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BOOK OF ABSTRACTS

The Fifth International Symposium on Agricultural Engineering



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PREFACE

After the four successful International Symposiums on Agricultural Engineering – ISAE, that were held in Belgrade at the Faculty of Agriculture, thanks to our colleagues we are organizing The Fifth International Symposium on Agricultural Engineering – ISAE 2021. Together with the University of Basilicata, School for Agricultural, Forestry, Food and Environmental, Sciences (Potenza, Italy), University of Sarajevo, Faculty of Agricultural and Food Sciences (Sarajevo, Bosnia and Herzegovina), Aristotle University of Thessaloniki Faculty of Agriculture, Thessaloniki (Greece), University of Belgrade, Faculty of Mechanical Engineering, Department of Agricultural Engineering, Belgrade (Serbia), Vinča Institute for Nuclear Science, Belgrade, Serbia, Serbian Soil Tillage Research Organisation, Belgrade, Serbia, Institute of Agricultural Economics, Belgrade, Serbia and thanks to the Ministry of Education, Science and Technological Development, Republic of Serbia, support of the AMAPSEEC, RebResNet and BENA, and sponsor and donors, we have managed to organize the presentations of the 29 papers that were submitted to the Scientific Committee of the ISAE 2021 Symposium. We have arranged them in to four sections and categorized them as Original scientific papers, Scientific review papers, Firs (short) communications, Case studies, Professional (Expert paper) and Popular papers. All papers within the Proceedings of the ISAE 2021 were reviewed by the members of the Scientific Committee and kind assistance of some members of other Conference bodies.

Book of Abstracts of the ISAE 2021 International Symposium is organized in four thematic sections. Section I – Sustainable agriculture and biosystems engineering (9 abstracts); Section II – Soil tillage and agroecosystems protection (7 abstracts); Section III – Energy and energy efficiency in agriculture (12 abstracts) and Section IV – Economics in agricultural engineering (1 abstracts).

We wish to thank to all the authors for their contribution to the ISAE 2021 Symposium and to the all the Institutions, Associations, Universities, Sponsors and Donors for the contribution in ISAE 2021 Symposium organization.

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TMA EXPLOITATION INDICATORS FOR MECHANIZED DRILLING OF PITS FOR PLANTING FRUIT

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Abstract: *Performing works with the land where a lot of mechanical work is engaged, such as making pits for planting fruit, needs to be mechanized. This replaces human labour with a tractor-machine aggregate with an increase in productivity and thus makes the process cheaper. For the proper selection of individual means of mechanization, it is important to determine the optimal agrotechnical parameters of their application. Proper selection and use of mechanization tools for planting have a decisive influence on the intensity and progress in cultivation technology. Defining energy and exploitation parameters of tractor-machine aggregates during mechanized construction of pits is the subject of this research. The pits are intended for individual planting of fruit seedlings as well as the installation of trellis poles. The test results of the tractor-machine aggregate show that the lowest driving force engaged for drilling was achieved in the field and was 6.36 kW for the excavated pit with the depth of 885 mm and with a diameter of 520 mm, the number of revolutions of the drill was 93 rpm and drilling was achieved in 27 s. The highest driving force for drilling was engaged in field III, which was 30.8 kW for the excavated pit 780 mm deep with a diameter of 490 mm, the number of revolutions of the drill bit was 111 rpm and drilling was realized in 30 s. The results obtained in these tests show that the consumption of motor power largely depends on the type of soil, the quality of previous soil preparations and the number of revolutions of the tractor PTO shaft. The time required to move the aggregate from one to the next drilling site is crucially influenced by the terrain configuration, the state of soil preparation and the skill of the tractor driver and auxiliary worker.*

Keywords: *tractor-machine aggregate, hole drill, spiral drill, aggregate productivity, exploitation parameters*



INFLUENCE OF VEHICLE CENTER OF GRAVITY CHANGE ON DYNAMIC CHARACTERISTICS

Davidović N. Mitar^{1*}, Blagojević A. Ivan², Petrović V. Dragan¹, Mileusnić I. Zoran¹, Miodragović M. Rajko¹, Dimitrijević Ž. Aleksandra¹, Bošković Biljana¹

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Abstract: *The position of the vehicle's center of gravity is one of the most important vehicle parameters, which has a significant role in the dynamic behavior of the vehicle (roll, pitch, yaw and load transfer). When the vehicle body moves, the weight of the vehicle is redistributed, which affects grip and stability. The aim of this work is to prove experimentally the influence of the change in the height of the center of gravity on the vehicle dynamic characteristics by adjusting the suspension system. Changes in the angles of the vehicle body in the longitudinal and transverse planes were observed. The experiment was performed on a vehicle that has a mechanically adjusted support of the spring which changes suspension system parameters and the height of the center of gravity. The test was performed using the Moose Test, defined in ISO 3888-2, with roll, pitch and yaw (angle, rate and acceleration) and longitudinal speed and acceleration being measured by equipment installed in the vehicle. With this experiment we have quantified how the height of the center of gravity affects the dynamic characteristics and showed how much the dynamics of the vehicle is disturbed by ≈ 55 mm change in the height of the center of gravity.*

Keywords: *center of gravity, stability, suspension, Moose test.*



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ANALYSIS OF THE LOAD DISTRIBUTION IN A ROLLING BEARING - WITH AND WITHOUT DAMAGE

