II. Natural Hazards and Climate Change Conference

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Agroclimatic Trends and Adaptation: Challenges and Future Perspectives in Hungary

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Agriculture is one of the most exposed sectors to the increasing frequency of climate extremes caused by climate change. The intensification of temperature rise, droughts during the growing season, and significant modifications in extreme climatological and meteorological parameters have contributed to the deterioration of arable land conditions, yield reductions, and declining crop quality in recent years.

Following the historic drought of 2022, the Hungarian agricultural sector has undergone transformation, with increasing attention given to its vulnerabilities and the policy-driven adaptation responses available. Besides climate change, soil degradation, water management, and the European Union's Green Deal also pose significant challenges to the national agricultural sector.

In this research, we primarily focused on recent agroclimatic observations and future scenarios. The analysis was conducted using homogenized and interpolated agroclimatic databases and crop yield data, with special emphasis on temperature and precipitation indicators during the growing season.

A long-term climate analysis is necessary to understand the drought events of 2022 and 2024 and to ensure the success of future adaptation and mitigation strategies. The findings may assist stakeholders in the agricultural sector in effectively reducing the adverse impacts of climate change, thereby enhancing resilience to similar shocks and preventing increased vulnerability within the industry.

Biodiversity of cultivable bacteria in the rhizosphere of industrial crop plants in Hungary

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The efficiency of agricultural production in temperate regions is increasingly threatened by rising average temperatures, desertification due to uneven distribution of precipitation, and the emergence of new pathogens linked to climate change. The widespread application of chemical pesticides, the appearance of their residues in the food chain, as well as the excessive use of fertilizers leading to eutrophication and nitrate pollution further exacerbate environmental concerns. Consequently, there is a growing demand for alternative, eco-friendly soil management strategies based on beneficial microorganisms that enhance plant growth and alleviate environmental stress. One of the primary challenges in utilizing beneficial microorganisms for agricultural purposes is the variability in their field efficacy. A promising approach to overcome this limitation is the development of soil inoculants that incorporate multiple beneficial microbial strains rather than relying on a single strain.

Our ultimate goal is the development of a complex, multi-microbial soil inoculant to mitigate the adverse effects of climate change in the cultivation of major crops such as soybean, maize, and sunflower. As a first step, we are assessing soil microbial biodiversity in the cultivation systems of these industrial plants.

Soil samples were collected from maize, sunflower, and soybean fields at three different locations. A total of 120 potential plant growth-promoting microorganisms were isolated. Based on existing literature, the isolated bacterial and fungal strains include several species with plant growth-promoting (e.g., Arthrobacter sp., Bacillus mojavensis, Epilithonimonas ginsengisoli, Priestia aryabhattai, Pseudomonas thivervalensis, Trichoderma sp.), biocontrol (e.g., Bacillus velezensis, Bacillus subtilis, Priestia megaterium, Pseudomonas koreensis, Trichoderma sp.), and bioremediation (e.g., Bacillus halotolerans, Pseudomonas frederiksbergensis) properties.

This research contributes to the development of sustainable agricultural practices by identifying microbial consortia that can enhance crop resilience to environmental stressors while reducing reliance on chemical inputs.

The study was supported by the Proof of Concept Fund of the University of Szeged.

Comparison of salt stress induced biochemical responses of *Lepidium sativum* (garden cress) and the salt tolerant Lepidium crassifolium

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Brassicaceae family contains many valuable plant species with different medicinal compounds. Lepidium sativum (garden cress) a nutrient-rich plant species from this family with hepatoprotective, antioxidant, anticancer, antimicrobial, anti-inflammatory, hypoglycemic, diuretic, and antihypertensive effects. As functional food, it contains phenolics, flavonoids, essential fatty acids, γ-tocopherol, and phytosterols, and seeds are recognized with therapeutic applications for age-related diseases, immune support, and fracture healing. Compared to the well-studied garden cress, the biochemical responses of its salt tolerant relative, Lepidium crassifolium remain to be explored. Lepidium crassifolium (other scientific name Lepidium cartilagineum subsp. cartilagineum) is a halophyte plant species naturally occurring in sodic soils in Great Hungarian Plain. Our study reveals the main different biochemical responses of these two Lepidium species during salt stress in controlled vertical farming system and simulated salt treatment conditions using mild (100 mM) and severe (300 mM) NaCl concentrations. Our results decipher some species-dependent alterations in growth parameters and related stress markers. These investigations contribute to apply halophyte plant species for human health promotion in the future not only in our planet but also in the extraterrestrial conditions.

