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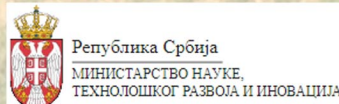
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Preface

Welcome to the 6th International Symposium on Agricultural Engineering, a milestone event in our decade-long journey of advancing agricultural innovation. This Book of abstracts encapsulates the essence of our ongoing commitment to exploring and sharing cutting-edge developments in the field of agricultural engineering.

Over the past ten years, our symposium has evolved into a vital platform for researchers, practitioners, and experts from around the world to converge, exchange ideas, and foster collaborations. It is within this collaborative spirit that this compilation of abstracts finds its purpose.

Within these pages, you will discover a diverse array of research, insights, and innovations that span the breadth of agricultural engineering. From precision farming and sustainable practices to the integration of digital solutions and robotics, these abstracts showcase the collective efforts to address the challenges and opportunities facing modern agriculture.

We would like to extend our heartfelt gratitude to all the authors who contributed their research and insights to this book. Your dedication to advancing agricultural engineering is commendable, and your contributions form the foundation of this symposium's success.

As we embark on this 6th edition of our symposium, we look forward to the discussions, debates, and discoveries that will undoubtedly shape the future of agriculture. Together, let us continue to sow the seeds of innovation and cultivate a brighter and more sustainable agricultural landscape.

Thank you for being a part of the 6th International Symposium on Agricultural Engineering.

Prof. Dr. Ivan Zlatanović
ISAE 2023 Scientific Committee President

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Sustainable agriculture and biosystems engineering

THE INFLUENCE OF TILLAGE SYSTEM ON THE WHEAT SOWING QUALITY

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Abstract: In agricultural production, sowing is one of the most important agro-technical operations that influence the quality of the product and yield. The crops sowing quality, including wheat, depends on properly prepared soil, that is, on the quality of soil cultivation. However, despite well-executed soil cultivation, satisfactory results cannot always be achieved if sowing is not done in an appropriate manner. The achieved depth of sowing affects the speed of sprouting, rooting, resistance of plants to low temperature and drought, intensity of budding, growth and development, and achieving the highest yield in certain conditions. In unfavorable agro-technical conditions, and especially in the conditions of dry farming, optimal conditions for high-quality sowing often cannot be ensured by applying the conventional method. Therefore, new cultivation and sowing systems are being applied in order to perform high-quality sowing in time. During the experiment, the influences of the tillage system and sowing method on the sowing depth and the depth of the formation of the tillering nodes were registered. The results of two-year study are given, where four methods of tillage were applied, namely conventional tillage at depths of up to 25 cm and three reduced tillage methods at different depths. Reduced cultivation with a disc harrow was done at a depths between 8 and 12 cm, and reduced cultivation with rototiller was done at depths of 5-10 cm and 10-15 cm. During the tests, the sowing depth and the depths of the tillering nodes were determined by direct measuring of the knots positions of the analyzed plants. Furthermore, it was verified that depth of the knot has a significant effect on the resistance of wheat to low temperatures during winter and lack of moisture during summer droughts. Achieved results enable further optimization of applied cultivation and sowing systems.

Keywords: *classic tillage, reduced tillage, sowing depth, tillering node.*

POTENTIAL OF URBAN GREEN ROOFS AS A HABITAT FOR BEES

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INVITED PLENARY LECTURE

Abstract: The intense development and urbanization of the cities last decades significantly influenced on increase of pollution and formation of urban heat islands. Further, the rapid urbanization impacted on decrease of green areas in cities. Looking at the data of development for Belgrade, Serbia, in a period from 2016 to 2020, the square meters of built space increased 350%. Furthermore, Serbia has $2.1 \cdot 10^9$ square meters of dwellings build before 2012, which means that the thermal properties of the buildings' envelope were much lower than it is now recommended. Moreover, with a intense urbanization, the number of bee population significantly decreased. All these issues represent a high potential for the refurbishment of buildings using green systems, either the green roofs or together green roofs and green facades. Different types of green roofs and facades are considered to be a good habitats for bees in urban areas, and a lot of cities worldwide recognized this potential. Serbia has a great potential for developing the green roofs at the top of the existing buildings, which need refurbishment, since the majority of these buildings has an optimal height for the bees habitat, up to eight floors. This concept is beneficial in many directions: contribution to energy efficiency and better indoor environmental quality, decrease of urban heat islands, decrease of urban pollution, increase of number of green areas in cities and in the same time saving of bee population in urban areas.

Keywords: *green roof, green façade, bees, urban habitat, building refurbishment.*

THE EFFECT OF NANO TITANIUM COLD PLASMA ON THE SHELF LIFE AND QUALITY CHARACTERISTICS OF STRAWBERRY FRUITS

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Abstract: Different post-harvest diseases in fruits and vegetables cause heavy economic losses worldwide. Strawberry fruit is extremely corruptible and prone to mechanical damage, rotting, and physiological bruising in postharvest period. Nowadays, one of the essential issues in societies is to reduce postharvest losses of fresh crops to increase food security and prevent loss of capital. In this study, Nano titanium cold plasma of Erdwelle company was used to reduce degradation rate of it during 7 days of storage and increase shelf life. Samples of strawberry were treated with cold plasma for 5 min and color indicators were measured immediately after the plasma application. The results indicated no significant difference between the indicators in control and treated samples. According to the results of sensory evaluation after 7 days of storage, the texture, color, and general acceptance (acceptability) of plasma-treated samples were significantly better than those of control samples, but no significant difference was observed in terms of the odor. In this context, it may be concluded that cold plasma may be considered a novel approach to increase shelf life of strawberry fruits.

Keywords: *nano titanium cold plasma, strawberry, sensory evaluation, postharvest, shelf life.*

DESIGN, MANUFACTURE AND EVALUATION OF THE ANTI-FREEZING DEVICE FOR TREES IN THE SPRING SEASON WITH INFRARED LASER NETWORK TECHNOLOGY

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Abstract: The growth and performance of agricultural plants is a function of all environmental factors and their interactions. These factors include weather factors, soil moisture, food and gases, which increase or decrease plant growth depending on their amount in the environment. Among these factors, latitude, height above sea level, distance and gradient to the sea and slope as the most important climatic factors and rainfall, solar radiation (including the length of the lighting period), air temperature, air humidity, soil humidity, soil temperature and Wind can be named as the most important meteorological variables that have the greatest impact on agriculture. The temperature of the plants is not constant and changes under the influence of temperature changes in the surrounding environment. In autumn and spring, the ambient temperature changes a lot, so that sometimes the temperature even drops below zero degrees. All the vital activities of plants are carried out in the temperature range of 0 to 50°C, which is the coagulation point of proteins. Beyond these temperatures, the chemical structure of proteins (enzymes) changes and as a result the biological activities of plants stop, or start to stop. When the air temperature is reduced, plants and living beings can partly resist cold weather. Yet, if the cold increases, it will be damaging. This injury which is called frostbite is a very important and dangerous factor for agriculture and has been threatening gardens for many years. Due to the rapid temperature difference in the spring season and the momentary drop in temperature at night and the rapid blooming of some trees such as apricots, it causes the blossoms to freeze and the fruit fertility is lost and heavy losses are caused to the farmer. The device made by the team, which acts similar to the action of the Earth's atmosphere against sunlight, creates an infrared laser network at the height of the tree and maintains the temperature between the tree and the ground until the middle of the night. Field evaluations in the fields showed that there was a temperature difference of 8 degrees between the top and bottom of the laser grid.

Keywords: *infrared laser, anti frost, farms, spring.*

OVERVIEW OF THE USE OF CONVOLUTIONAL NEURAL NETWORKS IN PLANT DISEASE RECOGNITION BASED ON THE LEAF IMAGE

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Abstract: The use of artificial intelligence in modern agriculture is on the rise, due to the fact that it provides a possibility for more efficient production, better decision making and reduction of the costs. This research takes into consideration the use of the convolutional neural networks for diagnosing plant illnesses based on the leaf image. Detection of plant diseases in the early phase can improve the quality of the food products and minimize the losses. Convolutional neural networks are a type of deep learning method that is one of the most used models for solving image recognition, classification and detection tasks. Therefore, it is justified to anticipate that they can be very effectively applied in the agriculture sector. This paper covers few different plant species, taking into account the diseases that most often affect them. Various models have been presented and analyzed, while highlighting their advantages and disadvantages when applied for solving this task.

Keywords: *convolutional neural networks, plant disease recognition, artificial intelligence.*

APPLICATION OF DIGITAL TECHNOLOGIES IN BEEKEEPING

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INVITED PLENARY LECTURE

Abstract: The honey bee (*Apis mellifera L.*) is the most important pollinator that participates in the pollination of over 200 species of cultivated plants. With its role as a pollinator in the ecosystem, the honey bee affects the quantity and quality of food for humans. Breeding of this useful insect produces direct bee products such as honey, pollen, royal jelly, wax, propolis and bee venom. As a result of various negative factors, the honey bee population suffers losses. The application of digital technology and machine learning in beekeeping affects the improvement of bee colony research, the prevention of undesirable phenomena and diseases, and the improvement of beekeeping production.

Keywords: *beekeeping, honey bee, digital technologies, bee colony monitoring.*

USE OF CONSTANT FLOW VALVES (CFV) ON KNAPSACK SPRAYERS TO IMPROVE CROP PROTECTION QUALITY

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Abstract: To achieve high yields and good fruit quality, adequate, timely, and high-quality crop protection is required. Farmers on small farms use knapsack sprayers for crop protection, which as such are not reliable for high-quality crop protection because the pressure at the nozzle outlet is uneven, resulting in low-quality pesticide application. Since knapsack sprayers are unreliable, the objective of this paper is to determine the extent to which constant flow valves (1 bar, 1.45 bar, and 2 bar) affect the quality of crop protection and thus the cost. The flow rates with the constant flow valves were 240 ml/min (CF -valve 1 bar), 303 ml/min (CF -valve 1.45 bar), and 331 ml/min (CF -valve 2 bar), the nozzle itself 261 ml/min. During the test, the working pressure was determined by the regulator used, the operator's movement speed was constant at 1.2 km/h, and the distance to the object was 1 meter. The average coverage of the treated area ranged from 5.76% to 35.85%. The average size of droplets ranged from 490.88 μm to 639.72 μm , and the average number of droplets per cm^2 of surface area ranged from 44 to 102. Based on the results obtained, it was concluded that constant flow valves have an impact on leaf coverage, number and size of droplets, and cost of crop protection, and therefore can be used very effectively for these purposes.

Keywords: *constant flow valve, knapsack sprayer, pesticides, quality of spraying, coverage of treated area.*

REVIEW PAPER ON VARROA INFESTATION, DETECTION AND PREVENTION IN BEEHIVES

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Abstract: The widely recognized insect known as the honey bee (*Apis mellifera*) has a beneficial impact on both the environment and human life, making it important to protect them not just for ecological reasons but also for the economic and social advancement of countryside regions. Their existence is so essential that the recent decrease in honey bee hives has caused a growing interest in them. One of the reasons for bees' decline in population is infestation with a parasite known as *Varroa destructor*. In order to effectively treat the *V. destructor* infestation, it is critical to monitor the amount of infestation in hives. While there is at present no specific sensor for this job, continuous and discrete monitoring of hive infection levels as well as other critical bee colony characteristics, such as temperature and humidity, is wanted. The use of chemicals by apiarists is a method of controlling the infestation that is the most common strategy. Substitute tactics include the use of organic compounds, organic products like essential oils, and biotechnological techniques like mite trapping. Therefore, successful therapy and preventing harsh chemical use can reduce bee mortality and economic losses.

Keywords: *smart apiculture, varroa, honey bee, monitoring.*

ARTIFICIAL INTELLIGENCE APPLICATIONS IN AGRICULTURE: RECENT ADVANCES AND PERSPECTIVES

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Abstract: One of the most important fields of industry is agriculture. Recently agriculture is aided by advanced technologies like artificial intelligence (AI). In the current work, various technologies of artificial intelligence and its allied techniques like machine learning, deep learning, deep reinforcement learning, metaheuristics, deep learning, explainable artificial intelligence and interpretable machine learning, ARM, IoT, IoT data analytics and operations research have been reviewed. The major problems which are faced by farmers are soil condition monitoring, water level follow up, control of pests in the field, unforeseen weather, yield improvement, etc. The applications of the AI and related tools for soil moisture monitoring and irrigation, optimization of irrigation, smart irrigation, agricultural water harvesting, identifying and classifying pests, crop yield prediction, agricultural data analysis, precision agriculture, cultivation classification, managing risk and optimizing production practices in agriculture and sustainable agriculture supply chain performance have been summarized. Finally, the current problems existing and future directions are discussed.

