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Dear Colleagues,

The International Conference of Young Scientists on Energy and Natural Sciences Issues (CYSENI 2023) has been organized already for the 19th time since 2004, which became an annual tradition. We are very proud to bring together talented young scientists to participate in the 19th CYSENI conference. We expect that this will contribute to exchange of ideas, improved knowledge of young researchers, development of their acquired abilities and contribute to increasing level of exercised research activities. The initiative for such an event came from young and enthusiastic researchers of Lithuanian Energy Institute (LEI). They realised that there are a lot of young, smart and science-oriented young people and they do need a place to share their views, generated ideas and present the latest research results.

This year, Lithuanian Research Centre for Agriculture and Forestry together with Lithuanian Energy Institute as well as RTO Lithuania continued a partnership in co-organizing the CYSENI 2023 Conference. This partnership allowed us to expand the topics of the conference and maintain a high number of participants – more than 140 from around 20 countries.

The conference once again has brought together young researchers and scientists to discuss recent trends in energy and natural sciences sectors worldwide. We are pleased that young scientists further found the conference valuable to present their State-of-the-art research results and share scientific experience. We thank all the contributors who made this conference possible. This includes all people from scientific and organising committees.

We would like to thank all participants for their contribution to the Conference and submission of their research papers. Moreover, special thanks to Keynote speakers: Tony Donné, Marcos Nogueira, Inga Minelgaitė, Jaakko Leppänen, Anatoli Popov, Guðmundur Gunnarsson, Runar Unnthorsson, Christiaan Richter, Ana Pytlak, Bozena Smreczak and Catherine Brewer.

Sincerely,

Conference Organizers

PLENARY SPEAKERS

- **SPEAKER | Tony Donné**
  SINCE JUNE 2014 PROGRAMME MANAGER (CEO) OF EUROFUSION, GERMANY:
  Why don't we have fusion yet – and what is EUROfusion doing to get there?

- **SPEAKER | Marcos Nogueira**
  H2020-AURORAL PROJECT COORDINATOR, BELGIUM / PORTUGAL:
  Smart Communities – a contribution for a free, united and independent Europe.

- **SPEAKER | Inga Minelgaitė**
  PROFESSOR AT THE UNIVERSITY OF ICELAND, CO-FOUNDER OF INFINITUS LABS, ICELAND / LITHUANIA:
  Leading in projectified environment: how well are we failing?

- **SPEAKER | Jaakko Leppänen**
  RESEARCH PROFESSOR FOR REACTOR SAFETY AT VTT TECHNICAL RESEARCH CENTRE OF FINLAND:
  Nuclear energy for district heating

- **SPEAKER | Anatoli Popov**
  SENIOR RESEARCH FELLOW AT THE INSTITUTE OF SOLID STATE PHYSICS OF THE UNIVERSITY OF LATVIA:
  Radiation defects and their thermal annealing in functional ceramics for nuclear applications

- **SPEAKER | Guðmundur Gunnarsson**
  SENIOR SCIENTIST/PROJECT MANAGER AT TÆKNISETUR (ICETEC), ICELAND:
  CO2 free aluminium for energy storage

- **SPEAKER | Runar Unnthorsson**
  PROFESSOR AND THE HEAD OF THE FACULTY OF INDUSTRIAL ENGINEERING, MECHANICAL ENGINEERING, AND COMPUTER SCIENCE AT THE UNIVERSITY OF ICELAND:
  Aluminum-Ion Batteries - A Promising Alternative for Stationary Battery Storage

PLENARY SPEAKERS

- **SPEAKER | Christiaan Richter**
  PROFESSOR IN CHEMICAL ENGINEERING AT THE UNIVERSITY OF ICELAND:
  The future of fuel – is it up to politics, science or both?

- **SPEAKER | Anna Pytlak**
  WORKS AT DEPARTMENT OF NATURAL ENVIRONMENT BIOGEOCHEMISTRY, INSTITUTE OF AGROPHYSICS, POLISH ACADEMY OF SCIENCES, POLAND:
  Methane in the environment and in the human economy - why should we be concerned?

- **SPEAKER | Bożena Smreczak**
  PROFESSOR AT THE INSTITUTE OF SOIL SCIENCE AND PLANT CULTIVATION – STATE RESEARCH INSTITUTE, POLAND:
  Soil monitoring systems in Europe, why they are important

- **SPEAKER | Catherine Brewer**
  ASSOCIATE PROFESSOR IN THE DEPARTMENT OF CHEMICAL & MATERIALS ENGINEERING AT NEW MEXICO STATE UNIVERSITY, USA:
  Engineering Co-Products to Support Sustainable Agriculture

Dr. TONY DONNÉ

WHY DON'T WE HAVE FUSION YET – AND WHAT IS EUROFUSION DOING TO GET THERE?

Since the start of fusion research many different challenges had to be overcome. For example: how can a plasma (i.e. an ionized gas) be confined at temperatures that are 10 times higher than in the centre of the sun and how can we isolate this hot plasma from the walls of the reactor vessel, such that they will not melt. Many of the original challenges have been overcome in the global fusion research. But still much research needs to be done to tackle the remaining challenges. To prioritize the research in Europe, a Fusion Roadmap was developed with the international fusion reactor ITER, the demonstration reactor (DEMO) and the International Fusion Materials Irradiation Facility (IFMIF) as main research facilities. The Fusion Roadmap gives a reasonable indication how much more time is needed to get electricity from fusion.

Dr. MARCOS NOGUEIRA

SMART COMMUNITIES – A CONTRIBUTION FOR A FREE, UNITED AND INDEPENDENT EUROPE

During last 25 years, Marcos has devoted he carrier to public service leading the development of a significant number of projects and programs for public entities, at all levels of public authority, with special emphasis on cities and regions in Portugal, in addition to continued activity in other member states of the European Union. Practitioner in field of European affairs since the 90s Marcos currently leads the representation to the EU of Alentejo, region he vigorously adopted, and is H2020-AURORAL Project Coordinator.

Dr. INGA MINELGAITĖ

LEADING IN PROJECTIFIED ENVIRONMENT: HOW WELL ARE WE FAILING?

Acceleration of use of projects in all fields of life has been coined projectification in 1960s and in observed in modern societies ever since with projects being placed at the centre and transforming organizations into project-centric. It became evident that manging projectification is a prerequisite for surviving and thriving of contemporary organizations with proliferation of projects and continues adjustment to the transformation of internal and external environment. Project-centrism enabled organizations to become more flexible, attuned with socio-cultural climate, and uncertainty-proof resulting in increasing complexity that employees and organization are faced with. Projectification is intensified by continues aspiration of individuals, organizations, and states for advancement in order to improve the quality of life. Furthermore, it is operationalized through specific measures, e.g., European Union projects, where „about half of the EU budget is allocated to funding projects in one way or another", which in return contribute to increasing number of projects and overall complexity of environment.

Dr. JAAKKO LEPPÄNEN

NUCLEAR ENERGY FOR DISTRICT HEATING

The energy sector is one of the major consumers of fossil fuels, and therefore also a major contributor to carbon emissions. In many contexts, energy is used as a synonym for electricity, but in reality, most of the world's primary energy is consumed as transportation fuels and heat. Investing into low-carbon electricity production consequently provides only a partial solution to the climate crisis. Decarbonizing the industrial and heating sectors is necessary for meeting the climate goals, and this requires more drastic changes in the ways energy is produced and consumed.

In 2020, VTT Technical Research Centre of Finland started the development of a small low-temperature nuclear reactor for the purpose of district heating. The LDR-50 reactor is specifically designed to supply heat for small, medium-sized and large district heating networks in Finland, but the potential market also covers other European countries with cold winter climate. The motivation for the development is to provide a low-carbon replacement for fossil heating fuels, taking into consideration independence from the electricity market, and requirements for security of supply.

The LDR-50 features a combination of conventional light water reactor technology and passive safety design. The unit size is 50 megawatts, and the heating plant may consist of one or multiple independent reactor units. The reactor operates at around 150 degrees temperature, without any turbine cycle. In 2023, the project received significant new funding, which enabled moving the development into a new phase. The first demonstration plant is to be commissioned by the end of the decade, followed by commercialization of the technology in the 2030's.

Dr. ANATOLI POPOV

RADIATION DEFECTS AND THEIR THERMAL ANNEALING IN FUNCTIONAL CERAMICS FOR NUCLEAR APPLICATIONS

The industrial progress of 21st century could greatly benefit from development and exploitation of fusion reactors producing environmentally clean friendly electrical energy. One of a key problem here is need in new advanced materials able to operate under extreme conditions (high temperatures and intensive neutron/gamma radiation).

In this report, I will provide a brief overview of both general information on the status of the problems and the most interesting results obtained within the two EUROfusion Enabling Research Projects – "***Advanced experimental and theoretical analysis of defect evolution and structural disordering in optical and dielectric materials for fusion applications (AETA)***" (2019-2020) and "***Investigation of defects and disorder in nonirradiated and irradiated Doped Diamond and Related Materials for fusion diagnostic applications (DDRM) – Theoretical and Experimental analysis*** " (2021-2023).

In a series of joint works by ISSP UL (Latvia), UT (Estonia) and KIT (Germany), radiation damage of some promising functional materials (Al_2O_3, $MgAl_2O_4$, SiO_2, diamond and few more) from the priority list of the EUROfusion consortium was studied under neutron, proton, heavy ion [1-4].

The optical and dielectric, vibrational and magnetic properties of numerous crystalline and ceramic materials were carefully studied. Based on this study, we developed new theoretical methods able to evaluate and predict some important properties of these materials as well as their radiation damage evolution under extreme reactor conditions.

Dr. GUÐMUNDUR GUNNARSSON

CO_2 FREE ALUMINIUM FOR ENERGY STORAGE

Aluminium has a volumetric energy density of 23.4 kWh/l, which is higher than that of liquid hydrocarbon fuels and much higher than that of gaseous fuels like methane and hydrogen, that are stored at high pressures. Aluminium could therefore be an interesting option for seasonal storage of energy. Production of aluminium is an energy intensive process which in Europe requires an electric energy input of 15.1 kWh for production of 1 kg of aluminium from alumina. In addition, the energy input from the carbon anodes used in the process is about 3.8 kWh/kg aluminium. The energy required is therefore about 19 kWh/kg aluminium, which can be compared to the specific energy density of aluminium which is 8.63 kWh/kg. For aluminium to become energy storage alternative with low carbon footprint, energy consumption in production of aluminium should be decreased and CO_2 from the process eliminated. Preferably electric energy for aluminium production should also be of low carbon footprint. In this presentation work in Iceland on development of a CO_2 free aluminium process will be described. This work in based on the use of metallic anodes instead of carbon anodes and use of titanium diboride cathodes instead of carbon cathodes. Approaches to recover energy from aluminium will also be briefly described with special emphasis on projects where IceTec is a partner.

Dr. RUNAR UNNTHORSSON

ALUMINUM-ION BATTERIES – A PROMISING ALTERNATIVE FOR STATIONARY BATTERY STORAGE

The main materials used for the production of lithium-ion batteries are nickel, cobalt and lithium. With the demand for lithium and nickel projected to outgrow its supply in the coming decade, there is an urgent need to explore alternative battery chemistries that do not have the same resource limitations as lithium batteries. In this talk, we will provide an overview of the stationary battery storage market and explore an exciting alternative to lithium batteries – the aluminium-ion battery. Compared to traditional lithium-ion batteries, aluminium-ion batteries offer several benefits, including lower cost, greater safety and longer lifetime.

We will present an aluminium-ion battery that the Icelandic company Alor and its Spanish partner Albufera-Energy Storage are developing for stationary energy storage applications. We will discuss the fundamental chemistry and the advantages it holds over traditional lithium-ion batteries. Furthermore, we will present results from two usage test scenarios. This will provide insights into the commercialization potential of aluminium-ion batteries in the stationary battery storage market.

By the end of this talk, you will have a better understanding of the potential of aluminium-ion batteries and the role they could play in powering our future. This includes their ability to meet the growing demand for stationary energy storage systems while addressing concerns about resource limitations and safety issues associated with lithium batteries.

Dr. CHRISTIAAN RICHTER

THE FUTURE OF FUEL – IS IT UP TO POLITICS, SCIENCE OR BOTH?

When it comes to land, sea and air transportation… is the major barriers to sustainable transport just scientific, or just political, or both? If the widespread adoption of sustainable transport solutions requires any significant scientific breakthroughs, what are they? In this presentation I will suggest that for one potentially key process – the reaction of renewable hydrogen with carbon dioxide to produce methanol, the remaining barriers are pretty much just political.

I will share the perspectives of an erstwhile academic material scientist/chemical engineer who participated extensively in large scale eFuel project development for the last 5 years and running. The country of Iceland may be small, but in terms of eFuel it is surprisingly a world leader – the Icelandic company CRI operates an industrial 5 000 tonne/year eFuel plant since 2012, a full decade before any other comparable project. Even today, Iceland may have the lowest global production cost for certain types of renewable eFuel. It is from this perspective that I will propose the hypothesis that the barriers to sustainable fuel adoption are mostly political. A sensible transition can be done, even without any new scientific breakthrough or advance.

However, though not necessary, scientific progress can meaningfully improve eFuel economics in certain key areas. I will propose the key areas where research progress can accelerate eFuel use is:

1. The efficiency of electrolysis has not improved for about 90 years. Efficiency improvements of electrolytic hydrogen and/or lower electrolyzer material cost will accelerate the switch to green fuels.
2. Separations technology, in particular CO_2 capture and separation.
3. Neither batteries, nor the direct use of hydrogen, is *necessarily* required for an environmental and sustainable transportation future. However, both these modalities could realize their early promise if scientific breakthroughs pan out that resolve their respective Achilles heels. In the case of hydrogen it is the hydrogen storage problem, in the case of batteries it is the twin problem of extensive rare metals use and recycling.

Sometimes contributions also come from left field. Such an example is the ALICE waste to hydrogen project (Institute of Solid State Physics University of Latvia, Lithuanian Energy Institute, University of Iceland and IceTec). In the final part of the presentation I will share some insights from the ALICE waste to hydrogen project and how this form of green hydrogen can supplement hydrogen from renewable electricity while also increasing high recycling.

Dr. ANNA PYTLAK

METHANE IN THE ENVIRONMENT AND IN THE HUMAN ECONOMY – WHY SHOULD WE BE CONCERNED?

Methane is the most widespread hydrocarbon in the environment and also an important climate-shaping factor. Despite its low atmospheric mixing ratio (global monthly mean for July 2022 – 1904 ppb) methane it is estimated to be responsible for c.a. 20% of global warming. The reason is the high potential of CH_4 to bind solar energy, dozens of times greater than that of CO_2. Noteworthy, the increase in anthropogenic CH_4 emissions are recognized as one of the main driving forces behind the rapid global warming. Methane, being the main constituent of a natural gas is often used as a raw material for energy production as well as a substrate in many industrial processes. Extraction of fossil methane from underground deposits and subsequent transportation via pipeline systems generate large emissions into the atmosphere. The other important anthropogenic source of CH_4 is agriculture. Particularly harmful, in terms of methane emissions are rice cultivation and cattle breeding. In both cases, methane is de novo produced by biological decomposition of organic matter (in soil and digestive systems, respectively). Agriculture also negatively affects the natural mechanisms that limit atmospheric methane concentrations, namely its biological oxidation in soils. Disruption of the homeostasis of methane-oxidizing bacteria in soils occurs through, for example, excessive mineral fertilization. The aim of the presentation is to bring knowledge of the sources of anthropogenic emissions of methane and also of its biogeochemical cycling in the environment.

Dr. BOZENA SMRECZAK

SOIL MONITORING SYSTEMS IN EUROPE, WHY THEY ARE IMPORTANT

The European Green Deal and the implementation of other new strategies and directives refers to soils‘ health, functions, and ecosystem services. A considerable effort is undertaken to harmonize, verify and share the results on soil properties. For the last few decades, tremendous effort has been invested to determine soil chemical and physical properties at regional, country, and European levels. Various sampling designs, depths of sample collection in the soil profile, analytical methods, and aims of monitoring are the reasons which limit the proper harmonization of data. Therefore, in 2009, the European Commission extended the periodic Land Use/Land Cover Area Frame Survey (LUCAS) to sample and analyze the main properties of topsoil in 23 Member States of the European Union (EU). A consistent spatial database of the soil cover across the EU was established, based on standard sampling and analytical procedures. Many harmonized maps for the EU Members States were produced but the scale of these maps was too big to enable proper management of soils and their protection against degradation processes. Proper implementation of European soil-dedicated policy needs new solutions for soil management practices and soil protection based on scientific evidence. Therefore, a lot of effort is dedicated to select proper soil health indicators and their trigger value as well as to develop mapping methods for individual indicators and their groups characterizing soil ecosystem services at various scales. The EJP SOIL project „Towards climate-smart sustainable management of agricultural soils“, no. 862695, is one of the European projects expected to provide such data. The aim of the presentation is to indicate the main actions undertaken in Europe towards the identification of soil health indicators and the role of European and national soil monitoring systems in this process.

Dr. CATHERINE BREWER

ENGINEERING CO-PRODUCTS TO SUPPORT SUSTAINABLE AGRICULTURE

In the southwestern United States, the semi-arid environment support a surprisingly large amount of potential biomass resources: pecan wood and shells, guayule processing residues, forestry residues, animal manures, wastewater algae and sludge, and food wastes. The economic side of sustainable agriculture depends on value-added applications for these biomass resources. Biomass conversion methods, such as pyrolysis, hydrothermal liquefaction, supercritical fluid extraction, and fractionation, are the critical pieces between raw materials and energy, water quality, and agricultural applications. This presentation highlights some examples of interdisciplinary projects: bio-based insect repellents from guayule resin, hydrothermal liquefaction (HTL) of algae and sludges from wastewater treatment, HTL of food wastes, carbon adsorbents for removal of contaminants from water, biochemicals from high-cannabinoid hemp wastes, and biochars for soil quality management. Dr. Brewer will also give some perspectives on brainstorming for novel research proposals, collaborating across disciplines, and improving manuscripts to enable better outcomes during the review and publication process.

1. ENERGY SCIENCES

1.1. BIOENERGY, BIOMASS AND BIOFUELS

CHICKEN MANURE AND COW SLURRY CO-DIGESTION WITH PIG FAT WASTE: A COMPARATIVE ANALYSIS OF BIOGAS PRODUCTION PARAMETERS

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Abstract

The food production chain, from livestock and poultry farming to the meat processing industry, constantly increases the amount of offal and waste. Almost every participant in this chain encounters a problem utilising all the waste it produces. A big challenge in solving that problem is to get rid of fat waste, which is part of FOG (fats, oils, and greases) waste because such matters slowly degrade and can be utilised by few technologies. In our research, we applied an anaerobic digestion process to solve the fat waste utilisation problem and investigated how such waste treatment impacts biogas production. The study has been conducted on the anaerobic digestion of cow slurry and poultry manure using pig fat as the manure-based substrate supplement. Anaerobic digestion opportunities and challenges associated with manure-based substrates and fat waste as a supplement were identified and compared by comparative analysis of factors: the biogas yield from organic matter, the biogas calorific value, volatile solids reduction efficiency and energy balance. The research showed that pig fat waste co-digestion with chicken manure and cow slurry increased biogas yield, methane concentration in biogas, biogas calorific value and biomass energy yield in both cases. The increase of biogas yield was higher in fat co-digestion with chicken manure than with cow slurry at every organic load rate (OLR). The biogas production was the highest at OLR 4,5 kgVS/m^3·d. At this OLR, the biogas yield increased 2.09 times for chicken manure and 3.15 times for cow slurry. Meanwhile, the increase in feeding material was 5.26 per cent for chicken manure and 2.91 per cent for cow slurry. Fat waste utilisation through anaerobic co-digestion with manure-based substrates has a positive influence on biogas production parameters and could be an appropriate measure for solving the problem of fat waste utilisation for the food processing industry.

PROCESSING AND UTILISATION OF TERNARY CROP PLANTS FOR ENERGY CONVERSION

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Abstract

With the growing demand for energy and concerns about climate change, the use of biomass of various origins for energy production is becoming increasingly relevant. Wood biomass is mostly used for the production of biofuel pellets, but it is important to evaluate the possibilities of using other types of biomass as well. This report analyses the suitability of ternary crop biomass for solid biofuel pellet production and energy conversion.

The experiment was conducted from 2020 to 2022. One field (triple crop) had three crops (hemp, field bean, and maize) grown each year, which were dried, chopped, ground, and made into pellets using a low-power granulator. The physical-mechanical, chemical properties of the produced pellets and emissions during the burning of these pellets were investigated. The research was conducted in accordance with ISO standards and other standard methodology applicable to this type of research. Statistical results were processed using the MS Excel program. Averages of the obtained results were derived, and confidence intervals were calculated with a probability level of 0.95.

The length of the produced pellets varied from 22.6 mm (the 3rd year of the experiment) to 26.6 mm (the 2nd year of the experiment), and the diameter was 6.1–6.2 mm. The ash content in 2020, 2021, and 2022 was 6.08, 5.98, and 6.54 %, respectively.

Pellets density varied from 1139.29 to 1238.20 kg m^{-3}. The moisture content of the pellets produced in each year of the experiment was below 12%. The amount of chemical elements N, S, and Cl as well as Cd, Cu, and Pb in the pellets did not exceed the limit values set by the ISO 17225-6 standard, which sets quality requirements for non-wood biofuels. The analysis of CO_2, CO, NOx, and CxHy emissions performed under laboratory conditions showed that the produced pellets do not have negative consequences for the environment.

It can be concluded that pellets made from the biomass of the ternary crop can be used as a high-quality solid biofuel.

1.2. CROSS-CUTTING ENERGY ISSUES

CARBON CAPTURE STORAGE AND USAGE (CCSU): OVERVIEW AND CURRENT RESEARCH

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Abstract

Reducing CO_2 emissions is a worldwide challenge and responsibility. In addition to simply avoiding emissions, the effective further use and storage of carbon dioxide is also an important pillar of the energy transition. In the case of storage, mainly the geological subsurface is considered, where one differentiates the type of storage (aquifers, depleted hydrocarbon reservoirs, caverns) as well as the permanence of the storage process (permanent – called CSS as well as short-term as intermediate storage CSU).

The presentation will focus on the CO_2 storage in depleted oil and gas reservoirs, which is one of the most important and economical alternatives due to its proven integrity. The presentation and subsequent publication will discuss the current state of knowledge as well as the recent industrial applications. A brief overview of recent successful projects worldwide with their specific subsurface and surface conditions will help the audience to gain an overall understanding of the technical challenges that arise for existing and upcoming infrastructures for transportation and storage of CO_2. Based on this, current research needs will be derived and the necessary further development steps as well as the current state of research will be presented.

As a result, the advantages and disadvantages of aquifer and depleted hydrocarbon reservoirs for CO_2 storage will be presented and explained on the basis of current research experience and selected pilot projects worldwide. Special emphasis is placed on the integrity of the geological storage formation and the associated technical equipment. The results will be discussed in the context of the early stages of research and the emerging industrial applicability. For the future development of the topic, it is also noted that the storage and utilisation of CO_2 is still at the beginning of industrial use as well as permanently being investigated on a large scale.

1.3. ENERGY ECONOMICS AND POLICY

THE IMPACT OF DIFFERENT INDUSTRIES ON THE GREEN ECONOMY IN THE BALTIC STATES

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Abstract

Most of the energy that we consume today comes from fossil fuels. Oil, natural gas, coal, and shale are the main sources of fossil fuels in the Baltic States. They are the main sources of energy used in power generation and transport. A green economy is a type of economy that focusses on creating economic wealth without impacting the environment. The aim of this article is to find out which and why countries emit more carbon dioxide, and which emit less carbon dioxide.

The results show that countries with well-developed industry and energy production emit more greenhouse gases, while countries with less developed industry and energy production emit less greenhouse gases. Estonia due to the extraction and burning of large amounts of gas and fuel oil from shale emitted 123435.2 tonnes of carbon dioxide between 2011 and 2018, while Lithuania and Latvia together emitted only 79151.48 tonnes.

