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Challenges to
Climate
Change

Adaptation and mitigation of climate change in agriculture

– an interdisciplinary approach

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WATER MANAGEMENT CHALLENGES AND ADAPTATION STRATEGIES TO CLIMATE CHANGE IN ALANYA, TÜRKİYE

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Abstract

Global warming and climate change are currently perceived as one of the most significant threats to agricultural production and food security in the 21st century. Agriculture, especially in terms of water resources, is a climate-sensitive sector, with changing climatic conditions—particularly droughts and extreme rainfall events—imposing significant pressure on agricultural systems worldwide. In regions with a Mediterranean climate, such as Türkiye, water scarcity is an urgent problem, and the balance between water supply and demand is becoming increasingly challenging.

In Türkiye, the rapid expansion of cultivation areas for water-intensive tropical fruits like bananas and avocados in subtropical climate regions such as Alanya is significantly increasing the demand on water resources. Information about a 30% increase in agricultural water consumption due to tropical fruit cultivation in the Alanya Water Users Association (WUA) area, without a proportional rise in crop production, and a 100% surge in overall water demand due to rising population and tourist influx, is not directly supported by the currently provided sources. Producers' lack of sufficient technical knowledge regarding irrigation timing and quantity, neglect of plant water consumption, and improper irrigation methods negatively impact production efficiency and quality. Although modern drip irrigation systems are widespread, the lack of volumetric water measurement and parcel-based real-time plant water needs can lead to excessive consumption. Furthermore, water pricing mechanisms based on area rather than volume do not encourage efficient use.

To combat these negative impacts of climate change and enhance the resilience of agricultural systems, various adaptation strategies are crucial:

Improving water use efficiency is essential for efficient water resource management and irrigation. Modern, precise irrigation techniques such as drip and sprinkler systems significantly increase water use efficiency and improve yields. Increasing farmer training and agricultural advisory services are essential. Modernizing irrigation infrastructure through increased public support and encouraging the adoption of pressure irrigation systems is critical. The reuse of treated used water in agriculture also offers significant potential for water resource conservation.

In conclusion, the increasing pressure of climate change on water resources and agriculture necessitates the adoption of integrated and multifaceted strategies. These strategies will contribute to establishing sustainable and resilient agricultural systems through effective water management, the development of climate-resilient crop varieties, improved soil health, and the use of innovative agricultural technologies.

Key words: Climate Change, Water Management, Agricultural Adaptation, Tropical Fruits

CROP PRODUCTIVITY AND SUSTAINABILITY IN RAINFED LOESS PLATEAU OF CHINA

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Abstract

Agricultural practices in semiarid regions, especially the rainfed Loess Plateau, confront water scarcity, erosion, low productivity, and the urgent need to mitigate greenhouse gas (GHG) emissions. With crucial climate parameters like low rainfall (390 mm) and cool temperatures (6.7 □), agricultural output is constrained to one crop per year. This study evaluates the efficacy of plastic mulch versus stubble mulch in enhancing crop productivity and sustainability in the rainfed Loess Plateau conditions. Multiple experiments were performed to explore various agricultural practices, including conservation tillage with stubble management, tillage methods, nitrogen rates, organic amendments, organic fertilizer substitution rates, planting density variations, and the application of weather-resistant plastics. Findings from conservation tillage research since 2001 indicate improved yield sustainability, increased soil organic content, reduced carbon footprint, and maintained nitrogen footprint through no-till with stubble retention in wheat-pea crop rotation. Plastic mulching in dryland agroecosystems increased soil organic carbon (SOC) sequestration and crop carbon fixation. However, plastic mulching increased GHG emissions by 108% compared to non-mulching, with plastic film applications contributing 52% of GHG emissions and fertilizers contributing 34%. Subsoiling before mulching, an optimal nitrogen rate of 200 kg ha-1, and 37.5% organic substitution emerged as effective practices for enhancing yield, water use efficiency, and mitigating environmental impacts. Stubble mulching demonstrates the potential to improve yield WUE and reduce the carbon footprint of wheat and peas. Plastic mulching proves advantageous for crops requiring higher temperature accumulation. Implementing subsoiling, optimal nitrogen rates, and organic substitutions are crucial to achieving high yields, water use efficiency, and minimizing the environmental impacts of rainfed maize production on the Loess Plateau. Additionally, reclamation and reuse of plastic film offer solutions to plastic pollution and help mitigate the increase in carbon footprint.

Key words: Conservation agriculture, Greenhouse gas emissions, Plastic mulch, Rainfed agriculture, Stubble mulch, Crop Sustainability.

CARBON FOOTPRINT OF FOOD PRODUCTS - LIFE CYCLE APPROACH

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Abstract

Carbon footprint is the total amount of greenhouse gas emissions and is used to quantify the impact of food industry and/or its products on climate change. Life cycle assessment is a standardized method with the potential to analyze the impact of climate change "from the farm to the fork and beyond" covering all parts of the food chain continuum, from primary production to households.

In general, according to ISO 14040:2006 and ISO 14067:2019 it's important to: (i) define life-cycle boundaries and functional units, (ii) based on inventory, collect the main data and evaluate quality of data; (iii) calculate the carbon footprint, considering allocation if needed (iv) interpret the results joint with sensitivity analysis. Although the entire life-cycle approach is "standardized", many challenges when calculating carbon footprint of food products occur.

One of the main challenges is the potential of comparing the results within the same agronomy / food sector where choice of system boundaries and functional units results in (un)comparable results. This is even pronounced when new / modified agricultural practices or food technologies are applied such as the "Zero residue" concept or application of nonthermal food processing technologies.

Based on the results and interpretation, the next step is to introduce decarbonization initiatives and mitigation strategies in combating climate change.

Finally, it is important to address another challenge related to climate change in the agronomy / food sector - the need to raise the competences among both students and teachers. Recent studies analyzing how climate change education is handled at universities show several obstacles such as lack of funding for climate related research, lack of staff expertise, and inflexible curriculum. This question is of great importance knowing that today's students will pave the road for decreasing carbon footprint of food products in the near future.

Key words: climate change, food chain, inventory, carbon footprint competence

ADOPTION OF THE SITE-SPECIFIC CROP MANAGEMENT PRACTICES IN THE CZECH REPUBLIC

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Abstract

Site-specific crop management uses precision farming technologies to differentiate agronomic practices within the fields based on the assessments of soil properties and plant status. Numerous studies suggest that this approach meets goals of sustainable agriculture by optimizing crop inputs (fertilizers, pesticides, fuel, etc.) while addressing the local variability of soil, crop canopy and environmental limits. Also, evaluations of precision agriculture adoption across selected EU countries have shown that these technologies are actively promoted by policy and advisory institutions as a direction to enhance land productivity while preserving natural resources. The implementation of precision agriculture technologies in Czech Republic has been facilitated by the relatively large average size of farms and field blocks area compared to the EU average. The initial phase focused on GNSS guidance technologies, later followed by variable-rate fertilizer applications based on the soil and crop mapping. More recently, systems such as controlled traffic farming (CTF) and contour farming have been adopted. A significant shift in site-specific application of nitrogen fertilizers has occurred in recent years. Besides crop sensing by on-the-go sensors or satellites, current practice increasingly involves the delineation of field management zones from time series of satellite multispectral imagery and subsequent variable-rate nitrogen application based on nutrient balance principles. Field-scale trials conducted by Mendel University in Brno have demonstrated that variable-rate nitrogen application results in more balanced nitrogen budgets, particularly by reducing fertilizer inputs in low-yielding areas compared to uniform application. This reduces nitrogen losses and mitigates environmental risks, especially near water resources. High-resolution drone mapping, combined with advanced deep learning methods, enables detection of weed infestations for site-specific herbicide application. Studies indicate that patch/spot spraying can reduce herbicide use by several tens of percent. The efficiency of site-specific spraying may be increased by new generation of sprayers with nozzle-level control. The integration of these technologies into farming practices requires validation of their economic and environmental benefits, as well as sufficient user education. Experience from the Czech Republic shows that farmers are willing to adopt new technologies even without substantial subsidies provided by government. An increase of regulations on the use of chemical substances by farmers and the growing impact of climate change on agricultural land also can accelerate site-specific crop management practices as a core component of climate-smart farming.

Key words: precision agriculture, variable rate application, crop sensing, soil mapping

Acknowledgement

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REIMAGINING SEASONS: TOWARDS A DATA-DRIVEN FRAMEWORK FOR SEASONAL CLASSIFICATION

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Abstract

Seasonal dynamics profoundly influence ecosystems and human systems, yet conventional seasonal classifications— meteorological and astronomical —fail to reflect the complexity of biosphere-atmosphere interactions in the era of climate change. These traditional frameworks inadequately represent the evolving seasonal cycles and the way living systems, including human activities, anticipate and respond to them. This research proposes a paradigm shift in how we define and detect seasonal transitions, using biosphere-sensitive metrics derived from satellite-based and field data. Central to our approach is the use of vegetation indicators such as NDVI, EVI, LAI, fPAR, and the Bowen ratio, which together reflect the biological responses to changing environmental conditions. We introduce the seasonality index (DTRT - Daily Temperature Range normalized by average temperature) as a reliable, biologically grounded metric for quantifying seasonal dynamics. Our results show that seasonality index trends mirror phenological indicators and observed seasonal changes across various ecosystems—from boreal to Mediterranean zones. By analyzing key features of the DTRT time series—such as trend shifts, extremes, and inflection points—we identify the onset and duration of seasons with greater precision than traditional classifications allow. The findings reveal notable seasonal shifts in the Euro-Mediterranean region: shorter winters, longer summers, and sharper seasonal transitions. Geographic factors such as proximity to large water bodies, urban heat effects, and atmospheric circulation patterns (e.g., the Gulf Stream) further modulate local seasonality. This framework offers a scalable, ecosystem-sensitive alternative to existing seasonal definitions, with direct implications for climate adaptation in sectors including agriculture, urban development, healthcare, tourism, and financial planning. By redefining how we perceive and quantify seasonal changes, we lay the groundwork for more resilient and informed responses to a changing climate.

Funding

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UNCERTAINTY OF SOILS MOISTURE MEASUREMENT

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Abstract

The greatest influence on the level of agricultural plant production is the temperature distribution and the amount of available water. Measuring air and soil temperature is simple and precise, but measuring soil moisture is characterized by high uncertainty. So far, scientific research has practically ignored a very important issue – biological water retention in soil. All measuring probes measuring the volume of water in soil (FDR, TDR, TDT, HPP, DHPP, GPR-B and others) are not selective towards the water contained in living organisms. Consequently, the measured soil water content should be reduced by the water content in plant roots and other organisms. World literature does not address this topic.

The second source of uncertainty is the relationship between the probe sensitivity zone and soil variability. Measurement practice shows that humidity measurements at points even a few centimeters apart may differ significantly, but there are no scientific reports on this topic. Given the large spatial variability of soil moisture distribution, random selection of a measurement site as a reference point for estimating soil moisture for a larger area may therefore have serious consequences.

The aim of the research undertaken was to determine the influence of biological water retention on measurement error and to determine the spatial variability of soil moisture in selected locations on a scale of 1 m².

The problem of the influence of biological retention on the measurement error using the TDR and gravimetric methods was assessed in a series of experiments comparing the moisture content of soil with plant roots and the moisture content of the same soil after isolating the plant roots, while maintaining the same volume of tested samples.

Soil moisture variability was determined at 1m2 sites by establishing a measurement grid with a 20cm pitch resolution of 36 measurement points. Each of the 36 measurement points was a 12cm diameter circle, at which 5 measurements were taken using a TDR probe.

The correct measurement of soil moisture should be that which determines the water content in the soil itself – the soil without roots. In this approach, the measurement uncertainty, depending on the experience, ranged from 13.9 to 346.7%. This means that in extreme cases the measurement error reached 3.5 times the total water contained in the soil. The results indicate that the lower the total water content in the soil, the greater the measurement error resulting from biological retention.

The obtained results show very high variability of soil moisture. On a surface of 1 m2 the range of marked humidity reached 18.7%V/V. On a surface of only 113 cm2 the spread reached values of up to 15%V/V.

The obtained results of biological retention error and spatial variability of soil moisture were not correlated with the variability of granulometric composition and organic carbon content.

When analyzing the results of soil volumetric moisture measurements, one must be aware that the result obtained is the sum of water contained in the soil and living organisms. The choice of a reference point to reflect soil moisture for a larger area should not be random, but should be the result of prior measurement of the selected area with high resolution.

Key words: measurement error, soil variability, biological water retention, TDR

ENVIRONMENTAL IMPACTS OF SEAWEED – USING LIFE CYCLE ASSESSMENT AS A TOOL

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Abstract

Exploration of alternative sources of biomass for food, materials and energy is crucial for sustainable development. Seaweed represents a renewable biomass that has potential to facilitate a transition to a sustainable blue-green bioeconomy. Unlike terrestrial crops, seaweed can be cultivated or harvested without competing for arable land, freshwater resources or relying on mineral fertilizer and pesticides. To explore the climate and environmental impact of seaweed, life cycle assessment (LCA) can be used as a tool. Life cycle assessment is an increasingly important tool that is applied both in the production and consumption of food to reduce the climate and environmental impact.

The aim of the paper is to investigate the climate and environmental performance of seaweed-based products using life cycle assessment as a tool – by reviewing the existing literature and assessing a case study.

The review of LCA studies (Waqas et al. 2024) showed that most studies have been conducted in Europe, despite Asia accounting for most of the seaweed production. The majority of the LCA studies focused on brown seaweed species. Different seaweed products and applications in the different studies resulted in varying functional units and system boundaries, complicating comparison across studies. Key hotspots in seaweed production and processing include energy consumption for drying and processing in addition to fuel for transportation and infrastructure production. Developing consistent LCA methodologies is vital to assessing the climate and environmental potential for seaweed's diverse production systems and applications. The case study showed low climate impact and negative eutrophication potential Renewable energy adoption is key to reducing the climate impacts.