Keywords: *AI in agriculture, smart irrigation, crop yield prediction, agricultural data analysis, precision agriculture.*

CASE OF STUDY FOR DRAFT FORCE MAP SMOOTHING IN PRECISION AGRICULTURE

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Abstract: There are many physical and chemical properties of soil that can be measured and mapped. Such maps can be very important decision-making tools in precision agriculture. However, unlike yield maps and crop scouting maps, all other maps show a lower degree of reliability in terms of decision utility. Soil compaction is the most representative feature of the production plot from the domain of physical and chemical soil properties. This paper first presents an experiment designed to measure soil compaction, and then a mapping of the results in a commercial software. The test field with an area of one hectare was reduced to a control limit of 60 meters in width and 120 meters in length to ensure the uniformity of speed and other parameters. The resolution of the draft force measurement as an indicator of soil compaction was 50 Hz. This resulted in the existence of missing data on the draft force map itself, because several draft force values were related to one spatial coordinate manifested as longitude and latitude. The paper further shows the procedure of data smoothing and generation of complete maps without missing spatial data.

Keywords: *draft force, strain transducers, missing data, smoothing.*

DEVELOPMENT OF SUSTAINABLE AGRICULTURE IN THE COMMUNE OF GAROUA, NORTHERN CAMEROON

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Abstract: In Cameroon, agriculture is the primary source of development, whether in rural areas or in large cities. In recent years, rapid industrialisation has had a major impact on the agricultural sector. This study focuses on the commune of Garoua, which is located on the banks of the River Benoue. The main economic activities are farming and livestock rearing. Over the past ten years, agricultural activity has been influenced by two main factors. The first is the urban development policy. As a result, agricultural land has declined sharply. The second is the economic development of the market, which has influenced agricultural production in commercial cooperation. The commune of Garoua enjoys favourable economic conditions for livestock farming. For example, the commune has a huge pasture to feed it. It is also located close to commercial centres where beef consumption is high. Livestock production plays an important role in the domestic economy. However, the supply of seed in the villages is unstable, so disease control is limited. In addition to agricultural activities, non-agricultural activities are playing an increasingly important role in households. They help farmers earn money quickly. However, they are leading to a reduction in the agricultural workforce. The younger generation no longer wants to participate in the agricultural sector. Traditional agriculture is at great risk of losing production. Agricultural production in the Garoua commune has many advantages, but there are also difficulties. Specific policies are therefore strongly recommended to help farmers move towards sustainable development.

Keywords: *agriculture, sustainable development, industrialisation, garoua.*

TECHNICAL AND TECHNOLOGICAL PARAMETERS OF THE PROTECTION ZONE PROCESSING IN PERENNIAL PLANTATIONS

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Abstract: Maintaining modern intensive plantations requires the latest practical and theoretical knowledge, the application of which achieves top-quality production results. In recent years, more and more attention has been paid to both energy efficiency and environmental aspects as the ultimate goal of the sustainability of each production. The sustainability of a process can limit reaching the maximum of said process. In the technologies of soil maintenance in perennial plantations in recent years, it becomes imperative that the chemical treatment of the soil, immediately adjacent to the plant and within the row, be replaced by mechanical processing. This need is primarily aimed at minimizing the use of pesticides in order to respond to the environmental requirements. Regular land cultivation is a technically complex problem. The given area is made up of up to 25% of the total land area of the plantation. The paper presents the results of testing a rotary harrows with a deflection, which in one pass achieves the processing of a part of the inter-row surface and half of the protective zone. The results of the research show that the optimal speed of movement of the aggregate carried out in the plantation of the orchard is 1.56 m/s, and in the plantation of the vineyard 1.23 m/s. Productivity of aggregates in the orchard 0.24 ha/h, in the vineyard 0.19 ha/h. Fuel consumption in the vineyard 7.2 l/ha, and in the orchard 6.8 l/ha. Productivity of the aggregate is largely conditioned by the technical solution of the aggregate and the technology of plantation cultivation.

Keywords: *rotary shredder, soil cultivation, perennial plantation, aggregate productivity.*

THE VERTICAL GREENHOUSE. A CONCEPT OF FUTURE AGRICULTURE

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Abstract: This paper provides a comprehensive overview of vertical greenhouses highlighting the importance of vertical greenhouses today, their advantages and disadvantages, their construction technology, the types of crops that can be grown in a vertical greenhouse, the challenges, and limitations they face and their main construction details. An analysis of their future use in agriculture is also referred. The main advantages of vertical farming or vertical greenhouses are a) Efficient use of space b) Increased crop yield, c) Reduced water use, d) Protection from pests and diseases, e) Energy efficiency. The design and construction of vertical greenhouses involves careful consideration of construction materials, lighting and ventilation systems, irrigation and nutrient supply systems for vertical cultivation, and automation and control systems. Vertical greenhouses face challenges and limitations that must be carefully considered. High initial investment costs, technical complexity, limited crop diversity, dependence on artificial light and climate control, and the need for skilled labor and specialized knowledge are key factors that can affect the successful operation of vertical farming. However, with advances in technology, continued research and increased awareness, these challenges can be overcome, leading to more efficient sustainable and diverse crop production in vertical farming systems.

Keywords: *vertical farming, vertical greenhouses, urban agriculture, sustainability, land saving, energy saving.*

INNOVATIVE APPROACHES FOR PROLONGING THE POSTHARVEST FRESHNESS IN THE FRUIT SECTOR

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Abstract: Edible films and coatings encompass thin edible layers that can either be peeled away or ingested along with food items. Edible active packaging involves utilizing edible polymers combined with natural antioxidants. Edible coatings have demonstrated their efficacy as a primary packaging solution by effectively retarding the ripening process, maintaining nutritional attributes, and curbing quality deterioration through the reduction of various inherent mechanisms such as gas exchange, respiration, and transpiration rates. In this paper we present recent advancement in the augmentation effectiveness of edible coatings and films through the infusion of active natural elements with demonstrated antioxidant and/or antimicrobial characteristics. These packaging materials are classified as active due to their capacity to interact with fresh fruits, constantly releasing bioactive components. This integration of active agents within biopolymer matrices not only enhances the fruits resistance to oxidation but also impedes the proliferation of foodborne pathogens. Consequently, these packaging innovations offer supplementary safety measures for food products, even in conditions where refrigeration is absent.

Keywords: *fruit sector, postharvest technology, films and coating, bioproducts.*

DIGIBEE: DIGITIZATION OF BEEKEEPING

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Abstract: Germany has an approximate total of 870.000 beehives, managed by about 130.000 beekeepers of which 96% have up to 25 beehives, 3% between 26 to 50, and 1% have more than 50 beehives. The total honey production is 15.000-25.000 tons per year, which contributes significantly to the economy of small, medium, and large producers. Furthermore, they play an essential role in supplying important ecosystem services and in maintaining biodiversity. The role of beekeepers in keeping the beehives operational and producing honey is indispensable. Among a beekeeper's activities, periodic external and internal visual inspections of the beehives are required according to German food regulations. Internal inspection (i.e. opening the hives), however, may cause a critical disruption of the bee's activity and have a substantial impact on the honey harvest. Considering the large number and the wide dispersion of the beehives, maintaining accurate, non-invasive, real-time monitoring has become a matter of great interest among professional beekeepers. Various technical solutions to this challenge have recently been developed. Against this background, DigiBee was designed as a Do-It-Yourself (DIY) project for school children with the purpose to raise interest for academic careers in Science, Technology, Engineering, and Math (STEM) disciplines. The beehives are equipped with sensors for temperature, humidity, noise, vibration, and weight, using an Arduino-compatible microcontroller. Furthermore, this project includes the application of an Augmented Reality (AR) lens for field inspections, providing the possibility for an internal inspection without disturbing the bees. In addition, a microphone embedded in the AR lenses allows for hands-free documentation of the beehive status using a voice command module. Further development includes Artificial Intelligence (AI) supported data analysis for predictive maintenance and possible future threats by invasive hornets.

Keywords: *beekeeping, digital monitoring, STEM education, augmented reality, sustainable apiculture.*

PLANT-IT: A SMART CITY APPLICATION FOR GREENING THE URBAN SPACE WITH CITIZEN'S PARTICIPATION

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Abstract: This paper presents a smart city application that aims to strengthen green spaces in the city through the public contribution of citizens. Research from several experts has shown that as urban agglomerations become larger and more compact, green spaces disappear. This fact is crucial as we are already in front of rapid urbanisation and unprecedented climate stress is expected in many cities. Green spaces can boost the resilience of cities to heat waves, floods, landslides, and even coastal erosion, and in addition they enhance sustainability by improving air quality, protecting biodiversity, and mitigate urban heat island effect. Through this application there is a great potential for collaboration between experts (i.e. agricultural scientists, botanists, landscape architectures, urban planners), citizens and municipal authorities in order to expand the urban green and enhance the quality of life in cities. The 'Plant it' app is founded to create awareness among citizens to become city gardeners and contribute to the work of the municipality to make all neighborhoods better with some small green corners in public and private spaces (private gardens, balconies) as well. Users can also upload a picture of their plants to the platform by scanning them to update and be informed about them, talk with other users exchanging ideas as well as find green spaces in each neighborhood to plant a flower or a tree. Users collect points with each planting where they can be redeemed.

Keywords: *urban greening, smart cities, participatory design, greening app.*

TEST RESULTS OF SEEDERS WITH PNEUMATIC APPARATUS FOR MAIZE SOWING

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Abstract: Optimum layout and the appropriate number of maize plants per area unit are the essential prerequisites for successful production. By maize sowing with precision seeders, significant savings in seed and working time are achieved, and proper and uniform seeds distribution of by depth, length, and width, enables better germination, sprouting, and higher yields. Understanding the importance of correct sowing becomes even more important considering the fact that mistakes made while sowing cannot be corrected later with other agrotechnical measures. The paper presents the test results and quality assessment of the Vaderstad Tempo T6 and Sola Prosem K8 maize seeders. The trial is aimed to determine the work of the mentioned seeders for wide-row sowing when sowing maize seeds in the production conditions of the observed area. The seeders worked in similar test conditions, and the corn sowing was done in the vicinity of Pancevo, in the Banatsko Novo Selo location. Tests and evaluation of the quality of seeders were performed according to ISO standards 7256/1 and 7256/2. The obtained results show that with the seeder type A-Vaderstad Tempo T6, the sowing of maize achieved better quality, bearing in mind that higher values of the QFI index (quality of feed index) were achieved, above 96%.

Keywords: *seeder, pneumatic device, seeds distribution, sowing, QFI index, maize.*

EFFECTIVENESS OF INSECTICIDES IN THE CONTROL OF CEREAL LEAF BEETLE (*OULEMA MELANOPUS*) USING AN UNMANNED AERIAL VEHICLE

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Abstract: Modern management of sustainable agriculture requires fast information about the condition of cultivated plants and a quick response to unwanted phenomena such as the appearance of pests in crops. According to the areas on which it is grown wheat occupies the first place in Serbia while the European Union is the world's largest producer of wheat. However, the technology of wheat production is demanding, especially in extreme climatic conditions such as large oscillatory changes in temperatures and rainfall during the year. The appearance of insects in wheat crops can cause significant crop damage and yield reduction, especially if protection measures are not implemented in a quality manner, in a timely manner, i.e. in the initial stages of insect development. A pest that can cause a significant reduction in wheat yields is the cereal leaf beetle (*Oulema melanopus*). The cereal leaf beetle feeds on leaves that remain bitten in the form of stripes while the larvae bite only the upper layer, which leads to the appearance of white elongated lines. Due to the decrease in leaf mass, there is also a decrease in the yield of wheat. In Serbia, chemical protection of wheat is most often applied using field sprayers, which recently often show insufficient effectiveness in protecting wheat. Modern pesticide application techniques involve the use of unmanned aerial vehicles (UAVs). Their main advantage compared to conventional field sprayers is the achievement of higher performance as well as better distribution of pesticides on the targeted surface, which results in greater efficiency and flexibility. The aim of this research was to examine the effectiveness of insecticides in controlling the cereal leaf beetle using two different techniques, unmanned aerial vehicles and field sprayer. The insecticide that was used in this research with an unmanned aerial vehicle showed a high efficiency, namely 3 DPT - 94.67%, that is, 97.46% - 9 DPT.