Climate change is accelerated by carbon dioxide emissions. The electricity and heat generation sector are the largest emitter of greenhouse gases globally. In countries with well-developed industrial and energy sectors, CO_2 accounts for the majority of greenhouse gas emissions.

THE APPLICABILITY OF THE EUROPEAN GREEN DEAL IN THE TRANSPORT SECTOR: A QUALITATIVE ANALYSIS

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Abstract

The European Green Deal is a comprehensive strategy proposed by the European Union (EU) to make the EU carbon-neutral by 2050. The article uses qualitative analysis methods to assess the applicability of the European Green Deal assumptions in the transport sector. A PESTEL analysis was conducted. From a political perspective, the Green Deal initiative, and the reduction of greenhouse gas emissions in the transport sector are supported by the EU and individual member states. There is political pressure to implement stricter regulations for reducing the emissions.

From an economic perspective, the higher costs associated with the development and production of low-emission vehicles and infrastructure can lead to higher prices for consumers. There will be challenges related to changing societal attitudes and behaviours about transportation, such as reliance on private vehicles and the need for more sustainable modes of transportation. Advances in technology have made low-emission vehicles and alternative modes of transportation more feasible and accessible. Reducing greenhouse gas emissions and combating climate change is the main goal of the European Green Deal, which is a serious environmental challenge. The transport sector requires many changes to reduce the negative impact on the environment. A PESTEL methodology analysis has been conducted, which shows that the implementation of the European Green Deal poses a variety of challenges and development opportunities.

The implementation of such a large revolution in the functioning of the economy requires a detailed analysis of the feasibility of implementation. The consequences of political decisions will be felt for many years and may be irreversible. This should be borne in mind when remembering the consequences of broken supply chains during the COVID-19 pandemic. We propose to extend the discussion, which will prepare the transport sector in more detail for the challenges of the European Green Deal.

ADDRESSING ENERGY POVERTY THROUGH ENERGY EFFICIENCY

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Abstract

Energy poverty is a pressing issue affecting a significant number of households in the EU, including Lithuania. While subsidies and immediate relief can provide short-term support, a long-term solution is needed. An analytical approach is used to evaluate the effectiveness of government policies and analyse technical constraints. The review concluded that energy efficiency is mostly missing as a policy instrument and result oriented policy asks to focus on energy efficiency as a measure to reduce energy bills and increase energy self-sufficiency. The study proposes extensions to Lithuanian policy instruments, including a targeted energy efficiency program and a revolving fund to provide low-interest loans for energy efficiency measures. These proposals can have a positive impact on the economy, the environment, and the social well-being of vulnerable households.

FORMING OF THE BENEFIT ASSESSMENT MODEL OF CLIMATE CHANGE MITIGATION MEASURES IN HOUSEHOLDS

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Abstract

Climate change is one of the most important ecological problems with enormous negative consequences for all populations of the world and the economic development of countries. Households emit about 70% of all greenhouse gases due to energy consumption, but the possible contribution and position of households in climate policy is not well understood, and current climate change mitigation measures are not focused on households. To achieve the objectives of sustainable energy use, it is very important to understand the preferences and their behaviour of energy consumption and saving, the use of renewable energy resources and mitigation of climate change. Scientists are increasingly emphasizing the significance of all stakeholders' preferences when determining the effectiveness of different policies intended to attain goals. Therefore, in this study, based on the analysis of the scientific literature and empirical studies, a model was created for estimating the benefits of climate change mitigation measures related to households' energy consumption. Economic assessment is the basis for justifying and promoting climate change mitigation measures and for developing effective policies. However, although economic factors are used as the main factors, quantitative modelling of households is also important and necessary for choosing the most effective energy efficiency policies.

The created model allows to evaluate climate change mitigation measures based on the preferences of different stakeholders – residents and energy experts (who are proposed to be divided into three categories: scientists, policy makers and energy suppliers/producers) according to three indicators – economic efficiency, effectiveness, and efficacy. The model uses willingness-to-pay (WTP) methods, the Delphi technique and, finally, multi-criteria evaluation methods to identify stakeholder preferences and assess the benefits of climate change mitigation measures.

1.4. ENERGY EFFICIENCY, RELIABILITY AND SECURITY

PASSIVE HOUSE IN LITHUANIA: LONG-TERM MONITORING RESULTS ANALYSIS

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Abstract

The Passive House (PH) algorithm, developed in Germany, is the world's leading standard for energy-efficient construction and is the basis for the design of Passive Houses. The Passive House Planning Package (PHPP) models and certifies them. According to the Lithuanian national certification system, Passive Houses certified in Lithuania are A+ or A++. In Lithuania, NRG Pro is used for the design process, and NRG-sert is used for the energy performance assessment of the designed building and the certification of the constructed house. This study focuses on the data collected since 2015 on ambient air and indoor temperature changes, measured by the weather station, monitoring of ventilation, heating, and hot water energy consumption, measured by electricity meters, for the first single-family residential building in Lithuania, built in Vilnius and certified by the German Passive House Institute. A comparison is also made between the actual performance of the building and the results obtained by the modelling software PHPP and NRG-sert. The study shows that a building certified to the PN standard has excellent long-term performance, which is close to the results predicted by the PHPP certification.

In contrast, the data reported in the national certification differs from the monitoring results obtained sometimes. One reason could be that the PHPP algorithms are continuously improved and are based on active monitoring and analysis of monitoring data since 1990. In Lithuania, NRG-pro and NRG-sert are updated only to comply with legal requirements. To date, no building has been formally tested to confirm that its calculations correspond to the actual energy performance of buildings. Passive Houses, which started to be built in Lithuania more than ten years ago, are still keeping pace with, and often significantly outperforming, most of the houses built in the country today in terms of energy efficiency and comfort. It is necessary to establish the consistency of the modelling and certification programs used in the national certification system with actual performance. To this end, it is necessary to start audited long-term monitoring of buildings of different energy performance classes and for different purposes, to establish the relevance of the modelling and certification tools used in the national certification system to the actual performance, and to improve these tools continuously.

POTENTIAL OF AN ARTIFICIAL INTELLIGENCE APPLICATION IN BUILDINGS SECTOR: A SYSTEMATIC LITERATURE REVIEW

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Abstract

Artificial intelligence (AI) is a rapidly growing field that has the potential to transform many industries, including the building sector. AI applications can improve the energy efficiency and sustainability of buildings, enhance occupant comfort and safety, and optimize maintenance and operations. This study explores the potential of AI applications in the building sector and discusses some of the challenges and opportunities associated with their implementation. The study also highlights some of the current and emerging AI technologies and their potential applications in the building sector, including building automation systems, energy management systems, predictive maintenance, and occupant behaviour modelling. The study concludes that AI has the potential to significantly improve the performance and value of buildings.

PROBABILISTIC SENSITIVITY ANALYSIS OF ELECTROCHEMICAL MODEL RESULTS FOR BATTERY SIMULATION

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Abstract

Lithium-ion batteries are vastly employed for energy storage applications in electric vehicles, electronics, appliances, and other systems. They are favoured for features such as high energy density, high power density, and long-life cycling. However, safety, durability, and cost concerns impose limitations on their wider applications. A battery management system (BMS) is essential for monitoring appropriate levels of safety, performance, charge rates, and longevity. Measurements used by the BMS can be applied to calculate key quality indicators of a battery: State of Charge (SOC) and State of Health (SOH). Various models are also employed for offline calculations, such as data-driven estimations utilising machine learning and electrochemical models simulating processes within the cells of lithium-ion batteries. Here we consider the Single Particle+ (SP+) electrochemical model.

The SP+ model includes geometrical, material, and other basic design parameters of the battery. In total, 15 parameters must be identified for accurate estimation of battery quality indicators. Mainly, the SOC-OCV (open current voltage) relationship, representing the electrochemical processes and thermodynamics at various SOCs, is evaluated. As the estimation or testing of each parameter entails varying time and cost resources, probabilistic sensitivity analysis (SA) was used to prioritize identification (estimation) efforts. SA reflects how uncertain parameters impact the uncertainty of the result of a model. Using SimLab software, random samples of parameters are generated based on their distributions and ranges found in several articles that explore modelling of $LiFePO_4$ batteries. Model results are analysed for each parameter to determine these sensitivity indices: Pearson, Spearman, partial and rank correlation coefficients, standardised regression coefficients, FAST, and Smirnov indices. Probabilistic SA measures then rank model parameters by importance and help to prioritize their identification which efficiently leads to more accurate model results.

WASTE HEAT RECOVERY FROM FLUE GAS USING A COILED-TUBE HEAT EXCHANGER

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Abstract

Many countries anticipate shortages of energy and water, which will become increasable more noticeable in the upcoming years. To address this issue, renewable and alternative fuel sources must be utilised to boost efficiency of energy production or optimize old energy systems. Consequently, there is a growing interest in recovering waste heat and water from exhaust flue gas in thermal power and boiler plants using condensing heat exchangers. However, their performance has not yet been thoroughly studied due to the complexity of the condensation processes.

Researchers' studies on condensation heat transfer have primarily focused on single vertical tubes in parallel flow and horizontal tube bundles in a crossflow, leaving a knowledge gap in how to optimize the operation of condensing vertical tube-equipped heat exchangers in the flue gas environment. At the Lithuanian Energy Institute, researchers have conducted experimental investigations on water vapor condensation with non-condensable gas processes in a coiled-tube counter-current type condensing heat exchanger with vertical tube bundles arranged in-line.

During the experiments, various parameters, such as flue gas temperature, velocity, composition as well as cooling water flow rate and inlet temperature, were varied to analyse their impact on the condensation process. The studies were conducted with cooling water flowing in both open and closed loops. The findings indicated that the temperatures of the flue gases and cooling water as well as the total Nusselt number fluctuation along the test section, were comparable in both case studies. The research discovered that changes in the Reynolds number had a relatively minor effect on the overall Nu number, particularly when the water vapor mass fraction was lower in both scenarios. However, at higher flue gas Reynolds numbers, an increase in water vapor mass fraction caused Nu to grow by approximately 2.8 times in a closed loop and 2 times in an open loop for comparable parameters.

CONDENSATION OF WATER VAPOR IN A HUMID AIR FLOW

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Abstract

When maximising production in industry the use of waste heat generated is very important following the circular economy approach, as it is an important efficiency measure. Such goal is foreseen in EU Horizon 2020 iWAYS project (Innovative WAter recoverY Solutions through recycling of heat, materials, and water across multiple sectors), which deals with waste resources appearing in industry such as waste heat, water, and materials. The use of such waste resources would lead industrial companies to the overall reduction of resources consumption and increase of energy efficiency. Authors of this study are involved in iWAYS project activities and data presented are closely related with project activities. In this study the experimental investigations on condensing heat exchanger were performed to better understand fluid behaviour and optimize condensation efficiency. It was investigated the effect of different inlet temperatures on the condensation efficiency.

It was found that the condensation efficiency increases with decreasing inlet temperature, which is consistent with previous studies. Additionally, the Nusselt number, which is a measure of the heat transfer rate, also increases with decreasing inlet temperature. These findings suggest that optimizing the inlet temperature can help to improve the performance of condensing heat exchangers for waste heat recovery.

A REVIEW OF REMOTE METHODS FOR DETECTION OF SMART METERS READINGS ANOMALIES

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Abstract

Installation of Smart Meters (SM) and their connection to Advanced Metering Infrastructure (AMI), enables energy suppliers to monitor network loads and detect consumption anomalies or faults, end-users to adjust their electricity consumption patterns to reduce costs. Measurement errors, energy theft, technical and non-technical losses in the grid, and vulnerabilities in the security of the data network can lead to variations in metering data. Such anomalies have a negative impact on economic performance, on the fairness of the consumer's billing and on the loss to the supplier. The aim of this presentation is to provide an overview of techniques for continuous monitoring and anomaly detection of SM readings.

This review focuses on the causes of anomalies due to measurement errors of smart meters, thefts of electricity, losses in the grid and others. The review also covers remote error detection techniques using sum (check) meters and built-in standards in SM. Existing challenges in AMI networks such as non-uniform timing of collected data, unsynchronized SM readings, masked meter errors due to losses in grid and behind-the-meter generation are summarized. Research references and technical reports are reviewed aiming to compare various methods in respect to the method's sensitivity to network topology, amount of training data required, detection accuracy and specificity, classification ability, and specific meter generating anomalous data identification. Methodologies for validation of anomalies remote monitoring techniques and comparison criteria are discussed. It is suggested that instead or in addition to expensive massive training and testing data collection from real smart meters, the synthesised network status parameters obtained by modelling a standardised grid assuming customer power consumption profiles is an attractive alternative. The growing volume of open data made available in open repositories makes the former approach even more relevant.

1.5. FUSION ENERGY, NUCLEAR FISSION AND RADIATION PROTECTION

ANALYSIS OF THE EFFECT OF SORPTION COEFFICIENT IN CONCRETE ON RADIONUCLIDE RELEASE FROM A NEAR SURFACE REPOSITORY

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Abstract

Radioactive waste requires specific handling, storage, and disposal as it imposes a long-term hazard for human and environment. Low and intermediate level short-lived radioactive waste is usually disposed of in near-surface repositories. To minimise radionuclide migration from the repository, concrete barriers are installed. While performing safety assessment of the repository, due to high uncertainties in disposal system and its environment evolution over long time periods, various assumptions have to be made. The common approach for preliminary assessment of potential radionuclide release from the repository is to assume conservative parameter values. However, to achieve a more accurate representation of the system, the models are refined.

This study presents the modelling of the radionuclide migration through the bottom concrete barrier of the near surface repository assuming two different approaches for selection of the radionuclide sorption coefficients (Kd) in concrete. In the first case constant Kd values are used. For this case several sources of Kd values for concrete were compared and the lowest values were selected. The other model takes into account the fact that Kd is closely linked to concrete degradation and change of pH in the concrete. A fractional flux of 5 radionuclides (C-14, Cl-36, Cs-137, I-129, and Pu-239) is compared for both cases. The initial activity of each radionuclide is assumed to be 1TBq. The chemical evolution of concrete and radionuclide migration is modelled for 1E+5 years. It has been obtained that in the case when Kd values are selected based on pH evolution, for weakly sorbed long-lived radionuclides I-129 and Cl-36, the flux has been slightly lowered and delayed when compared with the constant Kd case. The highest difference (over two orders of magnitude) in maximal fluxes between the cases is observed for well sorbed radionuclides Cs-137 and C-14. Pu-239 radionuclide flux has not been impacted significantly.

VERIFICATION OF MAVRIC MODULE AGAINST MONACO MODULE WITHIN SCALE CODE AGAINST PHOTON FLUX

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Abstract

Radiation shielding analysis is important for the development of a shielding design against the harmful effects of ionizing. In this study radiation shielding analysis using SCALE code 6. 2. 4. with two modules of Monaco and MAVRIC is discussed. Monaco module is a Monte Carlo transport code for shielding applications with direct particle transport calculation. MAVRIC module is designed for deep penetration problems based on the Monaco module using an automated variance reduction method to calculate fluxes with low uncertainties. MAVRIC module performs a radiation shielding analysis in two steps including the calculation of adjoint flux as a function of position and energy using the Denovo module (3D Cartesian geometry discrete ordinates transport code) and particle transport calculations. The variance reduction method is applied through an importance map over a grid geometry for biasing during particle transport. The user is responsible for the construction of a grid for the importance map.

The aim of this study is to verify the estimated photon flux using the MAVRIC module against the Monaco module results. The verification analysis was performed for the penetration problem of 50 cm concrete with a discrete photon source. The mean values estimated by the MAVRIC module resulted in the range of the Monaco module results considering uncertainties. Therefore, it is concluded that the MAVRIC module and the constructed grid over the geometry for the importance map were verified.

This study was performed under the ICONDE project which is supported by the EAA Grant of Iceland, Lichtenstein, and Norway.

COAL-TO-NUCLEAR – THE PROCESS OF DECARBONIZATION OF THE POLISH ENERGY SECTOR USING SMR REACTORS

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Abstract

Polish energy policy aims to become carbon neutral by altering the way that basic energy sources are used. Poland must progressively stop using fossil fuels in favour of using low-emission alternatives, it is widely agreed. A method's technical viability and economic viability should be taken into account when choosing a decarbonization strategy. The modernization of coal sources toward the usage of nuclear reactors is an extremely promising direction for the decarbonization of such sources. SMRs are the nuclear reactor technology best suited for the repowering of most polish coal plants. Different generations III/IV and various technologies of SMRs are taken into account. Technical considerations, such as the power of the reactor, the temperature of the steam produced, and the characteristics of the fuel, are crucial when selecting nuclear technology. Other factors, such as nuclear safety are also significant and ought to be taken into account. All these considerations are the subject of the ongoing project called Desire Project (Plan of decarbonization of the domestic power industry through modernization with the use of nuclear reactors). The goal of the project is to evaluate energy generation systems in the context of decarbonization investments. This strategy will include general evaluation criteria. In this regard, a process's overall nuclear safety-related challenges are essential to its successful execution.

In this study, some of the mentioned issues are presented. The key aspects of the coal-to-nuclear strategy for Poland are highlighted and the methodology of the evaluation process is shown.

1.6. HYDROGEN ENERGY AND FUEL CELL TECHNOLOGIES

FROM NATURAL GAS AND BIOMETHANE TO GREEN HYDROGEN: GASEOUS FUEL TRANSITION ASSOCIATED RISKS

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Abstract

Green hydrogen is a fuel of choice for the European Union (EU) energy future, and an energy carrier, which most likely will play an important role in its emerging energy security of supply strategies. Being fully dependent on large-scale green electricity production as well as installed electrolysis capacities, green hydrogen will also be rather sensitive element of any such strategies. Thus, its versatility will unlock wide potential for energy sector integration as part of smart energy frameworks and will contribute to the EU's energy transition.

Transition from natural gas and biomethane to green hydrogen will be gradual and associated with two major categories of risks: methane rich fuel associated risks and non-methane rich fuel associated risks. The first category addresses solely the natural gas and biomethane related risks like leaks, fire, explosion, and suffocation. The second category covers green hydrogen blended with methane and biomethane related risks. The safe share of hydrogen in a blend may range up to 10% by volume, although this is a subject to ongoing debate. The main risk factors associated with high concentration of hydrogen in hydrogen-methane blends are: leaks, as hydrogen can diffuse through many materials considered impermeable to other gases, buoyancy as hydrogen rises quickly under atmospheric conditions, flammability when mixed with air, – can easily ignite or/and explode, hydrogen-induced cracking as reduction in the ductility of a metal can occur due to absorbed hydrogen (steels, iron, nickel, titanium, cobalt, and their alloys). Also, the energy content of hydrogen is about one-third of the natural gas. Thus, not only a large volume of the hydrogen-blended natural gas is needed to deliver the same amount of energy to users compared to pure natural gas but also a higher volumetric flow rate is required. Options for the latter include increasing operating pressure in a distribution system or replacing the existing pipelines with ones of larger diameter.

STRATEGIC ANALYSIS OF EXTERNAL EFFECTS ON THE THERMAL HYDROGEN PRODUCTION

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Abstract

The demand for green energy is increasing worldwide and will continue to rise during the energy transition. To meet this growing demand, it is necessary to generate energy sustainably and to transport it sustainably. The energy carrier hydrogen is seen worldwide as an important component of the future energy economy. Especially in the case of hydrogen, the question of how the hydrogen is obtained is always necessary for the evaluation of its sustainable properties. With the help of thermal hydrogen production from depleted hydrocarbon reservoirs, hydrogen can be obtained by reinjection of CO_2 as green/blue hydrogen. This method is a way to sustainably reuse the existing completions and existing facilities and infrastructure at depleted oil reservoirs as well as for the entire petroleum industry. In this study, thermal hydrogen production from oil reservoirs is subjected to a strategic analysis of external influencing factors. The Pestel scheme is applied and based on this, the individual categories are first explained and then evaluated in relation to thermal hydrogen production from oil reservoirs. Technological and economic factors as well as political factors have a strong impact on thermal hydrogen production. Whereas the external effects of social and environmental issues take a back seat. The results of the analysis are summarized with interference effects and critically discussed regarding their significance for the near and distant future. Based on that there are some data driven recommendations for the E&P-industry for applying the thermal hydrogen production form depleted oil reservoirs. All in all, thermal hydrogen production from depleted oil reservoirs is a process with big potentials for the future.

WHAT CAN WE LEARN FROM HISTORY ABOUT THE LARGE-SCALE PRODUCTION OF HYDROGEN IN METAL-WATER ELECTROLYTE REACTIONS (AND OUR ROLE IN IT TODAY)

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Abstract

It seems that we are on a brink of going all in on hydrogen and hydrogen energetics. Hydrogen (H_2) as gained a lot of traction and seems to be the new cool kid on the block. But is that really true? For the true implementation of H_2 into the current system, there are many problems to solve, such as production. Even though there are conventional methods worth investigation, there are alternatives, such as metal redox H_2 production. In this case, various metals can be used, such as aluminium and iron. In this study, we investigate what has fallen out of focus chasing the new trends to learn from history.

The first records of a gas that could be H_2 (although not known at the time) can be found in the notes of an alchemist and physician, Theophrastus Paracelsus, in 1520. He immersed iron in sulfuric acid and observed the release of a gas. Turquet De Mayerne, repeating Paracelsus's experiment in 1650 found that the gas was flammable. In 1700, Nicolas Lemery showed that the gas produced in the same reaction was explosive. Henry Cavendish used zinc metal with hydrochloric acid to isolate a gas 7–11 times lighter than air, burned in air, and formed water in 1766. He called it "inflammable air from metals". Lavoisier later named this element "hydrogen" (1783). The light gas interested balloon enthusiasts, and the first H_2 balloon with a diameter of 4 m rose into the air in France in 1783 (Prof. Jacques Charles). Later balloons with diameters up to 12 m were made, which required up to 74 kg of H_2. The H_2 was produced by reacting iron filings with sulfuric acid. Iron was already widely used at that time, and structures and objects were turned into filings for H_2 production. Aluminium was discovered only in 1825, but now much of aluminium ends up in the trash, which can be used for H_2 production. A bird's-eye view allows for a clear picture of the opportunities for implementing the results of our investigation of aluminium use for H_2 production and investigation of the byproducts in the circular economy.

ECONOMIC EVALUATION OF THE COMBINED HYDROGEN AND HEAT GENERATION BY ALKALINE ELECTROLYSIS

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Abstract

The diversification of energy sources is one of the most important strategies for the achievement of the German government's targets for the reduction of greenhouse gas emissions by 2030 and climate neutrality by 2050. This can be achieved through the 'Power to X' (Pt-X) processes, i.e., by converting electrical energy into hydrogen (H_2) and oxygen (O_2) using electrolysis. In addition to producing H_2 and O_2 gases, the electrolysis process also generates heat as a by product. The alkaline water electrolysis is one of the mainstream H_2 production methods that can operate at a certain range of pressure and temperature, 1 to 30 bar and 40°C to 90°C, respectively. A single-stage heat pump using the refrigerant R1234ze can be connected to the electrolyser stack for simultaneous heat extraction and cooling of the electrolyser stack.

This study deals with the economic evaluation based on the annuity and net present value method of the combined production of H_2 and heat using 30 MW alkaline electrolysis. The thermodynamic calculation of the single-stage heat pump shows that an output heat of 55,470 MWhth can be produced from the alkaline electrolysis waste heat of 53,500 MWhth.

The economic results show that the total annuity and net present value after 30 years of operation are 7.4 million € and 79.9 million €, respectively. Furthermore, the production costs are 4.81 €/kg for H_2 and 0.03 €/kWh for generated heat. Summing up this study, it can be derived that the waste heat from the 30 MW alkaline electrolysis can be economically used. Moreover, the higher H_2 production cost can be justified by the auxiliary system such as water treatment, H_2 purification among others that were considered in the economic evaluation.

