II. Natural Hazards and Climate Change Conference

Session 9 Towards Resilient Agroecosystems

Microgreens and vertical farming- a sustainable tool for investigating plant salt stress responses – *Ágnes Szepesi, Andrea Rónavári, Adedokun Oluwatosin Peace, Batnasan Ganbold, Rebeka Karginov, Péter Pálfi, Zoltán Kónya*

Using Earth Observation and AI for Irrigation Management Amidst Meteorological Hazards: A Case Study in Limpopo, South Africa – *Nxumalo Gift Siphiwe, Zsolt Feher, Ramabulana Tondani Sanah, Nagy Attila*

Effect of irrigation with "greywater" on Triticum aestivum – *Brigitta Roxána Horváthné Dani, Martin Horváth, Anna Skribanek*

The Role of Historical and Recent Land Use and Land Cover Changes in Promoting Biological Invasions in Hungary – *Márton Bence Balogh, Zalán Tobak, Dominik Kaim, Péter Szilassi*

Large scale production of peptaibols for plant protection – *Gergő Terna, Bence Váczi, Dóra Balázs, Fanni Kovács, Chetna Tyagi, Ákos Rozsnyói, András Szekeres, Mónika Varga, Csaba Vágvölgyi, Tamás Papp, László Kredics, Tamás Marik*

Assessment of Vegetation Water Demand and Drought Index in Arid and Semi-Arid Regions Using Satellite Data and Plant Water Metabolism – *Mukesh Singh Boori,* Komal Choudhary

Microgreens and vertical farming- a sustainable tool for investigating plant salt stress responses

Ágnes Szepesi[1], Andrea Rónavári[2], Adedokun Oluwatosin Peace[1], Batnasan Ganbold[1], Rebeka Karginov[1], Péter Pálfi[1], Zoltán Kónya[2,3]

[1]*Department of Plant Biology, University of Szeged, Szeged, Hungary*

[2]*Department of Applied and Environmental Chemistry, University of Szeged, Szeged, Hungary*

[3]*MTA-SZTE Reaction Kinetics and Surface Chemistry Research Group, Szeged, Hungary*

According to the report of FAO, more than 10 percent of the total global land area is affected by salinity and due to the climate crisis and human mismanagement, excessive salinization could risk an additional one billion hectares (FAO, 2024).

Controlled environment could offer a suitable strategy for investigating the salinity induced stress responses of plants. Two departments of University of Szeged (Department of Applied and Environmental Chemistry and Department of Plant Biology) established a controlled indoor greenhouse with precision technology in cooperation with industrial partners in the frame of GINOP project to install a modern vertical farm system with precision lightning system to study the plant metabolism. Our study focuses on investigating model plant species like Lepidium sativum and Lepidium crassifolium in order to compare their salt stress responses and decipher the mechanisms behind salt stress tolerance.

This sustainable and cost-effective manner for investigations could enhance our knowledge in salt stress-specific plant responses and contribute to make plants more tolerant to different stress conditions. In this study, an overview about the advantages and limitations of this strategy will be demonstrated.

The study was funded by GINOP_Plusz-2.1.1-21-2022-00080 project.

Using Earth Observation and AI for Irrigation Management Amidst Meteorological Hazards: A Case Study in Limpopo, South Africa

Nxumalo Gift Siphiwe[1,2], Zsolt Feher[1,2], Ramabulana Tondani Sanah[3], Attila Nagy[1],
[1]*Institute of Water and Environmental Management, University of Debrecen, Debrecen, Hungary*
[2]*National Laboratory for Water Science and Water Safety, University of Debrecen, Debrecen, Hungary*
[3]*Institute of Geography and Earth Sciences, University of Pécs, Pécs, Hungary*

