XXIII INTERNATIONAL ECO-CONFERENCE® 2019
XIII ENVIRONMENTAL PROTECTION OF URBAN AND SUBURBAN SETTLEMENTS

25th–27th SEPTEMBER 2019
NOVI SAD, SERBIA

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THE ECOLOGICAL MOVEMENT OF THE CITY OF NOVI SAD: AN IMPORTANT DECISION OF ITS PROGRAMME COUNCIL

Since 1995, the Ecological Movement of the City of Novi Sad organizes „Eco-Conference® on Environmental Protection of Urban and Suburban Areas", with international participation.

Twelve biennial conferences have been held so far (in 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, 2015 and 2017). Their programs included the following environmental topics:

Session 1: Environmental spheres: a) air, b) water, c) soil, d) biosphere
Session 2: Technical and technological aspects of environmental protection
Session 3: Sociological, health, cultural, educational and recreational aspects of environmental protection
Session 4: Economic aspects of environmental protection
Session 5: Legal aspects of environmental protection
Session 6: Ecological system projecting (informatics and computer applications in the field of integrated protection)
Session 7: Sustainable development of urban and suburban settlements–ecological aspects

Conference participants have commended the scientific and organizational levels of the conferences. Conference evaluations have indicated that some aspects are missing in the conference program. In addition, since a team of conference organizers was completed, each even year between the conferences started to be viewed as an unnecessary lag in activity.

Eco-Conference® on Safe Food

With the above deliberations in mind, a decision was made that the Ecological Movement of the City of Novi Sad should embark on another project – the organization of Eco-Conferences® on Safe Food. These Conferences were planned to take place in each even year. Preparations for the first Eco-Conferences® on safe food started after the successful completion of the Eco-Conference® '99.

So far ten Eco-Conferences® have been held (in 2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014, 2016 and 2018.) focusing this general theme.

Theme of the Eco-Conference®

By organizing the Eco-Conference® on Safe Food, the organizer wishes to cover all factors that affect the quality of human living. Exchange of opinions and practical experiences should help in identifying and resolving the various problems associated with the production of safe food.

Since 2007 Eco-Conference gained five times in a row, a sponsorship from UN and their sectorial organizations (UNESCO and UN-FAO) and became purely scientific Conference.

Objectives of the Eco-Conference®

– To acquaint participants with current problems in the production of safe food.

– To make realistic assessments of the causes of ecological imbalance in the conventional agricultural production and the impact of various pollution sources on the current agricultural production.

– Based on an exchange of opinions and available research data, to make long-term strategic programs of developing an industrialized, controlled, integral, alternative and sustainable agriculture capable of supplying sufficient quantities of quality food, free of negative side effects on human health and the environment.

Basic Topics of the Eco-Conference®

Basic topics should cover all relevant aspects of the production of safe food. When defining the basic topics, the intention was itemize the segments of the

production of safe food as well as the related factors that may affect or that already have already been identified as detrimental for food safety and quality.

The topics include ecological factors of safe food production, correct choice of seed (genetic) material, status and preparation of soil as the basic substrate for the production of food and feed, use of fertilizers and pesticides in integrated plant protection, use of biologicals, food processing technology, economic aspects, marketing and packaging of safe food.

To paraphrase, the envisaged topics cover the production of safe food on the whole, individual aspects of the production and their mutual relations, and impact on food quality and safety.

Sessions of the Eco-Conference®

1. Climate and production of safe food.
2. Soil and water as the basis of agricultural production.
3. Genetics, genetic resources, breeding and genetic engineering in the function of producing safe food.

4. Fertilizers and fertilization practice in the function of producing safe food.
5. Integrated pest management and use of biologicals.
6. Agricultural production in view of sustainable development
7. Production of field and vegetable crops.
8. Production of fruits and grapes.
9. Livestock husbandry form the aspect of safe food production.
10. Processing of agricultural products in the framework of safe food production.
11. Economic aspects and marketing as segments of the production of safe food.
12. Food storage, transportation and packaging.
13. Nutritional food value and quality nutrition.
14. Legal aspects of protecting brand names of safe food.
15. Ecological models and software in production of safe food.