Keywords: *unmanned aerial vehicle (UAV), knapsack sprayer, cereal leaf beetle, efficiency chemical protection, modern techniques, insects.*

MOBILE SMARTFARMOWL – A PROJECT SUPPORTING THE PROCESS OF DIGITALISATION FOR GERMAN FARMERS

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Abstract: Many German farms are using tools like apps, digitally supported animal welfare or application maps for their farm machines. Nevertheless it has to be stated that most of the farm processes are still operated in a non-digitalised way. On the other hand politics asks more and more for a reduction of chemical plant protection or fertilizer in outdoor work resulting in new regulations which have to be fulfilled by the farmers. This demand for a smaller environmental impact and footprint can be implemented focusing on the individual demands of livestock and field plants and by using tools of digitalisation and state of the art agricultural machines. In order to support farmers on their transformation process towards more digitalisation, the project Mobile SmartFarmOWL has been started in spring 2021. Its main goal was to support farms and farmers in their transformation process for outdoor work and is accomplished by training, consulting, professional networking and a basic starter kit of data. The project core team is composed of the Federal Chamber of Agriculture, a regional business development council, SME companies and the University of Applied Sciences and Arts Ostwestfalen-Lippe and complemented by 60 farms and 15 agricultural SMEs in the region Ostwestfalen-Lippe, which is part of the federal state of North Rhine Westphalia in Germany. This paper describes the initial situation and the approaches and tools developed by the project team to support the farmers and SMEs on their way towards the application of more digitalisation. Furthermore, some products like training courses and preliminary results with respect to the acceptance of the proposed tools and the ways the farmers have made use of the training, consulting and data support are presented. The impediments of digital transformation for farmers in the outdoor work business is discussed briefly. As the projects ended in June 2023, a recommendation will be given for future work both from the project and the farmer's point of view.

Keywords: *transformation process, digitalization, e-learning platform, agriculture.*

TOWARDS RESILIENCE: CLIMATE CHANGE MITIGATION IN PLANT PRODUCTION THROUGH INNOVATIVE STRATEGIES AND POLICY MEASURES

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Abstract: With climate changing, plant production has been a crucial issue to the world's food security and is confronted with unprecedented difficulties. This study explains most of the significant effects that climate change will have on plant productivity and suggests many numerous way of mitigating tactics to address these issues. The paper gives a deep insight about the effects of temperature, water cycle, and other climatic changing on crop production, growth patterns, and diseases vulnerability by concentrating on the interaction in between them. The use of high quality flooding methods, the integrated pest management, the cultivation of agroforestry systems, and the adoption of climate-resilient crop varieties are some of the main mitigation strategies covered. These approaches work in concert with environmentally friendly farming methods to lessen the climate change. The study also discusses policy initiatives and the strategic planning, making use of both modern agricultural knowledge and technological breakthroughs. The conclusions, although support the significance of adopting flexible, sustainable measures to assure food security under changing climatic conditions through an extensive literature study and case studies. In other to deal with the effects of climate change on plant productivity, this research underlines the urgent necessity for proactive planning and action required.

Keywords: *climate changes, plant production, mitigation strategies, sustainable agriculture, climate-resilient crops, integrated pest management.*

SOME POSSIBILITIES OF APPLICATION OF NANO DRONE TECHNOLOGIES IN MODERN AGRICULTURE

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Abstract: The use different types of drones in almost every sector of the World economy is growing fast, but drone usage in the agricultural is suddenly increased. According to some data from literature, only the agricultural different drone market is expected to grow from a 1.2 billion USD in 2019 to 5.5 billion USD in 2024. A particularly interesting phenomenon is the acceleration using nano types of drones in the World and the possibility of some use them in agriculture production. The world of drone technology has taken a massive leap forward with the introduction of nano drones, where for example, some modern solutions nano drones have dimensions less than 2x2 cm. These miniature drones promise to greatly improve certain processes in industry (and agriculture) with their advanced features, portability, affordability and use in different purposes. Nano drones are ultra-small remote-controlled aircrafts that are capable of performing a variety of tasks. They are equipped with advanced sensors and features such as obstacle avoidance and high-speed maneuverability characteristics. Some models even have the ability to take aerial photographs, remain airborne for prolonged periods of time and fly autonomously. Nano drones are now more affordable than ever before. Prices range from a few hundred dollars to several thousand depending on the model and features. Today nano drones are affordable to the everyday consumer, who can use them for activities such as aerial photography for a variety of purposes from leisure activities to the science. The technology applied to these drones is continuing to improve, with the introduction of new features such as facial recognition, obstacle avoidance and flight stability. These advances have been made possible due to the miniaturization of components and the improved efficiency of motors and batteries. This paper presents a description Nano drone technology (e.x. type of Nano drones and equipment) as a new greenhouse application: There are some stages that greenhouse growers can consider for the use of nano drones; Safe inspection of greenhouse structural components; Processes of pollination (e.x. the role of RobotBee); Application of glass shading compound; Crop monitoring/inventory. Some possibilities applications of the described nano drones for the actual production situation of certain vegetable crops in the greenhouses of the Republic of Serbia were analyzed.

Keywords: *nano drones, possibilities of application in greenhouses, production of vegetable crops.*

MODEL OF INSTALLATION AND CALIBRATION OF THE YIELD MAPPING SYSTEM ON A COMBINE HARVESTER

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Abstract: The integration of modern technologies, data collection, analysis and management of the obtained data represent the standard when it comes to the application of precision agriculture. The main goal of agricultural production is not only the amount of yield obtained, but it is necessary to measure the amount of yield on individual parts within a plot, i.e. to perform yield mapping. Mapping is the collection of yield data from various locations within a plot and the creation of maps or a spatial representation of yield variation. Mapping provides insight into the heterogeneity of realized yield within the plot, thus providing an opportunity to make decisions and appropriately plan subsequent activities on the plot. This paper presents the technical and technological procedure for installing and calibrating the "Trimble Yield Monitoring" mapping device and the "Ag Leader" moisture sensor on the "NewHolland CR 7.90" harvester. During the work, the following parameters were monitored: grain moisture, amount of threshed mass, hectoliter mass of grain, and based on the obtained values, the calibration process of the yield mapping system was carried out to minimise the possibility of errors.

Keywords: *precision agriculture, GPS, data acquisition, sensor.*

RISKS IN TROUT AQUACULTURE IN SERBIA, BOSNIA AND HERZEGOVINA AND NORTH MACEDONIA

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Abstract: Trout farming is conducted in various aquaculture systems all over the world. Significant risks and uncertainties are connected with trout aquaculture and they can play decisive role in production and financial results of trout farming. This article deals with risks in trout aquaculture in Serbia, Bosnia and Herzegovina and North Macedonia. The analysis has shown that there are numerous risks and that they are specific for culture system and for location of the farm as well. There are also some differences in risks between analyzed countries. It is advisable to include risk analysis in any future trout farming investment in all countries.

Keywords: *trout farming, risks and uncertainties.*

DEVELOPMENT OF A SELF-PROPELLED BERRIES FRUIT HARVESTER

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Abstract: This paper analyzes the problems related to the reconstruction of a semi-mounted berry harvester into a self-propelled one specified for exploitation on smaller orchards. The components of the self-propelled machine, their purpose and mutual functional connection are described in details, which retained the principle of unilateral picking of half the row of bush berries from its semi-mounted predecessor. Among the most important general design features, the following stand out in particular: the drive of the harvester working components, which is achieved by means of appropriate combinations of hydraulic and mechanical power transmissions, which allows it to be highly adaptable to different working conditions on the terrain, and the control device, which is designed to maintain the movement of the machine in the direction set by the driver, without decreasing the safety and passability requirements of the machine itself. In the technology of berry fruit production in the Republic of Serbia, the harvesting process is still the basic limiting factor. Manual picking participates as much as 75% in total production costs. The costs of mechanical harvesting are between 2.05 and 2.27 times lower in comparison to manual picking, depending on whether the machine is a towed or self-propelled. The paper also provides a comprehensive analysis of the energy parameters of work for both versions of the harvester. The results indicate that power losses on rolling and slipping are lower in the self-propelled version 10 and 40%, respectively, while in the semi-mounted version the power lost on the climb is 60-70% lower compared to the self-propelled version. As the harvesting process is still a limiting factor in berry fruit production, in addition to reducing costs by applying mechanized solutions, one of the goals of the work is the optimization of applied technical solutions for the same.

Keywords: *harvester construction, berry fruit, oscillations, losses, hydraulic motors.*

THE SIGNIFICANCE OF THE FIRST 100 DAYS OF LACTATION ON THE KEY PRODUCTION AND REPRODUCTIVE INDICATORS IN HOLSTEIN-FRIESIAN AND SIMMENTAL COWS

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Abstract: Contemporary dairy production, due to the increasing demands of the market, implies continuous improvement. Milk production during the first 100 days of lactation of Holstein-Friesian and Simmental cows can be a valid indicator of production success for the entire lactation period, especially given that maximum milk production is achieved 40 to 60 days after calving. The examination of milk yield and quality in the first 100 days of lactation was carried out on 28 farms in the districts of Belgrade, Mačva, Kolubara and Moravica. Important production and reproductive indicators were monitored in 150 Holstein-Friesian and 115 Simmental cows. The average milk yield in the first 100 days of lactation in the population of the Holstein-Friesian cows was 3,159 kg of milk with 3.89% milk fat and 3.28% protein, while the population of Simmental cows in the first 100 days produced an average of 2,229 kg of milk with 4.04% milk fat and 3.24% protein. The longer average duration of the service period also led to a longer average calving interval in both breeds.

Keywords: *100 days of lactation, production traits, reproductive traits, Holstein-Friesian breed, Simmental breed.*

SPECTRAL REFLECTANCE INDICES IN GRAIN YIELD ESTIMATION OF MAIZE (*ZEA MAYS L.*)

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Abstract: Maize (*Zea mays L.*) is one of the most important crops having wide adaptability under different environmental conditions. Since that maize production is affected by different factors which can reduce yield, management of nitrogen is crucial to improve maize productivity. Non-destructive and rapid estimation of canopy traits are important for predicting plant growth, managing nitrogen application and early yield estimation. Recent studies suggest that spectral reflectance (SR) measurements have been proved in assessing grain yield and plant response to different environments. Therefore, in this study during the two growing season an active multispectral proximal optical sensors namely Plant-O-Meter (POM) was used in field trials to assess differences and provide early yield estimation. In a field trial, maize cultivars were grown with five different nitrogen (N) supplies of 0 (control), 70, 140 and 210 kg/ha. During the two growing season canopy reflectance of maize crop were measured between 4-leaf growth stages (V4) until the end of blister stage (R2). The relationships between grain yield and SR indices measured during the both seasons were estimated using Pearson's correlation coefficient (r). The results showed that variation for SR indices differed on an overall basis and depending from growth stage of maize. Several SR indices and exposed the strong positive relationship between the grain yields in V4 growth stage. These results indicated that these indices, as well as this stage, can serve as suitable for early maize yield estimation.

Keywords: *maize crops, spectral reflectance*

DIFFERENT NDVI MEASUREMENTS FOR EARLY GRAIN YIELD ESTIMATION OF MAIZE

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Abstract: Considering the importance of maize production, as well as the high variability in productivity, the early yield estimation of maize and the accuracy of this evaluation could be of great importance. Recently, numerous devices became available and proved for measuring yield and yield related traits. In the present study an active multispectral proximal sensor namely Plant-O-Meter (POM) was used in field trial to provide early yield estimation. Maize crops were grown in conditions of field trial with four levels of nitrogen (N) supplies (0, 70, 140 and 210 kg/ha). The aim of this study was to investigate the influence of three different NDVIs (NDVI-the normalized difference vegetation indices), NDVI Red (NDVIr), NDVI Green (NDVIg) and NDVI Blue (NDVIb) on grain yield estimation during the season. Canopy reflectance and NDVI estimates were measured between 4-leaf growth stages (V4) until the end of blister stage (R2) of maize. Pearson's correlation coefficient (r) was used to estimate the relationships between grain yield and different NDVI indices measured during the season. Maize grain yield showed the strong positive correlation with different NDVI between the early and late vegetative stages, while the greatest correlation was observed at 9-leaf growth stages (V9). The highly significant and positive correlation were observed for the NDVIb ($r = 0.41^{**}$), NDVIr ($r = 0.40^{**}$) and NDVIg ($r = 0.36^{**}$). The findings suggest that the NDVI measurements could be an adequate indicator for early crop estimation within different N treatments and early yield prediction.