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Abstract. *Due to action of an external radial load on the bearing assembly, the load is transferred through the rolling elements from one bearing ring to another. However, not all rolling elements are equally involved in the load transfer from the shaft to the housing. This directly reflects on the non-uniformly load distribution on the rolling elements, which depends on the internal geometry of the bearing and the intensity of the external load. The main character of load distribution on the rolling elements of a single-row rolling bearing with radial contact with and without damage on the rolling race was analyzed in this paper. The Finite Element Analysis for a particular ball bearing type is developed for these purposes. The influence of damage dimensions variation, as well as external load intensity on the load distribution within the bearing is considered. The obtained results show that when damage dimensions increase, the load transmitted by rolling elements located just below central plane increases, while the loading on the rolling elements whose center is in the direction of external load decreases. However, with the increasing of the external load, and in the case of damage appearance on the rolling race, load distribution between rolling elements become very similar to the load distribution for the case of the bearing without damage.*

Key words: *rolling bearings, load distribution, damage, Finite Element Analysis*



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TECHNICAL RESOURCES FOR SPECTRAL CROP SCOUTING – CURRENT STATE AND PROSPECTS

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INVITED PLENARY LECTURE

Abstract: *From planting to harvest, the primary aim of agricultural producers is associated with monitoring cultivated plant species (arable crops or fruit plantations) in arable field areas during the vegetation period in order to make timely and appropriate decisions regarding the implementation of adequate agricultural measures to provide optimal plant development and to maximize the yield. Information about the current state and recent changes in crop sets over the vegetation period represents an important basis for reaching more precise decisions in the spheres of agronomy, economics, and environmental protection. By analyzing large amounts of interdisciplinary spatial data over longer periods of time, key information becomes available, facilitating monitoring crops in larger land areas, and providing the definite picture of changes in arable plots and ecosystems. Spectrometry is the most widespread method of scouting crops. Indirect analysis of the data obtained this way can help determine nutritional deficiencies of crops, as well as defective states caused by diseases, weeds, or pests. Consequently, it is possible to ensure the distribution and administration of optimal doses of appropriate fertilizers and pesticides subsequent to or concurrent with monitoring within the optimal agricultural frame and/or with changeable dosage norms. This review covers various technological processes for spectral crop scouting contingent on various technical resources and sensors. At the end of the paper, advantages and disadvantages of each resource are given, and the key comparisons are made in terms of the efficacy and precision of these resources.*

Keywords: *crop scouting, spectral sensors, sensor carriers, tractors, unmanned aerial vehicles, satellites*



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ENHANCING AGRICULTURAL INDUSTRY THROUGH INDUSTRY 4.0

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Abstract: *Agricultural industry is essential for humanity. It provides it with food, fibers, fuel and raw materials that are necessary for a normal living. As the technology advance, it is vital to see how the same technology can be implemented in other industries. With the development of Industry 4.0, many industries are trying to implement new technologies. Industry 4.0 represents the current peak of industry development. Today there are demands in various industries for shorter delivery and production time, more efficient, cost efficient and automated processes. The technology of Industry 4.0 can be applied to agricultural industry as well. Improvements of agricultural machineries in terms of electronic, sensors to enhance their current performances. Using electronics, sensors and drones, supports the data collection of agriculture key aspects, such as crops behaviour, weather, animals etc. The main task is how to implement the right methods in order to enhance agricultural industry with the help of Industry 4.0.*

Keywords: : *Industry 4.0, agricultural industry, industry, technology.*



EXPERIMENTAL ANALYSIS ON CONCRETE BLOCKS REINFORCED WITH ARUNDO DONAX FIBERS

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Abstract: *Over the last decade, there has been a growing attention in research and development on non-conventional building materials and technologies, such as vegetable fibers (e.g., flax; hemp; jute; etc.), to be used as eco-friendly materials in a wide range of applications in civil construction. The main reasons of this interest are related to the specific properties, price and sustainability of natural fibers, which can be considered as “green” building materials. In this article, a new kind of fibers, extracted from stem of the Giant Reed Arundo donax L., has been investigated as a potential reinforcement of construction materials. These fibers, which widely grow in Mediterranean areas, but that are diffused all around the world as well, have been extracted from the outer part of plant stem. Then, some experimental concrete bricks, have been prepared with the addition of different weight percentages of vegetal fiber. To assess the mechanical properties of these bricks, tensile tests on single fiber have been performed, as well as compression tests on the whole block. Hence, the differences between concrete bricks without any fiber and those reinforced with different weight percentages of natural fiber have been analyzed, and their potential applications in bio-architecture have been assessed.*

Key words: *bio-architecture, concrete bricks, Arundo donax fiber, mechanical properties, tensile test.*



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REDUCTION OF PLANT WEIGHT LOSS IN THE PROCESS OF HAY BALING USING WATER STEAM