Attempts will be made to make the above conference program permanent. In this way will the conference become recognizable in form, topics and quality, which should help it find its place among similar conferences on organized elsewhere in the world.

By alternately organizing conferences on environmental protection of urban and suburban areas in odd years and conferences on safe food in even years, the Ecological Movement of the City of Novi Sad is completing its contribution to a higher quality of living of the population. Already in the 19th century, Novi Sad was a regional centre of social progress and broad-mindedness. Today, owing first of all to its being a university centre, Novi Sad is in the vanguard of ecological thought in this part of Europe.

It is our duty to work on the furtherance of the ecological programs of action and, by doing so, to make our contribution to the protection of the natural environment and spiritual heritage with the ultimate goal of helping the population attain e higher level of consciousness and a higher quality of living.

Director of the Ecological Movement
of Novi Sad
Nikola Aleksic

CONTENT

Biosphere

TECHNICAL-TECHNOLOGICAL ASPECTS OF ENVIRONMENT PROTECTION (ECO-INGEENERING)

SOCIAL ASPECTS OF ENVIRONMENTAL PROTECTION (SOCIOLOGICAL, HEALTH, CULTURAL, EDUCATIONAL, RECREATIONAL)

ECONOMIC ASPECTS OF ENVIROMENT PROTECTION

LEGAL ASPECTS OF ENVIROMENT PROTECTION

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CIRCULAR ECONOMY IN FUNCTION OF OBTAINING THE BIOGASS

Abstract

Thanks to the development of new technologies for processing biological waste into energy products and the increasing use of circular economy in environmental protection, the rate of increase in the use of alternative fuels is increasing significantly. The aim of this study was to determine the effect of digestates, such as bio-stimulating nutrients, on the yield of biomass of sorghum and biogas in divergent years. The results showed that digestate positively affects the increase in sorghum productivity, biomass of dry matter and biogas yield. Modern technology of production of agricultural crops, who's imperative is economical, has high standards, not only in terms of biomass production but also preserving natural resources and protecting ecosystems.

Key words: *biofuels, biogas yield, circular economy, digestate, sorghum biomass*

INTRODUCTION

By the long-lasting and ever-increasing use of the main products for energy purposes, in the world, it will be gradually reduce the amount of food necessary for the ever-increasing population. The consequence of reduced quantities of foods is a price increase, which can cause unrest in a wider geographic area, especially in developing countries. Therefore, it is necessary to improve the industrial plants that would use the non-nutritious part of plants, that is, the harvest residues of field (and other) crops and plantings for the production of biofuels. Sorghum is excellent culture for biofuel production.

Due to the large polymorphism of cultivated forms, sorghum has great importance and multi-use. As an agricultural crop, it is cultivated for grains that are used for the feeding of humans and domestic animals, or above ground biomass, as very good voluminous animal feed (Ikanović et al., 2015).

Sorghum is an important plant for food-stuff (sugar syrup, oil, soft drinks and alcoholic beverages), textile, construction, chemical industry, home-made and as a significant raw material for the production of biofuels (Lakic et al., 2018). The advantage of sorghum over other grain crops is the possibility of growing in arid conditions and on the soil of less natural fertility (Ikanović et al., 2013). Due to the fact that sorghum can be grown on marginal and devastated soils, it becomes increasingly important for the phyto-remediation of these areas and their preparation for reuse for agricultural purposes.

For the production of biogas, fresh biomass of arable crops of energy crops, manure, side products of industrial processing of plant material, various organic waste from the farm, sludge obtained by cleaning waste and sewerage system water, etc. can be used. The mentioned raw materials have different methane content so that in the process of obtaining this gas, by mixing various solid and soft materials, the process of anaerobic digestion and the amount of separated bio-gas are improved. Biogas production is the biological process of fermentation of organic, carbon compounds, which are converted by oxidation-reduction processes into methane, CH_4. In order to translate this complex process from the highest degree of oxidation to the highest degree of reduction, microorganisms take part as catalysts.