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Development of a healthy casing alternative from spent mushroom compost

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During the cultivation of white button mushroom (Agaricus bisporus), the mostly peat-based casing material – which covers the compost colonized by mushroom mycelia – plays an important role in the formation of fruiting bodies and in high-water retention capacity. Today, the supply of casing material for champignon cultivation is a major problem, as peat mines are being exhausted, furthermore, peat mining is a destructive industry, as peatlands - the world's largest terrestrial carbon sink - represent one of the most significant tools of climate change mitigation. Thus, it is a burning problem to develop new and healthy casing layer alternatives to avoid environmental damages and pollution.

A good quality casing material contains variable microorganisms. Our aim was to develop a healthy casing alternative from spent mushroom compost. Occurrent microorganisms in the spent Agaricus compost include both beneficial and harmful bacteria (e.g., Bacillus, Pseudomonas, Microbacterium, Alcaligenes species) and fungi (e.g., Trichoderma, Hypomyces, Fusarium, Lecanicillium, Mortierella, Rhodotorula species). From the genera Bacillus, Pseudomonas, Phanerochaete and Rhodotorula, many representatives have beneficial properties. Microorganisms (bacteria and fungi) were isolated from spent mushroom compost samples taken during a natural recomposting process. The isolates were identified, characterized, and a consortium was established to help the natural recomposting process, which resulted in a peat-like material full of nutrients. Mushroom cultivation trials in bags revealed, that mixed with peat in a 90:10 ratio, the recomposted spent mushroom compost is excellent for use as casing, furthermore, it also has potential as plant growing medium, therefore it has the potential to become a succesful example of circular agriculture.

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Effect of plasma-activated water seed priming on the development of *Arabidopsis thaliana* seedlings in a drought stress model system

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In the contemporary context of global climate change, plants are increasingly subjected to significant environmental stressors. Among these, drought represents one of the principal abiotic challenges, severely restricting crop productivity on a global scale. Various strategies have been developed to address drought-induced stress, with seed priming being a prominent technique. It is a cost-effective and sustainable approach with potential to improve drought resistance and subsequently enhance crop yield.

Plasma-based technologies facilitate the production of priming agents that are not only cost-effective and efficient but also exhibit a minimal environmental impact. Plasma-activated water (PAW) is generated using cold plasma, which enhances the concentration of reactive oxygen and nitrogen species (RONS) within the treatment medium. The concentration of RONS can be stabilized through the incorporation of zinc (Zn) into the solution [1], potentially augmenting the effectiveness of PAW as a priming agent. Seeds of the wild type Arabidopsis thaliana L. (Col-0) were incubated in various treatment solutions [distilled water (HP), PAW, PA(W+Zn), PA(W+ZnO nanoparticle)] for 24 hours, in darkness, at 24 °C.

To simulate drought conditions, polyethylene glycol 8000 treatment was administered for three days following an initial cultivation period of four days on stress-free agar media. Data on seedling growth such as root length, hypocotyl length, cotyledon area, stomatal density were collected. Additionally, cell viability, in planta zinc level, and the levels of in planta RONS (e.g. nitric oxide, peroxynitrite, superoxide radical, hydrogen peroxide) were detected.

Acknowledgement: The work was supported by the „Lendület” MOMENTUM project of the Hungarian Academy of Sciences (LP2023-14/2023).

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Future crop yield trends across Europe from past observations and ISIMIP climate scenarios

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A statistical crop yield model developed by the author, ABSOLUT [1], is capable of identifying the time aggregates of meteorological variables or indices most relevant for agricultural yields. Using ISIMIP climate change scenarios as input to the model calibrated on recent weather and yield data future crop yields have been projected for the districts of Germany and for Europe's NUTS-2 regions.

Results show strong weather effects on green maize (high coefficients of determination in leave-one-out validation) and a generally negative outlook for the future: The median scenario under CMIP6 SSP370 climate, represented by ten bias-corrected model realizations, shows 5–15% declines in green maize yields for the years around 2050 compared to nowadays levels in most European regions. Southern France, Northern Italy, and Bulgaria are predicted to experience yield losses of even more than 20%, albeit with lower reliability. The Mediterranean countries however include also some regions with positive trends on low confidence levels. In a more distant future of the years around 2080 the spatial pattern remains unaltered, but the strength of the changes will have doubled.

For winter wheat the model performs better in the eastern parts of Europe. Only slight declines in yield of 0–10% are projected there for the 2050 time slice; for the years around 2080 losses of more than 25% have to be expected, though. Drastic losses of 20–50% and exceeding 50% in the more distant future threaten many Mediterranean regions. There is however also a stable outlook for Britain and Ireland, The Netherlands, Belgium, and the North-Western parts of France. Yield increases are projected for Southern Finland and the Baltic states. This regional exception to the general downward perspective is in good agreement with a map presented in the European Drought Risk Atlas [2] whose authors implemented a different modelling approach.