Keywords: *maize crops, spectral reflectance*

TECHNICAL EQUIPMENT WITH MECHANIZATION ON MEDIUM-SIZED FAMILY FARMS

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Abstract: The work investigated the equipment of tractors, attachments and combines in a medium-sized family farm. The research was conducted on the registered family farm "Đurković" in the village of Čestin in the municipality of Knić. The farm cultivates arable and forage crops for feeding dairy cows and fattening oxen on an area of 44 ha. In the sowing structure, meadows are the most represented with 20 ha (45.45%), alfalfa 5 ha (11.36%), silage maize 3 ha (6.83%) and perko 0.4 ha (0.91%). The farm also grows barley on 2 ha, wheat on 1.5 ha, soybeans on 0.7 ha, oats on 0.4 ha, and peppers for processing on 40 ares. The production process is carried out with three tractors, 22 implements, a self-propelled combine for small grains and a combine for silage. One tractor with an average engine power of 41.4 kW works 14.67 ha of available land with 7.33 attachments. The total available power of the tractor engine is 129.43 kW, and the energy equipment of the farm is 2.94 kW/ha, which is the average of family farms in Serbia. If the combine engine power for small grain and silage were added, the energy equipment would increase to 7.85 kW/ha. Combines are underutilized because they are used only for subsistence. The average age of mechanization is over 40 years, so replacement and purchase of new agricultural machinery is not possible.

Keywords: *family farming, sowing structure, equipment and mechanization level.*

APPLICATION OF PLANT SCANNING SENSORS IN PRECISION VITICULTURE

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Abstract: Viticulture production is the result of complex interactions between plant, soil, climate and applied agrotechnical treatments, which concluding that the way of making decisions on the application of an agrotechnical treatments is crucial for the sustainability and productivity of such a system. Today's practice when making decisions in viticulture production is based on traditional patterns, previous experience, individual intuition, and mostly inherited habits from the past. Such a stochastic-inert way of managing production, which by nature is a temporally and spatially variable entity, brings results that are not optimal compared to the invested work and resources. Modern technologies are increasingly present and provide many opportunities for optimization and improvement of processes in various industries, and therefore also in the production of grapes and wine. In viticulture, one of the innovative technologies that is increasingly used is the use of plant-scanning device-sensors. These devices allow detailed scanning and analysis of the grape, which provides valuable information about its health and growth. In this paper, we analyzed the application of different plant scanning devices in viticulture production, as well as their advantages and disadvantages. These sensors are used to monitor plant health, timely detection of pests and diseases, and assessment of grape quantity and quality. The use of the analyzed sensors in viticulture production, in addition to improving the quality of the health condition of the plant and the grapes themselves, also enables significant financial benefits in the production process.

Keywords: *plant variability, GPS, management zone, inputs management, high quality grapes.*

ADVANCING AGRICULTURAL PRODUCTIVITY: NONDESTRUCTIVE OPTICAL SENSING FOR EARLY DETECTION AND MANAGEMENT OF PLANT STRESS

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Abstract: Plant stress poses a significant threat to global food security, driven by various environmental factors like drought, salinity, diseases, and nutritional imbalances. Traditional methods of assessing plant stress are often invasive, time-consuming, and lack temporal resolution. In contrast, nondestructive optical sensing emerges as a promising solution, allowing real-time data collection without disrupting the plant growth. We conducted experiments in a controlled indoor environment, employing red LED light sources and optical fibers to measure transmission of plants leaves. We explored plant stress induced by nutritional deficiency, water scarcity, intensity of white light and pathogen infection. The proposed nondestructive optical method detects early stress, demonstrating its potential for effective plant stress assessment and timely intervention ultimately enhancing agricultural productivity.

Keywords: *nondestructive optical method, leaf transmittance, plant health assessment.*

PERFORMANCE OF MACRODIVERSITY RF COMMUNICATION SYSTEM IN SMART AGRICULTURE

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Abstract: RF communication systems are often applied in agricultural communication systems and other applications in smart agriculture. Performance of RF communication system consisting of a macro-diversity system with 2 SC (Selection Combiner) micro-diversity receivers is analysed in this paper. Processing done on one diversity branch made SC diversity receiver suitable for practical realization. The SC receiver extracts the branch with the highest signal-to-noise ratio. When the noise power in all branches is the same, branch with the strongest signal in the SC receiver is selected. Two input SC receiver with $k - \mu$ fast fading and slow gamma fading is considered. Analytical expression of LCR (Level Crossing Rate) for the given system is calculated. Numerical and graphical results based on the given analytical expression were obtained. Results show LCR behaviour and received signal performance of the macro-diversity system depending on several system parameters: Ricean k factor, the depth of channel shading c and the number of clusters μ (left and right indentation).

Keywords: *fading, level crossing rate (LCR), macro-diversity system, smart agriculture, selection combiner (SC).*

STATISTICAL MODELS FOR DESCRIBING SIGNAL PROPAGATION IN FSO SYSTEMS IN AGRICULTURE

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Abstract: FSO (Free Space Optics) is a communication technology that enables wireless gigabit data transmission in both directions (full-duplex). FSO communication refers to Line-of-Sight technology that transmits modulated visible or infrared rays through the atmosphere to establish optical communications. Application of FSO systems in IoT devices, remote sensing and production optimization in agriculture is emerging. Channel description using appropriate model for design of a high-performance communication link for an atmospheric FSO channel is of great importance. There are several models for the joint distribution of amplitudes, although none is universally accepted due to importance of atmospheric conditions. This paper provides an overview of the most popular statistical models for describing signal propagation in FSO systems: Gamma-Gamma, Log-Normal, Negative Exponential, K-distribution, I-K distribution, Rice, Rayleigh, Inverse-Gaussian, Double Weibull, Exponential Weibull, Double generalized Gamma distribution. Basic characteristics and mathematical models as a function of signal intensity are given. Also, for general models, reducing one model to another is given.

Keywords: *Free Space Optics (FSO), FSO systems, signal propagation, statistical models, smart agriculture.*

Food production and processing

NATURAL POLYMERS IN FOOD PRODUCTION AND PROCESSING

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INVITED PLENARY LECTURE

Abstract: Naturally occurring polymers are a diverse group of materials that are currently in the spotlight as a potential solution to environmental and economic problems associated with the use of fossil fuels and synthetic materials. The food industry is also showing interest in the use of natural polymers, particularly as replacements for plastics and synthetic additives. The most promising areas in the food industry showing interest in natural polymers or already using these materials in the production cycle are production of biodegradable packaging materials, encapsulation of food ingredients and additives, separation processes, and food preservation. In addition, plant-based polymers are now being considered as the basis for new, more sustainable products whose processing produces fewer pollutant emissions compared to analogous animal-based products. To further reduce costs and negative environmental impacts, natural polymers can be derived from food and agricultural residues. Considering the importance of natural polymers for food industry and modern society in general, the aim of this paper is to present the latest trends in technology and application of natural polymers in food sector.

Keywords: *polymers, polysaccharides, proteins, pncapsulation, packaging.*

TESTING OF AN INDUSTRIAL CAPACITY LABORATORY CONDENSATION DRYER

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Abstract: Drying is one of the most important methods of preservation in the food-processing industry. The complete or partial extraction of water from biological materials is an extremely complex process that consumes a large amount of energy. The drying regime that will be applied for any specific case is determined by several influencing factors such as the time interval of the drying process, the quality of the product, the thermal sensitivity of the biological material being dried, etc. Traditional methods of agricultural products drying and the consumption of a large amount of energy in conventional dryers significantly lowers the final product quality and increases its final price. Applying alternative technologies in the drying process is the focus of many projects. Research in the field of drying systems that is focused on solving these problems is quite justified. In conventional dryers the air is heated to the drying temperature by electric heaters or heat exchangers, which intensifies the exchange of heat and matter. In condensation dryers combined with a heat pump, a significant amount of energy can be saved by keeping the latent and sensible heat of the product within the chamber. Condensation dryers operate as heat exchangers using both high and low temperature sources of a heat pump. These dryers reach slightly lower temperatures, up to 60°C, and are suitable for drying chopped fruits and vegetables, as well as herbs. The quality of drying in these dryers is exceptional, although somewhat slower than in conventional dryers. The paper presents the test results of drying carrots, as a representative of root vegetables. Laboratory condensation dryer with 100kg capacity was used, a product of the company NIGOS - Niš. The motive of this research is in the fact that this method of drying has numerous advantages: the high quality of the material is maintained in terms of color, taste, smell, nutritional value, etc.; electricity consumption is 3-5 times lower; of achieving very low humidity is possible; there is a high degree of automation of the process; high hygiene of the product (in accordance with the HASAP standard); there is no air exchange in the closed system, and the product is not covered with dust; the design is efficient and the use and maintenance is simple. In addition, the closed system allows it to work indoors and outdoors, since it does not discharge steam (like an open system) but condensate, so it does not humidify the room. A detailed schematic of the dryer is presented. All components, corresponding dimensions and a description of its operation are presented. Drying, in this experimental research, was carried out according to the manufacturer's pre-defined regimes. The temperature and relative humidity of the drying agent (air) are defined by the technology requirements of drying. They are fully monitored and maintained at the desired level, according to a predetermined program. With this dryer, there is the possibility of monitoring the dryer efficiency when the process is guided by the pre-set desired drying curve. The drying process is fully automated. As the result of the experimental research, a product with a final moisture content of 4% was obtained, which fits the recommended literature data for this type of vegetable.

Keywords: *drying, carrot, laboratory condensation, pre-defined regimes.*

INVESTIGATION OF CONVECTIVE DRYING CHARACTERISTICS AND SPECIFIC ENERGY CONSUMPTION OF APRICOT AND APPLE TREE DISCS

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Abstract: The aim of this work was to investigate the drying characteristics and specific energy consumption during convective drying of apricot and apple tree. The measurements were performed in an experimental dryer with disk-shaped wood samples of 20 mm thickness at the temperatures of 40, 50, 60 and 70°C. The velocity of the air during all experiments was set to be 2 m/s. Overall 8 experiments were performed – 4 with each tree type. Drying time and equilibrium moisture content were determined for each experiment. Analysis of drying curves showed that the increase in drying temperature decreases drying time. Based on the results of drying time, air temperature and velocity the specific energy consumption for drying of apricot and apple samples was determined and analysed.

Keywords: *apricot tree, apple tree, thin discs, drying kinetics, specific energy consumption, equilibrium moisture content.*

LOW-COST ARDUINO- AND PYTHON-CONTROLLED SOLUTION FOR AUTOMATION OF MASS MEASUREMENT IN LABORATORY DRYERS

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Abstract: This paper presents a solution for the automation of samples' mass measurement during drying process in laboratory conditions using open-source electronics platform Arduino and programming language Python. Special mechanism designed and constructed for this purpose was incorporated in existing laboratory dryer. The goal of the work is to automate otherwise tedious and time-consuming measurement of a mass of the samples during drying process without compromising the interior drying conditions within the drying chamber. The system is realized with a lifting platform using Arduino-controlled stepper motors. The whole process of mass measurement could be externally controlled by Python programming language. Presented hardware solution with engineering software tool could be successfully implemented in laboratories and research centres with limited budget.

Keywords: *arduino platform, python, drying process automation, mass measurement, low-cost solution.*

MODELING HEAT – FLOW PROTOTYPE DRYER USING ANFIS OPTIMIZED BY PSO

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Abstract: Chamber dryers are widely used in various industries in order to remove the moisture from solid materials efficiently. Optimizing the design and operational parameters of chamber dryers plays a crucial role in enhancing their performance and energy efficiency. In order to maintain the temperature at the desired level, it is necessary to implement a good control system. To be able to facilitate the process of finding and setting parameters of the controller, for many control algorithms it is essential to make the reliable model of the object. The aim is to develop both reliable and accurate predictive model that can assist in optimizing the design, structures, and inspection processes of chamber dryers, which will lead to enhanced energy efficiency, harvesting and improved drying performance. In this paper, the authors propose a novel approach for modeling heat flow transfer in chamber dryers using an Adaptive Neuro-Fuzzy Inference System (ANFIS). The Quanser chamber was selected as the object of the research because of how closely its geometry, material choice, and air flow resemble the structural properties of a dryer. To obtain the most realistic model possible, parameters of ANFIS were found using Particle Swarm Optimization algorithm. By incorporating historical operational data of experimental measurements, the ANFIS model can learn and adapt to the dynamic behavior of the dryer system.