Seaweed products show strong potential for supporting sustainable development and reducing environmental impact. However, realizing the potential requires continued research and development in the seaweed value chain.

Key words: life cycle assessment, seaweed, LCA, environment, climate impact

References

Waqas et al. (2024) Sustainable Production and Consumption 48: 123-142.

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Abstracts

THE IMPACT OF CLIMATE CHANGE ON THE WELFARE AND PERFORMANCE OF SPORT HORSES

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Abstract

Weather conditions and global temperature trends have changed considerably over the years. A sharp rise in temperature is predicted for the coming decades. Seasonal fluctuations in temperature, humidity, wind and precipitation are now considered a potential risk to equine welfare. They increase the risk of diseases associated with heat stress as well as infectious diseases and have an impact on reproduction, athletic performance and the management of equestrian events. Previous studies confirm the negative impact of weather extremes on the training and transportation of sport horses and the impairment of athletic performance. As a result of climate change, there are significant health risks for sport horses, including heat stress, UV exposure, exposure to allergens, air pollutants, extreme weather events, etc. When a horse is in the thermoneutral zone (5-25 °C), the normal body temperature is between 37.5 and 38.5 °C. A change in body temperature outside the normal range is considered a stress factor. At competitions, there is a possibility of heat stress if the horse is unable to maintain body temperature within a prescribed temperature range due to increased physical strain, stress reactions and general discomfort in various, often prefabricated, stalls that are unsuitable for hot and humid conditions. Heat stress can also occur during transportation and with inadequate nutrition, including a lack of water and electrolytes, as well as poor cooling management. Due to heat waves and high humidity, a horse's body temperature can quickly exceed a critical range during intense exercise and cause Exertional Heat Illness (EHI). Overexertion in heat and humidity, inadequate ventilation or a change of climate zone without acclimatization can lead to extremely dangerous heat stroke. The effects of climate change can be reduced by accurate measurements of climatic conditions and appropriate management of the horse. The Wet Bulb Globe Temperature (WBGT) is used at many international equestrian events to measure the heat index. However, in the Republic of Croatia it is not used and there is insufficient information on whether competitions should be postponed. The aim of this article is to describe the impact of climate change on the welfare of sport horses and to highlight innovative techniques that can be used to mitigate the risk. This area has not yet been sufficiently researched, and further research is urgently needed in view of severe climate change and extreme weather conditions.

Key words: climate change, sport horses, equine welfare

HYDROLOGICAL–AGRICULTURAL INTERACTIONS IN THE BARANJA REGION AND KOPAČKI RIT NATURE PARK

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Abstract

The Baranja region, located in northeastern Croatia and encompassing Kopački Rit Nature Park, is characterized by intensive agricultural production. A developed network of drainage canals lies at the interface between cultivated farmland and the protected wetland area, collecting surface and groundwater and directing it toward natural watercourses and floodplains. These drainage systems fulfil a dual role: while they regulate excess soil moisture and mitigate waterlogging risks during the growing season, they also serve as potential conduits for nutrients, pesticides, and other agricultural pollutants entering sensitive aquatic ecosystems. In recent decades, climate change has intensified hydrological challenges in the region. Altered precipitation patterns—characterized by prolonged droughts, extreme rainfall events, and seasonal shifts in water distribution—have significantly impacted canal hydrology, affecting the retention and transport of dissolved substances. Intense rainfall following drought periods accelerates soil leaching, resulting in the rapid transfer of nitrogen, phosphorus, and pesticides from agricultural fields into drainage canals. This increases the risk of eutrophication and water quality degradation in downstream floodplain ecosystems. This study investigates spatiotemporal variations in water quality within the drainage canals of the Kopački Rit area, to assess their potential for monitoring agricultural impacts on surface waters. Three canal profiles—Grabovac, Zlatna Greda, and Barbara—were analyzed using monitoring data from 2010, 2011, 2017, and 2025, supplemented by official datasets from Croatian Waters. Key focus was placed on nutrient-related parameters, particularly total nitrogen. Elevated concentrations of nitrogen, phosphorus, or specific ions may lead to soil degradation and reduced agricultural productivity (FAO, 1994). Long-term data analyses reveal pronounced seasonal and inter annual fluctuations in nutrient concentrations, driven by precipitation variability, agricultural practices, and climatic shifts. Integrating systematic monitoring of drainage networks with conservation planning is certainly the best way that leads to sustainable land-use management in transitional zones between agriculture and protected areas.

Key words: drainage canals, nutrient transport, water quality, agricultural impact, climate change

CHANGES IN PRECIPITATION, AIR TEMPERATURE AND DROUGHT SEVERITY OVER ROMANIA SINCE AD 1901

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Abstract

This work deals with the long-term trends in precipitation, air temperature, and drought severity over Romania within the framework of the research project CARVE (Changes in climate suitability for Romanian Vineyards), which focuses on the impact of climate change on viticulture, an important and evolving economic activity in Romania, the 6th largest wine producer in the EU and the 12th in the world. For this purpose, we used the dataset RoCliHom, a monthly homogenized dataset of precipitation and air temperature (mean, minimum and maximum) over the Romanian territory, which includes 156 weather stations for the period 1901–2023. The statistical significance of trends was analyzed with the nonparametric Mann-Kendall test (a robust, rank-based method, especially suitable for non-normally distributed data, data containing outliers and non-linear trends). Our results show that annual precipitation has slightly increased at some stations in southwestern, northeastern and southeastern Romania. However, most of the stations present no significant trend. Annual air temperature has an increasing trend country-wide, while monthly temperature is rising in winter (December and January), spring (March and May) and throughout the entire summer (June-August). Interestingly, the monthly temperature range, i.e., the difference between the maximum and the minimum (monthly) temperatures, is decreasing, suggesting that the thermal variability has diminished since 1901. Drought intensity was assessed with two indices: SPI (Standardized Precipitation Index) and SPEI (Standardized Precipitation Evaporation Index). Since SPEI also takes into account the effect of air temperature, it managed to emphasize the drought evolution more accurately. SPEI showed an intensification of drought, during the growing season (April-September) for the last 70, 60 and 50 years, respectively. However, the longer periods show no significant trend. The main conclusions of the study are: (1) There is a clear climate warming trend over Romania since 1901; (2) There are no major changes in annual precipitation amount; (3) Long-term data series demonstrated that the drought episodes that occurred in the last decades were not unprecedented, as they seemed to be from studies done over shorter periods (e.g., since 1961).

Key words: historical weather station data, meteorological drought, potential evapotranspiration, Hargreaves, extreme temperature.

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WEED DYNAMICS AND MAIZE PRODUCTIVITY UNDER DIFFERENT CONSERVATIN TILLAGE SYSTEMS AND NUTRIENT MANAGEMENT

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Abstract

Conservation tillage helps mitigate climate change effects on crop productivity and influences weed dynamics. Weeds are a major biotic stressor, especially during maize's critical growth stages. Fertilization can improve maize competitiveness, reducing weed pressure. This study aimed to evaluate the impact of conservation tillage and fertilization on weed infestation and maize yield. A field experiment was conducted in 2021 at the experimental site in Križevci, Croatia). The study was designed as a split-plot experiment with three replicates. The primary experimental factor was soil tillage, with fertilization as the secondary factor. Tillage treatments included: CT (plowing to a depth of 30 cm), CTD (loosening to 30 cm with ≥ 30% crop residue), and CTS (shallow tillage to a depth of 10 cm with ≥ 50% crop residue on the soil surface). Fertilization treatments were: FR (recommended NPK 170:150:225 kg ha-1), FH (50% NPK), GFR (NPK + GeO_2 - a biophysiological soil activator at 300 kg ha-1), and GFH (50% NPK + GeO_2). Weed sampling was done at critical weed-free period for maize (V10 growth stage) using four 0.25 m² quadrats per plot to assess weed density (counting individual plants) and biomass (cutting weeds at ground level). Chemical weed control was applied uniformly across all tillage and fertilization treatments. Maize was harvested manually, and grain yield was adjusted to 14% moisture. Tillage and fertilization had a significant effect ($p < 0.05$) on all investigated parameters. The highest weed biomass (7.09 g m-2), accompanied by the lowest weed density (15.75 m-2), was recorded in the CTS treatment in average. The addition of GeO_2 with optimal fertilization resulted in the average highest weed biomass (5.80 g m-2) and, despite that, the highest average maize yield (13.94 t ha-1). Significant interactions ($p < 0.05$) among tillage and fertilization were observed across all measured parameters. The lowest weed infestation was recorded in the CTS treatment with reduced fertilization (FH). On average, the highest maize yield was also achieved under the CTS treatment (13.55 t ha-1). Shallow conservation tillage (CTS) with higher crop residue retention effectively reduced weed density and supported high maize yields. The combination of optimal fertilization with GeO_2 increased both weed biomass and maize yield. Conservation tillage and fertilization management proved crucial for sustainable maize production.

Key words: weed infestation, soil conservation, fertilization, Zea mays yield

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The results presented in the paper are an output from research projects (IP-2020-02-2647). "Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation – ACTIVEsoil.

SUSTAINABLE FARMING SOLUTIONS IN HUNGARY: INTEGRATING CONSERVATION TILLAGE WITH MICROBIAL INOCULANTS

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Abstract

Agroecological plant production plays a crucial role in sustainable agriculture, particularly in Hungary, where environmental preservation and crop productivity are both high priorities. This study investigates the long-term effects of combined practices, such as crop rotation, conservation tillage and microbial inoculation on the performance of ecological plant cultivation, aiming to identify optimal rotation schemes that enhance soil health, support sustainable yields, and contribute to the resilience of agro-ecosystems. Through a comprehensive, multi-year field experiment, various crop rotation systems were implemented and monitored to assess their impact on soil fertility, disease incidence, weed pressure, and overall plant yield. Statistical analysis using one-way ANOVA revealed no significant differences across most measured parameters and over years ($p > 0.05$), which is consistent with expectations given the limited tillage prior to the experiment. Despite the lack of statistical significance in most short-term parameters, observable trends suggest that plots treated with microbial inoculants exhibited improvements in plant yield compared to non-inoculated and control plots. These results indicate that microbial inoculants may exert cumulative benefits over time by gradually enhancing soil health, supporting beneficial microbial communities, and improving nutrient cycling. The findings underscore the potential of combining conservation tillage with microbial inoculation to foster resilient, productive, and sustainable small-scale farming systems. The novel experimental setting highlights the necessity of long-term monitoring to fully capture the benefits of agroecological practices, reinforcing their importance in advancing sustainable agriculture and supporting the viability of small-scale farms.

Key words: biofertilizers; PGMP; conservation tillage; agroecology; no-till; soil fertility; plant nutrition

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DECREASING GHG EMISSIONS FROM CORN/SOYBEAN SYSTEMS BY INCREASING COVER CROP PRODUCTION VIA THE EARLY HARVEST OF GRAIN CORN

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Abstract

This paper proposes a systems approach to decrease GHG emissions associated with corn/soybean production through increased cover crop production, decreased fuel use for corn drying, manure digestion, and digestate injection as crop fertilizer. Cover crops grown between corn and soybean crops have been shown to reduce GHG emissions. However, cover crop establishment costs typically exceed the value of the crop due to the limited growing window between the traditional grain corn harvest and soybean planting. The cost associated with cover crop use has limited their adoption. We propose the early harvest of grain corn to provide a longer cover crop growing period. By harvesting corn grain 30 days earlier, the cover crop growing window is extended, and the longer growing period increases cover crop yields enough to recover the cover crop establishment cost. System circularity is achieved by feeding the early harvest corn grain to animals and co-digesting the resulting animal manure with the high moisture (24-33% moisture) corn stalklage remaining after early grain harvest. The harvesting and utilization of high moisture corn can additionally reduce carbon emissions through the elimination of emissions associated with grain drying, which are estimated to be as much as 22% of the corn grain footprint. Calculations indicate that the CI score of corn grain production would be decreased by approximately 40% by adopting this system. In order for the proposed approach to provide the desired GHG emission reductions, changes at multiple points in the existing production system would be required. Corn producers would be required to move to the earlier harvest of corn, and the earlier planting of cover crops. Similarly, farmers and granaries would be required to master the storage and handling of high moisture grain. While high moisture corn is currently used as cattle feed, the feed production industry would have to successfully process high moisture corn into swine feed. Additionally, the pork industry would have to embrace the use of high moisture corn, or feeds that were produced from high moisture grains. All members of this circular system would be required to adopt some changes in order to realize the reduction of GHG emissions offered by this approach.

Key words: GHG emissions, cover crop, corn, soybean, manure anaerobic digestion

DRIVERS OF CONSUMER PREFERENCES FOR SELECTED VEGETABLES IN KOSOVO

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Abstract

This study examines the key determinants shaping consumer preferences for selected vegetable products in Kosovo, namely tomatoes, peppers, potatoes, and onions. The primary objective is to identify and analyze socio-economic and socio-demographic factors, along with other elements that influence consumer decision-making processes, including purchase quantity and frequency, preferences for domestic versus imported products, price sensitivity, quality assessment, food safety considerations, product type, geographical origin, packaging, and seasonality patterns. Understanding these factors is crucial for improving market strategies, supporting domestic agricultural production, and enhancing the efficiency of the vegetable supply chain. The research was based on primary data collected through a structured questionnaire administered to 404 consumers residing in urban areas across Kosovo. Respondents were selected to ensure representation across various age groups, income levels, and educational backgrounds. Data analysis was conducted using SPSS software, applying descriptive statistics and inferential statistical methods, including ANOVA, correlation analysis, Chi-square tests, and other relevant statistical tests to determine the significance of relationships between variables. The findings indicate a strong overall preference for domestic vegetable products, with 82.7% of respondents rating locally produced vegetables as important or very important in their purchase decisions. Consumption frequency varied among respondents, with 47.1% consuming vegetables two to three times per week and 39.4% on a daily basis. In terms of specific product preferences, peppers were the most preferred (30.8%), followed closely by tomatoes (29.8%), potatoes (26.0%), and onions (13.5%). Statistical analyses revealed significant differences between consumer groups, particularly between place of residence and vegetable preferences ($p = 0.001$). Moreover, higher-income consumers demonstrated a tendency to select vegetables based on quality, nutritional attributes, and other health-related characteristics, suggesting that income level plays a pivotal role in shaping purchasing behavior. The study offers insights into consumer behavior in the vegetable market, supporting policy, marketing, and supply chain improvements, and providing a basis for future research to promote sustainability, boost domestic production, and align supply with consumer needs.