AN OVERVIEW OF HYDROGEN APPLICATION FOR ENERGY PURPOSES IN INDUSTRY

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Abstract

"Climate neutral and circular economy" concept is one of the major goals that EU has set for 2050 to mitigate the effects of climate change. This aim is in line with Paris Agreement and has spurred many national initiatives directed to decarbonisation of economies. Hydrogen has emerged as a promising climate-neutral energy carrier able to facilitate the processes of EU energy transition. In recent years there has been an increase in interest towards green hydrogen production through the electrolysis process for large-scale implementation of renewable energy-based power plants and other industrial and transportation applications. With growing amounts of renewable energy developments in EU hydrogen is seen as one of the most promising solutions for energy storage challenges, therefore the leading countries in the energy sector are heavily investing in research of the technical obstacles for hydrogen applications and assessment of current hydrogen market, which in turn leads to the acceleration of the upscaling of hydrogen production.

The main objective of this article is to provide a comprehensive overview of various green hydrogen production, transportation and industrial application technologies and challenges. Various water electrolysis technologies including production costs along with recent developments in storage and transportation solutions are investigated, performances and limitations of electrochemical processes are presented and analysed, research trends in the field are discussed and possible solutions for performance improvements are overviewed. The study proposes a discussion of perspectives in terms of future applications and research directions.

1.7. RENEWABLE ENERGY SOURCE

COMPREHENSIVE ANALYSIS OF THE EFFECT OF RENEWABLE ENERGY ON THE STABILITY OF THE ENVIRONMENT

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Abstract

This study represents a review of the effect of renewable energy on the stability of the environment through generating clean energy with no greenhouse gas emissions and lowering some types of air pollution by using comprehensive analysis of the processes such as consumption and production. It aims to audit the research articles in addition to the aspects and opinions to scrutiny and handle the challenges. Besides, creating an extensive vision aimed at completing research development by analysing the published articles, patents, and industrial designs in this field. Furthermore, this present study aims to highlight on the efficient energy conversion systems, sources of greenhouse gas emissions as an attempt to reach an optimal solution to preserve the environment and climate through modern technologies. Renewable energy has unstable and indirect performance due to changing of the climate in the current era. The unstable characteristics lower the popularisation and use of renewable energy resources. According to the energy consumption analysis, studies of management system refer to the generation of photovoltaic power and wind power capacity data are predicted accurately by multiple models which are combined with an optimal control solution equation to manage it scientifically with high efficiency. Also, the output of generating solar energy, wind power, or photovoltaic power can be flexibly selected and applied to the maximum extent. On the other hand, the energy consumption cost is minimised. So, the utilisation efficiency of renewable energy sources by electricity will be improved and made considerable contributions to improving the capacity of green energy and keeping the environment lower polluted.

PROSUMERS AS A TOOL FOR ENERGY TRANSFORMATION: A CASE STUDY OF LITHUANIAN REMOTE SOLAR AND WIND POWER PLANTS

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Abstract

The energy sector is undergoing a transformation towards a more sustainable and decentralized system, where renewable energy sources play a key role. Prosumers, defined as consumers who also produce energy, are seen as a promising tool to accelerate this transformation in Lithuania. This research focuses on the case of Lithuanian remote solar and wind power plants, which are designed to supply energy to remote areas of the country. The study explores the potential of prosumers in this context, analysing the benefits and challenges of their participation in the energy system. The findings show that prosumers can bring significant benefits, such as reducing energy costs and increasing the reliability of the energy supply. However, challenges related to technical, regulatory, and financial aspects need to be addressed to fully unlock their potential. The research contributes to the understanding of the role of prosumers in energy transformation and provides insights for policymakers and energy stakeholders on how to promote their participation in the energy system.

THE IMPACT OF CLIMATE CHANGE AND URBANIZATION ON WIND ENERGY

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Abstract

Wind power has many advantages over traditional fossil fuels have made it a key source of renewable energy. Despite the pressing need to investigate the effects of climate change on wind energy resources, there has been a lack of comprehensive analysis conducted in Lithuania, Europe, and across the world. To address this gap in knowledge, the author of this article has collected and analysed long-term wind observation data, along with projections provided by the Intergovernmental Panel on Climate Change (IPCC). Through their research, the author has discovered that the wind speed in Lithuania is set to experience a significant decline throughout the 21st century. Specifically, it was found that the coastal region will face a decrease of up to 0.45 m/s, while the central region of Lithuania is expected to experience a reduction of up to 0.33 m/s. In the eastern parts of the country, wind speeds may decrease by up to 0.17 m/s. The decrease in wind speed is anticipated to lead to a decline in generated wind energy of 8.1%, 7.0%, and 5.7%, respectively, for the coastal, central, and eastern regions of Lithuania. But climate change is not the only factor contributing to the decline in wind speeds. Increasing urbanization and urban sprawl are also posing challenges to wind energy. The analysis shows that the combination of climate change and increasing levels of urbanization could lead to a reduction in wind speeds of 2.4 m/s in the west, 1.95 m/s in the central part of the country, and 1.2 m/s in the east by the end of the 21st century. This would amount to 42.6%, 41.9%, and 41.1% loss of wind speed, respectively. Therefore, urban expansion alone would lead to a 38.5% reduction in energy production in any region.

These findings have crucial implications for the future of wind energy production in Lithuania and underscore the importance of further research and action to mitigate the impacts of climate change and urban sprawl on renewable energy sources.

FORECASTING OF METEOROLOGICAL VARIABLES IN RENEWABLE ENERGY PRODUCTION USING ARIMA AND ANN MODELS

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Abstract

Meteorological variables such as temperature, wind speed, and cloud cover play a vital role in predicting the electricity production from renewable energy sources (RES), and their accurate forecasts are necessary for efficient electricity production planning. Wind speed forecasts are crucial for determining electricity output from wind turbines and guide decisions regarding the purchase of electricity from the grid. Electricity production in solar photovoltaic (PV) power plants depends on irradiation and temperature. Forecasts of cloud cover allow to predict when and for how long electricity will be produced by solar PVs as well as when output will be reduced. Temperature forecasts help evaluate PV module efficiency. Inaccurate meteorological forecasts can lead to significant losses in energy production.

The aim of this study is to present two developed forecasting models, namely the Autoregressive Integrated Moving Average (ARIMA) and Artificial Neural Network (ANN), and to determine the most suitable model for predicting meteorological data. Hourly meteorological data for temperature, wind speed, and cloud cover for Kaunas city in Lithuania from 2020 to 2021 were utilised. The forecast of each model was compared with actual meteorological data and official meteorologists' forecasts provided by Lithuanian Hydrometeorological Service and available at the meteo.lt API page during the period from 21/03/2021 to 01/04/2021.

The results show that the ANN model is the most suitable for predicting all three analysed variables. The temperature forecast has Root Mean Square Error (RMSE) of 2.01 and Mean Absolute Error (MAE) of 1.68, while the wind speed forecast has an error of 0.98 RMSE and 0.69 MAE. The cloud cover forecast has an error of 25.52 RMSE and 18.92 MAE. These results indicate greater accuracy compared to meteorologists' forecasts.

The findings of this study can assist energy companies, policy-makers, and researchers in improving the accuracy of meteorological phenomena forecasting, which is significant for efficient electricity production from RES planning.

SUSTAINABLE FOREST WOOD BIOMASS POTENTIAL: EMPIRICAL STUDY

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Abstract

The concerns about climate change as well as biodiversity force us to look at the use of renewable resources from a different angle. The sustainable use of biomass becomes a relevant issue due to the European Green Deal, the strategic development of the European Union's sustainable circular bioeconomy, and the climate-neutral European economic policies. Forestry sector is important part of economic, also forest plays an important role in the global carbon cycle. Therefore, the sustainable use of forest wood biomass can reduce carbon dioxide emissions. The United Nations projects that the global population will reach 11 billion by 2100 (there are currently over 8 billion people in the world), and it is predicted that biomass use will increase by about 70–80%. Such increasing of global demand for biomass, including wood biomass, may affect forest supply and use. Wood biomass will be needed in a much larger quantity than today; therefore, this biomass should be used sustainably. In the last decade, various scientific disciplines researchers have focused on the conceptualization of sustainable biomass potential, and on the assessment of this potential, however, both theoretical discourse and empirical research focus on bioenergy needs usually. This study is focused on wood biomass potential from the forest for all purposes in terms of sustainable development. The new definition of wood biomass potential in terms of sustainable development is presented, distinguishing theoretical, technical, and sustainable biomass potential and detailing its constraints. The main aim of this study was to develop the methodology of forest wood biomass potential assessment in terms of sustainable development, and empirically check this methodology, taking into account economic, social and ecological constraints.

INTEGRATION OF GREEN HYDROGEN AND BIOMETHANE TECHNOLOGIES – CHALLENGES AND PERSPECTIVES

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Abstract

One of the main tasks of the European Green Deal is the transition from fossil-based energy sources to green energy. Biomethane and green hydrogen are important sources for this transition. Biomethane is one of the most universal renewable energy sources and is already present in agriculture sector and in many cities as wastewater, food residues and solid municipal waste treatment product. Green hydrogen is one of the most promising renewable energy sources of the nearest future, yet green hydrogen production is today quite expensive and production volumes are not big. In addition, new rules set out by the European Commission for renewable hydrogen definition should be taken into account.

Positive results can be achieved by integration of green hydrogen technologies in biomethane production facilities. For example, wastewater treatment process consumes significant amounts of energy, whilst during biomethane production process significant amounts of CO_2 are being released. Hydrogen production process generates H_2 and byproducts in form of heat and oxygen. All these products can be utilised in wastewater treatment and biomethane production. Combining of both green gases production technologies can lead to significant increase of biomethane production and decrease of green hydrogen price. Thus, green hydrogen and biomethane can help to meet growing demands of transport fuels and industry needs.

This study gives the review of green hydrogen and biomethane production process integration possibilities and addresses the challenges to be solved. The overview of hydrogen and biomethane market situation in Lithuania is also presented, as this is an important issue talking about the perspectives of application of these technologies in transport and energy sectors, including future smart climate neutral cities.

THE INFLUENCE OF DAIRY RUMEN ANAEROBIC BACTERIA INOCULUM ON BIOGAS YIELD FROM GRASS BIOMASS

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Abstract

The influence of dairy rumen fluid inoculum selected for anaerobic treatment of the organic fraction of grass biomass (GB) was studied. Dairy rumen fluid was taken from the dairy farm in southwestern Lithuania. The rumen fluid was packaged in an airtight container of 15 litres and stored at 37 ± 1°C container to be protected from environmental influences until the start of the experiment. The transportation period from the collection of rumen fluid to the start of the experiment took 2 hours. Dairy rumen fluid was filtered using 0,5 mm stainless steel mesh before starting the experiment. To evaluate the influence of dairy rumen fluid inoculum BMP experiment was performed in four sets of two 500 mL glass bottles with a working volume of 800 mL at 37 ± 0,2°C. In all the sets, the same amount of grass biomass (GB) was added – 16 g. Reactor set "A" was loaded with 800 g rumen fluid (proportion 100%/0%), Reactor set "B" was loaded with 400 g rumen fluid and 400 g digestate from bioreactor that runs on bakery waste (proportion 50%/50%), Reactor set "C" was loaded with 800 g digestate directly from the same bioreactor as mentioned in Reactor "B" (proportion 0%/100%). To evaluate inoculum BMP Reactor "D" was started without any GB addition and it served as a negative control for residual methanogenic activity. All experimental sets were set as triplicate samples (set as three repeated experiments). The outcome parameters of the BMP experiment showed that the maximum volumetric biogas yield (12.17 ± 0.62 l/l) was obtained from the contents used in test B with rumen fluid and the digestate composition. The feedstock composition in the experiment "A" partially met the physiological conditions of the ruminant animal rumen.

2. PHYSICAL SCIENCES

2.1. COMBUSTION AND PLASMA PROCESSES

INFLUENCE OF THE PLASMA ASSISTANCE ON CHEMILUMINESCENCE FROM FLAMES OF ARTIFICIAL BIOGAS MIXTURE

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Abstract

Addressing the escalating global energy demand, compounded by the ongoing political scrutiny of certain fossil fuels and humanity's persistent drive toward cleaner energy solutions, has led to an increased reliance on non-fossil fuel alternatives. Despite this shift, the overarching objective of achieving globally widespread carbon-free fuel for energy applications still needs to be achieved, trapping the industry in a transitional phase. To meet fuel demands during this transitional period, one viable option is the utilization of low-calorific gases, such as biogas, with low methane concentrations in the mixture. While those mixtures are notoriously challenging to ignite or even stay non-combustible under standard conditions, they necessitate assistance to enhance or enable the combustion process. Using propagators such as non-thermal plasma helps not only with refining ignition or augmenting flame propagation speed but also increases rates of radical emissions. Such radicals as OH* and CH* are known to be significant influencers on the combustion process, as well as C_2* is an essential marker of soot generation. This investigation focus on scrutinizing the impact of plasma parameters on biogas composition with low methane content in it, explicitly examining chemiluminescence and emissions of OH*, C_2*, and CH* radicals in both plasma and flame, assessing combustibility under lean mixture conditions, and elucidating the conditions for increasing the stability of the combustion process.

PLASMA GASIFIER FOR BIOMASS AND WASTE GASIFICATION

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Abstract

Nowadays, application of plasma-assisted gasification has received attention as a novel technology for circular biomass and waste conversion to recover energy or value-added products. The use of thermal plasma may overcome limitations specific to traditional waste treatment and utilisation techniques such as esterification, anaerobic digestion, pyrolysis, incineration, and "traditional" gasification. In this study, direct current (DC) thermal arc plasma was used to gasify biomass (wood pellets) into synthesis gas under atmospheric pressure. Water vapor was used as a plasma-forming gas and a gasifying agent. The quantification of the biomass gasification system was carried out in terms of the composition of the producer gas, the tar content, the H_2/CO ratio, the carbon conversion efficiency (CCE), the energy conversion efficiency (ECE), and the specific energy requirements (SER). It was discovered that the highest efficiency of the gasification performance was achieved at the water vapor to biomass ratio of 0.97. The producer gas mainly consisted of H_2 (43.86 vol.%) and CO (30.93 vol.%). As a result, the H_2/CO ratio and lower heating value (LHV) were equal to 1.42 and 10.23 MJ/Nm^3, respectively. Nevertheless, the synthesis gas contained high tar content (13.81 g/Nm^3). The H_2 and CO yields were 48.31% and 58.13%, respectively. Meanwhile, the highest producer gas yield was 2.42 Nm^3/kg biomass. The CCE, ECE and SER were equal to 100%, 48.83% and 1.78 kWh, respectively.

Rising energy demand coupled with ongoing politicization of some types of fossil fuels and constant will of humanity to move forward in ability to make energy sector cleaner leads to increasing usage of non-fossil types of fuels. The global goal, carbon-free fuel for energy applications is still not reached and industry is now stuck in transition period. One of the possibilities to fulfil the demands in the fuel in such period could be usage of low calorific gases, e.g., biogas with low concentrations of methane in the mixture. While those compositions are known to be hardly flammable or non-flammable under normal conditions, they require some assistance for enhancing combustion process or even making it possible. One of possible solution is usage of non-thermal plasma, which is promising technology for improving processes of ignition and flame stabilisation as well as increasing flame propagation speed. This study is focused on the influence of the plasma parameters on different biogas compositions, holding in scope emissions of the OH, C_2 and CH radicals in plasma and flame, mixture combustibility under lean mixture and conditions for higher influence on the emissions of non-desirable gases like NOx as well as on flame stability.

HIGH-SPEED IMAGING OF DISPERSED PARTICLES DURING THE PLASMA SPRAYING PROCESS

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Abstract

Plasma spraying is a thermal spraying method that creates a coating of molten or partly melted material onto a surface. The material in the form of powder is injected into a high-temperature plasma flow, where it is rapidly heated and accelerated to a high velocity. Hot particles splash on the substrate surface in a moment, spread, rapidly cool, and solidify, forming a coating. Plasma spraying is very complex because it includes a variety of nonlinear interdependencies among process parameters, in-flight particle properties and coating structure. Determining in-flight particle properties is necessary to improve the process efficiency and quality of produced coatings. The research presents the results of the experimental investigation on the behaviour of dispersed particles outflowing from the atmospheric pressure plasma torch. Experimental installation was developed for operation by feeding air and hydrogen gas mixed with dispersed particles. The power of the plasma torch was in the range of 28–45 kW, the mean plasma temperature was 3000–3700 K, and the plasma flow velocity at the outlet was 900–1200 m/s. A high-speed camera and motion analysis software have been used to record and study the behaviour of aluminium oxide particles during plasma spraying. The recorded trajectories of hot particles provided direct information about the physical processes involved in plasma-particle interaction. High-speed imaging assisted in detecting moving objects, determining the spraying stream geometry, and calculating the size and velocity of sprayed particles. The information is necessary to choose the correct substrate position and achieve good coating quality.

RESEARCH OF THE TRANSFERRED ARC PLASMA TORCH OPERATION CHARACTERISTICS IN THE VOLUMETRIC REACTOR

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Abstract

The growth of the global population inevitably causes increasing consumerism and anthropogenic pollution of the environment. Therefore, attention is recently focused on reusing materials and waste-to-energy conversion. Plasma technologies can potentially convert various materials into valuable products, such as synthesis gas and environmentally friendly vitrified slag. Consequently, the transferred arc plasma (TAP) torch and volumetric reactor for this plasma torch application were newly constructed at the Plasma Processing Laboratory of the Lithuanian Energy Institute. Before using a new volumetric reactor and plasma torch for material treatment, it is important first to determine TAP torch working conditions. Thus, this research aimed to establish the optimal operating characteristics of the newly constructed TAP torch. The impact of different parameters, including the plasma torch power, voltage-current, and distance between the anode and cathode, on the plasma torch operation characteristics, were analysed. The temperature distribution in the reactor and the influence of the pressure of water used to cool the volumetric reactor on the overall operation conditions were also investigated. The performed investigation revealed optimal conditions ensuring stable operation of the TAP torch, which is essential to guarantee a smooth material conversion process.

2.2. MATERIAL SCIENCES AND TECHNOLOGIES

A PATHWAY FROM BIOMASS TO HIGH ADDED VALUE PRODUCT: CARBON QUANTUM DOTS

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Abstract

Nanomaterials have gained much significant attention due to its superior properties. Quantum dots (QDs) are among the nanomaterials that have shown promising potential with considerable advantages including high fluorescence, electrochemical, optical, and good bio-compatibility properties toward numerous applications. Recently, more research has specifically focused on producing QDs with expanding their usage potential in advanced technologies. However, most commercial QDs are semiconductor materials which contain heavy metal. In this regard, biomass is taken into account as a great source to fabricating QDs via different methods to complete with commercial ones. Crystal structures, element compositions and physical properties of CQDOTs derived from biomass are analysed by Fourier transform infrared spectroscopy (FT-IR), Ultraviolet-visible spectroscopy (UV-vis), Transmission electron microscopy (TEM), X-ray diffraction (XRD), Photoluminescence spectroscopy (PL), Nuclear magnetic resonance (NMR) spectroscopy, X-ray photoelectron spectroscopy (XPS). Optical adsorption, PL properties, functional groups, surface chemical analysis, element compositions, electronic structures of elements, oxidation states, bonding forms of carbon atoms in crystal structures, crystal, and amorphous structures of CQDs are among the main results of the analysis techniques used. The results obtained from these analyses used show that CQDOTs produced from biomass have the potential to be used in fields such as sensors, drug delivery, photocatalyst, food packaging, optoelectronics, bioimaging, electrochemical applications, etc. Therefore, biomass derived carbon quantum dots (CQDs) need to be considered as pathway to contributing circular economy and sustainable development. In this present study, environmental-friendly CQDs production method and their potential usage in varied application field, especially energy area, is evaluated. A guiding study is presented for converting biomass into high value-added products and converting it into synthetic CQDs that are widely used.

SUSTAINABLE-GREEN BIOSYNTHESIS OF SILVER NANOPARTICLES USING AQUEOUS FERMENTED *HYSSOPUS OFFICINALIS* AND *CALENDULA OFFICINALIS* EXTRACTS AND THEIR ANTIBACTERIAL AND ANTI-OXIDANT ACTIVITIES

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Abstract

Plants can produce various secondary metabolites such as flavonoids, alkaloids, glycosides, terpenoids, saponins, tannins, steroids, quinones, and coumarins. They can synthesise various chemical compounds that are important for the maintenance of biological functions, growth, reproduction, and adaptation of pigmentation to adverse environmental conditions. Many of these phytochemicals have beneficial effects on human health as well, being effective in the treatment of various diseases. Green biosynthesis among other chemical or physical methods offers simplicity in operational and process conditions as its uses exclusively plant-derived metabolites and metallic salts while omitting the use of toxic reagents, catalysts, and solvents.

Silver nanoparticles (AgNPs) biosynthesised using aqueous medical plant extracts as reducing and cap-ping agents show multiple applicability for bacterial problems. Aim of this study is to expand the boundaries on AgNPs using novel low toxicity and production cost phytochemical method for the biosynthesis of nanoparticles from *Calendula offcinalis* and *Hyssopus officinalis* aqueous extracts. AgNPs were characterised by various methods (TEM, SEM, and EDS). Determined antimicrobial and antioxidative antimicrobial activity of medical plant extracts was compared with activity of the obtained green AgNPs. TEM results show mainly spherical shaped AgNPs. The size distribution depends on the medical plant extract type. The smaller AgNPs were obtained with *H. officinalis* extract (with size range of 17.5 ± 5.89 nm compared to 34.3 ± 7.76 nm from *C. officinalis* AgNPs). The *in vitro* antioxidant activity clearly demonstrated that both the plant extracts and AgNPs showed prominent antioxidant properties. Besides, AgNPs show much stronger antimicrobial activity against broad spectrum of gram-negative and gram-positive bacteria strains than the plant extracts used for their synthesis.

THERMAL ANALYSIS OF MAGNESIUM HYDRIDE AND STUDY OF ITS APPLICATION POSSIBILITIES

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Abstract

Global transport is gradually moving towards electric transport options, but maritime transport still needs to find alternatives for implementing sustainability measures in a timely fashion. Long-distance shipping also faces the impracticality of all-electric options. Given the marine sector's industrial importance and its significant contribution to global pollutant emissions, there is a pressing need to explore solutions for improving the eco-efficiency of intercontinental cargo ships. In order to reduce hydrodynamic resistance, there is a possibility of altering surface properties, thus reducing the usage of fossil fuels until an alternative fuel is proposed. This research investigates the thermal properties of magnesium hydride coatings to evaluate their suitability in facilitating hydrodynamic drag reduction. The tendency of hydrides to release hydrogen during water interaction suggests a potential contribution to facilitating the Leidenfrost effect. The samples prepared through the reactive magnetron sputtering technique underwent thermal analysis using a Netzsch STA 449 F3 Jupiter analyzer, complemented by Bruker Tensor 27 FTIR spectroscope. The surface characteristics were evaluated via an X-ray diffraction examination. The results of this study provided insights into the potential applications of magnesium hydride coatings as active surface materials.

Acknowledgments.

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EFFECTS OF ANNEALING ON THE PSEUDOGAP IN SLIGHTLY DOPED $HOBA_2CU_3O_{7-\Delta}$ SINGLE CRYSTALS

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Abstract

The pseudogap (PG) state, which is realised in high-temperature superconductors (HTSCs) at the characteristic temperature T*»Tc with the doping less than optimal, is one of the most mysterious properties of HTSC cuprates. Understanding the physics of the PG would answer the question about the mechanism of superconducting pairing in HTSCs, which is also not fully clarified yet. One of the most promising materials for studying the PG is the $YBa_2Cu_3O_{7-\delta}$ (YBCO) family. The effect of annealing at room temperature on the fluctuation conductivity (FLC) $\sigma'(T)$ and pseudogap (PG) $\Delta^*(T)$ in the basal ab plane of $ReBa_2Cu_3O_{7-\delta}$ (Re = Ho) single crystals with a lack of oxygen has been studied. It is shown that at all stages of annealing, the FLC near T_c can be described by the Aslamazov-Larkin and Maki-Thompson fluctuation theories, demonstrating a 3D-2D crossover with increasing temperature. The crossover temperature T_0 was used to determine the coherence length along the c axis, $\xi_c(0) = (2.82 \pm 0.2)$ Å. At the inter-mediate stage of annealing, an anomalous increase in 2D FLC was revealed, which is associated with the influence of uncompensated magnetic moments in $HoBa_2Cu_3O_{7-\delta}$ (HoBCO): $\mu_{eff,Ho} = 9.7\mu_B$. For the quenched sample S1, the temperature dependence of the PG has a shape typical of single crystals with a large number of defects. However, $\Delta^*(T)$ has two small additional maxima at high temperature, which is a feature of HoBCO single crystals with pronounced twins and indicates the two-phase nature of the sample. Upon annealing, the shape of $\Delta^*(T)$ noticeably changes, very likely due to an increase in the magnetic interaction (sample S2). More important is the change in the slope of the data at high temperatures, which has become about 3.5 times steeper. The ordering of the oxygen distribution due to the diffusion process during annealing somewhat compensates for the influence of magnetic interaction. But the slope does not change (sample S3). Interestingly, the slope turns out to be the same as for FeAs-based superconductors, suggesting the possibility of the existence of spin density waves in HoBCO in the PG state. The comparison of the pseudogap parameter $\Delta^*(T)/\Delta^*_{max}$ near T_c with the Peters–Bauer theory revealed a slight increase in the density of local pairs $<n_\uparrow n_\downarrow>$, which should explain the observed increase in T_c by 9 K during annealing.