Effective irrigation management is crucial in mitigating the impacts of meteorological hazards on agriculture. This study explores the integration of Earth Observation (EO) data—using both optical and radar sensors—with machine learning models and in situ meteorological data to enhance irrigation strategies in the Vhembe District, Limpopo, South Africa. Key parameters analyzed include crop drought prediction, major field crop delineation, soil moisture estimation, actual crop evapotranspiration (ETc), and secondary salinization classification.
To estimate reference evapotranspiration (ET_0), the Hargreaves (HG) method was employed, utilizing temperature-based meteorological inputs. Soil moisture was derived using Synthetic Aperture Radar (SAR) backscatter analysis, while ETc was retrieved through vegetation index-based approaches. Major crop delineation was performed using NDVI and regional yield data, applying classification algorithms to distinguish different crop types. Machine learning models, including random forests and deep learning approaches, were used for prediction and classification tasks, integrating ground-based meteorological data to refine model accuracy.
The novelty of this study lies in the synergistic use of multi-source EO data, AI-driven analytics, and a hybrid approach combining remote sensing and in situ data to optimize precision irrigation in a climate-vulnerable region. We introduce a novel approach to tracking soil salinity changes over time using SAR-based techniques, including polarimetric decomposition methods (the Freeman-Durden and Yamaguchi), multi-temporal coherence analysis, and interferometric SAR (InSAR) for soil structure changes. These techniques enable the detection of salinity-induced variations in soil dielectric properties and surface roughness, improving secondary salinization classification. The findings underscore the potential of these methodologies in improving irrigation strategies and enhancing climate resilience in agricultural systems.

Effect of irrigation with "greywater" on Triticum aestivum

Brigitta Roxána Horváthné Dani[1], Martin Horváth[2], Anna Skribanek[2]
[1]*Eötvös Loránd University, Budapest, Hungary,*
[2]*Eötvös Loránd University, Szombathely, Hungary,*

As a result of the increasing intense dry periods, irrigation with grey wastewater from washing and dishwashing is becoming more and more common practice worldwide. However, there are some ingredients in detergents that can pose a serious threat if released into the environment. Some of their components can be broken down by microbes under aerobic conditions, but no during anaerobic conditions or in several cases toxic substances are produced under anaerob conditions.
In our research, we irrigated Triticum aestivum organisms with a solution of three commercially available synthetic detergents and laundry soap (diluted 1:10) for two weeks.
Detergents caused severe drought stress for wheat crops. The moisture content of the organisms decreased sharply compared to the control crop, even though the soil moisture content was higher. In the 10-fold dilution of two tested synthetic detergents the shoot length of the plants decreased significantly compared to the solution of the laundry soap solution of the same concentration. Chlorophyll-a and total carotenoid content decreased in only one solution of synthetic detergent compared to the control (carotenoid content was reduced compared to the laundry soap solution), but the build-up of chlorophyll-b was inhibited by all synthetic detergents. The laundry soap solution did not inhibit the development of photosynthetic pigments. The activity of the enzyme guaiacol peroxidase, which is considered to be a stress enzyme, was significantly increased by one of the synthetic detergents, which characterizes the degree of stress exerted by detergents on plants. The laundry soap solution did not cause stress to the growth of wheat and its above-mentioned physiological parameters at the tested concentration.
Although our research examined the effects of solutions that are more concentrated than the concentrations that are realistically released into the environment after short-term exposure, based on our results, we conclude that long-term exposure can presumably cause detectable inhibition of Triticum aestivum even at lower concentrations of synthetic detergents.
This work was supported by the EKÖP-24 University Excellence Scholarship Program of the Ministry for Culture and Innovation from the Source of the National Research, Development and Innovation Fund.

The Role of Historical and Recent Land Use and Land Cover Changes in Promoting Biological Invasions in Hungary

Márton Bence Balogh[1], Zalán Tobak[2], Dominik Kaim[3], Péter Szilassi[1]
[1]*University of Szeged, Department of Physical and Environmental Geography, Szeged, Hungary*
[2]*University of Szeged, Department of Atmospheric and Geospatial Data Science, Szeged, Hungary*
[3]*Jagellonian University of Kraków, Department of Institute of Geography and Spatial Management, Kraków, Poland*

The dispersal of invasive plant species is influenced by a variety of geographic factors, including topography, climate, soil characteristics and hydrology. However, the significance of these factors varies according to the specific species in question. Another significant influencing factor that must be considered is historical and recent changes in Land Use and Land Cover (LULC). While LULC changes may facilitate the establishment of certain invasive species, the duration of their impact on biological invasions remains uncertain. This study assessed the potential relationships between historical LULC patterns over the past 200 years and the recent emergence of four common invasive plant species in Hungary: Ailanthus altissima (tree of heaven), Asclepias syriaca (common milkweed), Elaeagnus angustifolia (Russian olive) and Solidago spp. (goldenrod). The present study utilised Geographic Information System (GIS) data and statistical methodologies to undertake a comparative analysis of historical (1848–1990) and recent (1990–2018) changes in LULC with the contemporary distribution of the aforementioned invasive species in 2018. The results indicated that A. syriaca is more influenced by recent LULC changes, while A. altissima, E. angustifolia and Solidago spp. are more affected by historical LULC changes. A. altissima and E. angustifolia have been observed to thrive in areas of high land-use intensity. The analysis indicates that A. syriaca demonstrates a preference for areas characterised by mixed and decreasing land-use intensities, while Solidago spp. exhibits a preference for areas with continuously increasing and decreasing land-use intensities.