Key words: Consumer preferences, vegetables, socio-economic and socio-demographic Kosovo

Acknowledgement

The findings presented in this paper originate from the master's thesis research conducted by MSc. Granit Zymeri.

NEW VARIETES FOR A NEW CLIMATE: THE KEY TO AGRICULTURAL ADAPTATION TO CLIMATE CHANGE

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Abstract

Climate change is already having a significant impact on agricultural production. Frequent droughts, heatwaves, unpredictable rainfall, and the spread of new pests and diseases pose increasing challenges to the sustainability and security of food systems. In this context, the introduction of new crop varieties that are more resistant to climate-related stress is becoming essential for adapting agriculture to changing conditions. The aim of this paper is to highlight the importance of developing and applying climate-resilient crop varieties in arable farming, with a special focus on eastern Croatia. Concrete examples of wheat, maize, and soybean varieties that have proven successful under conditions of increased drought and temperature extremes will be presented. Another goal of this work is to explore and assess the potential of crop species that have not traditionally been cultivated in Slavonia, but which, due to their resistance to drought, pests, and diseases, may offer a viable alternative to currently dominant crops. The paper emphasizes the importance of plant breeding, from traditional methods to more modern selection technologies, which enables agricultural production to keep pace with new climate challenges. Special emphasis is placed on the connection between scientific research, domestic agricultural institutes, and the needs of farmers in the field, considering the potential for increased agricultural resilience through variety adaptation. Climate adaptation starts with seeds and new varieties are key to ensuring a more resilient and secure food production in the future.

Key words: Climate change, varieties, crop production, plant breeding

GREENOVATION, SUN-SMART CITIES AND SOCIETIES

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Abstract

Given the urgency of climate change, cities and their residents must become more innovative and progressive in transforming everyday life. Climate shifts are increasingly felt in urban areas, particularly due to the phenomenon known as the Urban Heat Islands (UHI) effect, which already presents a serious environmental and health challenge and is expected to intensify with growing urban populations and continued mass construction. Excessive use of artificial materials such as asphalt, concrete, and dark roofing. Osijek is one of the cities exposed annually to rising temperatures and heatwaves. However, due to its spatial and geographic characteristics, Osijek holds potential to become a green capital of Europe and a forward-looking model for future cities. Through a vision of sustainable urban living and active community engagement, the city can emerge as an example of how local action combats climate change and enhances urban quality of life. This work presents ideas and methods of green construction using biomaterials and living organisms that contribute to lowering urban heat. The use of plant-based materials and vegetated surfaces reduces perceived heat stress, improving both comfort and health outcomes. Green roofs, vertical gardens, urban forests, and high-albedo surfaces can be integrated into existing urban structures with minimal infrastructural disruption.

The paper aims to showcase innovative, site-specific solutions while raising citizen awareness about ways to improve urban life through collective action. Particular emphasis will be placed on mechanisms that foster synergy between local authorities, experts, and citizens through participatory planning and pilot projects that may serve as replicable models. Green interventions are no longer a decorative urban element but a strategic response for ensuring resilience and livability.

Key words: Urban heat islands, Green infrastructure, Climate adaptation, Sustainable urban design, Community engagement

PHENOMICS AND PRECISION LIVESTOCK FARMING: ADVANCING CLIMATE-SMART MEAT PRODUCTION

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Abstract

With rising temperatures, shifting water availability, and the spread of emerging diseases, climate change is putting increasing pressure on livestock farming and creating complex new challenges for production systems. Heat stress reduces animal productivity and welfare, water scarcity limits feed and pasture resources, and changing disease dynamics increase the risk of outbreaks that threaten both animal and human health. At the same time, the livestock sector faces mounting societal and policy demands to reduce its greenhouse gas emissions and overall environmental footprint. These pressures must be addressed while continuing to meet the nutritional needs of a growing global population by providing safe, affordable, and high-quality protein. Balancing productivity, sustainability, and resilience under these conditions requires innovative approaches that integrate genetics, management, and technology. Phenomics, an imerging new science which integrates phenotype with genomics, offers a way forward. Phenomics is the large-scale study of the observable characteristics of animals using advanced, high-throughput instruments. This information provides the link between genetics, physiology, environment and management practises. By collecting extensive phenotypic data using precision livestock farming (PLF) tools-such as imaging systems to assess body composition, wearable sensors to track activity and physiology, automated feeding monitors to measure intake and efficiency, and climate monitoring devices to track environmental conditions, phenomics enables continuous, real-time monitoring of animal performance. The obtainedintegrated data sets provide a multi-dimensional overview of traits such as feed efficiency, heat tolerance, growth patterns, welfare indicators and meat quality, and provide insight into how animals interact with their environment. These data sets support the prediction of resilience to climate stressors, inform breeding programmes targeting low-emission and stress-tolerant animals, and optimise management practises such as precision feeding and welfare interventions. When correlated with environmental conditions, phenomic data not only deepens our understanding of animal-environment interactions, but also guides the development of climate-smart production systems. Taken together, these approaches enable reduced emissions, more efficient resource utilisation and consistent meat quality, even under challenging environmental conditions.

Key words: phenomics, precision livestock farming, genomics, climate-smart agriculture

TOWARDS AUTONOMOUS SOIL CARBON MEASURING: ROBOTIC PLATFORM FOR SOIL RESPIRATION AND CARBON STATUS DETECTION

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Abstract

Agriculture is considered one of the most vulnerable sectors to climate change. Also, the intensification of agricultural production increases pressures on soil, including the reduction of organic matter content, which is a key indicator of soil quality and also affects atmospheric CO_2 concentration - one of the most significant greenhouse gases. Achieving climate neutrality requires the removal of CO_2 from the atmosphere and its long-term storage in soil (carbon sequestration). Therefore, the aim of this study is to improve and accelerate the measurement of soil respiration and carbon concentration by developing an autonomous robotic platform capable of independently collecting soil samples and conducting mentioned measurements. Most traditional methods rely on burning organic matter (Loss-on-Ignition) or on wet combustion of soil organic matter using strong acids. To speed up the analysis process and reduce the cost of often expensive laboratory procedures, soil carbon content was measured using Laser-Induced Breakdown Spectroscopy (LIBS), a system for analyzing soil organic carbon that is integrated into an autonomous robotic platform. LIBS is recognized as a technology with strong potential for rapid and precise soil carbon analysis. This technique is based on atomic emission spectroscopy, where a high-energy laser is focusing a pulse onto a sample, creating a plasma, and analyzing the light emitted from it. In addition to measuring soil carbon, the autonomous device also measures in situ soil respiration, a major source (pool) of atmospheric carbon dioxide. A key challenge in accurately measuring CO_2 flux is minimizing disturbances that could influence increased CO_2 inflow and transport within the soil (e.g., changes in air pressure). A closed dynamic chamber method was applied during measurement. In this closed system, the "captured" air is transported to an infrared gas analyzer, which then measures CO_2 concentration over time. This approach can provide relevant and useful information for farmers who in the future decide to certify their carbon removal activities. Moreover, the rationale for using this approach lies in the critical importance of obtaining accurate measurements of soil carbon content to reliably monitor carbon sequestration and assess soil quality.

Key words: soil respiration, soil organic carbon, autonomous robotic solution, LIBS, climate change

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EFFECTS OF TILLAGE SYSTEMS AND FERTILIZATION STRATEGIES ON SOIL CO_2 EMISSIONS IN WINTER WHEAT VEGETATION IN KRIŽEVCI, CROATIA

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Abstract

The relationship between tillage practices and CO_2 emissions is an important part of sustainable agriculture and climate change mitigation strategies. Tillage practices that minimize soil disturbance help to preserve soil organic matter and reduce greenhouse gas emissions. In 2023, a field trial was conducted in northwestern Croatia (Križevci) to evaluate the effects of different tillage systems on soil C-CO_2 emissions under winter wheat (variety Indira) cultivation on Gleysol, considering the effects of fertilization and environmental factors. The trial was set up as a completely randomized block design with a base plot size of 160 m². Three tillage systems were compared: CT (conventional tillage with ploughing to a depth of 30 cm), CTD (deep conservation tillage with soil loosening up to 30 cm and ≥30% cover with crop residues), and CTS (shallow conservation tillage with soil loosening up to 10 cm and ≥50% cover with crop residues). Fertilization included standard NPK fertilization based on recommendations (FR), and NPK fertilization supplemented with 300 kg ha^{-1} of Geo2, a biophysiological soil activator (GFR). During the study period, the highest average annual C-CO_2 emissions were recorded in the CTS-FR treatment (19.36 kg ha^{-1} day^{-1}), while the lowest values were observed in the ST-GFR treatment (16.38 kg ha^{-1} day^{-1}). Although the differences were not statistically significant, these results indicate a tendency towards lower emissions under reduced tillage conditions. In addition, treatments that included the application of the Geo2 showed lower average annual emissions across all three tillage systems compared to standard NPK fertilization alone, suggesting a potential mitigating effect of Geo2 on CO_2 emissions from the soil. Seasonal variation in C-CO_2 emissions was evident, with the highest C-CO_2 emissions observed in May (38.92 kg ha^{-1} day^{-1}) and the lowest in November (0.76 kg ha^{-1} day^{-1}). A positive correlation was found between average soil C-CO_2 emissions and soil temperature/soil moisture. Maintaining sustainable agriculture lies in the implementation of adaptive, ecologically mindful management strategies that balance productivity with long-term soil and climate health.

Key words: soil respiration, conventional tillage, conservation tillage, fertilization, agroecological factors

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FUNCTIONAL CROPS: BIOFORTIFICATION

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Abstract

In an era defined by the interconnected global crises of climate change and malnutrition, the development of resilient food systems is a prerequisite for achieving Sustainable Development Goals (SDG 2 – Zero Hunger; SDG 13 – Climate Action). This paper presents biofortification as a "climate-smart" agricultural strategy that simultaneously addresses hidden hunger and enhances crop adaptation to climate induced abiotic stresses. The primary aim is to provide a detailed analysis of the synergistic relationship between elevated microelement content in staple crops and their inherent tolerance to environmental stressors such as drought, heat stress, and soil salinity, which are intensifying globally. This research is based on a comprehensive literature review that synthesizes findings from plant physiology, genetics, and climate science. The methodology was structured to critically evaluate the specific physiological and molecular mechanisms by which key micronutrients, particularly zinc (Zn), selenium (Se) and iron (Fe), enhance plant resilience by protecting against oxidative damage. The effectiveness of integrated breeding programs that utilize modern tools like marker-assisted selection (MAS) and genomic selection (GS) to simultaneously target nutritional enhancement and climate-resilient traits. The literature confirms that higher concentrations of zinc improve the structural integrity of membranes and the function of enzymes that scavenge reactive oxygen species (ROS), thereby mitigating cellular damage during drought and heat.

Field trials consistently show that many biofortified varieties outperform their conventional counterparts in marginal environments. For example, iron-biofortified beans have demonstrated significantly higher yields under drought conditions, while zinc-biofortified wheat lines show increased tolerance to heat stress during the critical grain-filling stage. Biofortification must be recognized as more than a simple nutritional intervention; it is a powerful, integrated tool for climate change adaptation. By developing crops that are inherently more robust and nutritious, this strategy builds resilience from the plant's cellular level up to the entire food system. This approach moves beyond siloed thinking and offers a tangible pathway to future proof agriculture. To fully unlock its potential, stronger cross sectoral policy integration between ministries of agriculture, health, and environment is essential. Investing in biofortification is a direct and sustainable investment in building resilient food systems and, ultimately, more resilient societies capable of thriving in the face of climate change.

Key words: Biofortification, climate change, climate resilience, food security, micronutrients

VALORIZATION OF WASTE WOOL AS A SUSTAINABLE FERTILIZER: PRELIMINARY RESULTS ON TOMATO GROWTH USING WOOL PELLET FERTILIZER IN A MEDITERRANEAN CONTEXT

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Abstract

This study investigates the potential of sheep wool waste, a byproduct of the meat industry, as a sustainable alternative to synthetic fertilizers in Mediterranean agriculture. In Croatia, large volumes of low-grade wool, particularly from the Lička Pramenka breed, are discarded due to the absence of processing infrastructure. Through novel methods, this waste can be transformed into pelletized organic fertilizer, offering a circular solution to waste management and soil degradation. Focusing on preliminary findings, the study evaluates the effect of wool pellet fertilizer on the growth and productivity of two tomato varieties (Cherry and Marmande), compared with conventional chemical fertilizer of the same NPK mineral composition and unfertilized controls. The experiment was conducted under controlled conditions using standardized soil volumes, a digital IoT monitoring system for temperature and humidity, and digital image analysis for biometric measurements. Initial results indicate that wool pellets support healthy tomato development, acting as a slow-release fertilizer, showing promising outcomes in plant height, leaf growth, and early fruit set. Due to its slow nutrient release properties, it outperformed chemical fertilizers, enabling high dose administration while also improving soil texture and moisture retention. Comparative experiments with high dose generic chemical fertilizer proved fatal to the plants and did not contribute to moisture and texture soil enhancement. These findings suggest that wool-based fertilizers can play a role in replacing or supplementing synthetic fertilizers in Mediterranean agriculture systems, while contributing to mitigation of climate change effect on soil through its moisture retention and thermal insulation properties. By aligning agricultural productivity with circular economy principles, this research highlights the potential of locally sourced waste-based fertilizers in enhancing sustainability. While results are preliminary and focused on tomatoes, they lay the groundwork for broader multi-crop evaluations and regional implementation strategies.