The process of methane separation takes place in three phases – hydrolysis, acid and methane phases. In the first phase, mixtures of different plant material in anaerobic conditions are exposed to the action of fermentative bacteria which, by means of ferments, break down complex organic compounds into simple. In the second stage, the degraded organic compounds from the starting material, under the influence of anaerobic acid bacteria, are decomposed on acetic acid, carbon dioxide and hydrogen. In this process, alcohol and gas methane appear as products. In the third stage, methanogenic bacteria using pre-synthesized compounds intensively produce methane and carbon dioxide.

During the final process, a gaseous mixture (biogas) and by-products, which can be used as a means of land reclamation, are separated. The circular economy process itself gets more importance in recent years. The process of production of bio-gas depends on the heat conditions, the reaction of the solution (preferred pH in the first phase 4–8.5 and in the other 6.5–7.5) and of the starting material.

Sorghum during the vegetation period has large biomass, well covers the soil and alleviates all forms of erosion. According to photosynthetic activity, it is a C4 plant that, during photosynthesis, adopts large amounts of carbon dioxide from the atmosphere (but also other gases), which has a significant positive effect on the environment. It the end, the sorghum, by its powerful root, assimilates plant assimilates which have reached deeper layers of soil and thus prevents their rinsing into the underground watercourses.

The use of digestate in sorghum crop increases the economic profit in the production of sorghum, as it produces a higher yield of biomass and biogas. The obtained biomass of sorghum is of high quality. Digestate positively affects the increase in germination energy, the rate of sprouting, the faster initial growing and, also increases the biomass of dry matter and the yield of gas.

The aim of this study was to examine the effect of digestates, bio-stimulating nutrient on the productivity of sorghum produced in Serbia at the Dolovo site in divergent years.

MATERIAL AND METHODS

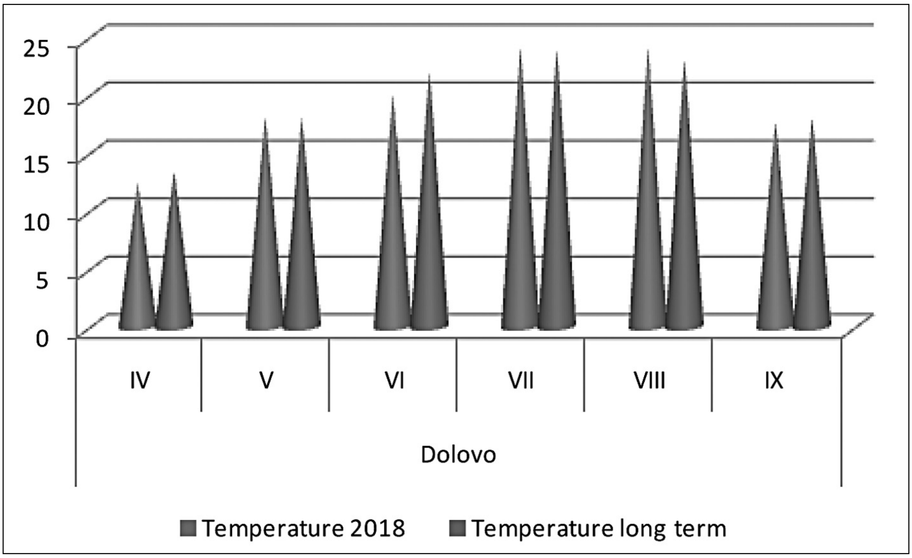
During 2018, a field micro-experiment was placed, based on the random block system in 10 repetitions with the size of the basic plots of 10 m^2 (5 m x 2 m) in Dolovo on the soil of the type of chernozem. The subject of the research was the sorghum hybrid – *Buldozer*. The experiments were performed in two variants: control – variant without digestate and variant with digestate. The aim of this study is to determine the effect of digestates, bio-stimulating nutrients on plant height, number of leaves, biomass yield of sorghum and yield of biogas in divergent years.

Digestate is a bio-stimulant nutrient in the form of a concentrated suspension with a significant content of organic matter, nitrogen, phosphorus and potassium. It is intended for plant nutrition at an early stage at the time of the formation of the root system but can be used for intensive plant growth. The active substances of the digestate are of natural origin; obtained by enzymatic hydrolysis and are characterized by high moisture content, dry matter and organic matter. So far research in the production of sorghum was related to the use of bio-stimulators and fertilizers. The main advantages of the digestate are its small volume mass, good water-air capacity and high content of organic matter (Rakaščan et al., 2019).