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Abstract: Hay is a bulky part of the meal that is most often used in the winter period of the year in all types of ruminants, while the role of hay in the meal of high-milk cows is invaluable. The most common way to produce hay is to dry the cut grass on the surface of the land in the field, using the energy of the sun. In the process of hay production, there is a reduction of nutrients in relation to the green mass, where the achieved yield and quality of hay largely depends on the technological operations that are performed during storage. In the baling process, the dried mass is exposed to the mechanical treatment of the working elements of the press, as a result of which the leaf mass decreases. Loss of leaf mass, which contains a large amount of nutrients, can greatly affect the achieved yield and quality of the obtained hay. One of the possibilities to reduce losses is the application of "DewPoint" technology, which involves the use of water vapor in the baling process. The steam produced by the device is injected into the mass-hay after lifting by the pickup device and further until the mass enters the pressing chamber. Mass treatment is achieved by injecting steam through a series of nozzles located inside the press. Water vapor is an extremely efficient medium for the controlled hydration of hay during the baling process, where approximately 450 l of water vapor can be produced from 1 l of water. By applying this technology, water consumption is 5-7 l per 1 t of hay, producing 2250-3150 l of water vapor. This amount of steam enables efficient treatment of individual plants (tree, leaf) in a mass of 1t to the desired humidity level.

Keywords: : hay quality, baling, losses, water vapor, hydration.



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THE IMPACT OF ADJUSTMENT OF VACUUM PLANTER ON PLANT EMERGENCE AND YIELD

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Abstract: *The correct adjustment of vacuum maize planter has a great effect on plant emergence and growth. Two field trials were executed in 2020 using vacuum maize planter Amazone ED 4500. In the first trial we adjusted five different planting depths, namely 3 cm, 4 cm, 5 cm, 6 cm and 7 cm. Daily emerged plants were counted. Later the distances between plants in the row were measured and at the end also the grain yield. In the second trial we combined the pre-seed soil cultivation with rotary harrow using 540 and 1000 rpm and the use of clod remover in the vacuum planter. Also in this trial similar parameters were monitored as in the trial with the planting depth. The results of both trials will be presented in this article.*

Key words: *vacuum planter, adjustment, plant depth, clod remover, emergence, grain yield.*



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WORKING HOUR DEMAND OF THE MECHANISED FIELD TOMATO PRODUCTION CONSIDERING THE TASKS OF THE MATERIAL HANDLING

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Abstract: *This paper focuses on introducing the up to date mechanized production technology of direct-seeded canning tomato, by determining the machine operational hours needed for the production technology and for the transportation task, like input material-, and end product transport.*

The investigations prove that the number of machine operation hours of field tomato production are high. It helps that the self-propelled tomato harvester completely utilizes its annual operating hour by harvesting 100 hectares of land, which means that its utilization and specific cost is favourable.

The results of the research show that 69 % of the total machine operational hours of the logistical tasks are related to end product transport from which the transport to the processing company takes 53 %. It is followed by harvest (10.5 %) and the proportion of the working hour demand of the other material handling operations of the technology almost reaches 5 % or 1 % in some cases.

Due to the long distance transportation of the end product 74.4 % of the total machine operation hours of tomato production are related to harvesting and the connected logistical tasks. It is easily recognisable that the time of crop transport depend on the distance between the place of harvest and the processing company. This could be more time-consuming than the plant production, so the post-harvest logistics could be very important and significant.

By the very careful handling of the product the harvester does not cause much damage to the tomatoes. Much more damage is caused during transport, so it is very important to take the crop to the processing company in the shortest possible time.

Key words: *working time demand, transportation, logistics, tomato production, machine utilisation*



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BIOMASS ASH UTILIZATION FOR SOIL AMENDMENT - IMPORTANCE OF THE PREDICTION OF PERSISTENT ORGANIC POLLUTANTS DEGRADATION PROCESSES

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Abstract: *Ash, as a by-product of combustion of various biomasses, contains a large number of substances, such as potassium, calcium, magnesium, phosphorus, micronutrients etc., which can be useful for plant growth. Therefore, it can be added to the soil to improve its properties, instead of being deposited and thus represents a problem in the environment. Since ash also contains substances that are both harmful and persistent, it is necessary to take into account both investigations in model systems and numerous experiments performed under conditions close to real, all in order to create mathematical models that could enable the prediction of the fate and behavior of such substances in the environment.*

Key words: *biomass ash, soil amendment, persistent organic pollutants, degradation, environment*



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THE COMPARISON OF DEGRADATION OF ORGANIC POLLUTANTS FROM BIOMASS AND COAL ASHES MIXED WITH SOIL – A REVIEW

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Abstract: *The overall content of polycyclic aromatic hydrocarbons (PAHs) in biomass and coal ashes is comparable, but the content of each of PAHs depend on many factors such as feedstock type, burning conditions. In many countries, such as Canada and USA, both biomass and coal ashes are used for soil amending, if background soil content of PAHs is low. For the reduction of PAHs content different processes could be responsible. Since PAHs represent hydrophobic compounds, they can be adsorbed to soil particles which makes them to be more persistent to the action of various processes. PAHs degradation can be induced by the action of sun light (photodegradation), soil microorganisms, phytoremediation (by fast growing trees like willow, maize, cereals), fungi and others.*

Key words: *biomass ash, coal ash, organic pollutants, PAHs, degradation*



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BURNING OF AGRICULTURAL BIOMASS WASTE ON FIELDS - ESTIMATION OF ENVIRONMENTAL RISK