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Isolation, identification and characterisation of potential biocontrol agents of walnut pathogens in Turkey and Hungary

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Walnut (Juglans regia) is a commercially significant hardwood species. Both Turkish and Hungarian walnuts are highly sought in global markets. However, climate change-related challenges, including cultivation difficulties and plant health issues, have continuously declined walnut yield and quality.

The decline of walnut trees is caused by pests and various bacterial and fungal pathogens, which increasingly affect trees as their natural resistance weakens. Presently, chemical pesticides are the primary means of protection. However, the accumulation of chemical residues in the food chain rises environmental and health concerns, intensifying the demand for sustainable, eco-friendly alternatives such as biological control methods.

In Turkey, Anatolia, particularly the Van Lake Basin, is a key genetic center for walnut and an important region for its cultivation. We aimed to detect Xanthomonas arboricola pv. juglandis (Xaj), the causal agent of walnut bacterial blight, and to identify potential biocontrol agents. Surveys conducted in 2024 across Van, Hakkari, and Bitlis provinces found no evidence of Xaj or disease symptoms. Bacterial isolates were obtained from walnut leaves in surveyed orchards, yielding 47 candidate biocontrol agents. Screening for plant growth-promoting traits revealed that 19% of isolates solubilized phosphate, 87% produced indole-3-acetic acid (IAA), 76.5% exhibited siderophore production, and 27.6% demonstrated nitrogen fixation ability.

In Hungary, our research focused on the microbial diversity associated with walnut trees. Soil and phyllosphere samples were collected from orchards with varying degrees of disease severity. Alongside walnut pathogens (Pantoea agglomerans, Agrobacterium tumefaciens, Alternaria angustifolia, Neofusicoccum parvum, Nothophoma spiraeae, Aspergillus sp.), potential biocontrol agents, including Trichoderma, Bacillus, Pseudomonas, Streptomyces, and Simplicillium species, were identified and are under detailed characterization.

Our findings provide foundation for future research on biocontrol strategies in walnut cultivation both in Turkey and Hungary.

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Osmotic stress-induced anatomical changes in pea (*Pisum sativum* L.) leaves

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Due to the weather extremities and decreased amount of rainfall in the last few years, drought stress has become a threatening factor for the plants, mainly in the southern part of Hungary. In order to elucidate the potentially detrimental effects of osmotic stress on the anatomical traits of plants, we used pea plants as model. In our study, pea (Pisum sativum L. cv. Petit Provencal) seeds were primed (pre-treated) with distilled water (hydroprimed, HP) for 24 h, then plantlets were cultivated for 10 days, finally the half of the plants were exposed to osmotic (drought) stress for 3 days, using 20 w/v% polyethylene glycol (PEG8000; indicated as PEG20). Since PEG-treatment caused spectacular decay of the leaves, we compared the leaf structure of HP and PEG20 pea plants. Leaf segments were fixed and embedded in agarose to make cross sections by vibratome. Leaf sections were observed and photographed by light microscopy, and the following parameters were measured: leaf thickness, mesophyll thickness, the thickness and the ratio of palisade and spongy mesophyll. Our results showed that PEG-treatment resulted in not only fewer leaves with withered leaflets but it decreased the thickness of the leaf blade and the entire mesophyll, and mainly the amount of spongy mesophyll cells which seems to be a characteristic anatomical response for drought stress.

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Enhancing hydrocarbon biodegradation: Repeated application of extracellular organic matter from Micrococcus luteus in used lubricant oil-contaminated soils

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Used lubricant oils (ULOs) can accumulate various harmful compounds (e.g., heavy metals, polychlorinated or polyaromatic hydrocarbons) and cause persistent pollution in the soil environment, thereby disrupting its natural habitat functions or potential future use. Under such adverse conditions, microorganisms, including hydrocarbon degraders, can enter a low- or zero-activity viable but non-culturable (VBNC) state. Consequently, the success of biological rehabilitation techniques largely depends on maintaining microbial activity or reactivating VBNC cells through the application of biostimulant agents. Resuscitation-promoting factors (Rpfs) have been shown to be effective in the initial stages of bioremediation of ULO-contaminated soils. In this study, we aimed to extend the early phase stimulatory effect of Rpf-containing extracellular organic matter (EOM) from Micrococcus luteus to enhance ULO-biodegradation efficiency in polluted soils. ULO-contaminated ex situ soil microcosms were supplemented with EOM at the beginning of the experiment (Day 0) and again at the end of the first ULO-biodegradation phase (Day 20). By the end the 60-day incubation period, the initial concentration (30,300 mg/kg) of extractable petroleum hydrocarbons (EPHs) was reduced by 56% in the soil treated with repeated EOM application combined with biostimulation (BS+2xEOM), while single EOM dosing (BS+EOM) resulted in a significantly lower ULO-bioconversion of 46%. Moreover, BS+2×EOM significantly increased microbial colony-forming units (CFUs), respiration, and soil enzyme activities (dehydrogenase, catalase, sucrase, and fluorescein diacetate hydrolase) compared to the corresponding control treatments (natural attenuation, biostimulation, biostimulation+EOM). Although BS+2×EOM and BS+EOM showed the most effective bioremediation outcomes, the germination index of oilseed rape (Brassica napus L.) decreased to 43% and 42%, respectively, in the treated soils. Our results indicate that while microbial activities were stimulated and pollution levels reduced, these improvements do not necessarily translate to decreased soil phytotoxicity.