THERMAL PRE-TREATMENT EFFECT ON TiH_2 THERMAL DECOMPOSITION

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Abstract

Titanium hydride (TiH_2) is often used as a blowing agent in the manufacturing of metal foams. Metal foams are porous materials that possess appreciable thermal, acoustic, and electrical properties in many engineering applications. Metal foams possess high strength-to-density ratio, high stiffness, and greatly improved energy absorption. The hydrogen gas that is the result of the decomposition of TiH_2 causes the metal to foam. It is ideal when the foaming agent decomposes at a temperature slightly higher than the melting point of a metal to be foamed. However, due to its low thermal decomposition temperature of about ~450°C as compared to aluminium (melting point – 660°C), which is often used in the manufacturing of metal foams, it is difficult to achieve optimum results. Previous findings indicate that it is possible to raise the decomposition temperature up to 670°C with thermal pre-treatment at 500°C for 2 hours. In this study, researchers aim to examine the dependence of the onset temperature of decomposition on the duration of pre-treatment (for a specific sample size) using thermal programmed desorption (TPD) and the morphology of the pre-treated titanium hydride powders using X-ray diffraction (XRD) analysis.

SYNTHESIS AND CHARACTERISATION OF MNO_2 CATHODE MATERIAL

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Abstract

The demand for rechargeable lithium-ion batteries is increasing in the battery market, and the potential competitor, Zn-MnO_2 battery technology, has not been able to dominate the market due to its cathode material's low cyclic stability and low potential. To address this, nanoparticles and different element doping have been investigated to enhance the properties of the MnO_2 cathode material.

In this study, MnO_2 was synthesised at 120°C for 12 hours using $KMnO_4$ and $MnSO_4$ and doping with $Na_2MoO_4 \cdot 2H_2O$ was conducted at different concentrations. The resulting product was mixed with CB and PVDF to create an ink material for cathode preparation. X-ray diffraction (XRD) and SEM were utilised for phase composition and morphology determination, and a galvanostat was utilised to determine CV and OCP. The synthesised product exhibited a flower-like petal structure with a size less than 1 µm. XRD analysis showed that the synthesised product is composed of manganese oxide. The transformation from needles to flower-like occurred as the concentration of the doping agent increased, but when the concentration exceeded 5 mol% structure became amorphous. Flower-like nanoparticles demonstrated an increase in cyclic stability when MnO_2 was doped with Mo. In conclusion, nanoparticles and element doping were examined to enhance the properties of the MnO_2 cathode material, which could potentially rival rechargeable lithium-ion batteries in the market.

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EVALUATION OF THE EFFECTS OF THE DEMINERALISATION PHASE ON THE EXTRACTION OF CHITOSAN FROM SHRIMP SHELLS

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Abstract

Nowadays, chitosan production from shrimp shells waste is one of the most preferred industrial options to convert shrimp aquaculture waste with low economic value into economic wealth, which supports the circular economy principles and EU Green Deal targets. Shrimp shells have been shown to contain some minerals such as magnesium, calcium, and phosphorus, which might have a significant impact on chitosan extraction. Demineralisation is the initial phase of chitosan extraction from shrimp shells. The current research aimed to evaluate the influence of various acidic demineralisation concentrations on chitosan characteristics under stabilised conditions of deproteinization and deacetylation stages at room temperature. Shrimp shells waste were collected from a shrimp farm in Lithuania. Inductively coupled plasma mass spectrometry (ICP-MS) has been used to analyse the mineral content of shrimp shells. FT-IR spectroscopic analysis has been conducted to ensure chitosan formation under (1%, 2%, 3%, 4%, and 10%) HCl concentrations of demineralisation followed by 4% and 50% of alkaline deproteinization and deacetylation, respectively. The percentage of yield, moisture content, and ash content of the extracted chitosan were determined. The results showed that the most abundant mineral found in the shrimp shells was calcium with a content of 6.8%. The formation of chitosan was verified through FT-IR analysis, which was conducted under varying acidic concentrations and stabilised conditions of deproteinization and deacetylation with commercial chitosan as a reference. According to the findings, the chitosan derived from 2% HCl demineralisation exhibited the highest degree of resemblance to commercial chitosan. Additionally, the research indicated that a lower concentration of acidic demineralisation is more likely to result in a higher yield of chitosan.

INVESTIGATION OF THE INFLUENCE OF LASER PULSE ENERGY ON THE STABILITY OF GOLD, SILVER AND HYBRID NANOPARTICLES IN AQUEOUS SOLUTION USING THIN FILM AND BULK TARGET METHODS

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Abstract

Gold and silver nanoparticles have broad absorption bands in the electromagnetic spectrum and a localized surface plasmon resonance effect that determine their optical characteristics. Combining gold and silver into a single material can lead to new applications in biomedicine, sensors, catalysts, surface-enhanced Raman scattering, and components for optical and electronic devices. Laser ablation is well suited for surfactant-free generation of hybrid nanoparticles due to the purity of the nanoparticles and the homogeneous distribution of elements in the hybrid particle. However, colloidal solutions face the problem of long-term stability which limits their applicability. Therefore, the focus of this study is on stability, affected by the different laser pulse energies. Hybrid Au-Ag targets (100 nm) were produced by thin film evaporation. This method was used to analyse how hybrid nanoparticles are affected when made from films with different metal ratios and their order. Nanoparticles were generated in deionized water without any stabilising additives. An identical production process was carried out with bulk targets. The characteristics of the colloidal solutions were compared using a spectrophotometer, transmission electron microscopy (TEM) images, photographs, and spectra measurements over a period of 5 weeks. The results showed that the thin film approach compared favourably with solutions obtained from a bulk target: It produced more stable colloidal solutions, with nanoparticles of smaller size and dispersion. In addition, the best meta l layer ratio and laser pulse energy to achieve long term colloidal stability have been identified.

FEMTOSECOND LASER-INDUCED FORMATION OF WAVELENGTH-DEPENDENT PERIODIC GOLD NANOSTRUCTURES

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Abstract

Femtosecond laser single-pulse processing of highly elastic metals enables the fabrication of complex nanostructures on the surface of the thin film. The delamination and hydrodynamic behaviour of the heated or molten material upon the focused pulse exposure leads to the formation of several morphological shapes – bumps, cones, and jets. The morphology of the imprinted structures obtained using the direct laser writing method is mostly governed by the ultrashort pulse energy and the laser spot size as well as the used laser wavelength. The aim of this research was to investigate the dependence of the formation process and the structure dimensions on the laser wavelength (1030, 515, and 343 nm) by changing laser harmonics. The bumps and cones are obtained of quite similar shapes with all three harmonics, while the most prominent difference can be observed in the jets. The ones fabricated using infrared radiation are with non-protruded spikes, unlike the ones made with the remaining wavelengths. Furthermore, the higher absorption of the shorter wavelengths determines the lower required fabrication fluence and enables the formation of smaller-sized structures. The periodic arrangement of such nanostructures capacitates the excitation of plasmonic surface lattice resonance, thus the achievable minimal period amidst the structures was also investigated. The use of shorter wavelengths not only decreases the inter-structural distance in the grating but also slightly increases the quality of the excited plasmon resonance.

EFFECT OF MOLYBDENUM DOPING ON THE STRUCTURE AND PROPERTIES OF DIAMOND-LIKE CARBON FILMS

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Abstract

Nowadays it's essential to improve the properties of diamond-like carbon (DLC) films in wide application domains such as biological implants, automotive industry production, micro/nano-electromechanical systems (MEMS/NEMS), magnetic storage devices, solid-state batteries and so on. Thus, various metal dopants such as Ag, Ti, Ni, Cr, Ag, Mo, etc. are used to deposit metal doped DLC films.

The molybdenum (Mo) doped amorphous DLC thin films (Mo-DLC) were deposited on Si (100) substrates by magnetron sputtering. The graphite and the Mo cathode currents were fixed at 1.0 A and 0.25 A, respectively. The deposition duration was 10 min. The Mo content in the coatings was regulated by adjusting a slit wide in a shield mounted above the Mo target. The influence of the deposition temperature was investigated by changing the distance between the substrate and cathodes. It was obtained that the concentration of Mo in DLC films varied from ~1 at.% to ~6.5 at.% depending on the synthesis conditions. The increase of the Mo content and decrease of the deposition temperature led to a slight increase in the oxygen amount in DLC films. The sp3 C-C bond fraction decreased with increase of the Mo content due to the metal catalyst effect as obtained, which effectively promoted the graphitisation and slight oxidation. The Raman spectroscopy results that the sp2 carbon bond fraction increased with the increase of Mo concentration in DLC films. The microhardness measurement indicated that the addition of low amount of Mo increased the hardness of DLC films. The atomic force microscopy (AFM) (multimode 8 Bruker) was used to reveal the surface morphology and nano-tribological properties. The AFM results demonstrated that the surface roughness was reduced with the addition of low amount of Mo. The lowest friction coefficient was obtained when the Mo content in doped DLC film was ~2.5 at.%. Meanwhile, the un-doped DLC film has the highest friction coefficient.

GAS-SENSING PROPERTIES OF LIGHT-ACTIVATED, V DOPED TIO2

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Abstract

This project aims to address the limitations of the metal oxide-based gas sensors. Traditional gas sensors, which implement metal oxides in their design, only work effectively at elevated temperatures, typically between 175 to 500°C. Such activation requirements not only create a dangerous working environment, but also limit the applicability for flammable gas detection and impose regular upkeep and energy tolls. To overcome these restrictions, the project proposes an alternative approach where the metal oxide is activated using light, with the energy that can surpass the metal oxide's band gap. The semiconductor which we use to achieve this goal is vanadium doped TiO_2. Even though the base TiO_2 showed good response magnitude to volatile organic compounds, it still has several undesirable shortcomings in its photocatalytic activation. To deal with those issues, the TiO_2 doped with vanadium cations is implemented, with the expectation that the procedure should enhance the photoactivating performance and shorten its band gap.

The doping is conducted in the inert atmosphere, then the v-TiO_2 is dispersed in the butanol and thin film of the particles is prepared over the golden electrodes for the following gas-sensing measurements. The response of the v-TiO_2 samples is evaluated in the synthetic air both under the UV and simulated light using different amounts of volatile organic compounds. Several different vanadium percentages were synthesised and compared between each other. The Raman spectroscopy and X-ray diffraction (XRD) was performed to analyse the crystalline structure of the samples in their powder form. Also, XPS and diffuse reflectance spectroscopy (DRS) was performed as well, to analyse the chemical composition and the optical band gap in the same way. In addition, the thickness of the thin film is studied using scanning electrons microscopy.

2.3. THERMAL PHYSICS, FLUID MECHANICS AND METROLOGY

COMPARISON OF 1D, 2D AND 3D CFD MODELS FOR OPEN CHANNEL CAPACITY ASSESSMENT

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Abstract

In recent years, computational fluid dynamics (CFD) has been increasingly used in hydraulic engineering. However, despite its popularity, the computational complexity associated with modelling large-scale 3D problems remains one of the most significant challenges of CFD. Therefore, various simplifications are often required to make the modelling process feasible. In this study, different numerical analysis approaches, including 1D, 2D, and 3D models, are examined to assess the capacity of the existing tailwater channel of the Křimov dam (Czech Republic) for design flood discharge. The usefulness and effectiveness of numerical models in reducing the costs associated with modifying channels are demonstrated by the results of our study. Additionally, the results of the different modelling approaches are compared, and their applicability is evaluated. The importance of careful consideration when selecting modelling approaches for hydraulic engineering projects is highlighted by our findings. Ultimately, this research can help to improve decision-making processes and increase the efficiency and cost-effectiveness of hydraulic engineering projects.

Comparison of the 1D, 2D, and 3D modelling results performed in HEC RAS and Ansys for the Křimov trapezoidal channel showed similar results in terms of quality (the models showed an increase and decrease in the water surface level in the same places) and a slight difference in the numerical values of depth and velocity. However, the 3D model takes into account the curvature of channel and gives trustworthy results. Thus, with complex channel geometry, 1D and 2D models cannot take into account all the features and give approximate results, while the 3D model shows more accurate results.

MODELLING OF PIPE WHIP PHENOMENON INDUCED BY FAST TRANSIENTS BASED ON FLUID STRUCTURE INTERACTION METHOD USING A COUPLED 1D/3D MODELLING APPROACH

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Abstract

A sudden spike in the operating pressure of the pipelines in nuclear power plants (NPPs) can be attributed to the phenomenon of water hammer which tends to develop a pipe whipping effect causing severe damage to the pipe and the surroundings. The mechanical response of these pipelines under the influence of such fast fluid transients can be estimated using the fluid structure interaction (FSI) method. The computational time and expense are predominantly dependent on the number of finite elements developed in the model. Hence, an effective modelling technique with limited and efficient nodes and elements is desired to obtain the closest possible results.

A coupled 1D/3D finite element modelling approach using FSI method is proposed to determine the influence of fast transients on the mechanical pipe whipping behaviour of gas pipelines in NPPs. The geometric-coupled modelling approach utilises the presence of both the 3D solid elements and the 1D beam elements sharing a local conjunction. The Aquitaine pipe is modelled using a coupled 1D/3D approach with beam and solid elements using one-way FSI incorporating the Fluent and the Transient Structural module in ANSYS. The computational model is modelled for a pipe to wall impact test scenario taken from the previously conducted French Commissariat a l'Energie Atomique (CEA) pipe whip experiments.

The results of displacement, stresses and impact velocity at the 3D section featuring the elbow is compared for the change in the solid length at the juncture of the elbow. The computed results from the Ansys FSI coupling method using Fluent and Transient Structural modules provides fair validation with the previously conducted experimental results and correlates with the CEA pipe whip tests on pipe to wall impact models.

3. ENVIRONMENTAL SCIENCES

3.1. FOOD SCIENCES AND TECHNOLOGIES

FRUITS AND VEGETABLES BY-PRODUCTS MAY BE A PART OF SUBSTRATES OF EDIBLE MUSHROOMS CULTIVATION?

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Abstract

Agricultural wastes including processed fruits and vegetables by-products are a good source for growing mushrooms (Kamthan and Tiwari, 2017). Most agricultural residues are rich in lignocellulosic compounds whose handling and disposal are often problematic, due to their chemical structure and decomposition properties. Some of them are most used such as wheat straw, paddy straw, rice straw, rice bran, molasses, coffee straw, banana leaves, tea leaves, cotton straw, sawdust, etc. There is also known that banana leaves and tea leaves are used for cultivation of Volvallella and Pleurotus mushrooms (Sturion, 1994). Among the *Pleurotus* spp. (*P.*), *P. sajor-caju* had been widely studied for the cultivation followed by *P. ostreatus*. These studies mainly concentrated on the cultivation on wastes of forest and agricultural plants and focused on the higher yield and quality of fruiting bodies of *Pleurotus* spp. concerning cultivation times. For high yield in mushroom cultivation of its fruiting bodies, all nutrient requirements must be met at optimum concentrations. Various studies have shown that yield is low when nutrients are present in a medium at either low or high concentrations. Banana stalk and Bahia grass were used for the cultivation of *P. sajor-caju* with biological efficiency of 74.4% and 74.1%, respectively. There is a low yield achieved when they were supplemented with other components. This may be due to the high nitrogen concentration which hinders the yield (Thongklang and Luangharn, 2016). These examples show that it is a new direction for different kinds of edible mushroom cultivation on fruits and vegetables and its by-products as well as other agro-wastes such as wheat, paddy, or rice straws consisting of substrates. The cultivation of edible mushrooms offers the opportunity to utilise renewable resources in the production of edible, protein-rich food that will sustain food security for people in the future.

BIOCHEMICAL PROFILING OF RASPBERRY PLANT PARTS

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Abstract

Raspberries are among the most popular berries in the world, which are consumed as fresh fruits and processed into various products. Raspberries are well recognized for their health-promoting antioxidant substances which are mainly represented by vitamin C and various polyphenolic compounds. The study revealed that raspberry plant parts represent a potential source of natural food ingredients and can be considered as a potential raw material to receiving products rich in polyphenols or dietary fibre, which can provide healthy properties to food when used as an additive that may be economically attractive for consumers.

The aim of this research was to collect data on biochemical composition of different parts of the raspberry variety 'Polka' different morphological parts and to present potential of usage for primary processing in various fields of food industry.

Phenolic compounds in raspberry berries, leaves, stems, flowers, and roots were determined during the study. Determination of phenolic compounds by the high-performance liquid chromatography method. The data provided by the study confirm the need to properly optimize the processing of raspberries by exploiting all parts of the plant according to its chemical strengths, to strengthen the marketing of the products sold as labelling, consumer information and presentation of the actual composition of the product. The major phenolic compounds found in raspberry fruits are kaempferol-3-O-glucuromide and epigallocatechin, whereas procyanidin A1 and the quercetin are phenolic constituents of these berries.

EXTRACTION OF LIPOPHILIC COMPONENTS FROM CHOKEBERRY (*ARONIA MELANOCARPA*) POMACE WITH SUPERCRITICAL CO_2

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Abstract

Black chokeberries have a strong mouth-drying effect. Mainly they are used to make jams, juices, purées, jellies, syrups, teas, or wines. Pressing juices generates a large amount of pomace, which usually is discarded or used very inefficiently. For this reason, is very urgent to find a way how to recover high-added value bioactives. It is well known that chokeberries are a good source of lipophilic compounds such as fatty acids, triacylglycerols, tocopherols, etc. The aim of this study was to evaluate the possibilities of fractionation of the chokeberry pomace lipophilic fraction during supercritical fluid extraction with carbon dioxide (SFE-CO_2) with or without co-solvent ethanol (5%) in two post-extraction separators by changing the temperature in the range of subcritical CO_2 level at constant pressure and to characterise the composition of the obtained fractions. SFE with pure CO_2 gave a 14% lower yield, while the addition of 5% co-solvent EtOH increased the yield. The antioxidant capacity of extracts and fractions was measured by using an L-ORAC assay which measures the peroxyl radical scavenging capacity of antioxidants that may donate a hydrogen atom. First, it may be noted that the ORAC values of lipophilic extracts obtained in the first separator by pure supercritical CO_2 and 5% co-solvent EtOH were 2 folds higher than those of extracts obtained by supercritical CO_2. Highly unsaturated TAGs were majorly found in the extracts and fractions. Four tocopherols and 4 phytosterols were preliminarily quantified by their peak areas in the extracts and fractions. It might be concluded that, by modifying the supercritical extraction solvent and changing the parameters of the system separators, it is possible to produce fractions of lipophilic substances of various compositions.

THE EFFECT OF THE TALL OAT GRASS (*ARRHENATHERUM ELATIUS*) INCLUSION ON THE QUALITY OF PERENNIAL LEGUME SILAGE DURING AEROBIC EXPOSURE

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Abstract

The production of sufficient amounts of high-quality forage is prerequisite for the intensification of livestock production. Tall oat grass is a typical hay-meadow grass that is also well-suitable for forage mixtures, it requires low-intensity management and has a high nutritive value. *Arrhenatherum elatius* is highly resistant to disease and insects, easily established and adapted to excessively drained low fertility soils, and compatible with legumes. To evaluate the quality of the inclusion of tall oat grass on the fermentation and quality of perennial and perennial – legume silage, the fresh forage was ensiled in triplicate in three treatments (100% tall oat grass, 70% tall oat grass – 30% clovers and 80% clovers – 20% tall oat grass). Fresh biomass was ensiled at approximately 1 kg in polyethylene bags and sealed using a vacuum packing machine for 90 days before initial opening and kept in a lying position in ambient temperatures (20–22°C) in darkness. Aerobic exposure lasted for 28 days. Samples were taken on the day of opening and on the 3rd, 7th, 14th, and 28th days. Near infrared spectroscopy (NIRS) calibration equations were used for the prediction of qualitative indicators, including organic acids. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) concentrations slightly increased with time of aerobic exposure in 100% tall oat grass treatment from 697 to 784.4 g kg^{-1} and from 421.9 to 473.9 g kg^{-1}, respectively, while crude protein (CP) decreased from 61.2 to 27.6 g kg^{-1}. pH increased from 5.35 on the day of the opening to 6.4 on the day 28. Mixtures with clover showed better results with NDF, ADF and CP concentrations remaining stable in both treatments and pH showing no increase.

GREEN TEA, HONEY, BLACK CHOCOLATE AS ANTIMICROBIAL AGENTS FOR PREVENTION OF DENTAL CARIES

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Abstract

The World Health Organization emphasizes oral health, examines the impact of risk factors on the overall health of the body and quality of life. The prevalence pattern and severity of dental caries varies with geographical location, age, sex, economic status, food practice, and oral hygiene. Different microorganisms are responsible for causing dental caries. Obligately and facultatively anaerobic bacteria dominate the microbial community of dental caries and the most important agent of dental caries are Gram positive cocci *Streptococcus mutans* and *Streptococcus sobrinus*. Associated with caries also are Gram positive rods *Lactobacillus fermentum*, *Lactobacillus acidophillus*, *Actinomyces odotolyticus, Actinomyces israelii*, Gram negative cocci – *Veillonella parvula, Nesseria* spp., Gram negative rods – *Bacteriodes denticola*, *Escherishia coli*. Dental caries takes place when a tooth surface is colonised with microbes and food of sucrose or refined sugar. Fermentation of carbohydrates leads to the production of lactic acid by the action of bacteria which melts the hydroxyapatite crystal structure of the tooth which grounds caries. The aim of this study was to evaluate the antibacterial activity of green tea, honey, and black chocolate on different microorganisms. Assays of antibacterial activity were screened for their antibacterial activity, according to the agar well-diffusion method proposed by the Clinical and Laboratory Standards Institute. The following green tea, honey, and black chocolate concentrations of 5–100% v/v were prepared in a sterile solution and evaluated at minimum inhibitory concentration against the bacterial strains. All products have antibacterial activity depending on the concentration. Results demonstrated that 45% ethanolic green tea extract had a 23–37 mm zone of inhibition against the most important agent of dental caries – microorganisms.

EXTRACTION OF POLYPHENOLS FROM BLACK CURRANT (*RIBES NIGRUM* L.) BY-PRODUCTS WITH RAPID SOLID-LIQUID DYNAMIC EXTRACTION METHOD

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Abstract

Consumption of black currant (*Ribes nigrum*) has been related to many health benefits like improved cardiovascular health by inflammation reduction and improved blood flow; improved immune function, reduced age-related cognitive decline. These health benefits are partially a result of the phenolic compounds accumulated within these berries, such as flavonoids – anthocyanins, proanthocyanidins and flavonols, various phenolic acids. The aim of this study is to analyse the possibility to extract polyphenols soluble in water from processed black currant residues with rapid solid-liquid dynamic extraction method (RSLDE). The water-soluble phenolic compounds from different residue samples were extracted by using cyclically pressurised extraction also known as RSLDE. In this experiment black currant pomace was ground and separated to different fractions (particle size 1–3 and >3 mm). Distilled water was used as the solvent. Total phenolic content (TPC) was determined spectrophotometrically by using the Folin-Ciocalteu method ant the main anthocyanins was determined with high-performance liquid chromatography (HPLC). HPLC analysis revealed that delphinidin-3-O-glucoside, delphinidin-3-O-rutinoside, cyanidin-3-O-glucoside, and cyanidin-3-O-rutinoside were the major anthocyanins and constituted the main phenol class (approximately 90%) in both types of black currant tested residues. The highest TPC concentration was determined in >3 mm residue fraction. The extraction time up to 4 hours increases TPC concentration output up to 11%. Overall, this study demonstrates the improved efficiency of RSLDE over conventional solid–liquid extraction to recover fractions with a higher yield and enhanced functional properties in a fast and sustainable manner.