Standard agro-technical for sowing was applied. Mowing of plants was carried out at the beginning of the panicle phase (the second third of July). For the analysis of morphological properties of plant height and number of leaves, samples of freshly cut biomass were taken. The yield of dry biomass from each elementary parcel and biogas yield was calculated. The yield of biogas was determined by analysis of sorghum silage in the laboratory of the Technical Faculty in Novi Sad and converted to cubic meters/ton. The analysis of the obtained experimental data was done through analytical statistics using the statistic package STATISTICA 12 for Windows (StatSoft 2012). The results obtained are tabulated.

Meteorological data. Temperature and precipitation data for the Dolovo locality for the studied vegetation period 2018 are shown in Chart 1 and 2.

Meteorological data is variable (Popović et al., 2013, 2015; Glamočlija et al., 2015; Ugrenović, 2018; Ugrenovic et al., 2018). The mean air temperature during the growing season was 19.4°C, and total precipitation from April to September amounted to 493.9 mm (Figures 1 and 2). In the investigated years the precipitation was greater than the annual average for 123 mm (371 mm) while the temperatures were less than the perennial reference period for 0.35°C.



Graph 1. Average air temperature, mm, in the vegetation period 2018 for Dolovo

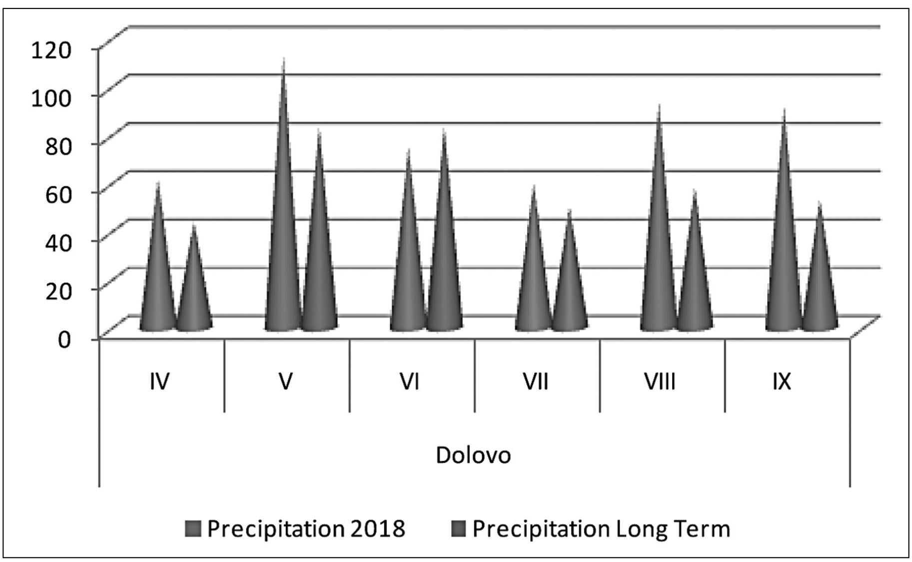


Chart 2. Total precipitation, mm, in the vegetation period 2018, for Dolovo

RESULTS AND DISCUSSION

Table 1 shows descriptive statistics for tested properties sorghum in the tested variants: control and feeding acompaned with digestate. The variability of the tested samples expressed by the coefficient of variation for all the properties was very small, indicating the homogeneity of the samples (1.60% <Cv <12.12%). The average values for all the parameters tested were higher in the variant with the feeding, compared with control. In the variant with the use of digestate, statistically significantly higher values were obtained for all investigated sorghum properties, Tables 1–2, Chart 3.

The nutrition showed a statistically significant effect on the change in the number of leaves per plant. The values for the number of leaves on the plants in the control material were 11.66 and were statistically significantly lower in comparison with the digestate variant, 12.66 ($p < 0.05$). There was a difference of 1.00 i.e. 8.58%.