A Research Station Plan for the Global Challenges of the 21st Century

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In Hungary, global climate change is reflected in rising annual average temperatures and decreasing total precipitation. The consequences include heat and drought stress in plants, desertification, and soil degradation due to carbon loss. These changes threaten food security, reduce biodiversity, shift phenological phases, and cause a range of other environmental impacts.

To investigate these challenges, we have designed a complex environmental monitoring station on a 4-hectare semi-natural grassland located between the towns of Hódmezővásárhely and Szeged. The research focuses on the following key areas:

The risk of dry summers is among the highest in the Southern Great Plain region. Given the limitations of irrigation-based agriculture, it is crucial to emphasize improving the soil’s water retention capacity. By measuring evapotranspiration, we aim to assess water retention and the improvements in water use efficiency resulting from no-till techniques in the Southern Great Plain.

Continuous monitoring of soil organic carbon content will help estimate the rate of carbon sequestration. Drought conditions negatively impact the soil’s ability to store carbon, and there is a strong correlation between annual precipitation and net ecosystem carbon exchange. In years of low rainfall, net sequestration may reverse, leading to carbon loss.

Nitrogen loss due to fertilization and how it is influenced by climate change is another core objective. Globally, around half of all applied fertilizer is not utilized by crops, placing a significant burden on the environment. The consequences include soil acidification, depletion of the stratospheric ozone layer, an enhanced greenhouse effect, the spread of nitrophilous species, acid rain, smog formation, and health hazards. Measuring the flux of ammonia and nitrous oxide emitted into the atmosphere from fertilization using photoacoustic methods is also part of the research station’s planned activities.

Plasma activated water-based seed pre-treatment affects the development, in planta reactive oxygen- and nitrogen species and photosynthetic activity of osmotic-stressed pea plants

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Nowadays, drought has become a prominent problem. New methods resulting in healthier plants and better yields are needed to alleviate drought stress. The use of plasma activated fluids enables a new green and sustainable approach. Seed-pretreatment is a technique with which we can enhance the growth and resilience of plants leading to better germination, yield and stress response.
The aim of our model experiments is to study the effect of plasma-activated water (PAW) seed pre-treatment on osmotic stress tolerance. The ratio of reactive oxygen and nitrogen species (RONS) in PAW were modified by the addition of zinc ion (Zn). The following treatments were used for pea (Pisum sativum L. cv. Petit Provencal) seeds: distilled water (HP), PAW, PA(W+Zn) and Zn. After one day long seed treatment, the plants were grown for 10 days, followed by 72 h of osmotic stress treatment (20 w/v% polyethylene glycol, PEG8000). PEG8000 significantly reduced the stem length, primary and lateral root number, which could not be significantly improved by seed pre-treatments. In contrast, PEG8000-induced viability loss and hydrogen peroxide accumulation were reduced by PAW seed pre-treatment. Osmotic stress significantly increased in planta nitric oxide levels, which were not significantly affected by any of the seed treatments. In further studies, we detected levels of other RONS in root tips. PAW seed treatments improved leaf development, therefore photosynthetic parameters were investigated using porometer and OJIP (with FluorPen).

Acknowledgement: The work was supported by the „Lendület" MOMENTUM project of the Hungarian Academy of Sciences (LP2023-14/2023).