Key words: circular economy, climate change, resilience, green technology, sustainable development

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CAN WE RELY ON SEED TOLAREANCE OF WHEAT IN COMBATING THE RICE WEEVIL?

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Abstract

Sufficient amounts of stored grains are considered a backbone of food security. However, global warming impacts post-harvest aspect of grain production as it i) aids distribution of stored product insect pests (SPPs), ii) increases pressure of SPPs and iii) increases losses of grains caused by SPPs. Due to occurrence of SPP tolerance to cretin insecticides and fumigants in some regions, the exploitation of inherently resistant/tolerant varieties is one of the most promising IPM approaches. However, it hasn't been exploited so far for seed protection from SPPs. To develop tolerant genotypes, it is necessary first to identify plant defensive traits and define underlying genetic bases that provide tolerance to certain pests. In this work aimed to tested suitability of over 30 wheat genotypes for the development of the rice weevil (*Sitophilus oryzae* L.) in "no choice" tests. The results from biotests were correlated with the results from extensive common and –omics phenotyping studies, as well as physical (grain hardness and color) and biochemical analysis (NIR and spectrometry). Wheat susceptibility to the rice weevil was determined based on the Susceptibility Index (SI), progeny production after one, two and three months and % of consumed grains after three months. Results indicate significant differences in susceptibility of wheat varieties to the rice weevil attack and suitability for weevil development. Based on the progeny production, significantly the lowest number of emerged adults was on Severina, Schwabenkorn, 24-C, NSD16/100, Roquin and Boulander and Vitagold, indicating the lowest suitability (i.e. certain tolerance level). The lowest % of consumed food was registered on the same varieties (1.87-4.80%), while on susceptible varieties it reached 61%. Progeny production and the % of consumed food were strongly negatively correlated with seed hardness and % of dry gluten, while positively with seed moisture and starch content.

Key words: *Sitophilus oryzae*, wheat, nutritive traits, tolerance

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PRECISION WEED MANAGEMENT: UAV MULTISPECTRAL IMAGING FOR AMBROSIA ARTEMISIIFOLIA DETECTION IN MAIZE CROPS

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Abstract

Maize is a predominant grain crop worldwide, essential for food security and industrial uses, and the yields are threatened by weed competition, especially from Ambrosia artemisiifolia (common ragweed). Around 80% of Hungarian arable land, including urban and agricultural areas, is infested by common ragweed, which competes aggressively with maize for water, nutrients, and sunlight, significantly affecting maize growth and production and producing allergenic pollen that poses public health risks. Weed management has become increasingly important, especially with precision agriculture tools, such as drones, which are equipped with multispectral cameras. This study focuses on the development and application of a multispectral camera-based unmanned aerial vehicle (UAV) system for early weed detection specific emphasis on Ambrosia artemisiifolia in maize fields for weed mapping for site-specific weed management at the Agronomy Institute field, Páter Károly út 1, Gödöllő, Hungary. The methodology employs UAV-based multispectral imaging to capture high-resolution spectral data, processed using QGIS to calculate the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Red Edge Index (NDRE). These indices differentiate A. artemisiifolia from maize based on their spectral signatures. Machine learning algorithms, such as supervised classification, are utilized to map weed infestations. Expected results include high-precision detection of A. artemisiifolia with precise mapping of weed patches across maize fields using NDVI and NDRE. The approach is anticipated to enable effective site-specific weed management, reduce herbicide use compared to conventional methods, and increase crop yields, thereby enhancing weed management efficiency and minimizing environmental impact. In conclusion, UAV-based multispectral imaging with NDVI and NDRE analysis offers a robust solution for early weed detection, promoting sustainable maize production through precise, site-specific weed management. This technology enhances agricultural efficiency, reduces chemical inputs, and supports environmental and public health.

Key words: maize, weed detection, multispectral image, Ambrosia artemisiifolia, NDVI, and UAVs.

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WHITE CLOVER AS A COVER CROP FOR SOIL AND CLIMATE RESILIENCE

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Abstract

In the context of increasingly pronounced climate change and soil degradation, white clover (*Trifolium repens* L.) is increasingly used as a cover crop due to its agrotechnical and ecological characteristics. As a perennial legume, white clover has the ability to fix atmospheric nitrogen in symbiosis with Rhizobium bacteria, thereby enriching the soil with available nitrogen and reducing the need for mineral fertilizers. White clover can fix an average of 50 to 200 kg/ha of atmospheric nitrogen annually, depending on soil and climate conditions and the presence of Rhizobium strains. In addition, white clover forms a dense ground cover and has a well-branched root system, which contributes to soil moisture retention, reduces evaporation, and prevents erosion and soil degradation. White clover is divided into three main groups: small-leaved, medium-leaved, and large-leaved types, with small-leaved ecotypes most commonly used as cover crops. Small-leaved varieties are characterized by low growth, good ground cover ability, and tolerance to trampling. Thanks to its dense green cover, white clover helps retain soil moisture, prevents drying, reduces high surface temperatures, and improves rainfall infiltration. Small-leaved white clover varieties are particularly suitable for long-term cover in perennial plantations such as orchards, vineyards, and olive groves, where they are usually maintained by natural low growth or occasional mulching, while mowing is carried out only when necessary. Given that white clover has a lifespan of 3 to 5 years, overseeding is recommended in perennial plantations to maintain the density and functionality of the cover. White clover is well adapted to various conditions and can tolerate moderate drought, which is important considering the increasingly frequent and prolonged droughts, especially during the summer months. Additionally, it contributes to maintaining a stable soil microclimate. The use of white clover as a cover crop represents a sustainable approach in agroecosystems, as it simultaneously increases soil fertility, contributes to moisture retention, and reduces the need for mineral nitrogen input. Given the climate change, the integration of such plant systems into agricultural practices is of key importance for building more resilient and regenerative food production systems.

Key words: *Trifolium repens* L, cover crop, nitrogen fixation, soil moisture conservation, climate change adaptation

ENHANCING CARROT CROP PERFORMANCE WITH AI-BASED PRECISION SYSTEMS

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Abstract

The aim of this review is to evaluate and highlight the effectiveness of precision agriculture technologies in carrot farming, focusing on improvements in water use efficiency, optimized input application, and enhanced yield quality. Carrot crops are particularly sensitive to soil moisture fluctuations, which can cause physiological problems such as cracking, reduced root uniformity, and lower market value, necessitating more precise management approaches. Recent advancements in precision agriculture provide solutions through a combination of remote sensing (using drones and satellites), AI-driven irrigation management, Variable Rate Application (VRA), and GPS-guided sowing and field mapping. Remote sensing techniques, especially multispectral imaging and NDVI (Normalized Difference Vegetation Index) analysis, enable early detection of plant stress and variability in canopy vigor, allowing for targeted nutrient and pesticide management. AI-enhanced irrigation systems integrate real-time soil moisture data with weather forecasts and evapotranspiration models to dynamically optimize irrigation schedules. This data-driven approach has demonstrated water savings of up to 35% while increasing marketable yield by 15–20%, primarily by maintaining more stable soil moisture and minimizing crop stress. Variable Rate Application (VRA), combined with GPS-guided machinery, enables precise fertilizer and pesticide application as well as uniform sowing patterns. Moreover, machine learning algorithms facilitate yield mapping, further supporting informed, data-driven decision-making throughout the carrot production cycle. Overall, the integration of these precision agriculture tools empowers farmers to achieve higher yields with reduced resource use, thus minimizing environmental impact and enhancing economic returns. This data-driven management framework establishes a foundation for the sustainable intensification of carrot farming, promoting both productivity and environmental stewardship.

Key words: Precision Agriculture, AI-Based Irrigation, Remote Sensing, Variable Rate Application (VRA), Carrot Crop Management

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AGROECOLOGY IN ACADEMIA – INSIGHTS OF THE ADVANCING AGROECOLOGY IN HIGHER EDUCATION CASEE PROJECT

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Abstract

This paper focuses on presentation of results and lessons learned from the Advancing Agroecology in Higher Education project in the CASEE (ICA Regional Network for Central and South Eastern Europe) countries. The project's aim was to strengthen the agroecology position within the partner universities by identifying how the agroecology paradigm can improve higher education programs, proposing a common curriculum for higher education that reflects the current context of agroecology and also by connecting scholars/professors that teach agroecology. A comprehensive situation analysis of higher education programs related to agroecology was conducted in the form of a written material, which included a comparative review of existing curricula, with a particular focus on the participating CASEE countries. This analysis, together with the key topics identified during a participatory workshop involving project partners, forms the foundation for the development of a one-year MSc curriculum in Agroecology, to be elaborated in detail at a later stage. In addition, the project team compiled a bank of research topics suitable for MSc and PhD theses, emphasizing opportunities for co-tutorship and fostering cross-institutional collaboration. The CASEE project contributes to the enhancement of agroecology education academic collaboration and institutional visibility It enables the creation and improvement of agroecology programs across CASEE countries by embedding agroecological principles into curricula, thereby equipping students with essential skills for sustainable agriculture. Integrating agroecology into higher education is a vital strategy for addressing the challenges of climate change within food and farming systems.

Key words: agroecology, higher education, curriculum, CASEE countries

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FARMER'S RELATION TO CONSERVATION SOIL TILLAGE

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Abstract

Conservation Soil Tillage (CST) is most commonly defined as a tillage system in which, after all tillage operations and the sowing of the next crop, at least 30% of the soil surface remains covered with crop residues. Although CST is one of the most prominent agrotechnical measures in the fight against climate change (in terms of adaptation and mitigation), many farmers express mixed views on its efficiency. While experienced practitioners recognize the long-term benefits of CST, its adoption is often hindered by challenges such as inadequate machinery, crop residue management issues, limited knowledge, and economic considerations, as farmers in all countries weigh the potential for reduced input costs and improved profitability. Farmers can generally be divided into two distinct and opposing groups. Both groups have arguments for their own opinion and stances, which can be paraphrased as follows: *"Some perceive Conservation Soil Tillage as a new and unnecessary innovation, introduced by scientists and promoted by government policies, that complicates crop production rather than supports it."*, or the opposite; *"Others recognize that Conservation Soil Tillage is not a new concept, and that its proper application can bring tangible benefits to their farm operations, including improved financial outcomes and positive environmental impacts."* However, there is also a difference between farmers who apply CST, which is based on their experience. One of them can be qualified as "farmers beginners" without previous experience in applications of CST (irrespective of the size of the estate). This group of farmers usually has a larger number of questions and doubts about almost every aspect of CST. Some potential challenges between "farmers beginners" primarily may arise from their subjective reasons, usually based on an insufficient understanding of the cropping system, which differs from the tillage system with plowing. Farmers qualified as "experienced" have a completely different opinion on almost every aspect of CST. Their experience is at a higher level, and they usually seek answers based on questions about improving and upgrading the implemented CST system. Despite recent progress in CST adoption, farmers still show varying levels of experience and face many unanswered questions about its implementation.

Key words: sustainable agriculture, conservation agriculture, soil tillage, crop production, farmers' experience

Acknowledgement

This work has been fully supported by Croatian Science Foundation under the project "Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation – ACTIVEsoil (IP-2020-02-2647).

REGENERATIVE AGRICULTURE AS A PATHWAY TO MORE RESILIENT CLIMATE STRATEGIES

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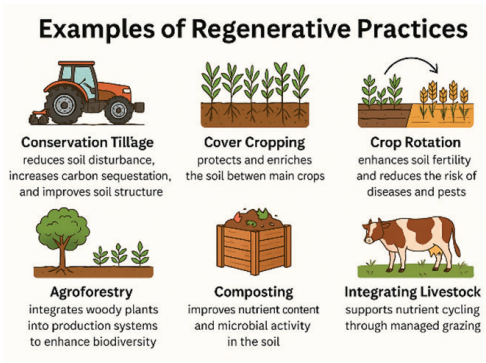
Abstract

Regenerative agriculture represents an innovative approach aimed at building more resilient climate strategies through the improvement of soil health, carbon sequestration, and the promotion of biodiversity. This practice includes methods such as conservation tillage, cover cropping, and crop rotation, which simultaneously mitigate the effects of climate change, ensure food security, and increase the resilience of agroecosystems. One of the key contributions of regenerative agriculture is carbon sequestration. Practices such as conservation tillage and cover cropping increase the amount of organic matter in the soil, turning it into an effective carbon sink, which helps reduce atmospheric CO_2 levels. At the same time, soil health and its water retention capacity are improved through better structure, infiltration, and moisture-holding capacity, thereby reducing vulnerability to droughts and floods. Regenerative agriculture also fosters biodiversity, through diverse crops, cover crops, and agroforestry systems, creating more resilient agroecosystems capable of adapting to climate stresses. In terms of climate change mitigation, reducing greenhouse gas emissions and increasing carbon sequestration make a tangible contribution to global climate goals. Additionally, food security is enhanced due to more stable yields and healthier soils, while resilience to climate shocks increases. Economic benefits include reduced input costs due to decreased reliance on synthetic fertilizers and pesticides. Furthermore, regenerative agriculture can have positive social effects by strengthening local communities, empowering farmers, and contributing to rural development.



By adopting regenerative practices, farmers create more sustainable and resilient food production systems that are better equipped to respond to the challenges posed by the climate crisis. This approach provides a foundation for a healthier planet and a more secure future for food production.