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Abstract: *Despite numerous appeals not to burn agricultural waste after harvest, after pruning fruits and vineyards, removing weeds or preparing land for new sowing, a great number of farmers are trying to speed up the removal of agricultural waste in this way. Such actions can cause, especially in the summer months, great material damage, because there is a danger that the fire will spread uncontrollably to neighboring fields, as well as other direct or indirect consequences. In this paper, we deal with the estimation of pollutant emission and environmental risk assessment, especially with regard to the impact of carcinogenic compounds created during biomass burning.*

Key words: *agricultural waste burning, harmful pollutants emission, environment, risk estimation*



APPLICATION OF CONTEMPORARY TECHNICAL SYSTEMS IN CHEMICAL PROTECTION OF FIELD CROPS: CASE STUDY OF WHEAT PRODUCTION IN SERBIA

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INVITED PLENARY LECTURE

Abstract: *The application of precision agriculture in chemical plant protection enables the realization of high yields while preserving natural resources. The quality of chemical applications depends on the type of technical system that performs for this job. The task of the technical system is to protect the cultivated crop precisely, economically and while preserving the environment, and all that depends on the precision and the quality of application of the protective liquid.*

The use of UAV's in chemical plant protection enables precise application of protective liquid, so their application is increasing in the protection of numerous crops. The same trend has been observed in field production, where the use of UAV's is on the rise.

*The paper compares the exploitational and technological characteristics of the field sprayer (FS) and unmanned aerial vehicle (UAV) in the chemical protection of wheat. The amount of deposited protective liquid on plants and losses of deposited on the surface of the earth were monitored. Using UAV (T4: $V = 3 \text{ m}\cdot\text{s}^{-1}$, $H = 1 \text{ m}$), the amount of protective liquid on the plant was determined to be $0.185 \text{ mg}\cdot\text{l}^{-1}$ compared to $0.037 \text{ mg}\cdot\text{l}^{-1}$ at FS, while the losses were $0.01 \text{ mg}\cdot\text{l}^{-1}$ at FS and $0.085 \text{ mg}\cdot\text{l}^{-1}$ at UAV. The presence of Fusarium (*Fusarium spp.*) after chemical protection was analyzed according to the compared technical systems and set treatments. It was recorded for 20% higher efficiency in protection against Fusarium (*Fusarium spp.*) using UAV (T5: $V = 3 \text{ m}\cdot\text{s}^{-1}$, $H = 2 \text{ m}$) compared to FS. The values of wheat yield were measured according to the compared technical systems and set treatments, where the highest wheat yield was achieved using UAV (T5) with $10,667.7 \text{ kg}\cdot\text{ha}^{-1}$, while using FS, 14.84% lower yield was achieved. The application of UAV's in the segment of chemical plant protection enables us to effectively protect crops, economical and optimized production, while preserving the environment in a way that has been completely new and unknown until now.*

Keywords: *unmanned aerial vehicle - UAV, field sprayer, protective liquid, quality of application, yield.*



INFLUENCE OF NITROGEN FERTILIZATION ON MAIZE GROWTH AND YIELD DETECTED BY ACTIVE OPTICAL SENSOR

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Abstract: *The influence of fertilization with different dosages on field crops yield has been confirmed in a number of research. The correlation between applied doses of nitrogen fertilizer and plant growth and yield in maize (*Zea mays L.*) is high.*

The results of the spectral analysis of plants are commonly expressed in a more intuitive manner as vegetation indices which represent mathematical combinations of surface reflectance at two or more wavelengths and they have been adopted with the aim to highlight particular properties of a plant. In this paper, we used, portable active multispectral optical device for precise plant stress detection and field mapping named Plant-O-Meter. The device has an integrated multispectral source that comprises light sources of the four most indicative wavelengths (850, 630, 535 and 465 nm), and enables simultaneous illumination of the whole plant. Sequential illumination and detection provide rapid reflectance measurements, which are wirelessly transmitted to android operated devices for processing and data storing.

In this experiment, we have detected different vegetation indices during the vegetation season of maize, treated with 16 different combinations of basic and additional fertilizations with nitrogen fertilizers. There was a correlation between some of the vegetation indices and maize yield parameters. Based on this research and additional experiments from other localities, it is possible to design an algorithm for early prediction of maize yield based on types and dosage of applied nitrogen fertilizers.

Key words: *Plant-O-Meter, multispectral device, vegetation indices, crop sensing, yield.*



SYSTEMS FOR FLUE GASES TREATMENT AT THE COMBUSTION OF (AGRICULTURAL) BIOMASS

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Abstract. Biomass combustion has many advantages compared to fossil fuels due to reduction of carbon dioxide emissions, but several issues are present during biomass combustion. One that must always be considered is emission of nitrogen oxides (NO_x), which have significant impact on the environment and health. At biomass combustion, main mechanism responsible for NO_x emission is oxidation of fuel-bound nitrogen. Increased NO_x emissions are particularly present at agricultural biomass combustion, due to its increased nitrogen content, which is further expressed by the use of nitrogen fertilizer. Denitrification methods are classified as pre-combustion, combustion control and post-combustion (flue gas treatment) methods. Aim of this paper is to provide insight in different flue gas denitrification methods (DeNO_x measures) from the review of existing literature, with emphasis on post-combustion methods, since they have higher efficiency. Also, pre-combustion and combustion control methods at agricultural biomass combustion often do not provide reduction below emission standards. Selective catalytic (SCR) and selective non-catalytic reduction (SNCR), wet scrubbing, adsorption, electron beam, electrochemical method, non-thermal plasma and microbial approach were considered. For each method, mechanism of NO_x reduction is given and discussed, alongside with efficiency that could be achieved. Overall comparison of advantages and disadvantages for these methods is provided. Further research of denitrification and optimization of described methods, to overcome NO_x emission problem is required. Application of these methods in commercial use and increasing their efficiency, while solving cost and methods disadvantages, is key for biomass to be used as a renewable energy source and fossil fuel replacement.