FERMENTATION IMPACT ON BIOCHEMICAL AND FUNCTIONAL PROPERTIES OF SEA BUCKTHORN (*HIPPOPHAE RHAMNOIDES* L.) LEAVES

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Abstract

Tibetan kefir grains (TKB) and the symbiotic culture *Medusomyces gisevii* (MG) are different ancient starter cultures used for lactic and acid fermentation processes. Both of them significantly impact bioactive compounds from plant materials. Generally, the lactic and/or acetic fermentation of plants enlarge bioactive compounds, and antioxidant activity, which has positive health benefits. Also, it has a significant impact on plants' colour changes. Sea buckthorn (*Hippophae rhamnoides* L.) belongs to the Elaeagnaceae family, widely spread in various locations in Europe and Asia. Sea buckthorn leaves (SBL) distinguish multiple pharmacological activities such as anti-inflammatory, immunomodulatory, cardioprotective, and adaptogenic. The aim of this study is to compare lactic and acetic acid fermentation impact, using TKG and a symbiotic culture of MG with SBL, respectively. Fresh leaves were mixed with symbiotic cultures in a ratio of 1:10 and fermented at 25°C for 48 hours. Afterwards, the total phenolic content was performed using the Folin-Ciocalteu's method, and antioxidant properties were tested using $DPPH^{\bullet}$ scavenging capacity and $ABTS^{\bullet+}$ radical cation assays for fermented samples. Besides, the colour of fermented SBL was measured by using CIEL*a*b coordinates. Results of fermented SBL colour changes indicated that both symbiotic cultures have a significant impact. Also, results of antioxidant activity show great potential for $ABTS^{\bullet+}$ in TKG fermented extract (22.1 µmol/TE mL) and MG fermented extract (18.5 µmol/TE mL) and for $DPPH^{\bullet}$ in TKG fermented extract (18.4 µmol/TE mL) and in MG fermented extract (14.1 µmol/TE mL). Fermented SBL shows significant bioactivity, which can be convenient for developing value-added functional food with potential nutraceutical properties.

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GREEN SYNTHESIS, CHARACTERISATION, AND ANTIMICROBIAL ACTIVITY OF SILVER NANOPARTICLES SYNTHESISED BY *HIPPOPHAE RHAMNOIDES* PLANT BY-PRODUCTS

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Abstract

Various types of nanomaterials like gold, copper, zinc, magnesium, titanium, and silver were used for antimicrobial activity against pathogenic microorganisms. Green synthesis provides advancement over chemical and physical methods as it is cost effective, environment friendly, and there is no need to use high pressure, temperature, and toxic chemicals. It has been reported that plant metabolites such as terpenoids, phenolics, tannins, flavonoids, terpenoids, alkaloids, and polysaccharides contribute to the reduction of Ag ions to AgNPs. The novelty of studies is the secondary use of by-products from the processing of fruit and vegetables. After extraction and use of biologically active compounds, the remaining substance will be used as a raw material to produce organic NPs. Extracts of plant by-products of *Hippophae rhamnoides* (*H. rhamnoides*) are used in the study. They are ideal for reducing, stabilising, and covering the green synthesis of AgNPs. The aim of this study was to synthesise AgNPs using an aqueous extract of *H. rhamnoides*. The morphology of the synthesised AgNPs was carried out by using SEM/EDS and TEM microscopy. Antioxidant activity analysis was performed for the raw and *H. rhamnoides*/AgNPs extracts by different methods: ABTS, DPPH•, CUPRAC, and FRAP assays. The antimicrobial activity was an investigation against gram-negative and gram-positive bacteria cultures by the agar diffusion test for the evaluation of an antibacterial activity. The raw and *H. rhamnoides*/AgNPs aqua extracts contain hydroxycinnamic acid, flavonoids, and phenolic acid derivates that provide antimicrobial and antioxidant activity. *H. rhamnoides* /AgNPs particles were spherical, 10–25 nm in size. *H. rhamnoides* /AgNPs inhibit the viability of gram-positives and gram-negative bacteria strains. It is concluded that AgNPs synthesised in extracts have a broad range of biological applications and it can be used as an eco-friendly material without having negative.

MYCOTOXIN PREVALENCE IN GRAIN OF MAIZE HYBRIDS AND BARLEY CULTIVARS DURING DELAYED HARVESTING

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Abstract

Maize and barley are important feed crops whose grains are a source of many valuable nutrients, energy, and biological components such as protein, fat, carbohydrates, fibre, minerals, and vitamins. However, they are targeted by microscopic fungi that release mycotoxins as secondary metabolites. It is therefore very important to monitor their concentrations in plants to ensure optimal conditions that minimise the risk of contamination. In 2022, two spring barley cultivars 'Laureate' and 'Luokė' and two maize hybrids 'Lapriora' and 'Duxxbury', were studied. A total of 48 maize and barley grain samples were collected delaying harvest time. The first maize and barley harvest took place at ripening maturity, the second harvest was 10 days later, and the third 20 days later. The High-Performance Liquid Chromatography – Mass Spectrometry (HPLC-MS) method was used for the detection of mycotoxins.

Research has shown that mycotoxins were found to be more frequently detected in barley grain samples than in maize grain samples. Noticeably higher numbers of contaminated grain samples in barley were found for nivalenol, deoxynivalenol, HT-2, zearalenone and enniatins B, B1, A, and A1. It was also observed that the concentrations of nivalenol, enniatins B, B1, A, and A1 in barley grain samples were from 4 to 27 times higher than in maize grain samples. Zearalenone concentrations in barley and maize grain samples were not significantly different, however, 13% of maize grain samples and 13% of barley grain samples exceeded the EU Commission's recommended levels for animals. No significant differences were observed when comparing the concentrations of all mycotoxins between grains of different maize hybrids and barley cultivars. Mycotoxin concentrations did not change significantly with a delayed harvest of maize grains. However, late barley grains harvesting shows an increase in the concentrations of enniatins B1, A, and A1.

3.2. GLOBAL CHANGE AND ENVIRONMENTAL FOOTPRINT

METHODS FOR EVALUATING THE IMPACT OF SUSTAINABLE ENTREPRENEURSHIP: A SYSTEMATIC LITERATURE REVIEW

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Abstract

In recent days, issues related to environmental degradation are increasing. The "business as usual" approach contributes to more environmental issues creating a need for environmentally sustainable entrepreneurship, defined as business practices that have a low impact on the environment. Entrepreneurship is central in transitioning towards a more sustainable future, whereas aligning the ecological objectives and ecological entrepreneurs play a role. This systematic literature review analyses the field of sustainable entrepreneurship and existing environmental sustainability evaluation methods, therefore filling a gap in the existing literature. It aims to analyse the depth of existing pieces of literature on sustainable entrepreneurship, its definitions, and the existing methods of its impact on environmental sustainability. This analysis is implemented by a literature search on the SCOPUS database using keywords "Sustainable entrepreneurship" and "Environmental impact evaluation methods". The scientific software VOSviewer is used to better illustrate the linkage of major categories and correspondent trends related to environmental impact and sustainable entrepreneurship.

THE EFFECT OF *PINUS SYLVESTRIS* FOREST ON THROUGHFALL DEPOSITION

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Abstract

To gain knowledge of the atmospheric pollution impact on forest ecosystems, it is necessary to assess the atmospheric pollutant fallout (deposition) and the amount of pollutants transported to forests. Throughfall is a key process in the distribution of atmospheric pollution in forest ecosystems. In this way, airborne aerosols, gases, and particles are deposited on the forest tree layer, ground vegetation and forest floor. In many cases, the pollutants have a lasting effect on forest ecosystem biodiversity and function. Airborne pollutants are introduced into ecosystems in two major ways: wet deposition of compounds with rain and snow and dry deposition of solid particles due to gravity or adsorption onto tree canopy, understory vegetation and ground vegetation.

Under the methodology of the ICP Forests monitoring program, the samples of monthly throughfall and open field precipitation were collected and chemical analyses for major ions, such as Na^+, Cl^-, SO_4-S, K^+, Ca^{2+}, NO_3-N, and NH_4-N, were performed. For this study, a 3M ICP Forest level II monitoring plot situated in the Scots pine (*Pinus sylvestris* L.) forest was chosen. This plot is in the Kazlų Rūda forest, in Central Lithuania.

The aim of this study was to evaluate the differences and trends between the chemical compound content within throughfall and open field precipitation in the sample study plot between 2012–2022. The obtained trends will allow us to identify the periods when a specific forest ecosystem was the most polluted by environmental pollutants.

BIOACCUMULATION POTENTIAL OF HEAVY METALS IN SEWAGE SLUDGE AMENDED SOIL BY ENERGY PLANT BASKET WILLOW (*SALIX VIMINALIS* L.)

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Abstract

Sewage sludge (SS) usage in agriculture and forest plantations is growing globally. The main risks of using SS are related with heavy metals (HM) input, HM are not biodegradable and may cause different adverse effects to living organisms and environment. Bioremediation using energy plant basket willow (*Salix viminalis* L.) is a good alternative to conventional remediation methods. Bioremediation is cheaper, requires less energy and is more environmentally friendly than conventional remediation methods. This study aims to evaluate Bioaccumulation potential of HM in sewage sludge amended soil by energy plant basket. Willows plantation was established in 2005 in Trakų Vokės Branch of the Lithuanian Research Centre for Agriculture and Forestry. Plantation was twice amended with SS in the period of cultivation: 20 t/ha of SSC dry material was spread in spring of 2011; 100 t/ha in spring of 2016. Plants were harvested in 2011 and for the second time in 2020 (repeatedly). The following parameters were evaluated of cuttings made after fifteen years of cultivation (2005–2020): bioaccumulation of HM (Co, Mn, Cu, Zn) in shoots and leaves, bioconcentration (BCF) and translocation factors (TF). The results showed that willow can accumulate HM by decreasing order: Mn (concentration in shoots was 12.69 ± 1.61 mg/kg and in leaves 261.95 ± 37.33 mg/kg, respectively), Zn (17.61 ± 2.31 and 67.39 ± 3.29 mg/kg), Co (0.79 ± 0.10 and 0.93 ± 0.14 mg/kg), and Cu (0.04 ± 0.01 and 0.05 mg/kg). Despite the presence of Cr and Cd in sewage sludge compost, the concentrations in plants remained below the detection limits. The BCF of Co, Mn, and Cu were < 1, which indicates that the plant absorbs these HM, but does not accumulate them, in contrast to Zn, which had high Zn BCF, showing high potential for Zn phytoextraction.

DYNAMICS OF NITROGEN AND PHOSPHORUS COMPOUNDS DURING LEGUMES-BASED PHYTOREMEDIATION OF PETROLEUM HYDROCARBONS CONTAMINATED SOIL

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Abstract

Soil contamination and nutrient depletion is a very common and important problem in the world. According to ecogeological studies of contaminated sites, the soil is usually contaminated with petroleum hydrocarbons (TPH). Soil pollution caused by TPH reduces soil fertility by affecting the biological properties of the soil. TPH pollution is very common due to the long and extensive use of petroleum products in the energy, industry, and transport sectors. The number of potential soil contamination sites in Europe is estimated at 2.8 million. Various methods are used to reduce soil contamination, but biological methods are highly desirable. Legumes are a very promising group of plants for TPH-polluted soil remediation, as they are able to reduce pollution and increase soil fertility at the same time. In addition, legumes can utilise insoluble phosphorus sources and enrich the soil with bioavailable phosphorus compounds. The objective of this study is to evaluate the potential of legumes to increase soil nutrient content during the phytoremediation process. Eight species of legumes were selected for the study. The plants were grown for 12 weeks in soils contaminated with heavy fuel oil (2.5 and 4 g kg^{-1}). Cultivation of legumes in TPH-contaminated soils increased the concentration of ammonium and inorganic phosphorus with the highest increase in *L. corniculatus* and *O. viciifolia*. Where *P. vulgaris*, *L. corniculatus*, and *M. albus* were grown, the soil nitrate content remained close to the initial level. The study showed that *M. sativa*, *L. corniculatus*, and *M. albus* were the most efficient in TPH decontamination and had a positive effect on the restoration of soil nutrient content.

HYDROLOGICAL DROUGHT FORECAST FOR LITHUANIA ACCORDING TO STANDARDISED WATER LEVEL INDEX

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Abstract

The intensification of hydrological droughts, especially in recent years, calls for a more detailed study of the possibilities of their rapid detection and response. Moreover, there is a need to create forecast method to identify potential threats and create a drought-resistant system based on such research. Several indices of hydrological drought are mainly used by the scientific community. In this study, the streamflow drought index (SDI) and the new standardised water level index (SWLI) were calculated and compared. This research mainly focuses on identifying the usability of SWLI, which is based on water levels, instead of discharge data, and analysing forecast data in the near and far future for two RCP scenarios (RCP 4.5 and RCP 8.5). Daily discharge, daily water levels, temperature and precipitation data were used for the calculation of hydrological indices and hydrological models. Forecasting of hydrological regime was based on three regional climate models using the HBV software. In the framework of this research, hydrological models were created for 3 rivers: Nemunas-Smalininkai, Žeimena-Pabradė, and Šešuvis-Skirgailai. During the hydrological monitoring of Lithuanian rivers, water levels are collected as operational measurements. Therefore, SWLI methodology can increase hydrological drought detection speed, instead of SDI which used the water discharge data.

It can be stated that the results obtained using the SDI with the SWLI are quite similar. The only exception is that SWLI shows a quite a greater number of dry days compared to SDI. The results obtained from forecasting models, shows the tendencies towards increasing severity and extremes of hydrological droughts in the future, mainly in the second part of 21st century. However, under certain physical and climatic conditions, there is also a tendency to decrease hydrological droughts in the future for the Šešuvis river.

We conclude that SWLI can be used instead of SDI for faster identification of hydrological drought and analyses future tendences.

IDENTIFICATION OF CELLULOLYTIC BACTERIA ISOLATED FROM AGRICULTURAL SOIL IN THE NEMORAL ENVIRONMENTAL ZONE CONDITIONS

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Abstract

Cellulolytic bacteria play a vital role in decomposing crop residues in soil, which is essential for nutrient recycling in ecosystems by breaking down plant materials. Thus, this study aimed to identify and characterise potential strains of bacteria that have the ability to break down cellulose, contributing significantly to crop residue decomposition in the soil. Thus, this study aimed to identify and characterise potential strains of bacteria isolated from agricultural soil in central Lithuania that have the ability to break down cellulose, which significantly contributes to crop residue decomposition in the soil. After conducting qualitative assays, identification of bacterial isolates that exhibited cellulose degradation ability was performed. Consequently, the isolates were then subjected to amplification of the 16S rRNA gene using universal primers 27F 5′- (AGAGTTTGATCMTGG CTCAG)-3 and 1387R 5′-(GGGCGGWGTGTACAAGGC)-3′. Different hydrolytic and one redox enzymes activity were quantified in soil extracts. Enzymes were extracted using a 3% lysozyme solution by a heteromolecular exchange. The results of the partial 16S rRNA sequence analysis indicated that the bacterial strains isolated from the agricultural soil had the highest similarity to the *Actinobacteria* phylum, followed by the *Firmicutes*, *Proteobacteria*, and *Bacteroidetes* phyla. The findings of the study suggest that the *Streptomyces* genus was the most prevalent among the culturable bacterial community present in the agricultural soil. Within the *Firmicutes* phylum, it was identified that 21 bacterial strains belong to the *Bacillus* and *Paenibacillus* genera, including 12 species with a similarity high than 98%. The bacterial strains exhibited varying patterns of enzyme activity, but only 15 out of 64 strains possessed endoglucanase activity. The level of endoglucanase activity observed ranged from 9.09 to 942.41 nanomoles of MUF mL. Among all the bacterial isolates, the presence of the beta-glucosidase enzyme activity was detected only in 23.4% of the strains. Through the characterisation of culturable bacterial communities isolated from agricultural soil in the Nemoral environmental zone, this study identified a diverse range of bacterial taxa that could play a crucial role in the decomposition of cellulose in the soil.

SEX DETERMINATION OF EUROPEAN POND TURTLE (*EMYS ORBICULARIS* L.) JUVENILES IN PROTECTED HABITATS OF LITHUANIA

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Abstract

The European pond turtle (*Emys orbicularis* L., 1758) is a freshwater turtle species inhabiting ponds, slow-flowing rivers and swamps. The species is endangered and strictly protected in Lithuania and in most European countries. *E. orbicularis* is included in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species and the Red Data Book of Lithuania. The objective of this study was to determine the effect of temperature in natural habitats on egg incubation and sex of *E. orbicularis* individuals, and to determine their sex according to the differences in plastron appearance and morphometric measurements. The research was performed during 2021−2023 years, in protected habitats of Meteliai Regional Park. The length and width of the carapace and central height of the shell were measured each year. Observations revealed that sexual dimorphism between *E. orbicularis* individuals exists. Also, the study confirmed that egg incubation temperature in natural habitats of the species has an impact on the sex determination of individuals. Climatic changes and complex anthropogenic factors influence the loss of suitable habitats and the decrease of *E. orbicularis* populations. Temperature fluctuations during the egg incubation period may result in different sex ratios within populations. In order to conduct more detailed investigations on this topic, it is important to save the natural habitats of the species and to restore or increase the size of small endangered populations of *E. orbicularis*.

ASSESSMENT OF THE CARBON FOOTPRINT OF BIOCHAR PRODUCTION AND USE

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Abstract

The need to find sustainable ways to reduce the harmful environmental effects is growing with the awareness of climate change. As a potential method for reducing climate change, biochar has drawn a lot of attention. Biochar, a carbon rich material that is produced by the thermal decomposition of biomass in an oxygen-free or low-oxygen environment. This research is concentrated on cradle-to-grave analysis of life cycle emissions of biochar using Life Cycle Assessment (LCA) methodology for a functional unit of 130 kg biochar from cleft timber, measured as dry mass. To produce 130 kg of biochar, 1 t of cleft timber is used by performing pyrolysis. Five cycle phases were considered: biomass production (A1), transport (A2), production (A3), transport (A4), and use (B1). The SimaPro 9.1 software and EcoInvent v.3.6 database5 have been used to perform that analysis. Furthermore, evaluation of life cycle greenhouse gas emissions was carried out by applying IPCC GWP100a v1.03 method and EF method 2.0. Results present that life cycle stage biochar production (A3) is the biggest contributor to the climate change, resulting in 179 kg of CO_2 eq (EF method 2.0.) and 146 kg of CO_2 eq (IPCC GWP100a v1.03 method). On the other hand, the phase biochar use (B1), where final product biochar is used in the soil because of its gradual release of carbon resulting in progressive enrichment of soil, generated 6,68 kg CO_2 eq (EF method 2.0) and 6,58 kg CO_2 eq (IPCC GWP100a v1.03 method). Overall, it was also indicated that the amount of carbon sequestered over a 100-year time horizon by the amount of biochar manufactured is equal to 425,3 kg CO_2 eq.

3.3. INNOVATIVE AGRICULTURE, HORTICULTURE, AND FORESTRY SOLUTIONS

THE IMPACT OF SWINE MANURE BIOCHAR ON THE PHYSICAL PROPERTIES AND MICROBIAL ACTIVITY OF LOAMY SOILS

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Abstract

It has been demonstrated that biochar affects the hydro-physical characteristics of soil as well as the variety and abundance of microbial communities. In the context of applying biochar, research on the interaction between the hydro-physical characteristics of soils and the variety of microbial communities is lacking. The soil used in this study was taken from a field experiment that is still running (2019–2024) and had three replications of each of the biochar (B1 = 25 t ha^{-1} and B0 = no biochar) and nitrogen fertiliser treatments. (N1 = 160, N2 = 120 kg ha^{-1}, and N0 = no fertiliser). The findings demonstrate that the B1N0, B1N1, and B1N2 biochar treatments considerably increased the total soil porosity and bulk density at various depths. The volumetric water content (VMC) was significantly increased by the B1N1 treatment by 5–7% at −4 to −100 hPa suction at 5 to 10 cm depth. At depths of 5–10 and 15–20 cm, all three biochar treatments increased the strength of macropores by 33%, 37%, and 41%, respectively, and by 40%, 45%, and 54%, respectively. However, applying biochar considerably reduced hydraulic conductivity (HC) and improved soil indices as well as the usage of carbon sources at various times. Additionally, under applications of biochar, a positive association between carbon sources, indices, and soil hydro-physical parameters was observed. In summary, biochar has the potential to enhance soil hydro-physical characteristics and the usage of the soil's carbon source; these modifications frequently increase fertility and the sustainability of *Cambisol*.

INHIBITORY EFFECT OF WINTER RYE AND LEGUME INTERCROPS RESIDUES ON RADISH GERMINATION

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Abstract

Intercropping plays an important role in cropping systems by providing ecological services: soil erosion, reducing nitrate leaching, increasing soil organic matter, and enhancing weed suppression by reducing synthetic herbicide inputs. Allelopathic action consists of various metabolites that are released by plant roots and can act as growth regulators or inhibitors. Therefore, allelopathy as a good strategy for plant competition can clarify the compatibility of plant species and the appropriate sequence of cultivation of different plant species. The aim of this study was to evaluate the allelopathic effect of winter rye (*Secale cereale* L.) and summer annuals legume (Fabaceae) intercrop on germination and seedling growth of other plants. Aqueous extracts of rye and legumes biomass (leaves and roots) were applied to radish (*Raphanus sativus*) seeds. Radish was selected as a recipient plant with high germination capacity and rapid growth. For seedling growth bioassay, seeds were sterilised by four different methods: using 1%, 6%, and 12% NaClO solution, and bleach, with <5% anionic surfactants, chlorine-containing agents, optical brighteners. Seeds were kept in the solutions for three different periods: 5, 10, and 15 min. Thirty sterilised radish seeds were germinated in Petri dishes with agar and affected with 5 ml of intercrop biomass aqueous extracts. Germination test was performed in a temperature-controlled germination chamber. Seed germination was evaluated after 24 and 48 hours by counting germinated seeds and after 96 hours by measuring root length. The results of the different seed sterilisation methods showed that the highest germination (100%) was obtained when 1% and 6% NaClO solutions were used for 5 min. The lowest values of germination were observed with bleach, germination decreased with increasing duration (after 10 minutes – 30% and after 15 minutes – 20%). Aqueous extracts of rye and legumes inhibited sterilised radish seed germination.

NITROGEN MIGRATION IN PLANTS AND SOIL

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Abstract

Crop diversification in crop rotation is a promising tool that can increase the productivity and resilience of agricultural systems to abiotic stresses in the face of climate change. When applying the crop rotation system, it is important to analyse the individual elements of the nitrogen cycles. Using isotopic methods allows for evaluating the circulation of nutrients and nitrogen migration at plants. A laboratory experiment was performed at the Agrobiological Laboratory of the Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry. In the control climate chamber (Climacell CLC-707-TV) 8 h – 15°C and 16 h – 20°C grown *Artemisia dubia* Wall., fertilised with ammonia nitrate, rich with labelling nitrogen isotope. The cut biomass was chopped into 3–5 cm pieces and incorporated into the soil. Spring wheat was sown and grown to full maturity. Crops and soil were sampled every two weeks. All samples were analysed for nitrogen isotopes. Preliminary results showed that wheat grown in natural soil produced higher biomass when fertilised with 15N and additional ammonium nitrate. The analysis of the following data will show how nitrogen isotopes were distributed in the plant and the soil during the entire development of the plant. Nitrogen isotopic abundances in different plant stages are expected to be similarly higher with the use 15N and additional ammonium nitrate.