Key words: climate resilience, regenerative practices, carbon sequestration, biodiversity, soil health

COMMUNITY AGROECOLOGY IN PRACTICE: VOLUNTEERING EXPERIENCES FROM THE SZIA GARDEN, GÖDÖLLŐ, HUNGARY

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Abstract

This study examines the student volunteer program at the Szent István Agroecological Garden (SZIA Garden) at MATE University in Gödöllő, Hungary, with a focus on understanding student motivation, participant qualities, and the relationship between these factors and the outcomes of the 10-week volunteering experience. Through a structured case study approach, qualitative and quantitative data were collected from volunteers engaged in hands-on agroecological practices, including organic cultivation, composting, crop diversification, and sustainable resource management. The research specifically investigated what motivates students to join the volunteer program, the personal and academic qualities of those attracted to community gardening, and how these qualities relate to the effectiveness and impact of their participation. The experiment took place at the SZIA Garden, which was established as a student-led initiative during the COVID-19 pandemic lockdowns and has since evolved into a hub for practical agroecological training, intercultural exchange, and community building. From 2020 to the present, the garden has cultivated over 40 plant species and 68 varieties, with 21 species and 25 varieties recorded in 2025 alone, demonstrating the feasibility and benefits of biodiversity in small-scale urban agriculture. Key impacts include strengthened community ties, increased environmental and food awareness, and practical skill development. SZIA Garden exemplifies the potential of volunteer-driven agroecology to promote climate adaptation, soil health, and food sovereignty. Its success highlights the importance of integrating community engagement and agroecological principles into strategies for climate-resilient agriculture, offering valuable lessons for similar initiatives in higher education and urban environments.

Key words: agroecology; student engagement; community engagement; climate resilience; urban agriculture; experiential learning

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We express our gratitude to the following individuals and organizations for their significant contributions to this project: the dedicated gardening staff of the Diversity Foundation and the volunteers of the SZIA Garden. Fernanda Ramos Diaz's unstoppable motivation, energy, and efforts in being the first coordinator. The Institute of Rural Development and Sustainable Economy at MATE University for their ongoing support and encouragement. MATE University's Directorate General for International Relations and Development to provide financial support, as well as the employees of the Centre for International Education, to help in materialistic ways. Last, but not least, the TIKA organization's initial investment in facilities and gardening tools. We are grateful for the support and collaboration of all involved.

TILLAGE STRATEGIES FOR MITIGATING OFFSITE POLLUTION IN SLOPED CROPLANDS

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Abstract

Conservation tillage management on rainfed croplands aimed to improve the soil's physical environment, reduce soil erodibility, and enhance conservation. During 2024, plowing, chisel, and subsoiling were monitored on soil erosion, sediment concentration, soil physical properties, and element losses in sloped Stagnosols under maize cultivation in Croatia, Bjelovarsko-bilogorska County. Nine experimental plots (100 m × 8 m) were established, three per tillage treatment, each equipped with a runoff and sediment collection system. Soil erosion and sediment transport were monitored throughout the growing season following major rainfall events. Results reveal reduced sediment concentrations by 49.1% at chisel plots compared to plowing plots, while subsoiling achieved a 77.7% reduction. The highest averaged sediment loss occurred under plowing (15.4 t ha^{-1}), while chisel decreased soil loss by 73.4% (4.1 t ha^{-1}) and subsoiling by 95.9% (0.6 t ha^{-1}). Nutrient losses followed a similar pattern, with the highest depletion observed under plowing (C: 3384 kg ha^{-1}, N: 278.3 kg ha^{-1}, P: 174.6 kg ha^{-1}, K: 4587.8 kg ha^{-1}), while subsoiling retained the most nutrients, limiting total losses to C: 88.6 kg ha^{-1}, N: 9.2 kg ha^{-1}, P: 6.0 kg ha^{-1}, and K: 173.6 kg ha^{-1}. The sediment collected from plowing plots was significantly enriched with nutrients and heavy metals compared to bulk soil, highlighting the role of soil erosion rates in nutrient depletion. In contrast, subsoiling showed no significant differences between sediment and bulk soil concentrations, reinforcing its role in reducing fine particle detachment and nutrient loss. Soil physical properties also improved under conservation tillage. Subsoiling significantly reduced bulk density (1.40 g cm^{-3} vs. 1.55 g cm^{-3} in plowing) and penetration resistance by 67.5% at 10–30 cm depth. Water holding capacity was highest under subsoiling (45.3%), 7.6% greater than plowing, contributing to better soil moisture retention. Biomass yields were highest ($p > 0.05$) under subsoiling (25.06 t ha^{-1}), 12.4% greater than a chisel. These findings confirm that subsoiling significantly improves soil structure, minimizes erosion, and reduces nutrient losses, making them viable conservation strategies for sloped agricultural landscapes.

Key words: Conventional, conservation tillage, soil health, environmental impact

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QUEEN RINGING FOR WINTER BROOD BREAK IN A CHANGING CLIMATE

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Abstract

Ongoing climate change is altering the seasonal dynamics of honey bee colonies, particularly by shortening or eliminating natural brood breaks that usually occur in continental parts of Croatia during winter. This enables the continuous reproduction of Varroa destructor, which increases the parasite pressure and reduces the effect of traditional control strategies. In this context, adaptive beekeeping techniques that restore brood breaks are increasingly important. Queen ringing is a novel method designed to prevent ovipositioning without fully confining the queen. Unlike traditional method of queen caging, this technique allows the queen to move freely with the winter cluster of bees throughout the winter. To evaluate the applicability of queen ringing under field conditions a study was conducted in continental Croatia from autumn 2023 to spring 2024. The study focused on honey bee colony development, Varroa mite infestation levels, honey consumption during winter, and overall queen and colony performance. Preliminary findings suggest that queen ringing could be a valuable climate-adaptive practice, supporting sustainable Varroa management and efficient overwintering. As climate changes continues to challenge conventional beekeeping practices, integrating innovative techniques like this may help maintain colony health and productivity in a changing world.

Key words: Apis mellifera, Varroa destructor, brood break, queen bee, ringing

THE AZORES AGRICULTURAL MONITORING AND WARNING NETWORK (RMAAA)

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Abstract

The Azorean agricultural monitoring and warning network (RMAAA) is an indispensable tool for guaranteeing the production of quality food, food safety and environmental protection on our islands, that focuses on phytosanitary problems affecting the region's main crops and extends to the Azorean nine islands. The following pests are being monitored: spotted wing drosophila (Drosophila suzukii), honeydew moth (Cryptobaldes gnidiella), codling moth (Cydia pomonella), chestnut tortrix moth (Cydia splendana), Mediterranean fruit fly (Ceratitis capitata), pasture army worm (Pseudaletia unipuncta and Spodoptera littoralis), banana weevil (Cosmopolitus sordidus), olive fruit fly (Bactrocera oleae) and banana thrips (Heliothrips sp.; Anisopilothrips sp. and Haplothrips sp.). Also, the incidence of three vine diseases: mildew (P. viticola), botrytis (B. cinerea) and oidium (U. necator)) is monitored, as well as three wood diseases, three species of citrus mealybug, olive cotton worm, whiteflies and citrus leaf miner. The field data collected are introduced on a cell phone application and automatically transferred to a computer platform, where data from the weather stations placed at the various biological observation areas (BOAs) are also recorded. Thresholds have been established for the presence and abundance of populations (pests) and incidence (diseases) which allow for the automatic emission of warnings sent by mobile phone and email to the technicians and farmers. The aim of this work is to learn about the temporal evolution of the pests but also to identify their population peaks, and together with the meteorological data collected, to validate models for predicting their field appearance. This will serve as a unique tool essential for technicians and farmers to support their decision-making regarding crops phytosanitary problems in the Azores archipelago.

Key words: warnings, agriculture, pests, diseases, platform

EFFICIENCY OF CONSERVATION TILLAGE SYSTEMS IN ENHANCING SOIL WATER RETENTION

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Abstract

Tillage practices have a profound impact on soil water dynamics (SWD), with no-till and reduced tillage systems generally offering advantages in terms of water conservation, infiltration, and potentially improved soil health. However, the specific effects can vary depending on various factors, and a holistic approach considering soil type, climate, and residue management is essential for optimizing water use and agricultural productivity. This study investigated the SWR under various tillage systems (conventional, conservation deep tillage, and conservation shallow) monitored with PR2 soil moisture probe (SMP). SMPs were installed on all soil tillage treatments in three replicates. The measurements were conducted 2-3 times per week, with frequency adjusted based on rainfall events. The goal was to study the dynamics of SWC in different tillage systems and, based on the results obtained, to propose the optimal tillage system in terms of soil water management, and thus mitigating the negative consequences of climate change, i.e., drought. Access tubes for the PR2 SMP were installed in all tillage treatments, with three replications per treatment. Within each access tube, the PR2 measured SWC (vol.%) every 10 cm, providing data at depths from 10 to 40 cm. Measurements were taken using a handheld HH2 meter. In average, the SWC ranged from 4.8 to 33.6 vol.% with the lowest values observed under conventional tillage and the highest under conservation shallow tillage. At a conventional tillage system, the SWC ranged from 4.8 to 26.5 vol.% (4.8<13.7<17.7<26.5 vol.%, corresponding to 10, 20, 30 and 40 cm of soil depth). A similar pattern was observed at all other measured depths, i.e., tillage systems where conventional tillage consistently exhibited the lowest SWC, and conservation shallow tillage recorded the highest. At a conservation deep tillage system, the SWC ranged from 12 to 29.9 vol.% (12<23.8<26.3<29.9 vol.%, corresponding to 10, 20, 30 and 40 cm of soil depth). At a conservation shallow tillage system, the SWC ranged from 17.8 to 33.7 vol.% (17.8<27.3<,30.9<33.7 vol.%, corresponding to 10, 20, 30 and 40 cm of soil depth). Overall, the PR2 sensors consistently demonstrated that conservation shallow tillage significantly improved SWR compared to conventional and conservation deep tillage, at all soil depths. This research highlights the critical role of tillage practices in managing soil water resources and underscores the importance of choosing appropriate sensing technologies for accurate and efficient SWC monitoring.

Key words: tillage systems, soil water retention, soil moisture probe

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The results presented in the paper are an output from the research project "Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation–ACTIVEsoil" (IP-2020-02-2647).

SEAWEED APPLICATION IN AGRICULTURE AS CARBON SEQUESTRATION MANAGEMENT PRACTICE

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Abstract

To minimize the negative impact of climate change, seaweed is increasingly being presented as a promising strategy due to its great ability to store CO2 from the atmosphere. It's a relatively undemanding, widespread and economical resource with a wide range of application possibilities. Since it's more efficient at biological fixation of CO2 than plants on land, in light of current trends of the increasing emphasis on the sustainability of production systems, this research aims to determine the potential for its use in agriculture, which will improve soil properties and store C in the SOM. SOM is an important sink for C sequestration, because levels of organic C are 4.5 times larger than the C pool in terrestrial plants and twice as large as CO2 pool in the atmosphere. Among many possibilities, the idea of converting seaweed into biochar through pyrolysis stands out, as it can sequester C for long-term storage. The downsides are the issue of energy consumption for drying and pyrolysis, as well as CO2 emissions, though these may be lower compared to some other techniques. Additionally, higher Na content in seaweed material, due to its marine origin, and the PTE content (e.g. As and Cd) can harm soil and plants. Previous research has shown that applying seaweed organic material increases soil respiration, i.e. biological activity, which releases CO2 into the atmosphere. Significantly higher respiration was found with higher concentrations of seaweed added to the soil. In terms of C sequestration, the goal is to bind C in the soil for a longer period of time, i.e. to store soil organic C in slow or passive SOM pools, in which case biochar could contribute more than seaweed applied in other forms. The findings so far have shown that seaweed has an excellent capacity for extracting CO2 from the environment and a good potential for transferring and storing C in SOM, but more research is needed to optimize the technology and determine how to avoid a negative impact on the soil.

Key words: Seaweed, C sequestration, Agriculture, Biochar, SOM

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ALFALFA CROP RESIDUES FOR SOIL CARBON SEQUESTRATION AS A RESPONSE TO CLIMATE CHANGE

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Abstract

In Europe, governments are increasingly focusing on reducing greenhouse gas emissions. Carbon dioxide is one of the most abundant greenhouse gases, and farmers are encouraged to implement various agrotechnical measures to reduce it, including measures that affect carbon sequestration, which significantly contribute to mitigating climate impacts, especially when applied in the long term. The aim of this study was to determine the impact of green alfalfa biomass applied as mulch in a maize crop on soil organic matter levels. The biomass was collected and chopped in the first cut of an established alfalfa field of the Osječka 99 variety in mid-May 2024, and then distributed as mulch in a maize crop in two treatments; the third treatment was a control where alfalfa was not applied (treatment A1 contained 70 m-3 alfalfa, treatment A2 contained 140 m-3 alfalfa, and treatment AK was the control treatment). Each treatment had three repetitions. The corn height was approximately 15 cm at the time of trial establishment. In the final soil state, where the mean humus value in treatments A1 and A2 was 2.15% and 2.31%, a statistically significantly higher humus content was determined compared to the initial soil state, where the mean humus value in treatments A1 and A2 was 1.55% and 1.68% (LSD=0.29, $p<0.01$). A statistically significantly higher total organic carbon (TOC) value was determined in the final soil state, where the mean TOC value in treatment A1 was 1.15%, compared to the initial soil state, where the mean TOC value in A1 was 0.83% (LSD=0.29, $p<0.05$). Freshly cut and chopped alfalfa biomass is rich in water and nutrients; therefore, it can protect the soil from evaporation, erosion, and weed outbreaks, regulate soil temperature, improve soil structure, and enrich the soil with carbon and nutrients. Since the results were collected on a one-year basis, which is not a sufficient indicator of carbon sequestration, it is necessary to conduct long-term experiments to determine carbon sequestration. The presented results can serve as an indicator of the potential of this agrotechnical measure in carbon sequestration and climate change mitigation.