Key words: biomass, combustion, nitrogen oxides (NO_x), denitrification, selective catalytic reduction (SCR), selective non-catalytic reduction (SNCR)



ACCIDENTS IN AGRICULTURE AND FORESTRY -INFLUENCE OF RURAL DEVELOPMENT PROGRAM ON WORK SAFETY IN THE REPUBLIC OF SLOVENIA AND THE REPUBLIC OF SERBIA

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Abstract: *From 1981 to 2020, accidents in forestry agriculture in the Republic of Slovenia tragically killed 1,756 or an average of 43.9 people a year. There is a noticeable trend of decreasing number of accidents with fatalities with tractors, especially in public transport, and less when working outside public roads. The first major decline in the number of accidents and fatalities with tractors in the R. of Slovenia was after the mandatory introduction of the cabins for all tractors in 1986, and the second decline in the number of tragic casualties was after the introduction of homologation on May 1, 2004. In forestry, the number of fatalities in the Republic of Slovenia remains high and with significant oscillations over the years, and especially when there were significant natural disasters. The question of the impact of the application of incentives (subsidies of the State of Slovenia through the Ministries for Investments in Agricultural and Forestry Technology) from the rural development program on the safety of work in these areas is raised. Recipients of incentives for forestry equipment in the period from 2014 to 2021 participated in the survey on accidents during the work performed. The number of accidents in the group of forest owners and forestry workers was numerically small, so it can be concluded that such a measure and investments in new equipment for agriculture and forestry have a positive impact on occupational safety.*

In the Republic of Serbia from 1980 to 2020 a total of 2,450 or an average of 61,25 people a year were tragically killed in accidents directly in the field of agriculture and forestry.

In public transport situation, accidents with tractors in this period amounted to about 7,25% of the number of all accidents in public transport (average of 2 accidents with tractors per day, most often in September). This resulted in an average of 63,45 deaths of people during this period.

Today, the R.Serbia has a significant trend of decreasing the number of accidents with fatalities with tractors in public transport. Significant decline in the number of accidents and fatalities in the primary areas of application of tractors (agriculture and forestry) was after the mandatory introduction of cabins or safety equipment, accessories and tractor markings, and especially the implementation of the new version of the Law on Road Safety in R. Serbia, after year 2009. Incentive measures from the institutions of the state of the R. Serbia for the purchase of new tractors in the period from 2012 to 2020. The year did not bring significant changes in the described problems of accidents when using tractors.

The safety of tractor use in the Republic of Serbia is not at a satisfactory level.

Keywords: *Republic of Slovenia, Republic of Serbia, agricultural and forestry equipment, accidents in public transport, accidents in agriculture and forestry, incentives from rural development programs*



ENERGY EFFICIENCY OF INCUBATOR STATIONS

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Abstract: *Energy efficiency will be of increasing importance in the future, and the aim of this research is to determine the consumption of human and machine work on three types of incubator stations for one-day-old chicken production. These stations differ in production volume, technical and technological characteristics. The energy efficiency of incubator stations was determined with chronograph measurement of human work, energy consumption for each machine and equipment involved in the incubation process. Comparison of obtained data was performed in numerical values of production per chicken. Mini-incubator station had the lowest energy efficiency with 83,15% of energy related to the incubator, 16,62% of lighting, and 0,23% of the ovoscope. This station consumed 652,2 machine work hours or 6,52 hours/chicken, human work 24,4 hours or 0,24 hours/chicken and electricity 31,75 kWh or 0,31 kWh/chicken. The medium-sized incubator station consumed 670,7 hours of machine work which is about 0,018 hours/chicken, human work 291,82 hours or 0,1076 hours/chicken, and electricity 8 341,21 kWh or 0,22 kWh/chicken. The large-sized incubator station consumed 1 310,1 hours of machine work or 0,013 hours/chicken, human work 769,14 hours or 0,008 hours/chicken and electricity 30 672,71 kWh or 0,32 kWh/chicken. The incubator station, Poljovet d.o.o., recorded a medium positive correlation between machine and human work and a strong positive correlation between machine work and electricity. Also, mini-incubator station in Pazarić recorded a strong positive correlation between machine and human work and a medium positive correlation between machine work and electricity. We concluded that energy efficiency was most affected by the heating system and large incubator stations had an advantage over small ones.*