THE COMPATIBILITY BETWEEN LEGUMES AND GRASSES IN FOURTH YEARS OF TEMPORARY GRASSLAND

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Abstract

Cultivating mixtures of different plants can be a sustainable tool for the maintenance of agricultural productivity and avoidance of negative consequences. Two factors were included in this experiment: A – different grass/legume mixtures (two pure grass swards and 10 multi-species swards), and B – swards without nitrogen fertilisation (N0) and fertilised with 150 N kg/ha/yr. (N 150). The experimental data were statistically processed using ANOVA. Tests of significance were made at $P \leq 0.05$. The analysis of total annual yield in the fourth year of sward use revealed the significant influence of different composition of swards, however, the nitrogen fertilisation or interaction of factors not showed reliable differences. The highest dry matter yield was for swards with lucerne, and white clover accompanied with grasses perennial ryegrass, ×*Festulolium*, meadow fescue, and timothy or lucerne and white clover accompanied with perennial ryegrass and ×*Festulolium* and white clover, red clover or lucerne, sainfoin accompanied with perennial ryegrass, ×*Festulolium*, meadow fescue, timothy (6644, 6440, and 6200 kg ha^{-1}, respectively). Comparing those mixtures with monocultures of perennial ryegrass and ×*Festulolium*, nearly double dry mass was received. In summary, several swards with different species compositions can provide competitive yields without nitrogen fertilisation in fourth-year use of temporary grassland.

BIOMASS AND CARBON STOCKS IN FOREST FLOOR AND GROUND VEGETATION IN SCOTS PINE STANDS OF DIFFERENT AGE

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Abstract

Forests have higher carbon (C) stocks in plant biomass and soil than other ecosystems. Recently, much attention has been paid to C sequestration in various components of forest ecosystems. This study was set out to assess the changes in biomass and C stocks in forest floor and ground vegetation cover in 1–3-year-old clear-cuts and recovered 6–130-year-old Scots pine (*Pinus sylvestris* L.) stands following clear-cuttings. Forest floor and ground vegetation were sampled and analysed for biomass (dry weight) and C concentrations (ISO 10694:1995). Forest floor mass and C stocks changed unevenly over the 1–130 years stand rotation after clear cuttings. During the first 1–2 years after clear-cutting, the mass of the forest floor decreased 2–5 times compared to the mature forest and fresh clear-cuts due to more intense mineralisation. The recovery of the forest floor mass was recorded in the 30-years old Scots pine stand, and it showed a consistent increase trend with the stand age. The mean C stocks were 8–10 t ha^{-1} in the forest floor of the mature forest and 1–2 years old clear-cuts, 3–5 t ha^{-1} in Scots pine stands up to 30 years old. The highest forest floor mass was fixed in the 70-year-old stand. The mass of dominant mosses (*Pleurozium schreberi*, *Hylocium splendens*, and *Dicranum* sp.) obtained in the Scots pine sites of different ages was quite similar along with the stand age gradient. The highest mass of the mosses was found in the mature stand with a slightly lower mass in the 1st year clear-cut. The lowest mass of the mosses was obtained in the 2–10-years old Scots pine stand. The mass of the dominant dwarf shrubs (*Vaccinium myrtillus* and *V. vitis-idaea*) increased during the first three years after clear cuttings. Further, the mass of the dwarf shrubs changed depending on the Scots pine stand development stages and silvicultural operations applied.

EXPLORING THE DIVERSITY OF ENDOPHYTIC BACTERIA IN FOUR SPECIES OF *ARTEMISIA MEDICINAL* PLANT IN LITHUANIA AS A SOURCE OF PLANT GROWTH ENHANCER AND BIOCONTROL AGENT

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Abstract

Endophytic bacteria are microorganisms that live within the tissues of plants without causing any harm to the host. The study involved the isolation and characterisation of endophytic bacteria from different parts (stem, root, and leaf) of the four *Artemisia* species: *A. absinthium*, *A. dubia*, *A. vulgaris*, and *A. campestris*, in different locations in Lithuania. 151 endophytic bacteria were isolated with *A. absinthium* having the highest bacterial diversity. 84 endophytic bacteria demonstrated significant antagonistic effects against the pea root rot pathogen, *Fusarium* sp., and *Aphanomyces* sp. *in vitro*. Isolated bacteria of A. *dubia*, *A. vulgaris* showed the highest inhibitory growth on fungal pathogens 91–93%. Based on microscopic observation it was found that most of the isolates were rod-shaped. According to biochemical tests, we found positive and negative results for gram reaction and catalase test of isolated endophytic bacteria. Furthermore, several isolates exhibited plant positive reaction to phosphate solubilization and Amylase production indicating their potential to promote plant growth. Additionally, the urease test results indicated the ability of the isolates to metabolize urea, a nitrogen source essential for plant growth. These findings suggest the potential use of isolated endophytic bacteria from *Artemisia* plants as biofertilisers and biocontrol agents in agriculture, which could reduce the reliance on chemical fertilisers and promote sustainable farming practices.

NITROGEN FIXATION EFFICIENCY OF SYMBIOTIC AND ASSOCIATIVE BACTERIA IN GREENHOUSE

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Abstract

Soybean, also known as *Glycine max* (L.), is one of the most essential grain legume crops globally due to its high protein and oil content. To achieve optimal growth and yield, soybeans form a symbiotic relationship with rhizobia bacteria that resides in root nodules and convert atmospheric nitrogen into a usable form for the plant. This process is known as symbiotic nitrogen fixation (SNF), and it is the primary source of nitrogen for soybean plants. A greenhouse experiment was conducted to test the combined effects of endophytes and bio-stimulants on soybean and spring wheat crops. Different bacterial strains and endophytes were used as treatments, respectively. Plants were given light irrigation three times a week and a full nutrient solution containing ammonium nitrate (NH_4NO_3). The crops were pulse-labelled three times and evaluated using leaf chlorophyll fluorescence parameters, chlorophyll content, and net photosynthesis rates at different stages of crop growth. Based on the analysis of fresh and dry root length and weight of soybean and wheat plants, it has been found that treatments (Endophyte 1 + Rhizobium 1 + Bio-stimulants) 11, treatments 12 (Endophytes 2 + Rhizobium 2 + Bio-stimulants), and treatments 13 have shown the best results in terms of chlorophyll value, weight, and length measurements of soybean. On the other hand, treatments 19 and 20 (wheat endophytes + Rhizobium) have given the best results for wheat plant growth. These findings suggest that specific treatments can have a significant impact on the growth and development of soybean and wheat plants, respectively.

THE EFFECT OF COLD PLASMA ON THE BIOSYNTHESIS OF SECONDARY METABOLITES OF *STEVIA REBAUDIANA* BERTONI GROWN IN AEROPONICS

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Abstract

Stevia rebaudiana Bertoni is an essential plant in the sweetener industry that deserves further research. Secondary metabolites of stevia are rich in sweet steviol glycosides and other beneficial phytochemicals. Diabetes and other sugar-related disorders are becoming more frequent worldwide, therefore it is important to continue the scientific analysis of alternative sweeteners. Thus, the value of stevia plant cultivation research of upgraded growing technologies is increasing. It is known that seed treatment with cold plasma (CP) promotes seed germination and plant stress resistance. It is the first time that pre-sowing seed treatment with CP and sprout growth in aeroponics have been used in a combined study. The aim of this study was the evaluation of various secondary metabolite (non-sweetener) biosynthesis in stevia plants grown in aeroponics after pre-sowing stevia seeds treatment with CP for 5 minutes. Total phenolic compound (TPC) and flavonoid concentrations were evaluated by the Folin-Ciocalteu and colorimetric Al(III)Cl methods, respectively. CP-treated groups had significantly higher ($p < 0.05$) concentrations of TPC (by 43%, from 49.2 mg GAE/g to 76.1 mg GAE/g) and flavonoids (by 19%, from 30.0 mg RE/g to 36.4 mg RE/g) compared to the control group, whose seeds were not treated with CP. CP treatment increased antioxidant activity measured by the DPPH radical scavenging method by 45% ($p < 0.05$) compared to the control group (from 82.2 mg RE/g to 129.9 mg RE/g). The determination of chlorophyll *a* and *b*, xanthophyll and carotenes was performed with spectroscopic analysis. The CP-treated groups showed significantly lower amounts of chlorophyll a (by 24%) and chlorophyll b (by 27%). The analysis of xanthophylls plus carotenes showed no significant differences from the control group. In summary, stevia seed treatment with CP and growth in aeroponics can increase the biosynthesis of some beneficial secondary metabolites.

PHYSIOLOGICAL AND TECHNOLOGICAL ASPECTS OF IMPROVING THE QUALITY OF GREENHOUSE VEGETABLE SEEDLINGS FOR HIGH-QUALITY CROP PRODUCTION: A REVIEW

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Abstract

The production of vegetable seedlings is a significant stage of good and high-quality vegetable quality. To regulate the growth and development of seedlings, reduction of the negative effects of environmental factors, can increase the yield of vegetables, and improve their quality. Selection of the most suitable substrate and the application of biologically active substances in greenhouse vegetable seedling cultivation is necessary. High-quality and healthy seedlings can lead to better disease and pest infection control, and the ability to survive in unfavourable environments after transplanting can form a well-developed root system and leaf area. Different types of biological preparations and the anaerobic digestates (liquid from manure, solid distilled grain waste, etc.) as influencers on the cultivation of vegetable seedlings and further vegetable production there introduced in the review. Many studies have been made about biological preparations and digestate influence on aromatic plants, leafy vegetable growth, and productivity, however, it is still a lack of information about the effect on greenhouse vegetables. These reviewed studies show the physiological and technological aspects of improving the quality of seedlings, which could contribute to the sustainable and environmentally friendly development of the use of preparations and substrates of ecological origin. This literature analysis will help to assess the lack of knowledge about the use of digestate and biological preparations in greenhouse horticulture, to select their optimal concentrations, to determine their impact on the seedling quality of fruit vegetable and plant productivity.

DIVERSITY OF ISOLATES, ISOLATED FROM ROOT NODULES OF FIELD PEA (*PISUM SATIVUM* L.)

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Abstract

The increasing interest in the use of rhizobia as a biofertiliser has prompted the identification of rhizobia strains and led to studies on their diversity and competition. To enhance symbiosis efficiency and improve nitrogen fixation it is important to characterise rhizobia diversity in soil and select competitive and highly effective nitrogen-fixing strains which could be used as microbial biofertilisers. In this research, five different *Pisum sativum* cultivars: 'Bagoo', 'Respect', 'Astronaute', 'Lina DS', and 'Egle DS', were selected for rhizobia isolation. All cultivars were growing in the same field, where ecological farming was applied, and no commercial rhizobia inoculants were used. Ten plants from each *Pisum sativum* cultivar were collected for rhizobia isolation. A single healthy-looking pink nodule (larger than 2 mm) was selected per plant root apparatus to obtain one isolate from one plant. A primary collection of 50 isolates was constructed. Each isolate was identified by sequencing of 16S rRNR, and atpD genes. Phylogenetic trees were constructed to analyse the diversity of rhizobia isolated from organically grown peas. Based on phylogenetic analysis by 16S rRNR genes, 47 isolates were attributed to *Rhizobium* spp. genera members. The remaining 3 isolates belonged to *Rahnella* spp., *Paenarthrobacter* spp., and *Peribacillus* spp. genera. AtpD gene analysis showed that all 46 isolates were identified as *Rhizobium leguminosarum* and one isolate was identified as *Rhizobium nepotum*. The results show that 16S rRNA gene is not adequate for identification at species level within the genus *Rhizobium*, additional genes such atpD gene analysis is necessary to analyse *Rhizobium* diversity at the species level.

FRACTIONAL EXTRACTION IS A NEW METHOD TO STUDY COMPOST COMPOSITION AND ITS INFLUENCE ON SOIL

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Abstract

Compost has been shown to have many beneficial effects on soil and plants. The use of compost in agriculture can not only benefit on agrochemical properties of soil and increase the yield, but also reduce the impact of biodegradable waste. Composts are most characterised by the total amount of nitrogen, phosphorus, and potassium. The attention of many researchers focused on increases in soil organic matter or heavy metal pollution. To evaluate the effectiveness of compost we suggest applying fractional extraction - the solvent separation of a mixture into its components. Evaluating solubility, nutrient mobility, and plant availability, fractional extraction will allow to divide the compost into fractions in the absorbable amount and evaluate it according to the quantity of nutrients absorbed by plants, but not by total quantities like we used to. We believe that the more the composts contain nutrients (N, P, K, Ca, and Mg) soluble in water and salt solutions, the more it increases their amount in the soil, which allows to obtain bigger, and better-quality yields, than composts with the same total amounts of nutrients in insoluble and organically bound forms.

Thus, the study will allow the creation of new compost evaluation methods and will complement the scientific knowledge of the composition distribution of composts.

COMPARISON BETWEEN CROWN THINNING AND GIRDLING TO ENHANCE SPORADIC TREE SPECIES IN A COPPICE STAND IN CENTRAL ITALY

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Abstract

Sporadic valuable tree species and especially *Sorbus* species have gained importance in forest management as they increase tree biodiversity, ensure a higher resilience of the stand to climate change, and enhance valuable timber production. This study reports the first results of a trial carried out in Central Italy in a Turkey oak coppice stand (aged 17 years) where three different silvicultural treatments (crown thinning, girdling, and non-thinned control) were applied to favour sporadic tree species. The monitoring was carried out for 5 years and showed the limits of girdling application as Mediterranean species like Turkey oak form easily scar cords and epicormic sprouting. Furthermore, the progressive reduction of the canopy cover of the competitors resulted from girdling and the effect of the thinning and girdling on the growth of selected service trees (*Sorbus domestica* L.) was evaluated. The first results of this research have pointed out some difficulties in the girdling application and a higher effect of crown thinning in stimulating the growth of selected service trees.

THE IMPACT OF WINTER WHEAT CULTIVARS MIXTURES ON DISEASES AND YIELD AFTER DIFFERENT PRE-CROPS

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Abstract

Different plant growing and cultivation technologies developed in agriculture, including reduced soil tillage and continuous wheat sowing, have become more popular in recent years. Wheat is the culture which is grown in the same field most often for at least 2–3 years in a row; in that way, this technology significantly impacts the development of diseases. Determination of fungal disease spread intensity in genetically different wheat mixtures and evaluation of benefits of wheat cultivar mixtures in terms of economic value and sustainable farming is the aim of this study. The absence of effective control of diseases is the major factor which predetermines yield losses. However, the chemical control of diseases has already reached the limit of negative residual effects, threatening water and air pollution, natural ecosystems, and human health. Different mixtures for cultivars enable the management of wheat disease resistance levels in the context of fungicide reduction. Based on a series of studies, the majority of 67% cultivar mixtures had the potential to reduce the number of fungicide applications compared with mono-crop. The cultivation of mixtures of genetically distinct wheat varieties has the potential to improve the overall condition of the crop compared to wheat grown as a mono-crop. Also, the number and proportion of wheat varieties in the mixture positively affect disease reduction in the crop and the quality of the grain yield. Studies showed that the impact of canopy architecture (such as the number of stems, the surface area of the leaves, and the distances between the leaves on the stem) on microclimate and spore dispersal could contribute to disease reduction in cultivar mixtures. One of the most important aspects is that the variety of mixtures could help reduce the selection of fungicide resistance. Based on four trial sites, the highest significant reduction in resistance development to azole fungicides by cultivar mixtures was 73%.

THE INFLUENCE OF ORGANIC FERTILISERS ON THE ABUNDANCE OF SOIL MICROORGANISMS AND AGROCHEMICAL INDICATORS IN EAST LITHUANIAN LIGHT SOILS

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Abstract

Soil is a unique environment full of microorganisms. Many processes occur in the soil; microorganisms perform certain functions here and are necessary for carbon cycling and plant nutrition. In agriculture, the application of fertilisers affects soil microorganisms' abundance and has a significant effect on agrochemical indicators. The growing problem of soil degradation is prompting a new revision of the application of organic fertilisers in agriculture. The aim of the research was to investigate how the applied fertilisers affect the most active soil microorganisms, to evaluate the release of mobile nutrients and their changes in the soil under the influence of different fertilising with organic fertilisers and their combinations with biological additives, to assess the influence of the above-mentioned fertilisers and their combinations on the accumulation of organic carbon in the soil. The content of microorganisms was calculated in colony-forming units per 1 g of dry soil. Mobile P_2O_5 was determined in extract using ammonium molybdate via the spectrometric method with a spectrophotometer Shimadzu UV 1800. Mobile K_2O was determined using flame emission spectroscopy with a JENWAY PFP7 flame photometer. Dry combustion with total carbon analyzer Liqui TOCII was used for organic carbon (C_{org}) determination according to ISO 10694:1995. The results of bacteria and fungi abundance in 2021 showed that fertilisation with organic fertilisers affected the abundance of organotrophs and nitrifiers, especially in variants PLM170, GPM170, CLM170, and GCM170. The highest abundance of soil fungi was determined after fertilising with combinations of GPM170+T and GCM170+T. Summarising the results of the agrochemical parameters, the mobile P_2O_5 and K_2O, and C_{org} concentrations in the soil depended on fertilisation with various organic fertilisers and their combinations with biological additives. The greatest concentrations of mobile P_2O_5 and K_2O, and C_{org} in the soil were determined when fertilising with combinations of GPM170+T and GCM170+T.

EFFECT OF DIFFERENT AGE RED FESCUE ON THE SOC AND WEOC CHANGES

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Abstract

Many strategies for dealing with climate change suggest reducing the amount of CO_2 in the atmosphere by converting it into stable forms of carbon. The cultivation of perennial grasses increases the amount of organic matter in the soil, which at the same time leads to the accumulation of soil organic carbon (SOC). Water extractable organic carbon (WEOC), as the most active SOC pool, can contribute to changes in SOC concentration and stabilisation. This study aimed to compare the carbon accumulation and botanical composition (BC) changes of the grasslands where red fescue (*Festuca Rubra* L.) was grown for 5, 10, and 15 years and in an arable field (AF) at the same site. The experiment was established at Akademija, Kėdainiai district. Soil samples were taken from three replications of the topsoil (0–10, 10–20, 20–30 cm depth). The SOC content was determined by a spectrophotometric measurement, WEOC – by the IR detection method using the ion chromatograph. Grassland biomass was cut and weighed twice per growing season. The analysis of variance (ANOVA) was performed, and the data were compared using Fisher's test ($P < 0.05$). Red fescue, cultivated for a long time, significantly increased the amount of SOC (1.3–2.8 times compared to AF). Results varied depending on the soil depth and the age of the grassland. The highest content of WEOC was determined in the 0–10 cm soil layer, where the most intensive carbon transformation process occurs. Also, the change in BC in older grasslands may have contributed to the slowing of SOC accumulation.

This study confirms that more extended grassland keeping is an important practice to improve SOC sequestration in the soil.

HEMP RESIDUES MINERALISATION AND CHEMICAL COMPOSITION

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Abstract

Climate change and soil degradation are among the most important environmental problems, mostly influenced by greenhouse gas emissions and non-sustainable use of resources. For the rapid reduction of greenhouse gas emissions, it is necessary to look for alternative ways to accumulate carbon and mineral substances in the soil. One of the ways to preserve the soil quality is to use biomass or biomass residues as a soil amendment. One of the potential crops for this could be hemp. Hemp plants reduce the population of nematodes and pathogenic fungi in the soil and can be grown without the use of pesticides, herbicides, or fungicides. Hemp loosens and softens the soil, while fallen leaves and straw left on the soil as mulch preserves the substances and bacteria in the soil. If hemp is grown for the extraction of phytocanabinoids, up to two-thirds of the organic matter returns to the soil. The aim of this study was to determine the speed of hemp residues mineralisation and evaluate its chemical composition. Three treatments were selected for the experiment. 15 g of the Hemp residues were put into nylon bags and 1 – dug into the soil, 2 – left on the soil till early spring and then dug into the soil and 3 – left on the top of the soil for all time. Each month the bags were taken out, weighed and the chemical composition of the hemp residues was determined. The results showed that after one-month faster mineralisation was in the bags which were dug into the soil, the lowest in the bags which were left on top of the soil. However, the bags which were left on the soil had faster mineralisation after 5 months from the beginning of the experiment.

The first results suggest that hemp straw mineralisation is affected using technology. If the results will be confirmed next year, it could be concluded that hemp residues can be potential mulch for non-tillage farming.

ROOT BIOMASS AND NUTRIENT STOCKS IN SCOTS PINE STANDS: EFFECT OF DEEP SOIL PLOUGHING

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Abstract

The aim of this study was to determine total root biomass and nutrient stocks in 20-year-old Scots pine (*Pinus sylvestris* L.) plantations established on deeply (up to 60 cm depth) ploughed soil and naturally regenerated Scots pine stand on non-ploughed soil. The study was carried out in Druskininkai district in 2021. Mineral soil samples containing all available roots of Scots pine were sampled from 0–10, 10–20, 20–40, and 40–60 cm soil layers from 10 places. In the laboratory, the Scots pine roots were carefully washed removing all soil particles, then dried up to constant mass and weighed. The root samples were chemically analysed for the concentrations of organic C, N, P, and K. The study results showed that the highest Scots pine root densities of 3.2–3.4 kg m^{-3} in the deeply ploughed site and 2.8–4.1 kg m^{-3} in the non-ploughed site were obtained in the mineral topsoil up to 20 cm depth. The root density was significantly lower in deeper soil layers of 20–60 cm depth than in the topsoil at both sites. Deep soil ploughing prior to afforestation caused 6.0- and 1.5-times higher Scots pine root density in the 20–40 cm and 40–60 cm depth soil layers, respectively, compared to the non-ploughed soils. The total C density in Scots pine roots at 0–60 cm depth amounted to 2.7 kg m^{-3} in the deeply-ploughed site and 1.8 kg m^{-3} in the non-ploughed site. Deep ploughing caused 9 times higher C density in roots in the 20–40 cm soil layer in comparison to naturally regenerated stand growing on non-ploughed soil. Total N density in Scots pine roots also was 1.2 times higher in deeply ploughed sites than in non-ploughed sites. Both P and K densities in pine roots were slightly higher in the naturally regenerated stand than in the deeply ploughed site.

ACIDIC SOIL PROPERTIES AND ITS EFFECT ON MINERAL NITROGEN RELEASE PROCESS FROM GRANULATED UREA FERTILISERS

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Abstract

The rate of N released and the dynamic of its reactions in the soil may interfere with soil acidification. An incubation experiment was conducted to examine the impact of different urea compounds on the rate of nitrogen release and the reactions that occur in acidic soil, which can potentially affect the Nitrogen release process. The treatments included urea, urea-potassium humate, urea cocrystal, and urea inhibitor (NBPT), all applied at a rate of 100 kg ha^{-1} N, in addition to a control with no nitrogen. The substances were spread on the surface layer of 5 kg of soil and placed in plastic pots with 20% moisture under thermoregulatory chamber conditions (T = 20°C and 60% air humidity). Mineral nitrogen and soil pH were measured at various intervals, including 0, 1, 3, 5, 10, 20, and 30 days after fertiliser application. For all the urea fertilisers, ammonium was the dominant form of nitrogen present in the soil for a period of up to 3 days. However, after 3 days of incubation, ammonium began to convert to nitrate. Throughout the incubation period, it was observed that the highest rate of ammonium release was exhibited by urea, whereas the urea cocrystal displayed the lowest rate of release over the entire duration of the experiment. This research is still under investigation, but we can highlight that the acidic soil properties affected the release process of all treatments except urea cocrystal which showed characteristics of a slow-release fertiliser.