Key words: greenhouse gas, humus, TOC, soil, agrotechnical measure

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ALFALFA GENETIC RESOURCES AND THEIR APPLICATION IN CROP ADAPTATION TO CLIMATE CHANGE

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Abstract

Climate change and its consequences, such as droughts, extreme temperatures, floods, etc., along with the growing human population and food demand, present one of the greatest challenges for agricultural producers today. At the same time, genetic erosion, in addition to all of the above, presents an additional challenge to plant breeders. The aim of this paper is to provide insight into available plant genetic resources of alfalfa and the possibility of their application in breeding processes for the purpose of developing new, more resistant or tolerant varieties with a broad genetic basis for facing frequent climatic challenges. Pre-breeding is a process for creating germplasm that can be included in breeding programs and creating new genotypes. It includes all activities of identifying desirable traits and genes from materials that cannot be directly used in breeding populations and transferring these traits to an intermediate set of materials that breeders can further use in the production of new varieties. Landraces, crop wild relatives, elite breeding materials, and modern varieties are important plant genetic resources that can be used to develop new, more tolerant, and adapted varieties that will give better yields in increasingly frequent extreme and unpredictable climate events. For most plant seed material, only basic passport and characterization data are available, while data on unique agronomic and economic traits are generally lacking, limiting their use in crop improvement. Given the lack of necessary data on the material, additional characterization and evaluation of the collected material are needed to avoid the transfer of undesirable alleles into the elite breeding collection. Molecular markers are increasingly used to accelerate the selection process and identify quantitative trait loci (QTL) and new genes. Their application in alfalfa breeding still lags due to the recent development of cost-effective whole-genome genotyping methods and the complexity of the genome of this autotetraploid species. To develop new, resilient alfalfa varieties amid climate change, plant breeders must collect new genetic resources and continue to utilize methods like pre-breeding and molecular markers for more effective results.

Key words: landraces, CWR, traits, genotypes, pre-breeding, varieties, molecular markers

Acknowledgement

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FFECTS OF DIFFERENT SOIL TYPES AND LAND USES ON MICROBIAL ACTIVITY AND BARLEY PHOTOSYNTHETIC PERFORMANCE

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Abstract

Soil type and land use have significant effects on microbial activity and plant physiological responses. This study aimed to investigate the effects of five different soils (L1–L5) with varying land use patterns (field, forest, and grassland) on barley seedlings grown in pots under controlled environmental conditions in a growth chamber for 14 days. The soil's physical and chemical properties, as well as microbial activities, were measured and correlated with the chlorophyll fluorescence of the barley seedlings to determine the effect of soil types and land use on the seedlings' photosynthetic performance. Results indicated variations in soil biological activity and barley photosynthetic efficiency with respect to land use. Forest and grassland soil had higher organic matter content (34-46% more total carbon, 26-58% more total nitrogen, and 22-38% more organic matter than the arable field soils), as well as a better microbial activity than the field soils with dehydrogenase activity being 27% higher and hydrolytic activity 24-45% higher than that of the field soils. The barley performance index (PITOT) was positively correlated with soil dehydrogenase activity and organic matter content, indicating that improved nutrient availability and soil structure enhance microbial activity and plant performance. On the other hand, high sodium and lower organic matter content negatively influenced microbial activity and plant performance indices of barley seedlings. It can be concluded that soil organic matter and high microbial activity were the most beneficial to plant performance indices, while low organic content and microbial activity can reduce plant growth and yield.

Key words: chlorophyll a fluorescence, soil dehydrogenase activity, fluorescein diacetate hydrolytic activity, soil structure

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GRAIN QUALITY OF WINTER WHEAT GROWN AFTER FABA BEAN AND WHEAT IN PURE AND MIXED SOWING IN TWO TILLAGE SYSTEMS

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Abstract

Due to its high yield potential and equally high technological value, winter wheat is considered the most valuable cereal crop. The technological value of wheat varieties depends primarily on the intended use of the grain. The aim of this study was to analyze and compare the impact of selected agrotechnical factors on certain quality parameters of winter wheat grain. The response of two winter wheat varieties, sown in pure and mixed sowing after different preceding crops (faba bean and winter wheat), was monitored against the background of traditional and reduced-plough tillage. The cultivation technology used and its impact on the baking quality parameters of the studied varieties were assessed against the background of weather conditions prevailing in selected study years. The study was conducted as a strict crop rotation experiment at the Experimental Station in Mydlniki near Krakow, belonging to the Department of Agroecology and Plant Cultivation, Faculty of Agriculture and Economics, University of Agriculture in Krakow. Poland (50°04' N, 19°51' E, 280 m a.s.l.) on standing lessive soil (SL). The field experiment was conducted between 2002 and 2017 on brown soil of the good wheat complex. The results of a three-factor randomized block experiment with a dependent design (split-split-plot) are presented, with four replications. Crop rotation experiment: a four-field cereal crop rotation using the following crops: 1) broad beans, 2) winter wheat, 3) winter wheat, and 4) spring barley. All crops were grown in each year. Protein yield showed a moderate positive correlation and was statistically significant ($p < 0.01$).

Gluten content showed a moderate positive correlation (r = 0.37) and was also statistically significant. Starch showed a very weak negative correlation (r = -0.07) and was not statistically significant (p = 0.48). Sedimentation index showed a moderate positive correlation (r = 0.36) and was significant. Hagberg falling number showed a weak positive correlation (r = 0.12) and was not significant (p = 0.18). Wheat unit number showed a moderate negative correlation (r = -0.35) and was significant (<0.01). A statistically significant interaction was observed: Forecrop × Cultivation Method. The difference between the number of wheat units for wheat cultivated with a plough after faba beans was greater by 2.06 jp. than for wheat cultivated after faba beans with ears, while with the simplified cultivation method this difference in favour of wheat cultivated after faba beans was 3.16 jp.

Key words: winter wheat, quality grain, tillage

Acknowledgement

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COST EFFICIENCY OF SITE-SPECIFIC WEED APPLICATION IN WINTER WHEAT: A CASE STUDY

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Abstract

Site-specific weed management (SSWM) represents an effective tool in precision agriculture, enabling substantial economic and environmental benefits through the reduction of herbicide use. However, the adoption of SSWM is associated with various expenses, including investments in advanced spraying technology, detection systems for weed infestation, and data processing software. There are multiple approaches to implementing SSWM, ranging from complete outsourcing of technology and analysis services to entirely in-house management, where farms independently handle UAV imagery acquisition, processing, and weed detection. Additional costs, therefore, arise from UAV acquisition, specialized software, computing equipment, and the agronomist's time dedicated to data processing and analysis. This study presents a practical case focused on site-specific herbicide application targeting creeping thistle (Cirsium arvense) infestation in winter wheat (Triticum aestivum) at the BBCH growth stage 33–35. The study was carried out on a medium-sized agricultural farm with a total cultivated area of 997 ha. The total monitored area of winter wheat fields infested with weeds was 252.52 ha. Weed patches were detected using a DJI Mavic 3 Multispectral UAV with an RGB camera with a ground sampling distance (GSD) of 7 mm. Imagery data were processed into orthomosaics using the open-source software OpenDroneMap. Weed infestation was then detected and mapped using Pix4Dfields software with the Magic Tool classification algorithm. Subsequently, herbicides containing the active ingredient clopyralid were applied at a rate of 0.3 l ha^{-1} with a spray volume of 270 l ha^{-1}, using a trailed sprayer Amazone UX 4201 Super with a working width of 24 meters featuring individual nozzle control with section management per nozzle every 50 cm. As a result of the targeted herbicide application approach, treatment was necessary only on 55.49 ha out of the total monitored area of 252.52 ha, achieving an average herbicide saving of 78.02% compared to broadcast application. The average herbicide consumption was thus significantly reduced. With herbicide costs at 43.7 € ha^{-1} and UAV-based detection technology costs at 10 € ha^{-1}, total net savings amounted to approximately 6,116 €. These calculated savings highlight only the reduced chemical use. Beyond economic benefits, targeted herbicide application significantly reduces environmental impact by lowering chemical inputs and potentially enhances crop yields by reducing stress on untreated areas. This study underscores targeted herbicide application as economically and environmentally advantageous for modern agriculture.

Key words: precision agriculture, SSWM, Pix4D, spot-spray, UAV

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PHYSIOLOGICAL RESPONSES OF MICROPLANTS IN AN AEROPONIC SYSTEM AS EMERGING SUSTAINABLE GREEN DEAL INITIATIVE

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Abstract

The Green Deal of the European Union aims to reform the entire food system, where microplants can represent an emerging component. The agricultural policy target six main objective and four could be linked to the production, trading and consumption of microplants. Edible microplants promote a better diet, sustainable production and meet the SGDs. A case study was performed to assess the performance of an aeroponic automatic system for producing microplants of garden cress, mustard, alfalfa, red clover, broccoli, radish, red lentil and green peas. A number of 400 seeds in three replicates were placed on a geotextile mesh stretched out for a stainless steel grill. The seeds germination take place at high humidity and full spectrum warm led light 12 H photoperiod. The microplants length, shoot-root ratio, relative chlorophyll content, stomata number, stomatal conductance, intracellular CO_2 mole fraction and photosynthetic yield (PSII) were assessed to highlight physiological performance between different species. Red clover had the highest relative chlorophyll content up to 130 SPAD and stomatal conductance around 1200 mmol $m^{-2}s^{-1}$. The highest values of shoot length around 8 cm and shoot:root ratio were observed at red lentil 0.7. Photosynthetic yield (PS II) was increased to garden cress and the highest intracellular CO_2 was registered to green peas higher than 400 ppm. In the aeroponic system, a uniform germination prevails between different microplants species and the microplants are produced in one week except green peas and red lentil, which needed three extra days. The microplants physiological assessment argues them as useful for urban and vertical novel farming systems. Clearly, microplants production represent a viable chain within the Farm to Fork framework and Green Deal strategies.

Key words: aeroponic system, physiological parameters, Green Deal, sustainable food production.

EXOCROP PROJECT OUTCOME – AN AGRONOMIC PERSPECTIVE ON SWEET POTATOES, COWPEA AND GROUNDNUT

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Abstract

The current agronomic context requires the maintenance of high crop yields to ensure the food necessity for a continuous growing population. This context is under constant pressure due to climate. One mitigation technique is the use of agro-climatic scenarios to understand the future suitability of an area for a set of crops. The aim of this paper is to analyze, with VoSviewer, the literature in Web of Science Core Collection on eco-pedological requirements for three species – sweet potatoes, cowpea and groundnut – that can be rescaled due to the climate changes. Sweet potatoes crop requirements (Figure 1) for temperature and precipitations show a large variability of results. Preferred soil conditions are deep to moderately fertile, with a high importance of texture. Cowpea is considered one of the most resistant crops in areas where precipitations are deficient. Soil drainage and texture are the most important eco-pedological conditions that ensure success for this crop (Figure 2). Groundnut is a niche crop (Figure 3.), that can provide both economic and ecological benefits. This species is sensitive to both temperature and precipitation, along with soil conditions. Numerous studies have shown the high temperature requirements for the success of cropping, based on water assurance and proper cultivation of soil (Figure 3).

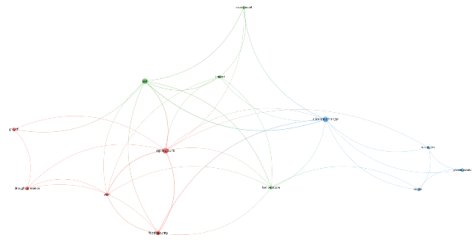

Figure 1. Bibliographic network of “Sweet potato” studies refined by climate change” x “soil”

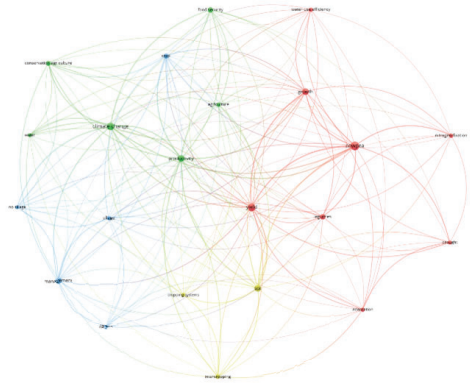

Figure 2. Bibliographic network of “Cowpea” studies refined by climate change” x “soil”

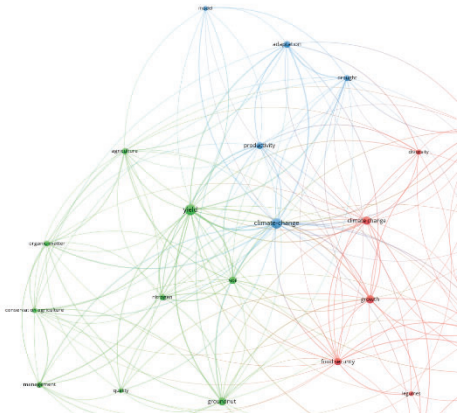

Figure 3. Bibliographic network of "Groundnut" studies refined by climate change" x "soil"

Based on literature review there are two types of scenarios for the three crops selected. The first one is the field validation of current knowledge and the identification of restrictive soil and climate traits. The second scenario is related to the integration of filed results in new forecasts to update the information and development of more site-specific technologies of cropping.

Key words: climatic scenarios, crop eco-pedological requirements, research database, crop suitability.

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The results presented in the paper are an output from research project 16PTE / 2025 - PN4-P7-72/04.02.2025 - „ExoCrop - Explorarea oportunităților climatice și evaluarea favorabilității teritoriului României pentru agricultură optimizată și performantă".

SEMEN QUALITY AND MORPHOLOGICAL CHARACTERISTICS OF HONEY BEE (*APIS MELLIFERA*) QUEENS MAINTAINED IN QUEEN BANK

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Abstract

Honey bee (*Apis mellifera*) queens mate once in their lifetime during nuptial flights, engaging in mating with several drones in mid-air. These matings typically occur at so-called drone congregation areas, where drones from multiple surrounding colonies gather. However, environmental stressors such as prolonged drought or excessive rainfall can reduce floral resource availability (nectar and pollen), which in turn suppresses drone production in colonies. As a result, young virgin queens may struggle to find sufficient mating partners, particularly toward the end of the summer. To overcome this problem queen breeders often maintain surplus mated queens in "queen bank" colonies, ensuring queen availability during periods of limited mating opportunities. To evaluate how queen banking affects queen quality, we conducted an experiment with 128 mated Carniolan honey bee queens (Apis mellifera carnica). At the start of the experiment (Day 0), 20 queens were sampled and analyzed. After 30 days in the queen bank, an additional 29 queens were analyzed (Day 30). The following morphological and physiological parameters were measured: queen body weight, ovary weight, head and thorax width, abdominal length, sperm concentration, and sperm viability. Queens on the day 0 (0,209±0,014 g mean ± standard deviation) were significantly heavier comparing to queens that spent 30 days in bank (0,197 ± 0,009 g), [t(49)=-3,571, p<0,001]. The same was for ovary weight, where queen at day 0 had significantly heavier ovaries [t(49)=-4,821, p<0,001]. There was no difference in head width (3,772±0,061 mm), thorax width (4,693±0,071 mm). and abdomen width (6,632±0,076 mm). When it comes to abdomen length, queens measured at day 30 (11,326±0,364 mm) had significantly longer abdomen comparing to day 0 (10,836±0,520 mm) [t(49)=3,154, p=0,002]. There were no significant differences when it comes to number of spermatozoa in spermatheca (4.306.122±1.146.423) and semen vitality (79,388±21,114 %). Storing mated queens in a queen bank for up to one month appears to be a viable and safe practice under conditions where natural mating may be impaired due to environmental constraints. Despite slight reductions in body and ovary weight, key reproductive parameters such as sperm count and viability remained unaffected, supporting the utility of queen banking as a management strategy during adverse mating seasons.