Keywords: *design and structures, optimization, ANFIS, PSO, heat-flow chamber dryer, energy efficiency.*

OPTIMIZATION OF YIELD OF A FLAT PLATE SOLAR WATER COLLECTOR BY SIMULATION WITH MATLAB

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Abstract: This study consists at the modeling and the application of numerical methods in order to optimize the performance of a flat-water solar collector under the meteorological conditions of Mali, particularly in the month of January when the sunshine is low and hot water consumption significant. The results obtained show that when the thickness of the glass pane is increased from 2 mm to 5mm, the instantaneous efficiency of the solar collector at the beginning increases from 41.46% to 41.49% with a maximum solar radiation intensity of 462 W/m² and an average wind speed of 3.5 m/s. When the thickness of the absorber is increased from 4mm to 5mm, the instantaneous efficiency of the solar collector can reach from 40.64% to 41.65%. When the absorber thickness reaches 6 mm, the instantaneous efficiency of the solar collector decreases from 42.35 to 42.14%. Increasing the thickness of the collector's absorber plate can significantly improve the collector's instantaneous efficiency. Increasing the thickness of the lateral side insulation does not contribute to improving the collector's instantaneous efficiency. When the thickness of the lateral side insulation of the collector increases from 2 cm to 8 cm, the instantaneous efficiency of the collector increases from 53.13% to 53.0%. When the mass flow rate of the fluid increases from 0.0265 kg/s to 0.04 kg/s, the efficiency increases from 53.14% to 59.18%. This study also showed that these parameters have very little influence on the temperature of the heat transfer fluid.

Keywords: *optimization, flat plate solar collector, efficiency, simulation.*

ARTIFICIAL INTELLIGENCE METHODS FOR ENERGY USE PREDICTION

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INVITED PLENARY LECTURE

Abstract: This paper covers the application of artificial intelligence in agriculture. Technology development has enabled measurement, collecting and processing high quality big data. These data can be successfully used to significantly improve numerous segments of agriculture sector. The accent in this paper is given on the models used for energy use prediction. The application of Artificial Neural Networks with different structure is presented, such as Feedforward Neural Network, Radial basis Function Network and Adaptive Neuro-Fuzzy Inference System. Support Vector Machine model is also shown. The improvements of individual models are elaborated, through the analysis of the ensemble and hybrid approach. All of the proposed models are capable of solving complex problem of prediction of energy use based on real, measured data. Ensemble and hybrid models are promising, as it has been shown that the prediction accuracy is improved by combining different single models in proposed manner.

Keywords: *agriculture, artificial intelligence, machine learning, energy use prediction.*

BIOMASS-BASED SUSTAINABLE ENERGY: PROS & CONS AND RECOMMENDED OPTIONS

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INVITED PLENARY LECTURE

Abstract: The topic of biomass and its application in energy production is complex and not always straightforward in terms of sustainability. While the benefits of biomass energy revolve around its potential as a substitute for fossil fuels, the main drawbacks stem from the fact that it is still a fuel that emits certain pollutants and that the current rate of use, primarily of wood biomass, threatens to reduce the area under forests and endanger biodiversity. Biomass, produced by agricultural and forestry sectors, is rarely used for energy generation in Serbia, even though it comprises 61 percent of the total potential of renewable energy sources. To encourage more intensive use of this valuable national resource, the paper evaluates the pros and cons of using biomass as an energy source, on the one hand, and provides guidelines for its use sustainably and efficiently, on the other. This was done with a focus on biomass combustion technologies. Ideal biomass users were identified, and recommendations were made on what should be done at the national level to empower and encourage them to greater use this energy source.

Keywords: *combustion technology, biomass, heating, agribusiness product processing.*

THE POSSIBILITY OF USING HORSERADISH LEAVES POMACE IN THE FOOD INDUSTRY

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Abstract: Horseradish is a plant that belongs to the Brassicaceae family and is native to southeastern Europe and western Asia. It is cultivated for its succulent and spicy root, which is used as a seasoning for meat, soups, seafood, etc. The horseradish root has a much higher culinary value than the horseradish leaf, which is usually discarded with the rest of the above-ground biomass and has no use in the food industry. However, the horseradish leaf can be used in the diet in the form of salad or in the preparation of various dishes, to which it gives a characteristic spicy flavor. The biological activity of horseradish is expressed as antimicrobial, insecticidal, anticoagulant, and gastro-protective effects of isothiocyanates, compounds formed by the hydrolysis of glucosinolates under the action of the enzyme myrosinase. In addition, the horseradish leaf is rich in vitamin C, polyphenols, and flavonoids, which is why it is desirable to press it to obtain juice that can be used in the food industry. Moreover, pressing leaves behind a pomace that could also potentially be used in the food industry. Therefore, this research aimed to analyze the content of phenolic compounds and the antioxidant potential of the horseradish leaves pomace, to achieve the full utilization of the plant and reduce biomass loss. Total phenolic content (TPC), total flavonoid content (TFC), total phenolic acid content (TPAC), and antioxidant activity (DPPH, ABTS, and FRAP methods) were determined by standard spectrophotometric methods. The results showed that the quantitative content of total phenolic compounds, flavonoids, and phenolic acids in horseradish leaves pomace, after pressing and obtaining juice, was 7825.50 ± 749.20 mg GAE/kg FW (fresh weight - FW), 9460.00 ± 138.60 mg CE/ kg FW and 8905.50 ± 336.90 mg CAE/kg FW, respectively. In the analysis of antioxidant activity, it was found that all three methods indicate the presence of antioxidant potential of horseradish leaves pomace, namely: 9.00 ± 0.70 mmol TE/kg FW (DPPH), 42.30 ± 3.80 mmol TE/kg FW (ABTS) and 17.30 ± 0.60 mmol TE/kg FW (FRAP). Based on the obtained results, it can be concluded that horseradish leaves pomace contains significant amounts of polyphenolic compounds and high antioxidant potential, making it a suitable raw material for the food industry, both from the point of view of waste prevention and potential enrichment of food products to which it is added (as a seasoning for salads and dehydrated soups, etc.).

Keywords: *horseradish leaves pomace; polyphenols; phenolic acids; flavonoids; antioxidant activity.*

DIMENSIONING OF BRAZED ALUMINIUM HEAT EXCHANGER FOR NEEDS OF AGRICULTURAL PROCESS PLANTS

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Abstract: Heat exchangers used in agricultural processes are mainly manufactured by three technologies: brazed copper-brass, mechanically assembled aluminium and brazed aluminium. The appropriate choice depends on various criteria: price, weight, corrosion resistance, performance in a limited volume, required pressure drops, temperature resistance, reliability, etc. Brazed aluminium is increasingly popular due to several advantages, such as resistance to high pressure and temperatures. Aluminium heat exchangers can be exposed to external and internal corrosion in various environmental conditions. Corrosion has a negative impact on the mechanical integrity and thermal performance of heat exchangers. Therefore, specific operating design parameters, as well as mechanical design characteristics, are of great importance for consideration in construction. Proper selection and design can ensure the successful and safe operation of the heat exchanger and the plant itself. The HVAC industry is directed towards the search for the best solutions in order to increase the performance, energy efficiency and durability of the equipment while reducing the costs of their production. Aluminium pipes and other aluminium components are increasingly replacing copper pipes. In this paper, application, design and operation considerations for brazed aluminium heat exchangers used for needs in agricultural processes are presented.

Keywords: *HVAC, heat exchanger, aluminum, dimensioning, agriculture.*

THE EFFECT OF PHASE CHANGING MATERIAL THICKNESS ON LIGHT CONSTRUCTION BUILDING INDOOR TEMPERATURE

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INVITED PLENARY LECTURE

Abstract: Due to the excessive use of air conditioners and heating systems, energy consumption by the building sector has been growing significantly in recent years, which leads to the accelerated depletion of conventional energy sources and to the fact that renewable energy sources are becoming more and more popular. Phase change materials are suitable for use in latent heat energy storage technology due to their high storage density and stable thermal properties. The thickness of phase change materials (PCMs) added to the thermal envelope of a lightweight building is investigated in this study. The simulations were run for 7 days in July, which was determined to be the hottest period of the summer based on the Meteorom weather file, and when it is difficult to maintain thermal comfort without using a lot of energy. The thermal behavior of the building without PCM and with built-in PCM in the envelope of the building in one wall on the south side and on the ceiling, with different thicknesses of phase-changing material was simulated and the results obtained were analyzed with the aim of establishing which thickness of phase-changing material is optimal for installation in the envelope of the building.

Keywords: *building, phase-change material, TRNSYS.*

NEW TRENDS IN REFRIGERATION TECHNOLOGY IN SERBIA

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INVITED PLENARY LECTURE

Abstract: The food and agriculture sector is constantly evolving, so in general refrigeration industry needs to follow these changes and to grow; however several directions of development currently stand out on the Serbian refrigeration market. The major direction in which refrigeration is developing is the use of natural refrigerants. Nevertheless, Freons (such as HFCs, HFOs, and its blends) still find important place for wide range of applications because of the familiarity in use and low prices. Whatever system is applied, the refrigeration industry in Serbia is witnessing several notable trends driven by environmental concerns, energy efficiency, and regulatory compliance. Although apparently different, these three concepts are strongly related to each other. The adoption of natural refrigerants, including carbon dioxide (CO₂), ammonia (NH₃), and hydrocarbons (such as propane R290, isobutane R600a, etc.), is gaining support (despite higher investment costs) due to their lower global warming potential (GWP) and zero ozone depletion potential (ODP), and good thermodynamic properties. Retrofitting and upgrading existing systems in an attempt to comply with legal and environmental frameworks is also a widespread tendency. Smart refrigeration systems, that incorporate remote monitoring and predictive maintenance, are used more and more to optimize performance. For sure, the cold chain industry must focus also on parameters optimization to ensure product quality and decrease waste. Compliance with the latest regulations and standards and aligning with new directives is an important aspect. Training and skill development programs need to be implemented to keep professionals up to date with new technologies and refrigerants.

Keywords: *refrigerants, cooling, ODP, GWP.*

SETTING UP AND OPTIMIZATION OF NOVEL CLEANING SYSTEMS FOR SOLAR PANELS USED FOR IRRIGATION

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Abstract: In recent years, thanks to developing technology, more energy has been required in agriculture. However, due to the ever-increasing demand and some geopolitical tensions, the cost of energy has increased. A renewable energy source such as solar is one of the alternatives. On the other hand, a decrease occurs in the efficiency of solar panels if the dust and dirt on the surface prevent sunlight from reaching the cells. Therefore, it is essential to constantly maintain and clean the solar panels. In this research, the cleaning method was developed for solar panels used for irrigation purposes. To clean 80 panels with a length of 40 meters, 7 pop-up type sprinklers were used. The transmitted water and rainwater to the panels were collected back and returned through a 1000-liter water tank. The system was operated via a timer to optimize regular cleaning instructions. It was run for 5 min (sunrise), 10 min (sunrise), 2x5 min (sunrise and sunset), and 2x10 min (sunrise and sunset) in a day. As a result, a portable cleaning system was carried out with a low-cost and sustainable system.

Keywords: *design, rainwater harvesting, pop-up sprinkler, photovoltaic, efficiency.*

SIMPLIFIED THERMAL CALCULATION AND MEASURES FOR SAVING ENERGY IN CHAMBER DRYERS IN THE BRICK INDUSTRY

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Abstract: This paper presents the simplified approach to global material and energy balancing of the drying process through cold air thermodynamics. The process of convective drying of brick products in chamber dryers is analyzed and graphically valued in the $h - x$ cold air diagram. The modified $h - x$ diagram is presented in greater detail, with emphasis on its advantages for quick graphical determination of basic drive characteristics of the process. A simplified mathematical expression has been derived for determining the technological usefulness of energy. There is emphasis on certain measures that enable determining the amount of specific heat consumption and specific air consumption as closely and as simply as possible, and some possibilities for saving energy have been established.

