years old. The root system of vetiver can be used to produce oils and perfumes, while the leaves can be used as animal feed or biofuel. It grows in extreme soil types, regardless of nutrient status, Ph, acidity, acid sulfate or salinity, and toxic minerals. These include sand, shale, gravel, toxic soils and tailings. It can grow in a wide range of climates - from less than 300 mm of rain to over 6,000 mm - from temperatures from -15°C to more than 55°C and is able to withstand long droughts (> 6 months).

RESEARCH IN EUROPE

In the southern regions of the German state of Saxony-Anhalt, the usability of vetiver grass as a renewable energy source was examined in the period 2006-2007. Vetiver plants native to the USA (Texas), Australia and Japan were tested. All plants that have been tested are labeled as hardy to winter conditions. The study was carried out on different surfaces: open-pit mine dumps (reclamation areas) and natural alluvial soil of the Elster River. All soils differed greatly in terms of structure, nutrient content, that is, homogeneity. In a two-year trial, more than 25,000 plants were grown in two stages and at five sites. Within the framework of the implemented tests, the production of biomass, changes in the composition of leaves, the root system, the survival of vetiver during the winter were examined. Within the framework of the implemented tests, the production of biomass, changes in the composition of leaves, the root system, the survival of vetiver during the winter were examined. It should be noted that during the tests, the methane content in biogas estimated by gas chromatography was higher than expected [2].

The application of vetiver grass and its use for bioengineering have not previously been studied in detail north of the Alps. Research in Germany has shown that vetiver grass can be grown even under northern climates. The use and cultivation of winter-hardy crops is one of the important prerequisites for the successful implementation of the project. Growing conditions must be studied in more detail in different locations and soil textures. Global warming and climate change will offer new application opportunities for vetiver grass [2].

DESCRIPTION OF THE TESTS CARRIED OUT IN SERBIA

In the face of global warming and climate change, the aim of this pilot study is to study the growing conditions of vetiver grass on different soils and localities in Serbia. The aim of the study is to obtain information on the possibility of using this plant as a sustainable raw material resource for the production of biofuels. This paper will present tests of vetiver grass that were performed in the period from 21.04.2021 to 29.12.2023. The plant material that is the subject of this study was imported to Serbia from Spain and it is a sterile and non-invasive "Sunshine" version of the grass Chrysopogon zizanioides, also known as Vetiveria zizanioides.
The primary objectives of the investigation were to:

1. examine the possibility of survival and development of vetiver grass in the climatic conditions of Serbia,
2. determine the types of soil on which vetiver grass can survive and develop.
3. recognize vetiver grass as a biofuel in Serbia

For the purpose of the first phase of testing, 30 plants were imported from Spain, which were planted in different locations and soil types. Planting was carried out on the test fields located in the Mining Institute Ltd. Belgrade, Sunčani breg in Rakovica and the internal repository PK Drmno. A total of 16 plants were planted in different soil types at the Mining Institute Ltd. in Belgrade (Zemun municipality). Of these, 10 plants were planted in poor quality soil, 2 plants were planted in ash from the Central Kostolac Island (SKO), 2 plants were planted in tailings from the internal landfill PK Drmno and 2 plants were planted in ash from the TENT landfill in Obrenovac. In plastic bottles with water with a volume of 1.5 l, 5 plants are placed. Four of the plants died before they were planted. On the test field in the municipality of Rakovica, at the location of Sunčani Breg, 5 plants were planted on agricultural land. The plants were planted at the end of May and June 2021, and their observation lasted until the end of December 2023. During this period, the plants were photographed, the height of the plants, the air and soil temperature at a depth of 5 cm and 10 cm were measured using a penetration thermometer in the test field at the Mining Institute Ltd. and the climate parameters from the nearest meteorological station Surcin Airport were taken over - maximum, medium and minimum daily air temperatures and precipitation. Based on the collected climate parameters, it is possible to determine the amount of stress to which plants were exposed at different times of the year, especially in the winter months. In the summer months of 2021, watering the plants was carried out twice a week on the test field at the Mining Institute. No artificial or natural fertilizer was used.