Key words: *incubator, chicken, energy, efficiency*



AN OVERVIEW OF BIOMASS COMBUSTION TECHNOLOGIES WITH AN EMPHASIS ON THOSE FOR AGRICULTURAL BIOMASS

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Abstract. Nowadays increasing energy needs are experienced, while facing environmental issues as air pollution, global warming and acid rains. Due to many disadvantages of fossil fuels biomass is considered as a possible replacement. For energy purpose biomass could be used in direct combustion or in biogas and biodiesel production. This paper provides a review of different direct biomass combustion technologies, with emphasis on agricultural residual biomass as an energy source. Properties of biomass being used directly affect design of combustion furnace and operating parameter. Many agricultural raw materials which might be considered as a potential waste in fact have a great energy potential and when used for combustion this waste management problem can be reduced or even solved. With biomass usage potential issues are present as storage, high moisture contents, lower heating values and possible high emission of NO_x during the combustion. New promising technologies and conventional combustion systems have been considered, among which are furnaces with combustion on grade, pulverized combustion, combustion in the fluidized bed and combustion in pushing furnace. Different agricultural biomass types are contemplated, alongside with applied technologies. Systematic comparison of described technologies is given in accordance with several different criteria, including overview of advantages and disadvantages. To achieve sustainable energy development, new technologies are necessary as well as advancement of the existing ones. In order for that to be achieved, it is important to systematize and categorize biomass combustion technologies.

Key words: combustion technologies, agriculture (residual) biomass, cigarette (cigar) combustion



SOME POSSIBLE EFFECTS OF CONSTRUCTION AND DEMOLITION WASTE LANDFILL ON THE ENVIRONMENT

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Abstract: *In cases of inadequate waste management, there is a tendency for inappropriate disposal of construction and demolition (C&D) waste, especially when its production surpasses the capacities of official disposal sites. By disposing of C&D waste on the edge of the protected natural area during the spring of 2021, a C&D landfill was formed near Reva pond, Belgrade. In this work, the qualitative composition of C&D waste in the field was assessed, including chemical analysis of landfill soil which was investigated by comparing its elemental composition with the control soil by utilizing SEM-EDS analysis. The presence of various C&D waste components, typical (concrete blocks, bricks, armature, glass shards, wood, soil of various origin) and atypical (furniture, industrial-type glass shards, paint bottles and cans), indicated that waste disposal was only partially controlled. Due to the high heterogeneity of the disposed soil, analysis can neither confirm nor exclude the possibility of heavy metal contamination. Herbaceous plants are already naturally colonizing the landfill; also, the aggressively spreading, heavy metal accumulator, honey plant species - the False indigo bush (*Amorpha fruticosa*), is abundant in the area, and it is expected that it will recultivate the landfill site. To get a full assessment of the landfill's impact on local ecosystems, continuous monitoring is recommended.*

Keywords: *C&D waste; waste disposal; excavated soil; environmental pollution; heavy metals;*



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THERMAL ENERGY STORAGES – MATERIALS AND APPLICATION

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INVITED PLENARY LECTURE

Abstract: *Thermal energy storage (TES) is a technology that gives an opportunity for using energy in the period when the production of energy is at a lower level or does not exist. TES are used when there is a mismatch between energy demand and energy supply. They increase heat generation capacity, enable better operation, increase system reliability, shift energy purchases from high to low-cost periods, they take role of expansion vessel and so on. This paper will present the field of Thermal Energy Storages (TES), methods and materials that are used as working mediums. The problems of using PCM materials as storing mediums were shown and discussed. The technics for overcoming the problem of low thermal conductivity of PCM were listed and described. At the end of the article the main applications of TES were given.*

Key words: *Thermal energy storage, PCM, heat transfer enhancement,*



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ANALYSIS OF ENERGY USE AND POSSIBILITY OF IMPROVING ENERGY EFFICIENCY IN GOAT FARM-DAIRY "BEOCAPRA", SERBIA

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Abstract: Nowadays people face challenges of rising energy consumption, energy costs, environmental impacts, consequence of global warming etc. All trends are directed to reduce those negative effects. In terms of energy consumption, the main goal of any production is to reduce energy consumption per product unit. At the goat farm and dairy Beocapra, located in Kukojevci in Serbia, energy was used for technological processes that include heating and cooling different types of working mediums as well as for heating and cooling spaces of the dairy. In this article the structure of used energy, energy quantities, temperature regimes and quantities of mediums and power consumption of the biggest systems were presented. The measures for improving energy efficiency and possibilities of using renewable energy sources for covering a part of energy demands were proposed. At the end of the article benefits of using proposed renewable energy sources were given.

Key words: energy, dairy, energy efficiency, renewable energy sources



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ESTIMATION OF THE SOLAR DESALINATION POTENTIAL TO COVER THE IRRIGATION CROPS IN THE GREEK ISLANDS

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Abstract: *Greece has a significant potential for the development of desalination plant. Especially in the Greek islands the available sea water is limitless and can be used to produce fresh water for various needs. At the same time fresh water is not available in sufficient amounts in the Greek islands and as a result many issues occur for activities especially during the summer months when drought is more intense. The development of agriculture in the Greek islands in small scale crops is of great interest specially to cover the local needs and to achieve lower cost products. Solar desalination plants could be low-cost solution for such projects as the solar energy potential in Greece is sufficient and can lead to the production of water amounts capable to cover the irrigation needs. In this study a theoretical study is performed, to estimate in which rate solar desalination can serve the irrigation needs of open filed agricultural crops in a few case studies of Greek islands. The irrigation needs of specific crop are calculated using the Penman method for the evapotranspiration of the crops and the local rain data of each region. Solar desalination potential is estimated via the solar intensity data for each region and the necessary energy for seawater evaporation. This study can be proven particularly useful in the initial phases of solar desalination plants installation as it provides information about the relationship between water production and needs. That way a preliminary evaluation of proper sizing and estimation of the desalination plant's viability can be performed.*