Keywords: *energy, matter, balance, $h - x$ diagram, drying, saving.*

FOOD PRODUCTION AND PROCESSING: REDUCING FOOD WASTE AND LOSS

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Abstract: With significant economic, social, and environmental implications, food waste and loss have become critical global challenges. This paper shows strategies to reduce food waste and loss in food production and processing stages to enhance food security and sustainability. Key factors contributing to food waste and loss are identified by a comprehensive review of relevant literature and theoretical background. In the methodology, we have adopted a mixed-method approach, including case studies, surveys, and statistical data from food processing industries. Results reveal that food processing industries experience an average waste rate of approximately 15%, with variations from one sector to the other. Overproduction, inadequate inventory management, perishability, and packaging issues contribute to consequent wastage. The discussion section highlights the importance of stakeholder engagement, technology adoption, and consumer awareness campaigns in combating food waste, and Policy implications include standardized waste management guidelines, investment in waste handling infrastructure, and incentives for technology adoption. Collaboration among governments, industries, and civil society is crucial for effective policy implementation. By embracing emerging technologies such as data analytics, Internet of Things (IoT), and artificial intelligence (AI), the food industry can optimize inventory, supply chain logistics, and transportation, leading to waste reduction. What's more, consumer awareness campaigns can promote responsible consumption habits. So, concerted efforts from all stakeholders are essential to mitigate food waste and loss effectively. By adopting sustainable practices and implementing suitable policies, the global community can create a more efficient and flexible food system, reducing environmental impact and promoting food security.

Keywords: *food waste, food production, food processing, food loss, sustainability.*

IMPLEMENTATION OF GIS TECHNOLOGIES FOR PLANNING THE VALORISATION OF AGRICULTURAL WASTE: THE TANGO-CIRCULAR PROJECT

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Abstract: The volume of waste produced by agricultural activities is constantly rising, due to the continuous increase of crop and livestock production, aimed to cover the nutritional needs of the accreting population of the Planet. According to recent estimations, the total amount of waste produced in the whole EU by the agricultural sector during the period 2010-2016, has been around 18.4 billion tons, which represents an average of 2.6 billion tons/year. This number is slightly exceeding the amount of waste from all other sectors combined. This enormous mass of waste has a significant environmental impact, which needs suitable solutions to reduce the carbon footprint of agriculture, while increasing the economic income for farmers. A promising way to reduce agricultural waste, passes through the valorization of agricultural co-products, by-products and residues, as well as other non-organic materials - such as plastics, widely used in crop cultivation and animal production - after the end of their working life. In order to involve farmers to play an active role on this issue, contributing to transform what they currently consider as a “waste” into a new “resource”, under the perspective of a circular economy and for a more sustainable agriculture, the Project TANGO-Circular has been financed by the EU Erasmus+ Programme. Aim of this Project is to train farmers and other agricultural stakeholders to be involved in finding viable solutions to exploit unusable remains of crops or animal farms, so as to enhance their financial input, while simultaneously contribute to reducing the environmental impact of their agro-livestock activities. With the aim of planning the valorization of agricultural waste, under the TANGO-Circular Project, a Geographical Information System (GIS) has been implemented through an open-access software (Q-GIS). This GIS has been structured into a first part dedicated to the quantification of agricultural waste flows – both organic, coming from agro-industrial activities, and not-organic, such as plastics - and a second part, focused on the spatial distribution of these flows in the study area of the project partners. Through GIS, the areas with high density of agricultural waste have been pointed out, and the suitable location of potential collection centres has been proposed. The maps that have been produced, as well as the GIS database, are always updatable tools, useful also for monitoring and optimizing the sorting and collection of agricultural waste from the farms, their suitable treatments and transport to the collection centers or recycling stations. The implemented GIS methodology has revealed very useful to support farmers and their associations, as

well as all public bodies interested to govern the agricultural waste flows, to individuate possible solutions designed for the valorization of these flows, in the perspective of a circular economy. The sustainability and economic, territorial, environmental and social convenience of each form of valorization designed have been investigated, and criticalities associated with each phase of the process and consequent implementation of appropriate solutions to each problem have been addressed. Finally, further possible solutions, aimed at an increasingly better valorization of these flows, have been proposed as well.

Keywords: *sustainable agriculture, circular economy, agricultural waste, farmers training, GIS technologies.*

USING SURPLUS FRUIT AND VEGETABLES TO PRODUCE A JUICE - A VIRTUOUS EXAMPLE OF FOOD WASTE RECOVERY IN THE PROJECT S.K.I.P.E.

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Abstract: Worldwide, 1.3 billion tons of food are currently wasted and this represents a major problem for the planet, as it produces negative impacts from a social, economic and environmental point of view. We can distinguish two types of issues: food losses and food waste. Food losses are determined upstream of the agri-food chain, especially in the sowing, harvesting, storage and, generally, in the first stage of the agrifood chain. Food waste are the losses that occur in the second stage of the supply chain, related to the industrial transformation, distribution and final consumption. The causes of this waste are to be found at all levels of the food supply chain, in particular, three macro areas have been identified where the most waste occurs: a) production stage, b) distribution stage, and c) consumption stage. The present work aims at carrying out experimental trials aimed at defining a line for processing surplus fruits and vegetables (edible food that cannot be sold for aesthetic or dimensional defects, and therefore destined to be wasted) into juices, in order to produce a more stable food with a longer shelf life, and to reduce the impact of food waste. The activity was developed at the Mac-lab of the University of Basilicata and it involved apples, fennel, rocket leaves and carrots. Some of the produce was collected with the cooperation of the company Ortoromi (Bellizzi-Salerno, Italy) and "Io potentino onlus" (Potenza, Italy), an association engaged in the recovery of food surplus to be redistributed to the underprivileged. Fruit and vegetable products were first characterized for the following parameters: size, firmness (N), sugar content (°Brix), external and internal color according to the CIELab system, dry matter (%), juice content (%), pH, titratable acidity of juice (% citric acid). All products were used for the juice production and two different blends were chosen (based on some preliminary trials, not reported in this paper), packed in glass jars and pasteurized with different time/temperature combinations. Physical and chemical evaluation was carried out for the two recipes, and the kinetic model of destruction was calculated for both vitamin C and anthocyanin content. Results were used to design a processing line for the production of juice and for the cost estimation of the line.

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Keywords: *Food chain, postharvest loss, thermal treatment, kinetic destruction model, processing line, cost estimation.*

NEW TECHNOLOGY OF READY TO COOK PORTIONED FROZEN VEGETABLE PRODUCTS AS AN ELEMENT OF A WASTE-FREE MANAGEMENT STRATEGY

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Abstract: Vegetable producers are developing and implementing new technologies of machine harvesting and processing (to increase efficiency). At the same time, the automation of these processes causes an increase in the amount of waste and contributes to increasing the loss of wholesome parts of these vegetables. Losses are caused at the stage of harvesting and pre-processing. The reason and the need is to reduce the losses of non-assortment vegetables (e.g. undersized, too large, of the wrong shape) and to reduce the formation of organic waste from vegetables at the processing stage by including the fractions removed from them into the stream of processed products for consumption purposes. During the production of frozen food, a lot of organic waste is generated, which can be an additional edible raw material (currently it is waste). The problem is the amount of waste resulting from the pre-treatment of vegetables, which amounts to 10-45% of the weight of the processed raw material - e.g. cauliflower, broccoli. On the other hand, the generated organic waste is a rich source of many valuable ingredients, including: minerals, vitamins, fiber (including pectins), organic acids, aldehydes, alcohols, and colored and aromatic substances. Therefore, the reason and the need is to reduce the waste of raw materials and to develop a technology that reduces the waste stream by increasing the efficiency of processing. The primary objective of the research was to develop a technology for the use of non-assortment vegetables, selected varieties, i.e. cauliflower, broccoli, carrot and parsley with specific physico-chemical and sensory properties, in the production of portioned frozen vegetables from a homogeneous paste, subjected to the briquetting process. These activities are aimed at reducing the waste of agricultural products. The composition of vegetables is characterized by a balanced nutritional value, sensory properties, color and consistency. Appropriate proportions between the individual puree ingredients and potatoes as a starch source have been developed. It was found that the composition of briquetted products from shredded vegetables statistically significantly affects the assessed texture characteristics and the sensory quality of the products. The most favorable texture parameters were obtained in the test with the highest share of potatoes. The increasing share of non-starchy vegetables had a statistically significant effect on most of the parameters characterizing their sensory quality. It was shown that non-assortment shredded vegetables can be a good material for the production of frozen vegetable balls, sensorially attractive and stable in terms of structure during the freezing process. As a result of the work, optimal varieties from individual vegetable species were indicated, the harvest of which can be synchronized, i.e. will take place at a similar time. This will enable the production of products (frozen vegetable balls) from selected species and varieties, without the need for prior freezing and storage of vegetable components. A way to manage non-assortment vegetables was indicated - processing them into vegetable puree in the form of frozen balls (portions) in 3 assortment lines - green (broccoli, cauliflower), orange (carrot, beetroot) and white (cauliflower, parsley), which are an innovative solution for both the food service and the retail consumer. **Project:** 00052DDD.6509.00111.2022.15, 2023-2024: New technology for portioning frozen vegetables of the Ready to cook type as an element of the strategy of waste-free management of agricultural produce.

Keywords: *freezing vegetables, cauliflower, broccoli, carrots, parsley, sensorics.*

Soil tillage and agroecosystem protection

MAINTENANCE OF UNMANNED AERIAL VEHICLES (UAVs) IN AGRICULTURE

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Abstract: In recent years, unmanned aerial vehicles (UAVs) have rapidly gained popularity in various industries, including agriculture, due to their wide application in agricultural production. The UAV is most often used for recording conditions in the field, monitoring the condition of crops, targeted application of chemical agents, yield assessment, etc. The efficient and reliable operation of UAVs applied in agricultural production depends to a large extent on the maintenance system. We divide UAV maintenance into two groups: maintenance before and after takeoff and maintenance due to unplanned situations. Both maintenance groups are crucial for preserving the working condition of the UAV with the aim of efficient operational work and extending the service life of the aircraft itself. In this paper is shown the importance of regular UAV inspections, the importance of following the manufacturer's instructions, and the maintenance of key UAV components that require attention during regular maintenance. In addition to UAVs that are used for recording fields (terrain and crops), this paper also analyzes the maintenance of UAVs that are used for chemical protection of crops. By applying a timely and appropriate UAV maintenance strategy, we can expect maximum efficiency, reliability and safety of the aircraft during their exploitation, as well as a longer working life - longer exploitation of the aircraft.

Keywords: *unmanned aerial vehicle (UAV), regular maintenance, crop condition, chemical protection, maintenance strategy, reliability.*

TOTAL PHENOLIC AND FLAVONOIDS CONTENT AND ANTIOXIDANT ACTIVITY OF COLD PRESSED AMARANTH MICROGREENS JUICE

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Abstract: Microgreens are recognized as new crops and potential foods of the future, because they are a rich source of highly valuable bioactive compounds with health-beneficial effects. Besides fresh consumption, microgreens can be successfully used for the production of some novel food products. Most often cultivated and analysed microgreens species are from Amaranthaceae families, primarily beet, chard and amaranth. Previous characterization of amaranth microgreens has showed a high content of different biocompounds such as vitamins, phenolic compounds and betalains. However, functional products from amaranth microgreens have only become attractive in recent years and have not been widely investigated until now. So, the aim of this study was production of cold pressed juice of amaranth microgreens and determination of its total phenolic (TPC) and flavonoid (TFC) content, as well as evaluation of antioxidant activity. Amaranth (*Amaranthus tricolor L.*) microgreens juice was obtained by pressing in a super slow cold juicer and further analyzed by well-known spectrophotometric methods such as Folin-Ciocalteu's assay for TPC and colorimetric assay with aluminum chloride for TFC. Antioxidant activity was evaluated using the following assays: ABTS^{•+} radical scavenging activity (ABTS^{•+}), DPPH[•] radical scavenging activity (DPPH[•]) and Ferric reducing antioxidant power assay (FRAP), which are based on different mechanisms of activity. Results were expressed in mg equivalents (gallic acid, quercetin and trolox) per 100mL of the juice. Determined TPC and TFC were 50.86 ± 0.26 mg GAE/100 mL and 45.94 ± 0.63 mg QE/100 mL, respectively. Results for the antioxidant activity were 101.61 ± 2.55 mg TE/100 mL for ABTS^{•+}, 14.98 ± 0.06 mg TE/100 mL for DPPH[•] and 99.93 ± 1.32 mg TE/100 mL for FRAP. As can be seen, the antioxidant activity of the amaranth juice high depends on the nature of amaranth biocompounds and their affinity according to ABTS^{•+} and DPPH[•] radicals, i.e., the tendency to reduce the $[\text{Fe}^{3+}-(\text{TPTZ})_2]^{3+}$ complex. Finally, the cold pressed amaranth microgreens juice showed the high content of phenolic compounds and good antioxidant activity using some in vitro screening assays, so it can be potentially defined as a novel functional product, however further research is necessary.