At the end of November and December 2021, two plants were dug up, which were divided and whose pods were planted in eight pots and grown during the winter in the office of the Mining Institute at room temperature. At the beginning of July 2022, by dividing the cultivated plants, 25 stalks of vetiver grass were obtained, which were planted in the internal landfill of PK Drmno. Weight in grams of dry root and leaf was also measured. In September 2021, a chemical analysis of dry vetiver leaves was performed at accredited Laboratory for Solid Fuels of the Mining Institute in Belgrade,

which determined their upper heat output (kJ/kg), moisture content (%), ash content (%) and C, H, N, S content (Table 1).

Table 1, Results of chemical analyses of dry vetiver leaves

Sample	Content Moisture (%)	Higher heating value (kJ/kg)	Content Ash (%)	Content Carbon C (%)	Content Hydrogen H (%)	Content Nitrogen N (%)	Content Sulfur S (%)
Rakovica	6.67	16384	7.10	42.81	5.22	0.52	< 0.01
RI	5.13	15703	9.89	40.10	4.67	0.58	< 0.01
Rakovica 1	6.86	16272	7.00	40.89	5.56	0.75	0.33
Rakovica 2	7.83	16313	7.28	41.80	5.35	0.87	0.66
RI	9.00	16619	4.99	41.95	5.56	1.57	0.01
RI- Vetiver 7 12.8.2021.	1.08	16536	6.58	41.69	5.39	1.18	0.34
Note: The results in the table are expressed for the sample with delivery moisture.							

On the basis of the data presented in Table 1, the following can be concluded:

1. Dry vetiver leaves have the fuel quality parameters of mediocre lignite (slightly worse than Kolubara).
2. The differences in terms of quality as a fuel are negligible between plants grown in RI or in Rakovica.
3. The content of sulfur as an ecological parameter is quite low, and in this sense it is advantageous to use vetiver leaf as a biofuel.

Also, in accredited Laboratory for Solid Fuels of the Mining Institute in Belgrade, the chemical composition of various types of soil on which vetiver grass was planted was determined (Table 2).

*Table 2, Results of chemical analyses of soil samp*les

Sample	pH ISO 10390	Electrical conductivity SRPS ISO 11265	C % SRPS ISO 29541	H % SRPS ISO 29541	N % SRPS ISO 29541	Wa % ISO 5068-2
SKO-ASH	7.45	807	2.74	0.11	0.04	3.65
TENT- ASH	7.85	306	1.41	0.03	0.08	8.94
RI-SOIL	7.52	303	10.22	0.66	0.37	6.58
DRMNO-LENDFILL	7.0	1021	2.83	0.29	0.02	5.31
SAMPLE 1-RAKOVICA	7.30	362	5.16	0.66	0.44	4.88
SAMPLE 2-RAKOVICA	7.13	181	2.02	0.28	0.11	2.65

At the end of the 30-month observation period at the test field at the Mining Institute Ltd. in Belgrade, out of 15 plants planted in poor quality soil, ash and tailings, all survived. On the test field in the municipality of Rakovica, as a result of mowing the plants to the crown, they were damaged, so out of a total of 5 plants planted, only two remained. Vetiver plants planted at the beginning of July 2022 at the internal landfill of PK Drmno were destroyed by the work of mining machinery in November of the

same year, so the planting was repeated at the end of July 2023 with 25 seedlings at a new location.

The annual growth cycle of vetiver grass is shown in Table 3.

Table 3,The annual growth cycle of vetiver grass

Spring	Summer	Autumn	Winter
Growing new grass	The grass reaches its highest height	Drying of leaves	Mowing grass

Previous cultivation experience has shown that it must be taken into account that when mowing the grass, vetiver should be left 2-3 cm of the leaf above the soil surface. Planting a plant should be done during April when the soil temperature is more than 10 ° C. The crown of the plant should be buried 2-3 cm below the ground and watered with water. The plant should be planted in moist soil or irrigated for the first four months immediately after planting if there is no rainfall.