Cellulose content in annual increments of Norway spruce (*Picea abies* (L.) Karst.) along an elevation gradient in the Rarău Mts (Romania)

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The studies on quantity of the cellulose content (CC%) of tree rings, calculated from the dry weight and the cellulose weight of a wood sample and its implication for dendroclimatological studies are quite scarce and even less is known about the influence of environmental conditions on the annual variability of the CC%.
CC% series from Norway spruce (Picea abies (L.) Karst.) was investigated in the Eastern Carpathians collected from three stands along an altitudinal gradient. Three individual trees were sampled in each stand and the α-cellulose of the annual increments laid between 1961 and 2020 have been extracted based on a modified Jayme–Wise procedure.
We hypothetized that (H1) positive correlation between CC% and mean summer temperature for the spruce stands; and (H2) CC% values can be lowest for high elevation tree-ring material, as a reflection of the colder conditions typically prevailing near the timberline.
The CC% series showed a significant increase in mean interseries correlation, such as low stand (r=0.1, p=0.4), middle (r=0.33, p=10-2), and high elevation (r=0.59, p=10-5) as moving toward the timberline. The mean CC% series showed positive correlation with thermal conditions of the growing seasons with a response peaking in the early growing season at the low elevation (rMay=0.27), and mainly in high summer at the middle (rMay-Aug=0.56), and high (rJul-Aug=0.65) elevation stands. These results from this pilot study support both hypotheses and encourage further testing of tree-ring cellulose content of Norway spruce as a supplementary proxy in dendroclimatology and dendroecology.

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Frost rings in Swiss Stone Pine (*Pinus cembra*) from Rodna Mts. (Romania) - Anatomical evidence of late spring frost in the past centuries

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In this study, we analysed the tree ring features of Swiss Stone Pine (Pinus cembra L.) from the Zănoaga Valley, Rodna Mountains, Romania. The aim was to build a tree ring chronology and detect anatomical evidence associated with historical frost damage in the xylem. Tree-ring width were measured and checked using a LINTAB measuring table and the TSAPWin software. A total of six discs (dead trees) and four core samples (living trees) were analysed and the tree ring width chronology spans from 1551 to 2007 CE, covering nearly half a millennium. In every individual sample there is evidence of anatomical modification typical for frost damage. A total of 58 frost injuries were detected within the studied period. In the first half of the period represented by the disc samples, 47 frost damages were identified. However, after 1831 CE, these samples no longer showed any frost injuries. In the core samples, 11 damages were visible, with frost-related anomalies still present in the early 20th century. A significant frost event was recorded in 1876 CE, with its imprint observable in 75% of the core samples.
Some of the frost ring event detected in the Rodna Mts are found in the frost-ring chronologies of the Călimani Mts (~70 km SE direction) and the Retezat Mts (~280 km in SSW direction) suggesting regional spring frost events in the historical time affecting extended regions across Southeast Europe.

The impact of polyethylene-based plastics and heavy metals on rapeseed root growth

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The efficient functioning of agriculture plays a vital role for society, so the study of abiotic stressors that threaten agricultural crops is particularly important. Artificial polymers, such as plastics, pose a serious environmental risk because they accumulate as waste, are fragmented and have the ability to bind pollutants such as heavy metals. In metal-polluted areas, where sewage is used as fertilizer, high concentrations of several metals often occur. When plastic pollution is also present, plants have to cope with multiple stressors during their development.
In the present study, we investigated the effect of three types of plastics, PE (polyethylene), LDPE (low-density polyethylene), LLDPE (linear low-density polyethylene), in the presence of solutions containing multiple heavy metals, on the early root growth of rapeseed (Brassica napus L.). During the experiment, 1 cm plastic fragments were soaked at different concentrations (0.5-1%) in distilled water and model wastewater containing heavy metals (Cd, Cr, Cu, Hg, Ni, Pb, and Zn) at the highest concentrations allowed by law.
The results show that plastics had a generally positive effect on rape root growth, while model wastewater treatment slightly reduced it. In most cases, the coexistence of plastics and heavy metals did not cause more stress than the combined heavy metal treatment. The presence of both contaminants together did not appear to significantly inhibit the early root development in rapeseed. A deeper understanding of the problem is of paramount importance for sustainable agriculture.

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The role of chitosan-encapsulated NO-donors in enhancing tomato resistance to fungal infections