Keywords: *microgreens, amaranth, juice, total phenolic content, total flavonoid content, antioxidant activity.*

TECHNICAL INSPECTION OF PESTICIDE APPLICATION EQUIPMENT IN EU

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Abstract: According to the European Directive 2009/128/ EC, each pesticide application equipment (PAE) must have a valid technical inspection label. Each member state must harmonize its legislation with the EU, and the accession countries must start preparing for this work. A new standard has been created for the technical testing procedure: EN ISO 16122. It consists of five parts: 1 – Agricultural and forestry machinery: testing of sprayers in use, part 1: In general; 2 – Field boom sprayers; 3 – Air assisted sprayers for bush and tree crops; 4 – Fixed and semi-mobile sprayers; 5 – Aerial spray systems. Most EU countries have introduced technical inspection of boom sprayers and air-assisted sprayers, fixed and semi-mobile sprayers, while inspection of hand sprayers and knapsack sprayers on hand, battery and motor drive as well as knapsack motor orchard sprayers, is not required yet. In this paper ISO 16122 standard will be explained, as well as inspection procedure and the necessary equipment to perform the test. In the past years of application of the said standard, shortcomings have been identified and an improved version has been created, according to which the inspections perform a technical inspection. Therefore, this paper presents the latest progress and prospects of mentioned standard. A brief overview of the situation of mandatory technical inspection in the member states is also given. At the end of the paper, future trends of technical inspection for all machines applying pesticides are described: Fogging equipment, seed treatment equipment and different types of granular or powder applicators.

Keywords: *air assisted sprayers, ISO 16122, pesticide application equipment (PAE), sprayers, technical inspection.*

TRACE ELEMENTS ENVIRONMENTAL RISK OF SOYA STRAW ASHES WHEN USED AS A SOIL FERTILIZER

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Abstract: Biomass is widely recognized as one of the most promising renewable energy sources in the world. Ash is a byproduct of biomass combustion that is produced in significant quantities. The environment could be overburdened and negatively affected by ash accumulation and its random return to the soil. Prior to utilizing ash as a fertilizer, it is important to determine trace element content and estimate the environmental risk using a variety of ecological indices. Among investigated trace elements, manganese has the highest concentrations in both ashes, while contents of cobalt in ash from the combustion chamber (CCB) and cadmium in cyclone ash (CB) are the lowest. CCB and CB ashes contain substantially lower concentrations than the maximum European limits for ash utilization in forestry and agriculture for most harmful trace elements. Based on the crustal enrichment factor, molybdenum displays the highest enrichment (CCB), while manganese and chromium (CB), as well as cobalt (CCB), show moderate enrichment. The modified potential risk index (MRI) is used to demonstrate the possible impact of these ashes to the environment. MRI value for CB is substantially higher than for CCB, indicating its considerable risk to the environment.

Keywords: *soya straw ash, trace elements, metal pollution index, modified potential risk index, environmental risk.*

UTILIZATION OF SOME AGROTECHNICAL MEASURES IN SERBIA COMPARED WITH THOSE IN THE FORMER YUGOSLAV REPUBLICS AND SURROUNDING COUNTRIES OVER A PERIOD OF THREE DECADES

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Abstract: Numerous changes occurred in the countries that constitute the former Yugoslavia between 1990 and 2020. This research examines trends in agriculture in these and neighboring countries throughout the chosen time period. The need for food increased, while production risks grew due to climate change, which reduced the yields of many crops. Agrotechnical measures such as the use of artificial fertilizers and pesticides were essential since agricultural production was connected with expensive investments and the primary objective of each agricultural producer was to maximize output. Agrotechnical measures in the aforementioned countries are associated with agricultural soil portions, rural population share, economic aspects, and predicted environmental effects.

Keywords: *agricultural soil, rural population, fertilizers use, pesticides, economic parameters, environmental impact.*

THE IMPACT OF PARTICULATE EMISSIONS ORIGINATED FROM AGRICULTURAL ACTIVITIES

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Abstract: One of the most prevalent health and environmental problems, particularly in developing countries, is air pollution. It can lead to diabetes, lung cancer, cardiovascular and other diseases. Particle emission comes from a wide range of both natural and antropogenic sources. Particle emissions in agriculture originate from a number of activities, including tillage, planting, applying fertilizers and pesticides, harvesting, and controlled burning of plant residues in fields. Burning biomass represents one of the most prevalent ways of generating particulate matter (PM). Wind erosion of soil (mostly fine sandy and peaty soils) is another particulate matter source containing particles with larger sizes. This particle source can be significant at certain times of the year.

Keywords: *particulate emission, biomass burning, open fires, crop yield, health risk.*

MEDICINAL PLANTS IN PROTECTED AREAS: A STRATEGY TO PRESERVE THE ENVIRONMENT AND BIODIVERSITY

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Abstract: Agricultural innovations during the 60s led to a significant increase in crop production, primarily driven by advances in technology, crop breeding, and agricultural practices. While they had many positive outcomes, it's important to acknowledge the negative consequences, more notably environmental damage. The increasing awareness of the need to combat environmental degradation, coupled with a heightened focus on making healthier dietary choices, has prompted a resurgence in the exploration of the therapeutic potential of medicinal plants. This includes spontaneous varieties, which have historically been used in pharmacopoeia, food and cosmetics. Farmers are progressively embracing the cultivation of medicinal plants, often without the necessity for substantial investments; moreover, they don't come at an environmental cost, because synthetic products such as fertilizers and pesticides aren't used. A shift away from this reliance reflects a more sustainable approach from both a landscape and environmental perspective. This study investigates the cultivation of various medicinal plants in a protected area in Basilicata, with the main focus on assessing the potential presence of agricultural plastic waste streams and their corresponding management practices. Initial findings confirm the scarcity of such waste, highlighting the sustainability of the medicinal plant supply chains.

Keywords: *agricultural plastic waste, sustainability, landscape, environment, life quality.*

SUSTAINABLE LAND AND WATER USE IN AGRICULTURE IN BOSNIA AND HERZEGOVINA: SMARTWATER PROJECT

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Abstract: Issues in the domains of sustainable land and water use in agriculture continue to grow, but on the other hand the scientific research is ongoing in order to decrease the destruction of these two main resources in agriculture. Destruction is often linked to erosion, pollution and excessive tillage practices (when it comes to soil) and pollution, unsustainable use and bad irrigation or drainage management (when it comes to water). In order to give a contribution to the sustainable use of land and water and to promote smart agricultural practices, SMARTWATER project (Promoting SMART agricultural WATER management in Bosnia and Herzegovina) was launched in 2021. This is a H2020 project, funded by the EC and coordinated by the University of Banja Luka (BiH). The main objectives are: 1) to reinforce the networking, research and innovation capacities of the University of Banja Luka (UNI-BL), University of Sarajevo (UNSA) and other BiH institutions in the field of sustainable agricultural water management and 2) to increase their competences and fund-raising skills for a successful participation in EU projects. There are a lot of pre-defined activities within this Twinning project: advanced courses, summer schools, joint experimental studies, academic exchanges, roundtable debates and the development and promotion of smart water management tools. Four main topics in project include: cloud-based smart technologies, new generation of satellite RS data, water-energy-food nexus optimization and climate change impact in agriculture. The three-year joint experimental studies are organized at two locations in BiH, in order to analyse maize productivity under different water and nitrogen treatments. With almost three years of experience, and with most of the activities finished with success, SMARTWATER consortium continues to contribute to the sustainable land and water management in agriculture, while SMARTWATER network continue to grow every day, including different target groups (academicians, students, early-stage researchers, farmers, policy makers, general public etc.).

Keywords: *environment, resources, networking, smart agriculture, irrigation.*

THE MERIT, CONSTRAIN SOLUTIONS OF FRUIT, VEGETABLE CROP PRODUCTION IN NIGERIA

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Abstract: The major fruits produced in Nigeria include mango, pineapple, plantain/banana, citrus, guava, pawpaw, while vegetables include onion, tomato, okra, pepper, amaranthus, carrot, melon, Corchorus olitorus (ewedu), Hibiscus sabdariffa (sobo), Adansonia digitata (baobab leaves) etc. In Nigeria, enormous quantities of fruits and vegetables are produced and staggering figures are sometimes given as estimated annual production. Fruits and vegetables play a very important role in the nutrition and health especially as they contain substances which regulate or stimulate digestion, act as laxatives or diuretics, pectins and phenolic compounds which play a part in regulating the pH of the intestines. Fruits and vegetables also contribute to the income of both the rural and urban dweller. The industrial potential of many fruits and vegetables available in Nigeria is enormous. What Nigerians need to do is embark on massive production of these fruits and vegetables not only for their high nutritive value but for enhancing the establishment of many processing industries. The development of their industrial uses will stimulate large scale production of the crops and enhanced diversification of entrepreneur to site processing plants in the rural areas which will improve the quality of life of the rural population and reduce the rate of rural-urban migration. Fruits and vegetable production in Nigeria is a serious business because it provides a means of livelihood for some people and also play an important role in the improvement of the health of Nigerians.

Keywords: *fruit, productions, Nigeria, entrepreneur, vegetable.*

Economics in agriculture

DIGITALISATION AS A TOOL FOR FARMERS COOPERATION CONCERNING PROCUREMENT AND DISTRIBUTION MANAGEMENT

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Abstract: Aim of this paper is to introduce a model, which provides effective solutions and support for establishment of the agricultural input and output market systems. Input used in agriculture are mostly technical systems, chemical materials and biological products. The output are the crops, livestock products and energy. Consequently, profit of agriculture is extremely low and production enlargement is not possible. Possibility to change this situation can be the online-marketplace, which can be created at the input or/and output side. These fields could improve procurement and distribution conditions of agriculture and imply chances to enlarge production through better profit. The system should foster the producers, should foster more successful production, and must not restrain them. Hence it should provide market advantages at all the elements of the production (regardless the size of property and production system). Therefore, a real solution could be made for practical development of agriculture by increase of suppliers' competition situations.

Keywords: *farmers cooperation, online-marketplace, procurement, distribution, price competitions.*

MACHINE FLEET MANAGEMENT OF PLANT PRODUCTION FOR BIOMASS AND BIOETHANOL PURPOSES CONCERNING LOGISTICAL AND MACHINE WORK COSTS

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Abstract: This work is a comprehensive examination that analyses the machine fleet formation and machine use of plant production farms that grow sweet sorghum too by using computer aided modelling. It considers the characteristics of machines used at the production technologies of different plants and it especially focuses on the appliance of machines with the convenient capacity and level from the side of costs at different farm sizes. We can conclude that the difference between the costs of the small and the large-scale farm size is significant. This all can be explained with the efficiency of the machine exploitation. In the field of costs there is also a difference between the use of modern and less modern machines. In case of small-scale farm size, with using less modern power-machines a more advantageous cost level can be reached, although the quality of the work and the circumstances of the working must be considered. In case of large-scale farm size, the difference between the operational costs of the less modern and more modern machines decrease significantly, because the operation of the less modern machines is more expensive at larger strain and the high-level constant costs of the modern machines decrease significantly, according to their better exploitation, considering one unit of work.

Keywords: *renewable plant production, farm size, machine fleet management, machine usage, machinery cost.*

TRENDS AND SPECIFICS OF THE IMPLEMENTATION OF INDUSTRY 4.0 AND SUSTAINABLE TECHNOLOGIES IN THE FOOD INDUSTRY IN SELECTED EUROPEAN COUNTRIES

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Abstract: According to the European Directive 2009/128/ EC, each pesticide application equipment (PAE) must have a valid technical inspection label. Each member state must harmonize its legislation with the EU, and the accession countries must start preparing for this work. A new standard has been created for the technical testing procedure: EN ISO 16122. It consists of five parts: 1 – Agricultural and forestry machinery: testing of sprayers in use, part 1: In general; 2 – Field boom sprayers; 3 – Air assisted sprayers for bush and tree crops; 4 – Fixed and semi-mobile sprayers; 5 – Aerial spray systems. Most EU countries have introduced technical inspection of boom sprayers and air-assisted sprayers, fixed and semi-mobile sprayers, while inspection of hand sprayers and knapsack sprayers on hand, battery and motor drive as well as knapsack motor orchard sprayers, is not required yet. In this paper ISO 16122 standard will be explained, as well as inspection procedure and the necessary equipment to perform the test. In the past years of application of the said standard, shortcomings have been identified and an improved version has been created, according to which the inspections perform a technical inspection. Therefore, this paper presents the latest progress and prospects of mentioned standard. A brief overview of the situation of mandatory technical inspection in the member states is also given. At the end of the paper, future trends of technical inspection for all machines applying pesticides are described: Fogging equipment, seed treatment equipment and different types of granular or powder applicators.