Large scale production of peptaibols for plant protection

Gergő Terna, Bence Váczi, Dóra Balázs, Fanni Kovács, Chetna Tyagi, Ákos Rozsnyói, András Szekeres, Mónika Varga, Csaba Vágvölgyi, Tamás Papp, László Kredics, Tamás Marik

Department of Biotechnology and Microbiology, University of Szeged, Szeged, Hungary

Chemicals used in today's agriculture harm the environment, therefore, there is an emerging need to replace them with efficient bioproducts. Members of the filamentous fungal genus Trichoderma are popular biocontrol organisms due to their rapid growth, intense sporulation, extracellular enzyme production and mycoparasitic behaviour. Certain Trichoderma species, which can grow at higher temperatures, could be used in agriculture under warmer conditions arising due to climate change, however, these species are also known as opportunistic pathogens in humans. The use of bioactive secondary metabolites produced by thermotolerant Trichoderma strains as biocontrol agents instead of using the strains themselves could minimize the risks arising from field application of potential opportunistic human pathogens.

Peptaibols are short, linear, helical antimicrobial peptides mostly produced by members of genus Trichoderma. Non proteinogenic amino acids such as α-aminoisobutyric acid (Aib) or D-isovaline are always present in their backbone, increasing the stability of peptaibols. They can form voltage-dependent ion-channels in cell membrane, especially in Gram-positive bacteria and filamentous fungi. Furthermore, peptaibol treatment of plants can induce systemic resistance in plants, through which they can act as biocontrol agents. We developed large-scale inexpensive and sustainable procedures to cultivate Trichoderma for peptaibol production. Two types of methods were established using certain grains and mycelia regrown several times on the same microbiological medium, and both methods significantly increased peptaibol production. The results of this study established the basis for commercial production of peptaibols, which is essential to introduce them in agriculture as biocontrol agents.

This work was supported by the Hungary–Serbia IPA Cross-border Co-operation Programme (project FERTILEAVES, HUSRB/23S/11/027) and by the Scholarship Program of the Ministry of Culture and Innovation, financed from the National Research, Development and Innovation Fund (EKÖP-24-4-SZTE-629, EKÖP-24-4-SZTE-605).

Assessment of Vegetation Water Demand and Drought Index in Arid and Semi-Arid Regions Using Satellite Data and Plant Water Metabolism

Mukesh Singh Boori[1], Komal Choudhary[2]
[1]*University of Central Asia, Khorog, Tajikistan*
[2]*Aarhus University, Aarhus, Denmark*

This study presents an integrated approach to assess ecological water demand (EWD) and vegetation drought stress in arid and semi-arid regions. We introduce a novel method for evaluating threshold EWD, focusing on the Tarim River Basin over the past 30 years. By utilizing remote sensing data, we estimated evapotranspiration and analyzed the dynamics of minimum and optimum EWD. A new analytical framework, inspired by the concept of "latitude" from ecosystem resilience, was proposed to quantify vegetation's water demand effectively. Our findings showed average minimum and optimum EWD values of 105.45 mm and 135.53 mm, respectively, with variations among vegetation types such as woodland, grasslands, and high-coverage areas. In addition, we address the challenge of monitoring vegetation drought by introducing the standardized Vegetation Water Deficit Index (SVWDI). This index, based on the Remote-sensing-based Water Balance Assessment Tool model, tracks vegetation's water deficit and its drought response. We examined the spatiotemporal evolution of vegetation drought in the study area from 1995 to 2025. Our results reveal that drought conditions were severe during the first two decades but have been alleviated in recent years. SVWDI showed a significant correlation with vegetation health, particularly with the normalized difference vegetation index (NDVI), and exhibited improvement over time. This study offers valuable insights into the role of EWD in ecosystem management and provides guidance for climate adaptation strategies, such as vegetation restoration in the study area and sustainable water resource allocation in arid regions.