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Agricultural production worldwide is severely threatened by fungal pathogens, which are responsible for approximately 70-80% of plant diseases, causing significant economic losses (Zhang et al., 2023). Among these pathogens, Botrytis cinerea, a polyphagous, necrotrophic fungus, is particularly dangerous as it can infect all parts of tomato plants through direct contact or wounds (Sarven et al., 2020). This infection leads to direct losses such as yield reduction and unmarketable crops, as well as indirect damages, including quality deterioration and increased control costs, resulting in annual economic losses amounting to billions. One promising approach for sustainable plant protection is the application of nanotechnology-based strategies, particularly those utilizing nitric oxide (NO). NO is a key signaling molecule involved in plant growth regulation and stress tolerance, with increasing evidence supporting its role in plant defense against pathogens. Its reaction product, S-nitrosoglutathione (GSNO), serves as an effective NO donor that contributes to enhancing plant immunity. GSNO-based polymer nanodonors, encapsulated in biodegradable chitosan (CHT), enable targeted and sustainable NO delivery (Seabra et al., 2022). This approach can strengthen plant signaling and defense mechanisms, offering an effective alternative to conventional fungicides. In this study, Solanum lycopersicum L. cv. Money Maker tomato fruits were infected with B. cinerea B05.10 at a spore concentration of 10^6 spores/ml. Prior to infection, fruits were treated with free GSNO, chitosan-encapsulated GSNO, or empty CHT nanodonors at 5 mM concentrations, applying 1 ml per fruit via spraying. Infection symptoms were assessed three days post-inoculation. The results provide insights into the effectiveness of nanotechnology-based approaches in reducing fungal infections while evaluating their impact on fruit quality.

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In silico assessment of the ecotoxicological characteristics of terbuthylazine as a pollutant in surface waters

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Terbuthylazine (TBA), a triazine herbicide is commonly applied in agricultural activities to eliminate weed species and optimize crop yields. Following application, the accumulated TBA can persist in the environment and contaminate water sources via surface runoff and leaching. Consequently, human exposure to TBA through food chain may lead to a range of adverse health outcomes [1]. In our research, we applied various in silico methodologies to predict the biomimetic properties of TBA and evaluate its ecotoxicological impact on living organisms [2].
Preliminary studies (ADMETlab 3) indicate a significant toxicological profile such as cancerogenity and respiratore toxicity. Activity on liver enzymes (CYP2D6), passage through the blood-brain barrier and consequent neurotoxicity and endocrine toxicity can be expected as well (ProTox 3). The predicted bioconcentration factor (assesses the potential for secondary poisoning and the risk to human health via the food chain) is 0.946. The aquatic ecotoxicity is considered through values of LC50FM=5.30 (96-hour fathead minnow 50 % lethal concentration), and LC50DM=4.22 (48-hour daphnia magna 50 % lethal concentration). The predicted oral toxicity, LD50 for TBA is 750 mg/kg (Class 4). We assessed the impact on the human body of consuming one liter of water for measured 8.2 μg/l of TBA (OPERA). Predictions show that TBA will be mostly accumulated in the liver (7.8 μg/ml) and intestines (5.3 μg/ml) which can cause liver damage. Pharmacokinetic predictions indicate a high degree of human intestinal absorption (HIA=0.894), which further increases the toxic effect of its increased concentration in the intestines. In the case of a pregnant woman, it can be expected to cross the placenta and cause liver damage (36.38 μg/ml) and kidney damage (28.25 μg/ml). There is also accumulation in the thyroid gland (13.91 μg/ml) which may lead to delayed fetal development. The obtained data indicate an important ecotoxicological risk of TBA and the possibility of toxic effects including pregnant women.

Zinc Oxide Nanoparticles: Dual Effects on Broccoli Growth Under Nutrient and Salinity Stress

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As climate change intensifies, rising temperatures increase evaporation rates, leading to higher soil salinity. In addition, irrigation with saline water is becoming an increasing challenge for crop production in many regions. Understanding plant stress responses is essential for developing strategies that can improve plant stress tolerance. Nanoparticles may be good candidates for this purpose, but our current knowledge of the effects of these compounds is limited.
Zinc oxide nanoparticles (ZnO-NPs) have attracted attention in agriculture due to their potential to enhance plant growth, but their environmental impact remains a concern. The ability of ZnO-NPs to alleviate salt stress suggests that they may be able to maintain agricultural productivity under such conditions. In our controlled vertical farming system, we investigated how ZnO-NPs affect the growth of broccoli microgreens (Brassica oleracea) under different nutrient levels and salinity, assessing their role as growth modulators and potential stressors.
Under nutrient-rich conditions, higher ZnO-NP concentrations maintained or slightly improved plant growth, while lower concentrations were more beneficial in nutrient-limited environments. Under distilled water treatment, exposure to ZnO-NPs negatively affected plant development, suggesting potential toxicity in the absence of nutrients. However, under salinity stress, ZnO-NPs significantly improved fresh weight compared to untreated plants, highlighting their ability to reduce salt-induced growth inhibition.
Our efforts are needed to properly balance the benefits of nanoparticle applications with environmental considerations, ensuring resilient and sustainable crop production in the face of global climate challenges.