CONSIDERATIONS OF VETIVER GRASS AS A BIOFUEL

From the test field at the Mining Institute in Belgrade, on January 18, 2023 (18 months after planting), a total of 1.302 kg of leaf with natural moisture, or an average of 0.0868 kg of leaf per plant, was obtained from 15 plants. From the test field at the Mining Institute in Belgrade on January 18, 2024 (30 months after planting), a total of 10.134 kg of leaf with natural moisture, or an average of 0.6756 kg of leaf per plant, was obtained from 15 plants. If vetiver grass were to be planted on a plot of 1 ha, 40,000 seedlings would be needed at a distance of 0.5 m from each other. Based on the above data, after 18 months it is possible to obtain 3,472 t/ha of leaf biomass, while after 30 months from planting, 27 t/ha of leaf biomass can be obtained. The potential of vetiver as a biomass source can best be seen in Table 4, by comparing it with other energy plants.

Table 4, Characteristics of biomass products of energy crops [3]

Energy crops	Average annual yield t/ha	Theoretical energy output (GJ/ha)
Hibiscus cannabinus	10 - 20	155 - 326
Cannabis	5 - 15	128 - 270
Arundo donax	15 - 35	240 - 600
Miscanthus	15 - 25	260 - 440
Sorghum halepense L.	10 - 25	174 - 435
Populus	8 - 20	144 - 360
Betula sp.	10 - 15	178 - 276
Amorpha fruticosa L.	10 - 13	128 - 270
Vetiver	*27**	*373**
**30 months after planting*		

If vetiver leaves are used in the classic way as fuel for combustion in the boilers of power plants, then we can indicate the following forecast data: By drying 27 t/ha of vetiver leaf, 10-12% of the mass is lost, i.e. 23.76 t/ha of dry leaf is obtained. If the minimum value for the higher heating value is 15703 kJ/kg, the combustion energy value is 373.103 GJ, which corresponds to an electricity of 103640 kWh (1 kWh = 3600 kJ). From 23.76 t of dry vetiver leaf, 0.103 Gwh of electricity can be obtained, i.e. for the production of 1 Gwh of electricity, it is necessary to formed vetiver plantation of 10 ha with the number of seedlings 40,000/ha , planting dimensions 0.5 x 0.5 m. It should be noted that the dry lignite of Kolubara-Vreoce has an upper heat output of 19,296 kJ/kg and that 5.36 kWh of electricity can be obtained from 1 kg of this coal. In our case, this means that 103,640 kWh of electricity obtained from 23.76 t/ha of dry vetiver leaves corresponds to 19.3 t of dry Kolubara-Vreoce lignite.

CONCLUSION

Vetiver is a herb that originates from India and is spread all over the world in different climates. This plant can be used for soil conservation and stabilization, bioremediation and other applications in environmental protection.

Available literature data show that vetiver grass has not been studied in detail in Serbia. Tests that were carried out on test fields in Belgrade and the internal landfill of PK Drmno in the period from 2021-2023. have shown that vetiver grass can be grown in domestic climatic conditions on various types of soil (arable land, ash, mine tailings).

It is necessary to continue with more detailed tests of vetiver grass and look at all the possibilities of its cultivation and use in the Republic of Serbia. It is necessary to form a multidisciplinary team of experts who, from a scientific and practical point of view, will be able to more accurately evaluate the values of this useful plant and its applicability as an energy herb in the Republic of Serbia.

LITERATURE

[1] The Vetiver Network International (TVNI) Prowen green environmenial solutions;
[2] R. Hommel, G. Bach, Ch. Mülker, M. Schmidt; Vetiver grass a new potential energy plant in Saxony-Anhalt, 2008;
[3] Biomass - energy crops for energy production (special review on the possibility of electricity production), Nenad Mitić, Belgrade, First Conference on renewable sources of electricity, p. 227-235.