Key words: Queen bank, *Apis mellifera*, semen quality, morphological characteristics

SELECTED AGROECOLOGICAL PRACTICES FOR FAVORABLE SOIL STRUCTURE: EFFECTS ON SOIL PENETRATION RESISTANCE, INFILTRATION, AND SOIL MOISTURE

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Abstract

In the context of sustainable agriculture, optimizing soil physical properties is crucial for enhancing water retention, supporting root development, and improving long-term productivity. This study, conducted in Hungary, evaluates the effects of different tillage regimes combined with microbial inoculant applications under ecological crop production systems. Specifically, we assessed soil penetration resistance, cumulative infiltration, and moisture dynamics. A field experiment was established with twelve plots cultivated with green beans (Phaseolus vulgaris), subjected to two tillage treatments: no-tillage and soil loosening, each with and without the application of a plant-specific microbial inoculant. Soil penetration resistance was measured at four depths (0–10, 10–20, 20–30, and 30–40 cm) across three time points: before, during, and after harvest. Infiltration and soil moisture content were also evaluated. Results showed that the no-tillage treatment combined with microbial inoculants significantly reduced soil penetration resistance in the subsoil layers (20–40 cm), indicating improved structural conditions. However, at 0–10 cm depth, the no-till + microbes treatment exhibited 17.36% lower moisture compared to loosened soil without inoculants ($p = 0.044$). Similarly, at 20–30 cm, moisture content under no-till without microbial inoculants was 22.25% lower than in the loosened soil with inoculants ($p = 0.004$). These findings suggest that microbial treatments, while beneficial for soil structure, may increase biological activity that potentially raises water consumption or alters water distribution within the soil profile. Overall, the results highlight depth-specific and context-dependent effects, with several treatment contrasts showing no statistically significant differences. This study supports the potential of integrating no-tillage with microbial inoculants to enhance soil physical quality and infiltration, while also emphasizing the need to consider water-use trade-offs. Future research should focus on the long-term implications of these practices under varying climatic and edaphic conditions to better inform agroecological water management strategies.

Key words: No-till, microbial inoculants, soil structure, water retention, agroecology, soil compaction, infiltration

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CLIMATE ADAPTATION CHALLENGES FROM THE HUNGARIAN FARMERS' PERSPECTIVE

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Abstract

The research explores how both organic and conventional farmers in Hungary are experiencing and responding to the growing pressures of climate change, and how they assess the role of organic conversion as a long-term strategy for sustainability. The study investigates how farmers perceive organic farming as a potential pathway to secure their livelihoods, ensure stable yields and high-quality produce, access reliable and value-based markets, and promote soil health and the protection of ecosystem functions. The findings are based on in-depth, semi-structured interviews conducted with 10 organic and 10 conventional farmers, covering a range of arable and mixed farming systems including arable land, grassland with livestock, and vegetable production. The qualitative data were systematically coded and analysed using NVivo software, allowing for an understanding of farmers' experiences and perspectives. Across both groups, farmers report increasing financial strain, heightened exposure to force majeure events, and significant physical and mental burdens stemming from climate-related uncertainties. While a range of adaptation strategies is being implemented - including changes in crop selection, water management, and technological innovations - these often come with additional costs, labour requirements, and knowledge demands, which can further increase vulnerability of farmers. The research offers a comparative lens on how different farming systems - conventional versus organic - cope with climate risks, and underlines the need for more tailored policy support, knowledge exchange platforms, and capacity-building efforts. In particular, the findings point to the potential of organic farming methods that favour minimal or no-tillage practices as promising avenues for building resilience, improving soil structure, and supporting long-term agroecosystem sustainability in the face of climate change.

Key words: organic farming, farmers' vulnerability, climate adaptive solutions, climate risk, holistic approach

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REDUCTION OF FOOD LOSSES AND FOOD WASTE FOR CLIMATE CHANGE MITIGATION

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Abstract

Globally, a third of all food produced - more than one billion tonnes a year - is lost or wasted along the supply chain, a figure that is expected to double by 2050. In the EU alone, over 58 million tonnes of food waste are generated every year. Uneaten food generates significant environmental, social and economic costs, including the loss of embedded resources and greenhouse gas emissions throughout the food system. The FAO defines food losses as those that occur before food reaches the market, while food waste refers to food discarded at any stage of the supply chain, from production to household consumption. Major drivers of food loss and waste include inefficiencies in production, processing, storage, transport, retail and consumer practices. The earlier food is lost or wasted in the supply chain, the greater its environmental impact. Food waste is a double burden on the climate - the waste of emissions from production and the creation of new emissions from disposal. Prevention of food waste is therefore the most effective strategy, followed by redistribution, upcycling and use as animal feed. Composting and anaerobic digestion are preferable to landfill or incineration. Both the upcycling of food by-products into value-added products and biological recovery (e.g., composting) are examples of the principles of the circular bioeconomy by expanding resource use, creating new value chains and closing nutrient loops within agricultural and food systems. An effective approach to reducing food losses and waste requires coordinated action across the supply chain, technological innovation, supportive policies, and informed consumer participation. This approach offers multiple benefits for climate change mitigation, as it reduces greenhouse gas emissions, conserves natural resources, and strengthens food security. Prevention of food loss and waste is one of the key elements of the EU "Farm to Fork" strategy, which lies at the heart of the European Green Deal (EGD) and aims to create fair, healthy, and environmentally friendly food systems.

Key words: food loss, food waste, climate change, mitigation

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THE MULTIFUNCTIONAL ROLE OF BIOCHAR IN CLIMATE CHANGE MITIGATION

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Abstract

This paper provides an overview of biochar's role in climate change mitigation, focusing on its carbon sequestration potential and energy-related applications. Biochar, a stable, carbon-rich product of biomass pyrolysis, offers dual environmental benefits: long-term atmospheric carbon removal and support for low-carbon energy systems. The production process yields a porous, recalcitrant material whose physicochemical properties can be tailored by selecting appropriate feedstock and pyrolysis conditions. The IPCC estimates that about 80% of biochar carbon applied to agricultural soils remains unmineralized after 100 years. Globally, this translates to about 1.1 Gt CO2-eq yr-1 considered economically viable at a carbon price of up to USD 100 per ton. Beyond soil amendment, biochar has multiple energy applications. Its high energy density and combustion properties make it suitable as a solid fuel or co-firing agent with coal. Its surface chemistry enables use as a heterogeneous catalyst in biodiesel production, bio-oil upgrading, and syngas tar reforming. In anaerobic digestion, biochar boosts methane and hydrogen yields, while its porosity and conductivity enhance performance in microbial fuel cells and advanced batteries. However, broader deployment faces challenges: variable quality due to inconsistent feedstocks and pyrolysis conditions, lower catalytic efficiency than commercial alternatives, and high processing costs. Combustion use raises concerns about air pollutant emissions, soil nutrient loss, and reliance on coal.

In conclusion, biochar offers a scalable strategy for climate change mitigation by combining carbon sequestration with sustainable energy integration. Its ability to sequester carbon, enhance soil health, and reduce fossil energy use highlights its potential as an effective climate technology. Realizing this potential requires overcoming performance and cost barriers through research, standardization, and integrated policy support.

Key words: biochar, climate change mitigation, carbon sequestration, renewable energy

THE IMPACT OF CLIMATE CHANGE ON SOIL COMPACTION IN AGRICULTURAL LANDS OF EASTERN CROATIA

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Abstract

Climate change has increasingly become a critical factor affecting soil health and agricultural productivity. In Eastern Croatia climate variability is exerting significant pressure on soil properties and function. One of the major concerns is the impact of climate change on soil compaction, which directly influences soil structure, pore spacing, crop growth, water retention, and overall soil fertility. Soil compaction refers to the process in which soil particles are pressed together, reducing pore space and hindering root penetration, air exchange, and water infiltration. In Eastern Croatia, prolonged periods of drought, followed by heavy rainfall events contribute to this problem. Dry periods often lead to the hardening of the soil surface, making it more vulnerable to compaction during subsequent rainfall or field operations with heavy machinery. On the other hand, intense precipitation can cause surface crusting and subsurface compaction, particularly in soils with poor drainage. Eastern Croatia is predominantly characterized by hydromorphic and pseudogley soils, many of which exhibit profiles with high clay content. These soils are inherently prone to compaction, especially when subjected to mechanical stress under suboptimal moisture regimes. Climate change has been associated with more frequent and intense extreme weather events in the region, including prolonged droughts and sudden heavy precipitation, which modify the soil water regime and exacerbate structural degradation. Soils in Eastern Croatia, particularly those rich in clay, are especially vulnerable because they retain water, become sticky when wet, and are prone to compaction. The compaction of agricultural soils has numerous negative effects. It reduces root development, limits access to nutrients and water, and can cause a decline in crop yields. Additionally, compacted soils are more prone to erosion and nutrient leaching, which further threatens the sustainability of agriculture in the region. To mitigate the impact of climate-induced soil compaction, several strategies must be adopted. These include the use of reduced tillage or no-till systems, the application of organic amendments to improve soil structure, controlled traffic farming to limit machinery movement, and planting cover crops to enhance soil porosity and resilience. Monitoring soil moisture and optimizing field timing are also crucial in minimizing compaction risks. In summary, the interaction between climate change and soil compaction dynamics in Eastern Croatia presents a serious agronomic and environmental challenge. Addressing this issue will require integrative approaches that combine climate-resilient agronomic practices with soil conservation techniques, supported by ongoing research and region-specific modeling of climate-soil-crop interactions.

Key words: soil degradation, soil properties, sustainable agriculture, agronomic practices

SeaSoil Abstracts

GENETIC VARIATION OF GROWTH AND HYPERSPECTRAL PROFILE IN SUGAR KELP FROM TWO NORWEGIAN REGIONS

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Abstract

Sugar Kelp (Saccharina latissima) dominates as a commercially produced seaweed species in Norway and is based on controlled reproduction of wild harvested parents. Genetic variation in growth and other traits between and within geographical locations are unknown and may represent potential for genetic improvement. The aim of this study was to compare two geographically distant Sugar kelp populations in Bergen (west in Norway) and Tromsø (north in Norway) when grown in a standardized environment and search for heritable variation within populations. 1056 sporophytes were produced and divided into 5 tanks with 8-hour light per day and 5 tanks with 12-hour light per day. After 7 weeks each individual sporophyte was imaged on a hyperspectral imaging platform from which total area and average spectral absorbance was calculated. Each individual was genotyped to produce a relationship matrix.

Effects of population and photoperiod on growth (Figure 1) and hyperspectral absorption (Figure 2) were significantly affected by population as well as light regime. The population differences in absorption remained when correcting for individual plant size. Principal component analysis detected 3 principal components, explaining 67% (PC1), 23% (PC2) and 9% (PC3) of the spectral profile. Estimation of genetic parameters was done in asreml, with a genomic best linear unbiased prediction model. Heritable variation within populations was not significant for growth but significant for PC2 (h^2=0.15±0.06). The results indicate that genetic improvement may not be the most effective tool to increase growth. The heritable component of the spectra profile indicates that chemical content may be partly heritable.

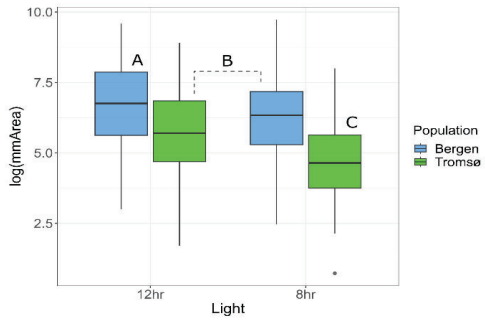

Figure 1. Box plot of surface area

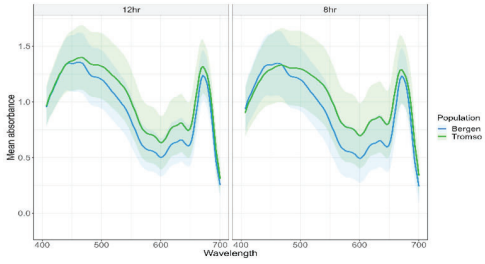

Figure 2 – Spectral absorption of the two populations under each light regime

Key words: sugar kelp, genetics, growth, hyperspectral imaging

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HOW TO USE MARINE-DERIVED RESIDUES FOR CROP NUTRITION

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Abstract

Seaweeds have beneficial effects on soil health and crop nutrition but are not a well-balanced fertiliser when applied alone. Seaweeds are rich in K, Mg, S, and micronutrients, but low in N and P. Hence, mixing seaweed with NP-rich materials, e.g. derived from fish is feasible. Residues from lean fish species such as cod (Gadus morhua) are available in Norway, and brown seaweed is easily accessible along the long coastline. At NORSØK, we have worked for many years to study how marine-derived materials may be utilized for crop nutrition, possibly after composting. High salt content may pose a significant challenge especially with dry conditions, and the content of toxic elements (arsenic and cadmium) also calls for further studies. Here, we present some major results of research done to develop commercial fertiliser products from marine-derived residues which are currently wasted. When mixed with bone-rich fish residues, seaweed residues gave significantly higher yields of grass-clover ley for several years (1). This fertiliser mix also supported the growth and quality of strawberries (2). High salt content did not hamper thermophilic decomposition of seaweed materials, and composting was performed with 100% marine-derived materials (fish bone, seaweed, and blue mussel meal (3). When diluted, tea from such compost tea supported seedling growth with acceptable germination rate (4). High rates of seaweed application may increase the uptake of As in aboveground plant material and lead to risk of tetany in ruminants if the crop is applied as feed (5). In humid regions, marine-derived fertilisers may be applicable, and may be of special interest in organic agriculture where fertilisers derived from conventional agriculture should be phased out. Application rates should be adapted to crop needs.