UNDERGROWTH UNDER THE CANOPY OF DECIDUOUS FORESTS ON VERY FERTILE FOREST SITES IN THE LITHUANIAN HEMIBOREAL FOREST

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Abstract

Public wants to see forest management without clear cutting based more on the principles of ecological forestry. Forests of the pioneer tree species (*Betula* spp., *Populus tremula* L., and *Alnus incana* (L.) Moench.) are common in the highly fertile forest sites of the hemiboreal forest zone. The abundant and varied lower storeys under canopy of these stands have great weight for the stand growth and regeneration. The evaluation was based on the standwise forest inventory data and limited to the analysis of mature and overmature forests. There is considered how the legal regulation of forestry methods can affect the distribution and species composition of lower storeys of forests. The lower storeys of the main tree species that can form the next generation of the stand are rarely common. The most important species of the second story and understory is *Picea abies* L. With an increasing forest mixture, the second story and understory are found more often. The lower storeys are dominated by shrub species, especially *Corylus avellana* L. in *Betula* spp. and in *Populus tremula* L. and *Padus avium* L. in *Alnus incana* (L.) Moench forests. The prevalence of *Corylus avellana* L. increases with increasing the age of stands and mix of stand composition. *Padus avium* L. distribution decreases with increasing age and species mixture of stands. We evaluated the regulation of forestry measures and found that the methods of forest cutting are not sufficiently directed to improve species composition of the lower storeys of the forest.

ENDOGENOUS INTER-CROP ROTATIONS IN MAIZE

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Abstract

Based on the EU Greening Program and the Green Deal, special attention is paid to the balance of pesticides and mineral fertilisers. Diversifying crops and increasing biodiversity also draw attention to the provisions of the Green Deal. Important results could be achieved in interrow of agricultural plants (including maize) by growing intercrops of various species and alternating them according to endogenous rotations. In a long term, new knowledge will allow to create a new generation of sustainable agrocenoses for energy, increasing the biodiversity and multifunctionality of the crop through endogenous rotation in the future. The investigations will be carried out in 2023–2025 at the Experimental Station of Vytautas Magnus University Agriculture Academy. The aim of the research was to create efficient rotations in maize continue crop characterised by stability, biodiversity, and high economic efficiency. In 2023, maize will be inter-cropped with *Fabaceae* family plants, in 2024, with Poaceae, in 2025, with Brassicaceae. The hypothesis of the research states that productivity and quality of the soil and the inter-crop productivity and phytosanitary conditions will not decrease, but probably improve when growing inter-crops in maize and rotating them according to the principles of endogenous rotation.

The research will use the determination of the properties of the soil, CO_2 gas emission and their concentration on the soil surface, allelopathic properties of inbred inter-crops, determination of crop development, biometric, productivity and quality indicators, crop weediness and diseases, energy, and environmental assessment of crop production.

CARBON DIOXIDE (CO_2) EFFLUX FROM DRAINED NUTRIENT RICH ORGANIC SOILS

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Abstract

In Lithuania Histosols occupy 9% of terrestrial land area and the largest part is consisted of nutrient rich organic soils (*Terric Histosols*). The most of these low moor soils have been drained. Drainage causes the decomposition of the peat and carbon dioxide (CO_2) efflux significantly increase after drainage event. Despite such importance of organic soils to the global carbon cycle and their influence on climate change dynamics, detailed information on regional emission trends is scarce. This study aimed to determine CO_2 efflux from drained organic-nutrient rich soils in forest land and perennial grassland during vegetation period (May–September). Study was performed in non-managed perennial grassland and in Norway spruce, silver birch and black alder stands. In study sites, three sub-plots of 500 m^2 area were established for soil CO_2 efflux, soil temperature and ground water level measurements. CO_2 efflux has been measured by EGM-4 (PP Systems, USA) once per month. In studied sites the significantly highest CO_2 efflux was determined in July–August months due to the highest soil radiation, air and soil temperature and the lowest level of ground water. These conditions are suitable for maximum microbial and root respiration and peat decomposition. In comparison with grassland CO_2 efflux in silver birch stand were 40%, whereas in Norway spruce and black alder stands were even by 2.5–3.0 times lower. Higher variation of CO_2 efflux among studied forest sites may correspond not only with environmental factors, but also with organic carbon and nutrients in peat under forest stands of different tree species.

3.4. PLANT BIOLOGY AND PHYSIOLOGY

THE IMPACT OF DIFFERENT ENVIRONMENTAL CONDITIONS DURING VEGETATIVE PROPAGATION ON PHOTOSYNTHESIS AND SPRING PHENOLOGY IN POPULUS HYBRIDS IN CLONAL FIELD TRIAL

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Abstract

This study investigates spring phenology of leaves, photosynthesis, and transpiration rate of *Populus* hybrids in field trials which may be predisposed by the simulated contrasting temperature conditions at their vegetative propagation phase. The clonal test plantation in Jonava was established using vegetatively propagated plants rooted and grown under contrasting environmental conditions simulated in the Phytotron of LAMMC Institute of Forestry. It was found that spring phenology of hybrid poplar clones grown in field trials, were affected by the rooting conditions. *P. balsamifera* × *P. trichocarpa,* which were rooted in the field and in the greenhouse, grew leaves the fastest – in 45 days. The leaves spreading phenology of *P. deltoides* × *P. nigra* hybrids were longest – 63 days – after root heating conditions. The most intense photosynthesis was observed in those trees that were rooted under cold conditions. Light intensity of photosynthesis was observed in those trees that were rooted under root heating conditions. The highest intensity of photosynthesis was found in *P. deltoides* × *P. trichocarpa* hybrid – 5.67 μmol m^{-2} s^{-1} while the lowest – 3.99 μmol m^{-2} s^{-1} in *P. balsamifera* × *P. trichocarpa* hybrid. The most intense transpiration rate was observed in those trees that were rooted under root heating conditions. The lowest intensity transpiration was found in hybrids rooted under cold conditions. The highest intensity of transpiration was found in *P. maximoviczii* × *P. trichocarpa* hybrid – 5,67 μmol m^{-2} s^{-1}, while the lowest – 0.1 μmol m^{-2} s^{-1} in *P. deltoides* × *P. nigra* hybrid.

BUTT ROT AND NORWAY SPRUCE VITALITY – BUTT ROT INDUCED CROWN DEFOLIATION AND CHANGES IN TREE RADIAL INCREMENT

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Abstract

Pathogen-caused wood decay is believed to be a major cause of decreasing tree vitality and increased susceptibility to external biotic and abiotic damaging agents. Using data collected from twenty decay-affected and unaffected Norway spruce (*Picea abies*) stands, this study aims to explore the interaction between butt rot and crown defoliation and radial increment as indicators of tree vitality. Study results indicate that vitality decline among butt rot-affected Norway spruce is expressed as a significant reduction in radial increment and considerably greater levels of crown defoliation. Decayed Norway spruce trees were found to have higher levels of defoliation, showing higher crown defoliation than undecayed spruce trees. Additionally, a radial increment reduction in the last five years and the last twenty years of the increment sequence was found when decayed Norway spruce tree growth was compared to undecayed. A stand age-dependent relationship was also found among visually healthy undecayed spruce trees, indicating that spruce trees show signs of increasing defoliation as part of the ageing process. Among decayed Norway spruce, however, no such relationship was found. Naturally, both decayed and undecayed trees showed a negative correlation between the level of crown defoliation experienced and the radial increment for the last five years before increment sequencing; among all stands however, only half showed a statistically significant correlation.

IMPACT OF CHITOSAN PRODUCTS ON SECONDARY METABOLITE LEVELS IN PLANT TISSUES *EX VITRO* DEPENDING ON CHITOSAN TREATMENT DURATION AND CONDITIONS

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Abstract

In order to find sustainable effective means of combating pathogenic fungi and to increase forest yields, it is necessary to look for natural or semi-natural products that are environmentally friendly and do not affect biodiversity. One option is the chitin derivative chitosan, which is usually extracted from crustacean shells and has been the subject of several studies on a wide range of plants, but not on trees. Chitosan has been shown to be effective as a fertiliser/protective agent by not only having a direct negative effect on pathogenic micro-organisms, but also by enhancing the natural production of secondary metabolites (SM) in plants, which have been linked to the overall vitality and growth of trees. In this study, chitosan isolated from the insect *Tenebrio molitor* (MKDS Ltd.) was investigated, which has the advantage of a comparatively easier purification process and lower molecular weight than chitosan derived from crustacean shells. The aim of this study was to investigate the changes in the levels of secondary metabolites and photosynthetic pigments that the chitosan product isolated from *T. molitor* induces in the tissues of ex vitro adapted Scots pine and black alder seedlings, depending on the duration of the storage of chitosan powder, the conditions of storage (ambient humidity and temperature), and the solvent used (0.1% acetic acid/water). Water as a solvent was found to have a strong positive effect on both Scots pine and black alder seedlings phenolic and flavonoid compounds, regardless of the storage conditions of the chitosan powder. Freshly prepared chitosan powder, dissolved in acetic acid, proved to be effective on photosynthetic pigment levels in pine seedlings. Black alder seedlings were more sensitive to 0.1% acetic acid solvent than pine seedlings – secondary metabolite levels have drastically dropped.

CHANGES OF ANTIOXIDANT ENZYMES AND ANTIOXIDANT ACTIVITY IN 2-YEAR-OLD NORWAY SPRUCE NEEDLES AFTER SEED TREATMENT BY COLD PLASMA

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Abstract

Although Norway spruce (*Picea abies*) is comparably resistant to pests and pathogens, more biotic and abiotic stressors, which can disrupt the health of stands, are expected due to climate change. Biologically active compounds in plant tissues are relevant for tree resistance to environmental stress. The antioxidant systems, which play an important role of reactive oxygen species (ROS) scavenging, are one of the essential mechanisms in plants. The aim of this study was to evaluate changes of antioxidant system of different Norway spruce half-sib families, after seed treatment by direct application of dielectric barrier discharge (DBD) plasma. For the assessment we treated seeds from ten different half-sib families with cold plasma 1 min (CP1) and 2 min (CP2). Untreated seeds were used as a control. The assessment of antioxidant enzymes and antioxidant activity was carried out using needles, which had been sampling from 2-year-old spruce seedlings. Concentrations of the compounds were estimated using spectrophotometric method. Our results showed that the effect of cold plasma to biologically active compounds highly depend on the treatment time and half-sib family. One out of ten families had a significant statistical difference between CP1 and control. The concentrations of antioxidant enzymes (CAT/APX/POX/GR) and antioxidant activity (DPPH/ABTS) were significantly higher after CP1 treatment, compared to control in family No. 457. The concentrations of CAT, APX, and GR were also higher after CP1 treatment, compared to control in family No. 548. Furthermore, negative significant statistical differences were recorded in antioxidant activity in one of ten half-sib families after seed treatment with CP2 (No. 454). Results emphasized that seed treatment with cold plasma may be used seeking to increase the concentrations of antioxidant enzymes and antioxidant activity in different half-sib Norway spruce families, however, it is dependent on half-sib family and treatment time.

DETERMINATION OF RADICAL SCAVENGING ACTIVITY IN POSTHARVEST MICROGREENS *BRASSICA JUNCEA* AND *AMARANTHUS TRICOLOR* GROWN UNDER DIFFERENT LIGHT INTENSITY

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Abstract

Our research objective was to determine how light intensity while growing can influence microgreens *Brassica juncea* and *Amaranthus tricolor* antioxidant activity and how it changes during postharvest storage. Light is one of the most important growing environmental factors which can influence nutritional value, visual appearance, and overall taste of plants. It is beneficial to know the changes in antioxidant activity, during the postharvest stage. The experiments were conducted in a greenhouse (lat. 55°), microgreens were grown in peat substrate with supplemental light-emitting diodes (LEDs) lighting, and the total PPFD of 100, 150, 200, and 250 µmol m^{-2} s^{-1} was maintained for 16 h photoperiod with 20 ± 3°C temperature. For supplemental light white LED Tridonic 105W lamps were used. Amaranth analysis showed that on the harvest day, the highest FRAP and ABTS antioxidant activity was found in plants grown under 250 µmol m^{-2} s^{-1} PPFD. On day three of storage plants held in the light had significantly higher FRAP and DPPH antioxidant activity. However, no differences on days one and five, in comparison to plants held in the dark was found. The PPFD level 250 µmol m^{-2} s^{-1} resulted the highest FARP and ABTS values in plants on storage day one and three, but on day five the highest activity was determined in plants grown at 150 and 200 µmol m^{-2} s^{-1}. For mustard, the analysis showed that on the harvest day, the highest FRAP and DPPH antioxidant activity was found in plants grown at 150 µmol m^{-2} s^{-1}. Mustard held in the dark had a higher DPPH antioxidant activity on storage days one and five and on day three there was no difference. On day one the highest antioxidant activity FRAP and DPPH was found in plants grown at 150 µmol m^{-2} s^{-1}, on day five the highest ABTS activity was found in plants grown at 250 µmol m^{-2} s^{-1}, and no significant differences on day three. To conclude, the highest antioxidant activity resulted under 250 µmol m^{-2} s^{-1} for amaranth and 150 µmol m^{-2} s^{-1} for mustard.

ESTIMATING THE MAIZE BIOMASS, GRAIN YIELD, AND ABIOTIC STRESS BY COMBINATION OF MULTISPECTRAL IMAGERY, GROUND-BASED MEASUREMENTS, AND MACHINE LEARNING

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Abstract

The global population is expected to rise by around 10 billion in the middle of the 21st century, which will increase the demand for food, energy, and fibre. To meet the demands of humanity, food production must double by 2050 on a worldwide scale. Maize is one of the most significant and widely cultivated crops, providing more than half of the world's non-meat calories and more than 70% of animal energy calories. Although maize is widely cultivated across the globe, the current growth conditions for this crop at high latitudes can be characterised as poor. The abiotic factors, which are the primary limitations and include drought, ambient temperatures, and nutrient deficiency, intensify the global loss in annual crop grain production. To maximise a plant's genetic potential and achieve high yields, monitoring plant stress and identifying early intervention are vital in modern agriculture. During the PhD studies in 2022−2026, maps of maize abiotic stress as well as biomass at different growth stages by combining ground-based measurements as the independent variables and UAV (unmanned aerial vehicle) remote data as the dependent variable with machine learning methods will be developed. Multiple methods will be combined, including three-year field experiments with maize fertilisation data under two contrasting soil types and covering different climatic conditions. The collected field and aerial data will be used when developing machine learnings algorithms, that will likely allow us to develop prediction models and to monitor maize biomass and abiotic stress.

THE SIGNIFICANCE OF NUTRIENT SOLUTION BUFFER CAPACITY FOR HYDROPONIC LETTUCE CULTIVATION

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Abstract

Nutrient solution provides all essential elements for optimal plant growth in hydroponic plant cultivation. One important characteristic of the nutrient solution is its buffer capacity, which refers nutrient solutions ability to mitigate pH changes, which naturally occur due to unbalanced ion absorption. Maintaining a stable pH interval is crucial for optimal plant cultivation, as fluctuations can negatively impact plant productivity. Nutrient solution buffer capacity is influenced by a variety of factors, including nutrient composition and concentration as well as the chemical composition of the water source. Therefore, our objective was theoretically and empirically determinate nutrient solutions buffer capacity and evaluate the effect of the molarity of supplementary buffering agent on hydroponically cultivated lettuce growth. In this study, theoretical nutrient solution buffer capacity was calculated using Henderson-Hasselbalch equation as well as two stage acid (HCl) and base (NaOH) titration were performed for empirical nutrient solution buffer capacity evaluation. Lettuce *Lactuca sativa* 'Hugin' was cultivated in deep water culture hydroponics systems in walk-in controlled environment growth chamber (21/17°C night/day temperature, PPFD 250 µmol m^{-2} s^{-1} at 16 h photoperiod, 1000 ppm CO_2, 55% RH,) with supplementary 2-ethanesulfonic acid (MES) buffering agent, which molarity was 0/1/3 and 5 mM. At technical maturity stage, plant biomass accumulation and nutrient solution pH fluctuations were recorded. Initial nutrient solution buffer capacity increase with 3 mM MES buffer resulted in 17,99% yield increase without negative physiological response.

FLAVANOL AND ANTHOCYANIN REFLECTANCE INDICES FOR EARLY GREY MOULD DETECTION IN LETTUCE

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Abstract

This study aimed to evaluate the uses of the flavanol reflectance index (FRI) and anthocyanin reflectance index (ARI2) as non-destructive methods for the early detection of grey mould (*Botrytis cinerea* Pers.) in red leaf lettuce (*Lactuca sativa* L.) grown under different lighting conditions. The experiment performed in controlled environment chambers, where day/night temperatures of 21 ± 2/17 ± 2°C and a 16-h photoperiod and relative humidity of 75–80%. High-pressure sodium (HPS; Philips SON-T Agro) and light-emitting diodes (LEDs, Heliospectra RX30, chosen wavelengths 400-, 450-, 530-, 620-, 660-, and 735 nm) lamps used for lighting treatment. Lettuces were inoculated (infected) by 7-day-old fungus *B. cinerea* isolate (LT13B_FRA_76) at the BBCH 21. The control was not inoculated (non-infected). The FRI = [(R410)−1−(R460)−1]R800, ARI2 = R800*((R550-1)-(R700-1)) were measured using the leaf spectrometer (CID Bio-Science). Our results showed that 1st day after inoculation (DAI), FRI of infected plants slightly increased compared with non-infected ones under HPS lighting. On the other hand, infected lettuce's FRI was lower than non-infected under LEDs. Analogously the same tendency was determined with ARI2. Furthermore, 3 DAI FRI of infected lettuce were significantly higher than non-infected under LEDs because flavanols and anthocyanins content increased due to stress caused by the fungus. Still, the ARI2 of infected plants under LEDs significantly decreased than non-infected ones under HPS. In conclusion, grey mould affected lettuce on 1 DAI, but significant differences appeared on 3 DAI. Response of lettuce to grey mould depends on lighting conditions and the time after inoculation. The selected indices are suitable for early detection of grey mould, but more research on fungus inhibition under different light conditions is needed.

SOIL SEED BANK AND THEIR RELATION TO SOIL PROPERTIES UNDER HILLY TERRAIN IN LITHUANIA

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Abstract

Assessing the relation between the soil seeds' accumulation and soil properties, particular characteristics of the soil have been determined: soil pH, organic carbon, total nitrogen, mobile phosphorus and potassium, humidity, structure, texture, microbial biomass carbon. Soil seed bank investigations were conducted in three agrophytocenoses: permanent grassland, cereal-grass crop rotation and crop rotation with black fallow, in different parts of the hill (summit, midslope and footslope). Analysing the permanent part of the seed bank, correlations with soil pH, mobile phosphorus and potassium, total nitrogen and organic carbon were determined in the depth of 5–15 cm of the midslope of the hill and in both depths of the footslope of the hill, where the conditions for plant growth were better. Analysing the whole seed bank correlation data with mobile phosphorus and potassium and soil pH, similar tendencies have been determined as assessing the permanent part of the seed bank. Correlation between the seed number and organic carbon as well as the total nitrogen was not determined. The seed number in the soil seed bank in most of cases depended on composition of aggregation in the soil (r = 0.40–0.68 in spring and r = 0.40–0.87 in autumn). In the footslope of the hill with higher amounts of organic carbon, there were less statistically significant correlations determined. Negative correlations were determined with aggregates in 8.0–0.2 mm diameter size, while positive correlations – with aggregates in 0.063 mm diameter size and dust. In 0–5 cm depth of the summit of the hill with the lowest humidity and the number of particles of clay in the soil, there were no correlations with the seed number in the soil seed bank determined. Negative weak and medium correlations with the number of particles of clay were determined in other parts of the hill. In autumn, correlation was found between the total seed number and soil microbial carbon biomass (r = −0.493–0.801).

CHANGES IN THE FUNGAL COMMUNITIES OF NORWAY SPRUCE ALONG A LATITUDINAL GRADIENT FROM SLOVAKIA TO NORTHERN FINLAND

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Abstract

A vital part of forest trees are fungi that play an important role in soil's energy flow, nutrient cycle, and transformation of organic substances. In addition, fungi associated with trees play a critical role in their health and may significantly impact future adaptation to climate change. The study aimed to assess the diversity and composition of fungal communities in *Picea abies* tissues and the rhizosphere soil under different environmental conditions in Europe. The needles, shoots, roots, and rhizosphere soil were collected in a 2700 km-long transect of climate gradient going through Finland, Estonia, Latvia, Lithuania, Poland, and Slovakia (12 sampling plots). Genomic DNA was used for PacBio-based amplicon sequencing of the ITS2 rRNA region. The results showed that the species richness of the fungal communities varied by site and tissue type. A greater diversity of fungi was found in spruce shoots than in needles, but needles were more often colonised by pathogens compared to other tissues or soil. Current analyses also indicate that annual mean temperature, the average temperature of the coldest quarter, seasonality of precipitation, and the concentration of NaCl in the soil strongly correlate with fungal species richness. Results also suggest that precipitation, precipitation in the driest quarter, and P_2O_5 concentration in the soil have the greatest influence on the shaping of fungal communities.

IMPACT OF POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) ON THE GROWTH OF BLACK ALDER (*ALNUS GLUTINOSA*) SEEDLINGS

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Abstract

Polycyclic aromatic hydrocarbons (PAHs) are released into the environment through combustion processes and can accumulate in tree tissues. Exposure to PAHs has been linked to reduced tree growth, changes in leaf structure, and decreased photosynthesis efficiency. The seedlings of black alder (*Alnus glutinosa*) trees were then transferred to hydroponic conditions with Hoagland nutrient medium supplemented with PAHs (pyrene, fluorene, naphthalene, phenanthrene) at one of four concentrations (0, 10, 100, and 200 μg L^{-1}). Plants' morphological parameters were measured: shoot height, root length, and the area of the largest leaf. Results showed that every half-sib family reacted differently to a different pollutant, but all were negatively affected. 100 and 200 μg L^{-1} concentrations of phenanthrene significantly affected the growing parameters of two half-sib families, and one half-sib family exhibited bigger resistance than the others. The lowest pyrene concentration (10 μg L^{-1}) did not affect half-sib families. Naphthalene had a divergent negative impact on all half-sib families and their growth rates, with no discernible trends. It is worth noting that there was no single half-sib family with any resistance to this pollutant. Similarly, fluorene affected all half-sib families negatively. Only the longest root results showed that this pollutant (concentration of 10 μg L^{-1}) did not adversely affect two half-sib families. Each black alder half-sib family showed different response mechanisms to the PAHs used. However, it can be noted that seedlings used in this experiment are more resistant to phenanthrene and pyrene and exhibited better growth rates. In contrast, naphthalene and fluorene had a much more negative effect and inhibited growth.

EXOGENOUS PHYTOHORMONES: PHOTOSYNTHETIC RESPONSE OF LETTUCE AND PEA

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Abstract

Plant phytohormones participate in all aspects of plant growth and development. Biostimulants based on phytohormones could also participate in regulation and optimization of plant growth. They are known for their ability to promote or inhibit bud development, relieve stress, improve metabolism, photosynthesis, which helps to achieve bigger, more stable yield. The impact of exogenous phytohormones on different growth strategy plants photosynthetic response was evaluated. Lettuce (*Lactuca sativa* L.) 'Green Cos Lobjoits' grew in a greenhouse with a 16-hour photoperiod, 70% humidity and an average temperature of 21–22°C during the day, and 15–17°C at night, was maintained. Pea (*Pisum sativum* L.) 'Respect' grew in a vegetation area with a shed during May-July (lat. 55°, Lithuania). Two phytohormones were chosen: kinetin (KIN) and indole-3-acetic acid (IAA), at 0, 15, 30, 45, and 60 mg L^{-1} for lettuce and 0, 30, 60, 90, and 120 mg L^{-1} for pea. Exogenous phytohormones were applied at critical development stages: BBCH 12–13 for lettuces and BBCH 14–16 and 51–55 for peas. Measurements were performed after 5 days of each application and at technical maturity. Results showed that KIN application influenced photosynthetic response in lettuce and IAA in peas. Different phytohormones affect photosynthetic response differently, depending on plant growth strategy.