Key words: *desalination, irrigation, solar energy, islands*



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BIOCHEMICAL POTENTIAL FOR THE PRODUCTION OF BIOGAS FROM AGRICULTURAL WASTE SAMPLES

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Abstract: Greece has a significant agriculture sector which is one of the biggest pillars for its economy. Nonetheless, the produced agricultural waste is not so insignificant and the need for its utilization is imperative. An innovative way to utilize the agricultural waste is through the anaerobic digestion process and the production of biogas to promote the use of Renewable Energy Sources. The aim is to reduce the environmental footprint, thus protecting the environment, which aligns with the global goals for a “greener” future while using renewable energy sources. The identification of the potential of agricultural waste materials used for biogas (hence methane) production will offer the possibility of low cost and environmentally friendly energy production solutions. Proper management and utilization of the agricultural waste can be achieved, through the anaerobic process, in order to cover a wide range of energy needs. for the benefit of the environment. Making agriculture more competitive through the complete utilization of agricultural waste provides huge potential and economic benefits which deserve to be explored. In this study an experimental study is performed, to estimate and determine the methane production potential in the laboratory of various agricultural waste samples. The biochemical methane production potential of the samples was determined following the Biochemical Methane Potential (BMP) method. In addition, the total and volatile solids were measured using the Standard Methods for the Examination of Water and Wastewater, APHA, 2005 and volatile fatty acid concentrations measurements took place in the solutions of the above samples, which were used in the batch reactors, upon completion of the biodegradation. This study can be proven particularly useful in the utilization of agricultural waste as it provides information regarding the methane potential of numerous waste samples byproducts of the agricultural activity. That way a preliminary evaluation and estimation of their potential can be performed.

Key words: agricultural waste, anaerobic digestion process, biogas, renewable energy sources, methane potential



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RETENTION OF BERRY FRUITS QUALITY BY FREEZE – DRYING: CHALLENGES AND RESULTS

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INVITED PLENARY LECTURE

Abstract: *Berry fruits are important crops in temperate regions such as R. Serbia and occupy an important position in the agriculture production. These attractive fruits are favored for their excellent taste and can be considered a very rich source of micronutrients and bioactive compounds with beneficial effect on health. However, berry fruits are highly perishable foods and have a rather limited shelf life, since they easily undergo degradation reactions by microorganisms, because of their high moisture content. The challenge is how to preserve this fruit in postharvest period and prolong availability during the year. Freeze-drying (lyophilization) is a modern process of drying that is increasingly used in industry of food processing. The process of water removing is done from the frozen samples by sublimation of ice under vacuum. The aim of this paper is to point out the benefits of freeze-drying in comparison to air-drying, through analysis of effect of two drying methods on the relevant parameters of quality of the strawberry, raspberry and blackberry fruits. The content of vitamin C, physicochemical properties, degree of rehydration, as well as evaluation of sensory characteristics of the fruits after freeze-drying and air-drying at 60°C were determined. The obtained results showed significantly better retention of vitamin C, physicochemical and sensory characteristics after freeze-drying of the berry fruits than air-drying. The degree of rehydration was also significantly higher in the freeze-dried samples. Generally, it may be concluded that freeze-drying represent a very suitable method for preserving these delicate berry fruits.*

Key words: *freeze-drying; air-drying; berry fruits; quality.*



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DRYING TECHNOLOGIES IN FOOD ENGINEERING

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INVITED PLENARY LECTURE

Abstract: *Drying is one of the primary methods of food preservation in the agro-industry and is a complex and energy-intensive process. In recent years, research in the fields of natural and technical sciences has focused on optimising the energy requirements of industrial systems to sustainably develop and modernise various technologies. Many researchers deal with drying in the agro-industry, as evidenced by an enviable number of publications on this topic. In recent years, a large number of conferences and round tables on the implementation of energy-efficient technologies have been held in the Republic of Serbia. Conclusions have been adopted that the Republic of Serbia, except for the Law on Energy, has no accompanying regulations that would regulate designing and constructing of centres for drying, storage and processing of agricultural products. Drying is one of the basic technological operations in the food processing industry. Attention was drawn to the extremely high energy consumption of drying plants. Some of the proposed solutions are rationalising energy consumption at existing plants and adopting new, more economical plants based on new technologies. This paper reviews the available literature and research of a large number of international authors dealing with advanced drying technologies, improving the energy efficiency of drying systems and environmental aspects of drying to ensure sustainable development, with a tendency to provide a comprehensive insight into the complexity of the drying process, trends in the development of equipment and technologies, as well as ways to properly select the appropriate technologies depending on the specific feedstock being dried.*

Key words: *Drying, dryer classification, modern technologies, energy efficiency, ecology.*