In 2018, the average height of sorghum plants for both variants was 2.97 m. The values for the tested parameter varied from 2.93 m (control variant) to 3.00 m (variant with digestate). Among the examined variants, there were no statistically significant differences in the values of the sorghum tested parameter, Tables 1–2.

Table 1. Parameters of sorghum productivity, 2018

Parameter	**No**	**Mean**	**Std. Dev.**	**Std. Err**	**–95,00%**	**+95,00%**
Variant	**Biomass yield**					
Control	3	57.100	0.200	0.115	56.603	57.597
Digestate	3	59.633	0.642	0.371	58.036	61.230
Average	6	58.366	1.451	0.592	56.843	59.889
CV	–	3.056	–	–	–	–
Number of leaf						
Control	3	10.666	0.577	0.333	9.232	12.101
Digestate	3	12.666	0.577	0.333	11.232	14.101
Average	6	11.666	1.211	0.494	10.395	12.937
CV	–	12.122	–	–	–	–
Plant height						
Control	3	2.933	0.115	0.066	2.646	3.221
Digestate	3	3.000	0.100	0.057	2.751	3.248
Average	6	2.967	0.103	0.042	2.858	3.075
CV	–	1.597	–	–	–	–
Biogas yield						
Control	3	150.066	1.150	0.664	147.209	152.924
Digestate	3	160.700	0.624	0.360	159.148	162.251
Average	6	155.383	5.882	2.401	149.209	161.556
CV	–	4.839	–	–	–	–

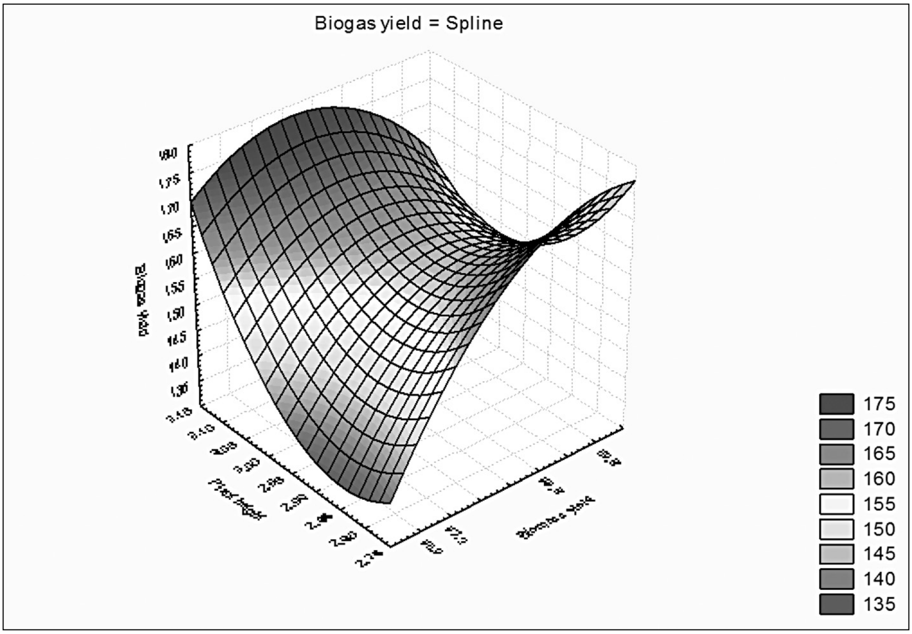
Biomass yield. In the control variant, there was statistically significantly lower biomass yield (57.10 t ha^{-1}) compared to the variant with digestate, 59.63 t ha^{-1}. The difference in biomass yield between the control and variant with digestate was 2.53 t ha^{-1} and was statistically significant, $p<0.01$, Graph. 3.

The average yield of biomass was 58.37 t ha^{-1}. In the control variant statistically significantly lower biomass yield (57.10 t ha^{-1}) compared to the variant with digestate was achieved, 59.63 t ha^{-1}. The difference in the yield of the biomass between control and the variant with digestate was 2.53 t ha^{-1} and was statistically significant, $p<0.01$, Tables 1–2, Graph. 3.