Keywords: *air assisted sprayers, ISO 16122, pesticide application equipment (PAE), sprayers, technical inspection.*

ECONOMICS IN AGRICULTURE: ECONOMIC EFFICIENCY OF DIFFERENT TECHNICAL SOLUTIONS IN AGRICULTURE. A STUDY OF NIGERIAN CONTEXT

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Abstract: This paper examines the economic efficiency of precision farming, irrigation systems, and mechanization in Nigeria's agricultural sector. A mixed-methods approach combining primary and secondary data was used to assess each solution's impact on productivity, profitability, and overall economic efficiency. The study found that each solution offers substantial benefits, including increased yield, improved water productivity, and time and labor savings. However, their adoption is hindered by challenges such as high initial costs, lack of technological literacy, and limited access to affordable credit. The paper recommends increased investment in agricultural technology, enhanced farmer training, favorable policies, and promotion of research and development to facilitate the adoption of these technical solutions. The findings underscore the importance of a tailored, farm-specific approach in leveraging these solutions for optimal economic efficiency in Nigeria's agriculture sector.

Keywords: *economic efficiency, precision farming, irrigation systems, mechanization, nigeria agriculture.*

THE FUTURE OF INFORMATION SYSTEMS FOR ROMANIAN FARMING SECTOR

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Abstract: The process of digitizing economic activity, in general, and agricultural activity, in particular, is on a growing trend in world-wide policies. Along with the development of information technology, the concern of scientific research has also increased in finding IT solutions aimed at leading to an increased efficiency of the use of resources (natural, financial and human) in the context of climate change. Information systems for agricultural and farm management are discussed in this paper, for providing conceptual framework for future design of an information system. An information system framework is comprised of various interlocking components, each playing a pivotal role in its functionality. Subsystems act as specialized segments, contributing their distinct expertise to the greater system's functioning. Processes ensure the smooth flow and efficient transformation of information, while mechanisms guarantee the synchronization of operations and optimize the system's performance. Altogether, these elements form a cohesive structure that not only empowers agricultural producers but also enhances the overall efficiency and sustainability of the agricultural industry.

Keywords: *digital agriculture, precision agriculture, farmer's needs, digital tools.*

ADVANCE OF DATA DRIVEN TECHNICAL-ECONOMIC MODELS FOR OPTIMIZATION OF ROMANIAN FARMER PRODUCTION PROCESSES

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Abstract: The agriculture sector relies heavily on knowledge and information. Farmers need to deal and process a range of data, including financial, climatic, technical, and regulatory details, to effectively manage their farms. In this context, in this paper we report on advancement and integration of data driven digital tools in current agricultural practices in Romania. Other concepts such as digitization, digitalization and precision agriculture are also discussed. Data driven systems for agricultural sector are sophisticated infrastructures designed to facilitate the entire spectrum of agricultural knowledge management. In essence, these systems serve as dynamic hubs where of agricultural information is not only generated but also seamlessly transformed and synthesized. The overarching purpose of this complex transposition is to provide a solid foundation for agricultural producers to effectively harness and employ the affluence of knowledge available to them. For improving the farmers' activity, both public and private sector is interested to provide them with pertinent data-based visions and analyses. However, deficiencies within this agricultural information framework, manifested as the inability to consistently deliver precise, timely, and easily accessible information, pose various obstacles for farmers.

Keywords: *data driven agriculture, digitalization, production efficiency.*

INTEGRATION OF AGRICULTURAL PRODUCTION TOWARDS CIRCULAR ECONOMY PRINCIPLES

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Abstract: In the context of contemporary arguments regarding the constraints posed by finite natural resources, the expansion of global populations, and the escalating impacts of climate change, the demand for active circular processes has grown more obvious. Circular economy, as a strategic approach, stands as a potential route towards cultivating more sustainable routes for our collective future. This paper is reporting on pathways for transforming agricultural sector through implementation of circular economy principles. The most important principle of this approach lies in preserving the utility and functionality of products for the maximum duration within the continuum of their life cycle, effectively perpetuating their value within the cyclical framework. An integral pillar of this paradigm involves the transformation of waste materials into newfound resources, effectively extracting (additional) value from what once might have been considered discarded remnants. This transformation not only strengthens the economic landscape but also holds the potential to catalyze additional revenue streams by bringing new life into materials that might have otherwise been overlooked. Of course, transitioning from a linear economic model to a circular one within the agrifood sector necessitates the introduction of inventive business frameworks. It is not enough to design innovative circular technological processes but is important to employ economic and social costs as well. Such kind of strategy encompass concepts like reverse logistics, novel perspectives on the dynamics between customers and suppliers, and fresh modes of organization and marketing strategies that converge at the juncture of diverse value chains.

Keywords: *circular economy, sustainable agriculture, biobased value chains.*

ANALYSIS OF COSTS RELATED TO BUILDINGS, MACHINERY AND EQUIPMENT BASED ON FADN DATA

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Abstract: Successful agricultural production requires appropriate fixed assets, while investments in their improvement and modernization are necessary for long term sustainability of agricultural holdings. As a consequence, costs related to fixed assets have significant share in total costs (total input) of farm activity. This research primarily analyzes costs related to buildings, machinery and equipment. As a base for the research FADN methodology is applied as well as EU FADN public database as a source of data. Within the analysis authors primarily discussed elements of Total farming overhead (SE336), such as Machinery and building current costs (SE340), Energy (SE345) and Contract work (SE350). Above mentioned FADN indicators cover variety of costs, such as costs of current upkeep of machinery and buildings, costs of fuel and electricity and costs linked to the hire of machinery, among others. Costs are discussed and compared for 14 farm types in the EU (TF14 classification of farms is applied). The results of the analysis enabled better insight and understanding of costs related to machinery, equipment and buildings in agricultural production of the EU, while the conclusions could be useful for Serbian agricultural holdings, as well.

Keywords: *fixed assets, overhead costs, FADN, costs of current upkeep, energy costs.*

AGTECH ECOSYSTEM OF THE REPUBLIC OF SERBIA - ANALYSIS OF THE ECONOMY NEEDS

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Abstract: Agriculture represents the traditional and least digitized industry, both in the Republic of Serbia and in the world. This situation presented an opportunity for the emergence and accelerated development of the AgTech industry, which is currently one of the fastest growing industries in the world, and is among the three most represented in the Serbian startup ecosystem. AgTech is a new generation industrial field that improves agriculture and the food industry, where the use of modern technologies to develop innovations, new business models and processes, as well as digitization and digital transformation of the industry. AgTech refers to hardware, software, business model, new technologies, new technical solutions, which are directed towards the digital space based on data collection, processing and analysis, as well as decision support tools. This paper presents the results of research conducted on a sample of 106 companies from the AgTech ecosystem in the Republic of Serbia during 2023., among which 85.7% of companies developed their innovations in cooperation with scientific institutions. The analysis of the needs of AgTech companies presented in this paper can be very important for the improvement and development of cooperation between the economy and scientific/research organizations in the Republic of Serbia, as well as the acceleration of scientific research and further commercialization of innovations and the successful transfer of technologies in this area.

Keywords: *agriculture, innovations, forms of support, knowledge transfer, digital transformation.*

MANAGEMENT AND FINANCING IN AGRICULTURE: AGRICULTUREAL FINANCING POLICIES AND RURAL DEVELOPMENT IN NIGERIA

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Abstract: The study examined the agricultural financing policies of the government of Nigeria and effects on rural development. The study found that though the government has made serious efforts at making good agricultural policies through schemes, programmes and institutions, it has not been able to back them up with adequate budgetary allocation and financing coupled with corruption in the execution of the policies. It is recommended that for the government agricultural financing policies to achieve its target of rural development, Nigeria will need an adequate level of strategically targeted investment in agriculture, upgrade rural infrastructure, boost productivity, and increase competitiveness of the farm output, in addition to fighting corruption.

Keywords: *agricultural financing, policies, institutions, rural, development.*

ENTREPRENEURIAL ORIENTATION OF FAMILY FARMS IN THE REPUBLIC OF SERBIA – ANALYSIS AND DETECTION OF DIRECTIONS FOR SUPPORT

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Abstract: Family farms in the Republic of Serbia are mostly small agricultural producers with arable land of small and medium size and with a low degree of process mechanization, where family members usually work, and farm management is assigned to one family member. Such farms are often in a subordinate position, with weak negotiation power compared to large agricultural producers and large enterprises engaged in agricultural production. Still, the chance of further development of such farms lies in their positive entrepreneurial orientation and readiness for innovation and change. This paper presents research on the entrepreneurial orientation of family farms in the Republic of Serbia. The survey sample consists of 72 farms from different locations in the Republic of Serbia. Entrepreneurial orientation is observed through the following elements: readiness of farms to join cooperatives, readiness for participation in large supply chains, readiness to standardize products and processes, export readiness, readiness for change and delegation of management processes, as well as readiness for farm development by improving agriculture, management, and entrepreneurship knowledge of the owner. The results presented in the paper provide clear insights to the support creators about the potential and directions for improving the position of small farms in the Republic of Serbia.

Keywords: *family farms, entrepreneurship, entrepreneurial orientation, support, Republic of Serbia.*

IMPACTS OF THE IPARD PROGRAMME ON RURAL DEVELOPMENT THROUGH AGRICULTURAL MACHINERY SUPPORT IN MONTENEGRO

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Abstract: The implementation of the IPARD initiative in Montenegro has brought forth significant advancements in the agricultural sector concerning the provision of agricultural machinery and equipment by equipping numerous farmers with a diverse range of tools, including tractors, trailers, balers, mowers, plows, irrigation systems, and more, all aimed at strengthening farming operations and productivity. The initiative has also encompassed infrastructural development to optimize the utilization of these assets. The anticipated impact of this support is poised to be transformative, as recipient farmers are empowered with the means to enhance their agricultural capabilities and overall efficiency. The initiative's effect is reflected in the data from Montenegrin municipalities, where 333 investments were channeled through four public calls for support that notably reached beneficiaries across various regions, with a few exceptions, highlighting areas where further attention is needed to ensure equitable distribution. While challenges such as criteria fulfilment, communication barriers, and expectation alignment surfaced, the positive outcomes underscored the potential of successful collaboration. Efficient information dissemination and administrative adaptability have showcased the way forward. This article provides insightful recommendations for the future and suggests innovative approaches, increasing user engagement in decision-making processes, transparent communication, and robust capacity-building initiatives. These recommendations collectively aim to create an inclusive and effective collaborative framework, driving agricultural modernization and sustainability. The lessons distilled from this collaborative endeavor are poised to guide forthcoming initiatives, enhancing collaboration, and steering Montenegro's agricultural sector toward modernization. The qualitative depth of insights derived from interviews with stakeholders has enriched our comprehension and informed the trajectory of Montenegro's agricultural evolution.

Keywords: *IPARD, Montenegro, agricultural machinery, modernization, rural development.*

NAVIGATING THE PATH TO SUSTAINABILITY: AN ECONOMIC ANALYSIS OF BARRIERS, DRIVERS, AND POLICY FRAMEWORKS IN AGRICULTURAL FOOD AND FEED TECHNOLOGIES

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Abstract: In response to the formidable challenges faced by the global agricultural sector in maintaining consistent food and feed production, there is an imperative to integrate economic considerations into the development of novel technologies and methodologies. This study delves into the potential applications of economics in fostering the evolution of sustainable food and feed systems, with a primary focus on efficiency, equity and environmental concerns. By accentuating the pivotal role of financial incentives in driving the adoption of sustainable practices, this study examines the intricate interplay between technological innovation, market dynamics, and governmental regulations. Through an extensive review of pertinent literature and the utilization of case studies, empirical research and survey data analysis, this research seeks to identify the principal economic catalysts for, as well as impediments to, the uptake of sustainable agricultural technology. Moreover, this study introduces an innovative paradigm designed to motivate policymakers, practitioners and researchers towards embracing eco-friendly yet economically viable agricultural practices. The unique insights provided herein have the potential to chart a groundbreaking course for the future trajectory of agricultural sustainability and food security. This study underscores the urgent need to blend economic perspectives with agricultural advancements, illuminating a path towards harmonizing production efficiency, equitable distribution and ecological well-being. Through the proposals outlined, the groundwork is laid for steering global agricultural practices into a more sustainable and secure future.

Keywords: *economics, agriculture, food security, economic incentives, environmental considerations, sustainable technologies.*

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