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The role of climate microrefugia in shaping intraspecific trait variability in *Myrmica ruginodis*

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Climate change is transforming habitats worldwide, altering environmental conditions critical for species survival. Heterogeneous landscapes, such as sinkholes, are becoming increasingly important as they provide diverse microhabitats that support species with different ecological requirements. A distinctive characteristic of sinkholes is their significant microclimatic variation, particularly on north-facing slopes and bottoms, which are cooler and more humid than the surrounding plateaus. While previous studies suggest that sinkholes harbour species with distinct traits, little is known about their influence on intraspecific trait variation—specifically, how populations of the same species adapt to different environmental conditions. To address this knowledge gap, we investigated how sinkhole habitats affect the functional and behavioural traits of the ant species Myrmica ruginodis, which can significantly impact their fitness. Our results showed no significant differences in overall functional and behavioural trait patterns. However, sinkholes had a notable impact on certain functional and behavioural traits. Virgin queens were more abundant on the plateaus, while males were more numerous in sinkholes, although colony size did not differ significantly between the two microhabitats. Sinkholes contained more worker brood, suggesting a greater potential for colony growth. Notably, worker aggressiveness was more consistent, and worker size showed greater variability in sinkholes, emphasizing the distinct individual traits of these colonies. These findings highlight the role of small-scale habitat features in driving intraspecific trait variation and emphasize the potential of habitat islands like sinkholes to promote ecological and behavioural diversity. As climate change continues to reshape ecosystems, such microhabitats may become increasingly crucial in maintaining biodiversity.

Temperature and geographical location induced fluctuations of population density of European ground squirrels in Hungary

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Rodent populations often undergo demographic fluctuations and cycles, highlighting the need to understand the underlying factors for accurate predictions, especially for endangered species. We analyzed long-term data from the Hungarian Biodiversity Monitoring Scheme on European ground squirrel populations to assess abiotic factors influencing spatial and temporal dynamics in Hungary. Using generalized additive models with splines, we examined the relationship between relative population density—monitored annually since 2000—and environmental and weather variables. Our findings identified location, year, and winter temperatures as key determinants of ground squirrel density. Populations in central Hungary had higher densities, while those in the northern and southern regions were lower. Additionally, winter temperatures during hibernation contributed to density fluctuations. Given the overall decline, our results suggest that rising winter temperatures may negatively affect ground squirrel survival and population density.

The accelerated spruce dieback in Central Europe is a warning sign of the climate change

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The Norway spruce (Picea abies (L.) Karst) dominates the European boreal forests, subalpine areas in the Alps and the Carpathian Mountains. It is also widely planted outside its natural range and has considerable economic and ecological importance. In 2023, a remarkable summer heat struck many parts of the Earth, leading to considerable tree dieback. In addition to the data of the statistical office, we collected data from citizens of the Hungarian administrative units from the Carpathian Basin to assess the intensity and extent of planted spruce dieback. As a result, the spruce tree loss had an alarming rate in the last year (59.1±1.5 percent of planted spruce tree dieback was reported) indicating accelerated climate change. Our study draws attention to several conclusions derived from this. Extreme climate events (1) increase people's will to react, (2) can make the species' survival impossible on a regional scale even within a few years and (3) can cause unpredictable, cascade-like complex transformations in ecosystems and in the agriculture, for which environmental policy must be prepared in economic and social aspects. (4) Extreme climate events can more quickly make drastic changes than we have thought and (5) the signs of it appear in basin areas first.

Extreme Dry Events in Vojvodina: Observations and Climate Change Projections

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As a result of climate change, the Vojvodina region in northern Serbia is witnessing more frequent extreme weather events. Considering the existing trends and future climate change projections, a wide range of impacts is anticipated on the agricultural sector. The Consecutive Dry Days (CDD) metric, commonly utilized in drought research, serves as an important indicator of drought severity by measuring the duration of dry spells. Understanding short-term droughts and their impact on agriculture and ecosystems is crucial. This research studied the occurrence and length of extreme CDDs during the growing season for historical (1950-2019) and future (2020-2100) periods in the Vojvodina region for 9 locations. This analysis utilized an ensemble of eight downscaled, bias-corrected regional climate models from the EURO-CORDEX database, focusing on the RCP8.5 scenario to assess future CDD events. The analysis of CDD events was conducted using the Threshold Level Method on precipitation data, defining extreme CDDs as periods of at least 15 consecutive days without rain. The adapted threshold was chosen as it is more relevant for agriculture, considering that field crops may suffer from water stress after 15 days without rain or irrigation. The research examined various aspects of the stochastic process for CDDs, focusing on the distribution patterns of three key elements: distribution of the number and duration of CDD events, and distribution of the longest CDD events. To determine if extreme CDDs events act as independent and identically distributed random variables, run tests at a 5% significance level were conducted for all nine locations, utilizing both historical data and the chosen ensemble of eight regional climate models. These run tests confirmed the randomness hypothesis. Additionally, serial correlation coefficients for the series of extreme CDD events were computed, and a significance test at the 5% probability level indicated the independence of these CDDs, revealing no notable serial correlation within the data. The Poisson distribution was used to model the number of extreme CDD events, the exponential distribution function was used to model the distribution of the duration of CDDs, and the Gumbel distribution was selected to model the durations of the longest CDD events. The results indicate an increased likelihood of more frequent and severe droughts in the future, compared to historical data. There is an expected rise in the probability of 3 to 6 dry periods in the growing season. Moreover, the lengths of the longest CDDs within a growing season are anticipated to extend, reaching up to 57 days for a 10-year return period and 83 days for a 100-year return period. This trend suggests a worsening in drought conditions, particularly in the eastern and northern areas of the Vojvodina region. These insights are valuable for predicting future agricultural drought scenarios, aiding decision-makers in adjusting agricultural practices to mitigate the adverse effects of climate change.