Key words: Seaweed, Ascophyllum nodosum, fish residues, salt, fertilisers, arsenic

Acknowledgement

The results were achieved in the projects “Sustainable utilization of MARIne resources to foster GREEN plant production in Europe” (MARIGREEN, 2021-24) and “Value creation and ecosystem services of European Seaweed industry by reducing and handling potentially toxic elements from breeding to soil” (SeaSoil 2022-25), funded by the EU Horizon 2020 program (ERA-NET BlueBio cofund, Grant No. 817992 and national funding bodies.

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MOVING BEYOND AGRICULTURE AND AQUACULTURE TO SUSTAINABLE FOOD SYSTEMS IN A CIRCULAR BIOECONOMY

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Abstract

The objective of this presentation is to present and discuss how systemic innovations can deliver a step change in the way food is produced in Europe. The production of healthy, safe and affordable food can contribute towards a just transition to net zero carbon (C) for Europe. A systemic and cross-sectorial approach can contribute to climate mitigation by transfer of atmospheric CO2 to the terrestrial biosphere using low trophic species (LTS), including plants, seaweed (SW) and mussels (i.e. C sequestration) and increasing organic C stocks in soils and vegetation biomass (i.e. C storage). In line with the European Farm to Fork strategy we propose the following: 1. Linking marine and terrestrial systems by closing the global C and N cycle using composted and processed marine and terrestrial waste and by-products in agricultural soils for long-term C storage. Useful tools based on digital technologies that can contribute to this include: WebGIS tool on predicting soil C storage and AI model systems to improve decision support systems in management of soil, vertical farming, and animal feeding. 2. Increase C sequestration by diversifying crop agriculture and aquaculture, including kickstarting a seaweed bioeconomy in Europe. Examples of relevant innovations here are: New machinery for low greenhouse gas diversified orchard farming and advanced breeding methods, including selection for new low trophic aquaculture species. 3. Reduce GHG emissions by developing circular feed systems for farm fish and cattle using cultured SW, by-products from fishery, aquaculture and processed terrestrial animal by-products from poultry and livestock. Innovative urban and vertical farming solutions shorten the distance from food production to urban consumers and to input resources, reducing GHG emissions from transportation and land area required. We also propose a custom configured and digital user-oriented co-creation approach for Responsible Research and Innovation (RRI). Altogether this can pave the way for linking and scaling up C-neutral marine and terrestrial food production systems into a future sustainable and circular bioeconomy.

Key words: low trophic organism, GHG

Acknowledgement

Results presented are output from “SeaSoil”, an ERA-NET BlueBio cofund project funded by Horizon 2020: EU Program for Research and Innovation (GA# 817992) and The Research Council of Norway (#339232).

IMPACT OF SEAWEED APPLICATION TO SOIL ON ECOSYSTEM HEALTH

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Abstract

Seaweeds have been applied as soil amendment for centuries. Biostimulants from seaweed may protect crops towards harsh climatic conditions such as drought spells. Seaweed application may also contribute to soil carbon (C) sequestration, aiding to mitigate climate change mitigation effort. However, brown seaweeds commonly contain arsenic (As) and cadmium (Cd), and hence their application in soil needs monitoring and assessment. During 2022-25, the "SeaSoil" project has investigated how seaweed application rate and soil characteristics influence As and Cd. The work aimed to assess the chemical reactivity and potential bioavailability of labile As and Cd and to evaluate seaweed's capacity for soil C sequestration in agricultural soils. The uptake of arsenic in plants, mimicked by diffusive thin film gradient sensors, increased with increasing application of seaweed materials to oats (Avena sativa L.), the uptake of cadmium was not affected. Preliminary results from the leaching experiments showed that soil newly amended with seaweed materials presented a larger risk of As and Cd leaching during intense rainfall events (10 mm/h). However, the leaching risk diminished rapidly few days or weeks after the seaweed application. Soil respiration measurements showed that adding 2% seaweed triggered a short burst of activity within four days, while 4% seaweed extended elevated respiration to seven days. This is expected, as more organic matter provides microbes with more energy and takes longer to break down. Once the seaweed is decomposed, respiration levels return to baseline, showing no significant difference from control soils. In a 6-month carbon sequestration trial, soil organic carbon (SOC) increased by 10.2% to 68.1% after six months, depending on the seaweed rate (2% or 4%). The smallest gains occurred in soils with initially high SOC. Sequestration efficiency ranged from 33.6% to 62.7%, highest in clay-rich soils. However, higher seaweed additions reduced sequestration efficiency.

Key words: arsenic, Ascophyllum nodosum, carbon sequestration, leaching, soil respiration

Acknowledgement

The results presented in the paper are an output from the project "Value creation and ecosystem services of European Seaweed industry by reducing and handling potentially toxic elements from breeding to soil" (SeaSoil), 2022-25, funded by the EU Horizon 2020 program (ERA-NET BlueBio cofund, Grant No. 817992).

SOIL RESPIRATION RESPONSE TO APPLICATIONS OF DIVERSE SEAWEED PRODUCTS AND RESIDUES

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Abstract

Seaweed has a long history of use in agriculture, particularly in coastal regions, due to its high content of organic matter, macro- and micronutrients, and bioactive compounds such as plant hormones. When applied to soil, seaweed can improve soil structure, water retention, and nutrient availability. It also stimulates microbial activity, which is essential for nutrient cycling and overall soil fertility. Commercial seaweed fertilizers—primarily based on brown seaweeds like Ascophyllum nodosum—are valued for their content of natural growth-promoting hormones which enhance root development, stress tolerance, and overall plant vigor. Given the sustainability concerns surrounding large-scale seaweed harvesting, there is growing interest in utilizing waste streams and byproducts from seaweed processing. Repurposing materials like Fucus or Ascophyllum byproducts that would otherwise go unused could reduce waste, increase resource efficiency, and offer new, cost-effective solutions for improving soil health and contributing to carbon sequestration. Soil respiration measurements revealed that adding 2% seaweed caused a sharp increase in respiration within the first four days. In contrast, with a 4% seaweed addition, the elevated respiration lasted up to seven days. This pattern aligns with expectations—introducing more organic matter extends the period of heightened microbial activity, as microorganisms have access to more energy and require more time to decompose the material. Once the seaweed is fully broken down, respiration levels stabilize, and no significant differences are observed between the amended and control soils. In a 6-month soil carbon sequestration study, results after six months of incubation indicated noticeable changes in soil organic carbon (SOC). Depending on whether 2% or 4% seaweed was applied, SOC levels increased by 10.2% to 68.1%. The smallest increase was noted in soils that initially had the highest SOC content. SOC sequestration efficiency ranged from 33.6% to 62.7%, with the greatest efficiency found in soils with the highest clay content. A higher application rate reduced sequestration efficiency for one seaweed type, while it increased it for the other.

Key words: Ascophyllum nodosum, carbon sequestration, Fucus, soil respiration

Acknowledgement

The results presented in the paper are an output from the project “Value creation and ecosystem services of European Seaweed industry by reducing and handling potentially toxic elements from breeding to soil” (SeaSoil), 2022-25, funded by the EU Horizon 2020 program (ERA-NET BlueBio cofund, Grant No. 817992).

SOIL BIOGEOCHEMISTRY OF ARSENIC AND CADMIUM FOLLOWING SEAWEED AMENDMENTS IN COASTAL AGRONOMY

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Abstract

Seaweed-based materials offer significant potential for enhancing nutrient cycling in coastal agronomy. Rich in organic matter and essential minerals, seaweed can improve soil fertility, stimulate microbial activity, and enhance water retention, making it a sustainable alternative to mineral fertilizers. However, seaweed also tends to accumulate trace elements from marine environments, notably arsenic (As), cadmium (Cd), iodine (I), and selenium (Se). In this study, we investigated the biogeochemistry of As and Cd, given their potential toxicity to crops, livestock, and humans when present above safe thresholds. A two-year randomized field experiment was conducted at the NORSØK campus in Northwest Norway. The experimental soil, with a controlled pH of approximately 5.5 and an organic carbon content of around 5%, was amended in 2023 with high and low doses of two seaweed materials. These doses were designed to match and exceed the national permissible limits for Cd application to agricultural soils. In 2024, the experiment was repeated at new plots to ensure replication. Oat was used as the test crop. Soil samples were collected before sowing, and both soil and plant materials were sampled at three key growth stages: post-germination, maximum elongation, and full maturity. A final soil sampling was conducted approximately one month after harvest. The experimental period spanned from May to September each year.

Diffusive Gradients in Thin Films (DGTs) were deployed in-house under controlled temperature and humidity conditions immediately after sample collection. DGTs were placed in water-saturated soils for 48 hours at each sampling interval. All soil, plant, and DGT samples were analysed for As and Cd concentrations. Preliminary results indicate that DGT-labile As concentrations in soils, were highest at the beginning of the growing season, followed by a consistent decline through September, a trend observed in both years. In contrast, DGT-labile Cd levels remained relatively stable throughout the season. Treatments with the highest As and Cd inputs also yielded the highest DGT-labile fractions of these elements, which was reflected in the concentrations found in plant straw. The correlation was stronger for As than for Cd. Notably, As and Cd concentrations in oat grains were not significantly influenced by the DGT-labile soil fractions. These findings suggest that repeated application of seaweed materials can increase the availability of labile As and Cd in soil, potentially leading to plant uptake or leaching. However, the extent of this risk is highly dependent on the seaweed species used and its pre-treatment.

Key words: Seaweed, DGT-lability, Arsenic, Cadmium, Soil, Fiel trial

Acknowledgement

These results were generated as part of the project "Value Creation and Ecosystem Services of the European Seaweed Industry by Reducing and Managing Potentially Toxic Elements from Breeding to Soil" (SeaSoil 2022–2025), funded by the EU Horizon 2020 program through the ERA-NET BlueBio Cofund (Grant No. 817992).

APPLICATION OF MARINE FERTILIZERS ON STRAWBERRY CULTIVATION

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Abstract

Strawberry (Fragaria × ananassa Duch.) is one of the most widely cultivated horticultural crops, grown across almost all continents. Due to its biochemical composition, taste, and flavor, it remains among the most popular summer fruits in European countries. To explore sustainable fertilization strategies for strawberry production, we designed a tabletop cultivation system in which two bare-root plants of the cultivar 'Albion' were established in pots filled with peat substrate [1]. Over two consecutive years (2022–2023), outdoor experiments were conducted to evaluate the effects of organic fertilizers derived from underutilized marine residual materials on strawberry growth, nutrient uptake, yield, and fruit quality [2]. The marine-based fertilizers were obtained from the fish and seaweed industries [3]. In 2022, five treatments were applied: cod bone powder, common ling bone powder, small cod bone powder combined with rockweed residue pellets, a chemical fertilizer, and a non-fertilized control. In 2023, a complementary trial was initiated to examine the combined effects of different peat-to-compost ratios, biochar, and an algae-based biostimulant. Compost application strongly influenced nutrient dynamics, leading to low nitrogen availability but enhanced potassium and phosphorus uptake. Moreover, fertilizers based on common ling bone powder and rockweed–fish residue pellets increased the concentrations of several macro- and micronutrients in strawberry leaves. Overall, the findings indicate that organic fertilizers derived from fish and macroalgal residues can effectively support strawberry growth and partially replace chemical fertilizers, contributing to more sustainable cultivation practices.

Key words: Seaweed, Residual raw materials, Fish residue, Algae residue.

Acknowledgement

This work is part of project "Sustainable utilization of MARIne resources to foster GREEN plant production in Europe" (MARIGREEN), funded by the EU Horizon 2020 program ERA-NET BlueBio cofund, Grant No. 817992 and national funding bodies.

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OVERVIEW OF MACROALGAE VALUE CHAIN AND ROADMAP TO MARKET

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Abstract

In Europe there is a long history of people utilising macroalgae for both food, feed stocks and fertilisers. With the management of the resource of different wild harvested species such as *Ascophyllum* for utilisation in both the alginates industry and the creation of bio-stimulants the SeaSoil project has looked at the cascading use principal for the resources coming from both aquaculture and the wild harvesting macroalgae industry in the creation of a circular industry with the total amount of the biomass utilised for food, feed, bio-stimulants, soil enhancers and soil amendments. Challenges around the potentially toxic elements such as arsenic, cadmium and iodine are key drivers in the process where the processed macroalgae product market and end user direction. Utilising industry partners and stakeholders information and surveys the SeaSoil project has investigated the opportunities that exist for macroalgae producers, harvesters and processors for the valuable blue bio resource along the value chain including the side streams and process residues that are available including their integration into the agricultural sector. With the increase of macroalgae been produced at sea and on land, there is now an influx of both high value and high quality macroalgae entering the market that some of this product will enter the bio-stimulant market directly due to the seasonality of the production process and the processing of the product. The SeaSoil project will present the opportunities for this production value chain from the hatchery to the end users and their market opportunities.

Key words: *Ascophyllum nodosum*, high value, high quality, aquaculture, wild harvesting

Acknowledgement

The results presented in the paper are an output from the project “Value creation and ecosystem services of European Seaweed industry by reducing and handling potentially toxic elements from breeding to soil” (SeaSoil), 2022-25, funded by the EU Horizon 2020 program (ERA-NET BlueBio cofund, Grant No. 817992).

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