POST-HARVEST DRYING KINETICS OF OKRA (*ABELMOSCHUS ESCULENTUS*) UNDER GREENHOUSE DRYING AND HEAT PUMP DRYING

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Abstract: *Drying is carried out to prolong the shelf life of food products to reduce post-harvest losses by reducing the moisture content present in it. Thin layer drying kinetics of okra (*Abelmoschus esculentus*) has been compared with open sun drying, heat pump drying and greenhouse drying with different glazing material such as UV Polyethylene sheet and drip lock sheet under passive and active modes. The experimental results showed that the reduction in moisture content of okra from 87.65 % to 10% was achieved in 16 hours under open sun drying (OSD), 14 hours using UV polyethylene sheet greenhouse dryer under passive mode (UVPM), 13 hours under drip lock sheet greenhouse dryer under passive mode (DLPM) and in UV polyethylene sheet greenhouse dryer under active mode (UVAM), 12 hours to achieve the moisture content of 9.3 % using drip lock sheet greenhouse dryer under active mode (DLAM) and 8 hours in heat pump drying (HPD). The highest dryer efficiency of 38.78% was achieved under HPD and 14.15% was achieved under DLAM greenhouse drying. Higher effective moisture diffusivity value of $2.09 \times 10^{-10} \text{ m}^2/\text{s}$ was achieved in HPD compared to other modes and lower effective moisture diffusivity of $1.04 \times 10^{-10} \text{ m}^2/\text{s}$ was achieved under open sun drying mode in drying okra. Heat Pump dryer had a higher Specific Moisture Extraction Rate (SMER) value of 2.60 kg/ kWh compared to other methods of drying. It was found that the products dried with minimum drying time in HPD compared to greenhouse drying but still in the economic point of view greenhouse drying has low cost.*

Keywords: *Active mode, Drying kinetics, Effective moisture diffusivity, Greenhouse dring, Heat pump drying, Passive mode*



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MODELING THE THIN-LAYER DRYING OF BEE POLLEN

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Abstract: *Bee pollen provides proteins, lipids, vitamins and minerals in bee nutrition. Bee pollen also has a significant nutritive value as a supplement to human nutrition. Fresh bee pollen must be dried in order to reduce water activity for the development of various microorganisms. Convective drying is common method for bee pollen dehydration. In this paper, several drying temperatures (40, 50 and 60°C) were investigated during the 3 hours convective hot air drying. Several drying models used in literature were fitted to experimentally obtained drying curves in order to find most suitable one. The best fit was achieved with Two-term (for 60°C) and Hii et al. (for 40°C and 50°C) drying models. The coefficient of determination was the primary criterion for selecting the best model to describe the drying curves.*

Key words: *Bee pollen, convective drying, drying models.*



RECENT ADVANCEMENTS OF SOLAR DRYERS WITH IMPLEMENTED PHASE CHANGE MATERIALS

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Abstract *Using solar energy for drying agricultural products is one of the oldest methods of preserving food. Excellent results are obtained by using solar dryers, both in the quality of dried products and in energy-efficient drying procedures. The problem occurs when the solar radiation is low intensity or absent, which makes it impossible for the solar dryer to work. This problem can be solved by implementing phase change materials (PCM) which improve the efficiency of the system and allow the dryer to work in a period during off sunshine hours. This review provides insight into the progress in the field of solar dryers in which PCM is implemented. The impact of using PCM on the quality and efficiency of product drying compared to solar dryers without PCM and open sun drying is shown. It has been noticed that the use of PCM improves the global thermal efficiency of the system. The temperature and the percentage weight of moisture removal was increased and the drying time of the product was reduced. Various cases of drying apples, tomatoes, basil, bitter melons, strawberries and medicinal herbs have been considered. Different positions of PCM in flat solar collectors increased the thermal efficiency of the flat plate collector in the range from 5.02% to 10.13%, and the overall efficiency varied from 21.92% to 25.72%. The use of hybrid systems consisting of two or more synchronized systems also have been considered. The hybrid solar dryer with implemented PCM and integrated geothermal system showed an improvement in performance efficiency of 20.5% compared to a flat plate solar collector. The progress of solar dryers with the implementation of PCM is given with the aim of further developing the application of renewable energy sources in food preservation.*

Keywords: *food, solar dryer, PCM, renewable energy*



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FINANCIAL ASPECTS OF WATERMELON PRODUCTION ON FAMILY FARMS IN THE REPUBLIC OF SERBIA

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Abstract: *Vegetable production in the Republic of Serbia accounts for about 3.5% of total crop production, within which there is a constant trend of declining areas where vegetables are grown, primarily due to the great need for hiring labor, which is decreasing. One of the most common vegetable crop grown in the Republic of Serbia is watermelon, which according to the Republic Statistical Office, along with quince, was grown on 5,700 hectares in 2019, while the largest areas under these vegetables were recorded in 2017 when they amounted to about 8,300 acres. The aim of this paper is to present the economic and financial aspects of watermelon production on farms in the Republic of Serbia in the period between 2015 and 2019, based on data from Statistical Office of the Republic of Serbia and the income and expense survey on the family farms, which represents calculations based on variable costs, conducted by the Institute for the Application of Science in Agriculture. Sensitivity analysis shows the price and yield influence on gross margin amounts in watermelon production. The obtained results indicate a variation in the amount of gross margin in watermelon production in the analyzed period, due to changes in prices, yields and variable costs. Data obtained on sensitivity analysis, determinate that changes in price and yield have a significant impact on the amount of gross margin in watermelon production.*

Keywords: *gross margin, watermelons, farms, Serbia*