Observed long-term trend in various extreme precipitation-related climate indices

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Precipitation is one of the most important meteorological elements, and its absence can cause severe damage to the ecosystems, agriculture and forestry, on the other hand, intense rainfalls may also led to devastation, e.g. flash floods, which are one of the most dangerous natural hazards. Therefore, climate monitoring is very important, which allows us to detect the long-term changes of meteorological variables including precipitation. In addition, it can help us to prepare for the adaptation to the expected change in climate extremes.
To analyse the observed climate trends, using measurement-based, long data series of good quality is essential. At the Unit of Climate Research of the Hungarian Meteorological Service (HungaroMet) the MASH (Multiple Analysis of Series for Homogenization) software is used for producing homogenised, quality controlled, completed (free from missing data) station data series. After homogenization process, in order to obtain spatially representative data for Hungary, the homogenised station data series are interpolated onto a 0.1° horizontal grid using the MISH (Meteorological Interpolation based on Surface Homogenized Data Basis) method developed specifically for meteorological variables.
On the HungaroMet webpage, several extreme temperature climate indices are already available for 24 settlements, as well as for the nationwide average, dating back to 1901. As part of this research, precipitation indices will be created and analyzed for the period 1901–2024 using homogenised daily station data series to support local climate adaptation efforts. In this study, the results are presented for Szeged and Budapest for the following extreme precipitation-related climate indices: consecutive dry days, the highest daily precipitation sum and very heavy precipitation days (days with a precipitation sum of at least 20 mm). The indices are illustrated on a yearly basis using graphs. A linear trend model is fitted to the index values to assess the impact of climate change in observations.

Eutrophication in Freshwater Ecosystems: Impacts of Nutrients, Groundwater, and Climate Change

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The eutrophication presents the natural response of freshwater ecosystems to increased nutrient inputs. It is noticed that uncontrolled algal growth is intensified by global warming, leading to deterioration of water quality. The sources of high nitrate and phosphate concentrations are usually caused by improper fertilization techniques, inadequate manure storage, and untreated wastewater impact. Due to increased content of organic matter in water bodies, its subsequent decomposition leads to oxygen depletion, pH decrease, and creates hypoxic or anoxic conditions, resulting in fish mortality and ecosystem destabilization. The phenomenon of blooming reduces light penetration, increases turbidity, and leads to layering of the water body, making it unsuitable for drinking or irrigation. In the case of harmful algal toxins appearance, the risks to aquatic life, livestock, and human health are significant. Although it is often acknowledged that surface nutrient loads are the primary causes of eutrophication, groundwater influx during surface water recharge should also be considered. The content of nitrogen and phosphorus can be further increased if the surface water recharges with nutrient-enriched groundwater, maintaining eutrophic conditions even during times when surface inputs are reduced. This kind of nutrient-loaded recharge can prolong algal blooms, disrupt natural self-purification processes, and decrease the effectiveness of lake management techniques like sediment management, biological restoration, nutrient load reduction, and algal bloom control. Sediment temperature has a significant impact on nutrient cycling. The temperature increase induces microbial activity, thus organic matter content and consequently releases phosphate (PO_4^{3-}) and ammonia (NH_4^+) from sediments. Because of longer stratification periods and higher microbial activity, summertime usually sees the most obvious nutrient release from sediments. The seasonal peaks are prolonged, and nutrient retention is increased by rising global temperatures. The intensification of eutrophication brought on by climate change reflects precipitation patterns, with heavy rains increasing nutrient-rich discharge and droughts lowering water exchange. Disturbed patterns of oxygen saturation, water layering and stratification impact biodiversity, and usability of water, emphasizing the need for climate-adaptive strategies to protect freshwater resources.