Table 2. Anova for tested sorghum parameters

Parameter	Degr. of Freedom	SS	MS	F	p
Number of leaf					
Intercept	1	816.6667	816.6667	2450.000	0.000001
Variant	1	6.0000	6.0000	18.000	0.013236
Error	4	1.3333	0.3333		
Total	5	7.3333			
Plant height					
Intercept	1	52.80667	52.80667	4526.286	0.000000
Variant	1	0.00667	0.00667	0.571	0.491767
Error	4	0.04667	0.01167		
Total	5	0.05333			
Biomass yield					
Intercept	1	20440.01	20440.01	90176.50	0.000000
Variant	1	9.63	9.63	42.47	0.002862
Error	4	0.91	0.23		
Total	5	10.53			
Biogas yield					
Intercept	1	144863.90	144863.90	169101.80	0.000000
Variant	1	169.60	169.60	198.00	0.000148
Error	4	3.40	0.90		
Total	5	173.00			

Biogas yield. The average of biogas yield was 150.06 m^3 t^{-1}. In the control variant it was achieved statistically significantly lower biomass yield (150.07 m^3 t^{-1}) compared to the variant with digestate, 160.70 m^3 t^{-1}. The difference in the yield of the biomass of sorghum between control and the variant with digestate amounted 10.63 m^3 t^{-1} and was statistically significant, $p<0.01$, Tables 1–2, Graph. 3.



Graph. 3. Biogas yield relative to biomass yield and the height of the plants

Sorghum biomass has green leaves and stalks that contain larger amounts of water. This biomass is of low nutritional value and with a high content of indigestible cellulose. If it is used for silage, it should be mowed up with silage-harvester and make silaging it together with a food of higher nutritional value (Ikanović et al., 2011; 2012; 2013; 2018a; 2018b; Cardoso et al., 2013; Sikora et al., 2016; Lakić et al., 2018; Bojovic et al., 2019).

The strategy that is always followed is that a quality bio-energetic crop needs to be developed and to provide as much as possible energy yield per unit of soil area on which it is cultivated, with as little as possible of measures and cost of setting up and of maintenance. By perfecting the technological process of obtaining biofuel from sorghum biomass and secondary products, it could be obtained energy products, which have a far wider application. The advantage of these fuels is that they come from renewable sources, which significantly reduces the dependence on imported fossil fuels which many countries do not own (Ikanović et al., 2011; 2013).

Digestate active substances are of natural origin, obtained by enzymatic hydrolysis and characterized by high moisture content, dry matter and organic matter. Digestation has been found to increase the germination energy, the rate of sprouting, the faster initial growth, and the dry matter biomass and gas yield increase. Also, bio-regulatory influence on photo-periodism on neutral and plants of short-day was observed. By using digestate in sorghum crop, the economic profit of its production increased.

CONCLUSION

By perfecting the technological process of obtaining biogas from sorghum biomass and secondary products, it has got an energy source, which is also used for biofuel production. These emergent come from renewable sources, which significantly reduces the need for fossil fuel imports. By using digestate in sorghum crop, the economic profit in its production is increased as the higher yield of biomass and high biogas quality is obtained.

The circular economy in environmental protection is gaining in importance and role because the use of digestate in sorghum production increases the economic profit in the production of sorghum both in the yield of biomass and in the amount of biogas.

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ЦИРКУЛАРНА ЕКОНОМИЈА У ФУНКЦИЈИ ДОБИЈАЊА БИОГАСА

Извод

Захваљујући развоју нових технологија прераде биолошког отпада у енергенте и све већом применом циркуларне економије у заштити животне средине, стопа пораста стопа раста употребе алтернативних горива значајно расте.

Циљ ове студије био је да се утврди утицај дигестата, као биостимулативног хранива на принос: биомасе сирка и биогаса у дивергентним годинама. Резултати су показали да дигестат позитивно делује на повећање продуктивности сирка: принос биомасе суве материје и принос биогорива. Савремена технологија производње пољопривредних усева чији је императив економичност, има високе стандарде, не само у погледу продукције биомасе, већ и очувању природних ресурса и заштите животне средине.

Кључне речи: *биогорива, биомаса сирка, циркуларна економија, дигестат, принос биогаса*

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