PROLONGED HIGHER TEMPERATURE DURING COLD ACCLIMATION AFFECTS METABOLITE ACCUMULATION AND FREEZING TOLERANCE IN WINTER WHEAT

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Abstract

Low positive temperatures up to 10°C are an essential environmental signal contributing to cold acclimation (CA) induction in winter wheat. CA activates numerous molecular changes, which lead to increased freezing tolerance (FT). Nevertheless, there is insufficient research regarding the effect of prolonged warmer autumns upon the efficacy of CA and the resulting FT, which remains one of the main factors conditioning grain yield in winter wheat. Our recently published studies (Vaitkevičiūtė et al., 2022a, b) compare the effects of constant low-temperature and prolonged higher low-temperature on shoot biomass and metabolite accumulation as well as FT in 6 different winter wheat varieties throughout CA, deacclimation (DEA), and reacclimation (REA). Shoot biomass accumulation was assessed by applying non-destructive RGB imaging-based phenotyping. Quantitative measurements of carbohydrates, hexose phosphates, organic acids, amino acids, proteins, and antioxidants were carried out in winter wheat leaf and crown tissues. Freezing tests were performed at the stages of CA, DEA, and REA. The prolonged higher low-temperature treatment during CA resulted in a significantly higher accumulation of shoot biomass and decreased FT in all 6 winter wheat genotypes in comparison to the constant low-temperature treatment. Metabolite accumulation patterns in leaf and crown tissues as well as the differences between the two temperature treatment groups throughout CA, DEA, and REA will be highlighted, and significant correlations between FT and these metabolites will be discussed.

3.5. PLANT GENETICS AND BREEDING

IDENTIFICATION OF GENETIC COMPONENTS OF ROOTS SYSTEM ARCHITECTURE (RSA) IN SPRING WHEAT UNDER DROUGHT USING SENSOR-BASED PHENOTYPING

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Abstract

Wheat is an important cereal crop which is affected by drought stress globally. In Nordic and Baltic regions, under drought stress, spring wheat roots go through challenges like reduction in size and nodal root length, making it difficult for the plant to uptake the required water and nutrients for healthy growth. There is a considerable loss of yield due to the drought stress in this region. Root system architecture (RSA) plays an important role in plant adaptation to water-limited conditions. Therefore, Genome wide association (GWAS) analysis using data obtained from phenotypic and genetic experiments, underlying root system architecture in wheat under drought stress is important to understand drought tolerance. Sensor-based phenotyping techniques using the pouch and wick method are powerful tools for characterising crop root traits. In this study, a set of 200 wheat genotypes with different levels of drought tolerance will be screened using a phenotyping platform, and the genetic basis of RSA traits will be investigated using GWAS. The results of this study will reveal significant associations between specific genetic loci and root traits, and insights into the genetic mechanisms controlling root system architecture in wheat under drought stress. The findings of this study will have implications for the development of wheat varieties with improved drought tolerance through the genetic engineering techniques for modification of RSA traits.

GENETIC DIVERSITY OF PLUM (*PRUNUS DOMESTICA*) HYBRIDS DEVELOPED IN LITHUANIA USING SSR MARKERS AND THEIR RESISTANCE TO *MONILINIA* SPP.

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Abstract

The European plum is a member of the *Rosaceae* family, *Prunus* genus. The biggest damage for *Rosaceae* family plants during the whole vegetation period is done by fungal diseases, especially brown rot, caused by *Monilinia* spp. pathogens. The breeding of European plums in Lithuania started in 1952. Besides good quality and yield of new cultivars, the main tasks for European plum breeding in Lithuania are the resistance to winter hardness and diseases. This study aimed to evaluate the genetic diversity of European plum (*Prunus domestica*) hybrids genotypes developed in Lithuania and their resistance to *Monilinia* spp. pathogens. The resistance to *Monilinia* spp. pathogens was evaluated in 39 European plum hybrids developed and growing in the Institute of Horticulture orchards of the Lithuanian Research Centre for Agriculture and Forestry. Blossom blight on the plum trees was evaluated on the annual shoots immediately after flowering in May, and the brown rot – on fully ripened fruits during their picking time in August - September. The genetic diversity of these genotypes was analysed using nine microsatellite markers (SSRs) previously published by the European Cooperative Programme for Plant Genetic Resources (ECPGR). The genetic structure was evaluated with the Bayesian model-based clustering method with software Structure v. 2.2.3. The phylogenetic tree was constructed using an unweighted pair group method with an arithmetic mean (UPGMA) clustering method. European plum genotypes were grouped into seven clusters in the phylogenetic tree according to their parental form. However, there was no correlation between genotypes' resistance to *Monilinia* spp. and the grouping according to molecular markers. Two separate groups containing 'Jure' parental form and its hybrids and 'Aleksona' parental form with its hybrids were observed in the genetic structure analysis with Bayesian clustering method.

DNA MARKER-BASED GENETIC STRUCTURE AND DIVERSITY OF NORWAY SPRUCE POPULATIONS IN LITHUANIA

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Abstract

Norway spruce is the most economically and ecologically important forest tree species covering 21.1% of the total forest area in Lithuania. However, yearly, more extensive areas of Norway's spruce forests are becoming vulnerable to pests and diseases due to the changing environmental and climate conditions. According to the EU Forest Strategy 2030, maintaining biodiversity in forest ecosystems is essential for adapting forests to climate change and restoring forests affected by it, as populations with lower genetic diversity may be more susceptible to environmental changes or diseases, which may reduce their productivity. DNA markers-based knowledge of the genetic diversity and structure of Norway spruce populations in Lithuania will help to increase their resilience and adaptation to climate change. Up to date, in Lithuania, Norway spruce has not been studied using different DNA markers (e.g., nuclear, chloroplast and mitochondrial DNA analysis). Previous genetic studies of Norway spruce have been based on phenotypic variation and the results from provenance trials. Therefore, the PhD study aims to investigate the evolutionary origin of Norway spruce populations in Lithuania based on nuclear and organelle DNA markers and to assess the genetic structure and diversity and possible loss of genetic variation due to genetic drift and inbreeding in Lithuania. The PhD project and its implementation plan will be presented.

TRANSCRIPTOME ANALYSIS OF DIPLOID AND AUTOTETRAPLOID *HEMEROCALLIS* RESPONSE TO DROUGHT STRESS

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Abstract

Chromosome doubling in perennial plants must mediate superior tolerance to abiotic stress. Drought is the most critical growth-limiting factor in a changing climate. Drought tolerance is one of the decisive factors for the survival, productivity, and appearance of perennial ornamental plants. Understanding and elucidating the molecular mechanisms that determine plant response to abiotic stress is essential. *De novo* transcriptome assembly of diploid and autotetraploid *Hemerocallis* spp. 'Trahlyta' was done under artificially induced stress to elucidate molecular mechanisms related to plant response to drought. In daylily mRNA, 237,886 transcripts were detected, and 42.4% of them were identified as annotated unigenes. Diploid plants were more stressed in the experiment, whereas 2,871 upregulated or downregulated DEGs (differentially expressed genes) showed a response to drought, while 1,599 DEGs were found in tetraploid plants. The proportion of upregulated DEGs between diploid and autotetraploid genotypes was 1.3 times, and downregulated was 1.8 times higher in diploid plants. Signalling pathways related to drought response were activated in daylilies, and key candidate genes were identified in both ploidy genotypes. In autotetraploid plants, more drought-related pathways were activated than in diploids – 43 and 19, respectively. Most abundant with DEGs in both cases were KEGG Metabolic (ko01100) and Biosynthesis of secondary metabolites (ko01110) pathways. Summarizing the data, it was found that autotetraploid plants of daylily have a wider potential for adaptation to abiotic stress. Therefore, they adapt faster and better to adverse drought conditions by activating alternative signalling pathways. The comparative transcriptome analysis among diploid and autotetraploid plants allows us to understand the molecular mechanisms of drought resistance and it is also essential for daylily breeding programs to develop drought-resistant genotypes in future.

USE OF IMPROVED REPRODUCTION MATERIAL TO AVOID SPIKE KNOTS FORMATION

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Abstract

Assisted migration is expected to boost the growth of coniferous trees in the Baltic Sea region. However, simply increasing biomass may not be sufficient to compete with regions that have larger annual tree increments. Therefore, it is necessary to consider stem and wood quality traits in tree breeding. This study aimed to examine the effect of family on spike knot incidence and its relationship to growth traits using repeated inventories and sample trees from open-pollinated progeny trials. The presence of spike knots was found to be associated with better height growth and the presence of lammas shoots, but family-level associations with growth were not clear. Although there was a statistically significant family effect on growth and spike knots, the correlation between both traits was weak. Spike knot incidence decreased with the age of the trees, indicating that inventory results at a juvenile age might be misleading. The heritability of spike knots was low. Although the presence of lammas shoots was rare, it had a strong positive genotypic relationship with the formation of spike knots in the next growing season. The study suggests that it is possible to select fast-growing families with a low probability of spike knots.

ASSOCIATION BETWEEN MORPHOLOGICAL TRAITS AND FUSARIUM HEAD BLIGHT (FHB) RESISTANCE IN SPRING WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract

Fusarium head blight (FHB) also known as scab, caused by *Fusarium* spp. complex is a destructive disease of wheat crop that leads to quality and yield losses, and the accumulation of mycotoxins in grains. The aim of this research was to identify the traits associated with resistance to Fusarium head blight in wheat. To achieve this objective, a collection of 336 genotypes of spring wheat of both exotic origin and local genotypes were used. The trails were artificially inoculated to visually evaluate the FHB resistance in the genotypes. The genotypes were assessed for type-I (initial resistance) and type-II (pathogen spreading within spike) resistance through spray and precise inoculation (i.e., 2×10^{-5} spores/ml spore suspension) respectively, under controlled and field conditions in 2022. The relationship between FHB scores and several morphological traits including, days to heading, spike length, spike density, and awn length which may contribute to passive defence mechanism against FHB was studied. Based on the results, there was a slight significant correlation between FHB scores and some morphological traits. Which revealed that longer and less dense spikes, along with late maturity related to fusarium head blight resistance in wheat.

POLYMORPHISM OF LITHUANIAN SMALL BALSAM (*IMPATIENS PARVIFLORA* DC.) REVEALED BY MOLECULAR MARKERS

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Abstract

Small balsam (*Impatiens parviflora* DC.) is an annual herbaceous invasive plant. It spreads mainly in European forest areas which are affected by human activities. Areas invaded by this species has been expanding due to many different factors. The purpose of our study was to estimate genetic variation of invasive species *I. parviflora* populations growing in Lithuania by amplified fragment length polymorphism (AFLP) markers. For AFLP analysis 105 *I. parviflora* individuals from 21 populations were sampled. Populations were located in south-eastern, central and north-western regions of Lithuania. Eight primer pairs were used for the analysis of AFLP loci. A total of 223 DNA fragments were found, 74% of them were polymorphic. Percentage of polymorphic loci ranged from 11.2 to 34.1 (mean value 20.1). Principal coordinates analysis (PCoA) revealed that most genetically related populations were in north-western Lithuania and the most scattered populations were in central Lithuania. Populations did not differ significantly according to their biotope, geography, or road types. According to analysis of molecular variance (AMOVA) genetic variance among populations was lower than within populations. Bayesian analysis revealed many genetic clusters according to AFLP loci. Results of the research suggest that *I. parviflora* has been introduced to Lithuanian regions multiple times and in various ways.

3.6. SUSTAINABLE PEST MANAGEMENT

TILLAGE AND CROPPING SYSTEMS IMPACT ON SOIL CO_2 EMISSIONS

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Abstract

Due to the warming climate, agriculture is facing considerable challenges. It is necessary to improve plant cultivation technologies that help preserve soil fertility and increase its vitality. Tillage systems, applied crop rotation, catch crops can influence soil carbon dioxide (CO_2) emissions differently. Often, no-till technology, cultivation of legumes reduces CO_2 and N_2O (nitrous oxide) emissions from the soil. CO_2 efflux from soil is related to many factors such as air and soil temperature, precipitation, soil water content. The field experiment was established in the Central part of Lithuania in 2021 having a split – plot design in four replications. The experiment consists of two backgrounds: tillage (conventional tillage (CT), no-tillage (NT)), and crop rotations. Catch crop – white mustard (*Sinapis alba* L.). Soil CO_2 emissions (μmol m^{-2} s^{-1}) were determined in a 0–10 cm soil layer with a portable analyser Li-Cor 6400-09 during plant vegetation period in 2022. Soil temperature and soil moisture were measured at the 5 cm depth using a portable sensor HH2 WET at the same time and same site with CO_2 efflux measurements. The aim of the research was to determine the impact of tillage practices in combination with different crop rotations on soil CO_2 emissions, soil moisture and soil temperature. The results showed that CO_2 efflux was higher in CT than in NT. Emissions intensity was highest in WW+CC-SW (winter wheat + catch crop-spring wheat) crop rotation in CT and in WW-SW (winter wheat-spring wheat) crop rotation in NT practices. In August, due to prevailing dry and hot weather, soil moisture reserves rapidly decreased in both tillage systems, in all studied crop rotations and the lowest CO_2 efflux was observed in the WW+CC-P (winter wheat + catch crop-peas) crop rotation in both tillage systems. The intensity of CO_2 emissions in CT was recorded in August, when the soil temperature was the highest.

THE INFLUENCE OF FOLIAR SPRAYINGS BY ESSENTIAL OIL ON THE STORAGE LIFE OF *DAUCUS CAROTA* L.

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Abstract

Chemical plant protection has been widely used in agriculture to control diseases, pests, and weeds. However, it poses several challenges and issues, including environmental impact, health risk, pests' resistance, regulatory challenges, and public perception. Therefore, there is a need for alternative disease management strategies that are more sustainable and environmentally friendly to address these challenges and issues. Using essential oils as foliar spray has great potential to improve the storage life and quality of fruits and vegetables, reducing waste and increasing their availability to consumers. This study aimed to evaluate the influence of foliar spray applications with essential oil obtained from *Thymus vulgaris* L. on the storage life of *Daucus carota* L. The experiments were performed at the Institute of Horticulture, LAMMC. *T. vulgaris* essential oil (0.01% concentration) applications were made from BBCH 15 and repeated five times during the plant vegetation period. The visually healthy harvested carrots were kept at about 5°C temperature for 24 weeks. The appearance and physical parameters were assessed every 8 weeks. One replication comprised 50 carrots. In this study on carrot storage, foliar sprayings of *T. vulgaris* essential oil did not improve storage time. However, it was noticed that minimal weight losses were observed until the 16th week of storage. Overall, further research is needed to determine the optimal concentrations and application methods for different essential oils to reduce decay and maintain quality of carrots significantly.

LYMANTRIA MONACHA OUTBREAKS ALTER THE COMPOSITION OF NON-TARGET INSECTS IN *PINUS SYLVESTRIS* FORESTS

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Abstract

The nun moth (*Lymantria monacha*), an important defoliator of coniferous trees in Central Europe is expanding its distribution range and abundance further northwards. Current climate scenarios also indicate more favourable conditions for the growth of nun moth populations in Lithuania, and significantly alter the outbreak dynamics. However, little is known about how the changes in the size of a single insect pest population harm populations of non-target insects and disrupt species interaction networks. This study aimed to investigate the effect of *L. monacha* outbreaks on epigeal non-target insect populations in Lithuanian Scots pine stands. The insects were counted in the second year after the pest outbreaks (May and October 2021), using Barber traps in two types of study sites I) *L. monacha* outbreaks – no treatment, and II) *L. monacha* outbreaks – treatment with biological insecticide Foray 76B (control). The results showed that untreated pine stands with *L. monacha* outbreaks had a higher richness of non-target insects than stands treated with the biological insecticide. However, the relative abundance of non-target insects in untreated stands (22.8 ± 1.5 individuals) was lower than in treated stands (32.2 ± 1.9). Such differences were strongly influenced by the reduced abundance of *Hymenoptera* in untreated stands. Outbreaks of *L. monacha* also cause significant changes in the trophic structure of non-target insects. In untreated stands, the ratio of entomophagous insects becomes lower than in treated stands, 82.9% and 88.2%, respectively, while in contrast, the ratio of coprophagous becomes higher in untreated (7%) than in treated stands (4.3%).

METAGENOMICS AND ITS APPLICATION IN ORCHARDS

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Abstract

Agricultural productivity is highly influenced by various microbial communities. Metagenomics, being a culture-independent technique, overcomes the bottleneck of cultivation and unlocks the ability to study all microbial populations, function and interactions with their host found in their natural environment. The goal is to completely characterise the structure of the community, functional activity of each microbial member and the intra species heterogeneity information. Most plant microbiome studies have focused on root systems, comparing with studies on other plant organs. Additionally, the diversity of microorganisms is affected by other biotic or abiotic factors. The metagenomics in the field of agriculture can be used for plant and animal health, crop production, yield improvement, studying symbiotic associations and many more. Metagenomics can be applied for identifying of antibiotics resistant genes in agriculture. The metagenomics was used for microbiome diversity studies during different growth stages and storage of strawberry plants, of apple fruits from different geographical locations and management practices and compared the differences of microbiome diversity between short and long-term natural and conventionally farmed apple orchards. In the studies of plums, it was stated that cultivar and growth season contribute to the structure of the bacterial and fungal communities associated with plum and that plum phyllosphere is a good source of antagonists effective against phytopathogens. Also, it was noted, that one of the bacterial isolates showed successful results after testing the production of volatile organic compounds inhibiting the growth of the *Monilinia laxa* pathogen. The role of metagenomics is important to understand the diversity and dynamics between microbial communities and within their host, to identify biocontrol agents as plant health detectors and influencers for application in sustainable farming.

SEPTORIA LEAF BLOTCH SEVERITY IN WINTER WHEAT AT DIFFERENT SOWING RATES AND TIMES

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Abstract

How to protect crops from disease without damaging nature and reducing the use of chemical and hazardous plant protection products is the main problem in crop protection today. Hence, the sowing patterns are one of the management techniques to control the impact of plant-pathogen interactions, this study focuses on low-cost and environmentally safe disease control in wheat through the choice of sowing date and seeding rate. This approach is particularly valuable and useful as it informs about future possibilities to reduce the risk of the fungal diseases of wheat. This study aimed to compare the susceptibility of winter wheat to fungal disease when sown at different sowing times and rates. A multifactor field experiment was carried out at the experimental field of the Institute of Agriculture of Lithuanian Research Centre for Agriculture and Forestry in 2021–2022. Three seeding rates (350, 400, and 450 seeds m^{-2}) and three sowing times (early, optimal, and late) were tested on the background of natural infection. The severity evaluation of Septoria leaf blotch was done at the different growth stages on 10 randomly selected main tillers per plot according to the methods described in the EPPO standard (PP1/26(4), 2012). Full randomization with four replicates and Duncan's multiple range test at the significance level $P \leq 0.05$ were used. In 2021, in late sown plots, the plots sown at 450 seeds m^{-2} were more affected. In 2022, the disease severity on the flag leaves in the early sown plots at different seeding rates was higher. The flag leaves were more affected in the plots sown at the highest seeding rate. Septoria leaf blotch infection on the flag leaves in the plots sown at the early time was much higher.

The results of the study suggest that Septoria leaf blotch severity was lower in the optimal sown crop than in other sowing times. It was a tendency for the crop at a lower density to have a slightly lower spot blotch severity than the dense crop.

TILLAGE AND COVER CROP MANAGEMENT IMPACT ON WINTER WHEAT AND WINTER OILSEED RAPE YIELD

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Abstract

Winter wheat and winter oilseed rape are the most popular and profitable crops in Lithuania. Both crops are common in all farmers crop rotation. It is very important to get high yields and to adapt to the requirements to use integrated weed management (IWM) in the farm. Integrated pest management is inevitable in a modern farming system. Field experiment was started on 2021 in the Institute of Agriculture, Akademija, Kėdainiai district. The aim was to evaluate suitable IWM in sustainable tillage for winter wheat and winter oilseed rape growing technologies. For that reason, it is very important to find the best way how to adapt IWM into the farms and to get more benefits. The experiment was established at split-plot design in 4 replications. Three tillage practices: deep ploughing (22–24 cm), harrowing (8–10 cm), and direct drilling with and without cover crops. Traditional technology – intensive herbicides usage, including glyphosate application before or after drilling, before emergence of crop and integrated – cover crops, herbicides usage on-demand, excluding glyphosate. The previous crop for winter wheat was field pea and field beans and for winter oilseed rape – spring barley and field pea. White mustard *Sinapis alba* L. was drilled after field pea harvesting and kept until the soil preparation and winter wheat drilling. Field beans *Vicia faba* L. were drilled together with winter oilseed rape in every second row. Persian clover *Trifolium resupinatum* L. seeds were spread on the soil surface using fertiliser spreader at the beginning of vegetation of winter wheat and winter oilseed rape in early spring. Based on one year data, winter wheat yield was higher using IWM technology comparing with traditional. Opposite results on oilseed rape yield, yield was higher in traditional growing system. Results suggest that white mustard and Persian clover as a cover crop for winter wheat are a promising tool for extensive tillage and especially no-tillage technologies.

STRATEGIES TO CONTROL APPLE SCAB IN INTEGRATED PEST MANAGEMENT (IPM) ORCHARDS BY INCLUDING INORGANIC PRODUCTS AND FOLIAR FERTILISERS

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Abstract

The apple orchards are perennial plantings where pesticides are applied to control numerous pests and diseases. The highest consumption of pesticides is required to control apple scab, caused by *Venturia inaequalis*. The extensive use of fungicides can lead to fungicide residues in fruit production. The solution would be to use fungicides and foliar fertilisers with a suppression effect on the fungus to make the plant protection strategy more precise. The aim of the study was to establish a treatment strategy, including fungicides and foliar fertilisers for apple scab control for low-residue production. A two-year (2021 and 2022) trial was performed in Latvia in an integrated farmer's apple orchards. Six different strategies of fungicides and foliar fertilisers were applied to control apple scab. The decision of the exact time for applications with inorganic and synthetic fungicides during the primary infection period was supported by the decision support system (DSS) RIMpro. Foliar fertilisers were applied at key phenological stages of the crop. The standard and non-standard class ratio regarding scab was calculated at harvest. Fruit samples were analysed for identification of pesticide residues by "multi-residual" quantitative analytical technique (GC-MS/MS and LC-MS/MS). The fungicide strategy combining inorganic fungicides with synthetic fungicides provided the highest standard production proportion in the high inoculum orchard. In the low inoculum orchard, all tested strategies using fungicides and fertilisers worked well compared to untreated control. The detected amount of fungicide residues in fruits was lower in the strategy combining inorganic with synthetic fungicides compared to a strategy with only synthetic fungicides.

EFFECT OF VARIETY, SEED TREATMENT AND SOWING TIME ON ROOT ROT SEVERITY AND YIELD IN WINTER WHEAT

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Abstract

One of the components to keep cereals yield safe is healthy seeds. Main threats for winter wheat in early growth stages are seed-borne or soil borne diseases such as seedling blights and root rots caused by (*Fusarium* spp., *Microdochium nivale*, etc.) or snow mould. To ensure the overwintering and survival of plants it is essential to choose healthy seed, right time of sowing and crop varieties with high levels of overwintering and resistance to diseases. Besides these factors, the chemical seed treatments are in high importance to protect the crops. In this study the effects of sowing time, varieties and chemical seed treatments on root rot severity and grain yield were investigated. Field experiments with optimal and late sowing times carried out. Each of them was laid out in five varieties: 'Skagen', 'Ada', 'KWS Emil', 'Etana', and 'Patras'. Selected varieties were artificially inoculated with *M. nivale* during winter wheat flowering. Prepared seeds of each cultivar were treated with 4 different and widely used seed treatment fungicides (STF), untreated seeds were sown for control plots. The severity of root rots was assessed on seedlings (BBCH ~21) in early spring. Yield was harvested when crops were fully ripe (BBCH 89).

The results suggested that, regardless of variety and seed treatment, winter wheat sown at optimal time were more damaged by root rots compared to later sown wheat seedlings. The highest root rot severity was in winter wheat variety 'Skagen' at both sowing times but that did not affect yields significantly. Generally, all used STF effectively controlled root rots and biological efficacy averaged up to 20.8% in optimal sown plots and up to 29.4% in late sown winter wheat. Disease control partially reflected in yield increases which fluctuated up to 0.7 and 0.8 t ha^{-1} in optimal and late sown plots, respectively. However, no effect of sowing times was recorded in comparing the yield data.