INTERNATIONAL CONFERENCE ON

Alternatives to Reduce Soil Degradation

BOOK OF ABSTRACTS

BUDAPEST, HUNGARY | 19 MAY 2026

ARSD 2026 Alternatives to Reduce Soil Degradation

AI 4 Soil Health

HUN REN ATK CENTRE FOR AGRICULTURAL RESEARCH

BME BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS

EJP SOIL European Joint Programme

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Alternatives to Reduce Soil Degradation – ARSD2026

Book of abstracts

19 May 2026, Budapest, Hungary

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Institute for Soil Sciences, HUN-REN Centre for Agricultural Research

Budapest

2026

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(HUN-REN ATK Talajtani Intézet – TAKI, Budapest, Hungary)

Co-organizers:

Budapest University of Technology and Economics (BME)

AI4SoilHealth – Accelerating collection and use of soil health information using AI technology to support the Soil Deal for Europe and EU Soil Observatory

EJP – European Joint Programme Soil

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International Conference on

Alternatives to Reduce Soil Degradation

May 19, 2026, Budapest, Hungary

Conference Schedule

May 19, 2026 08:30-17:00 Budapest, Hungary

8:30-9:00 Registration – upload presentations, put up posters

9:00-9:30 Conference opening (moderator: Ágota Horel)

9:00-9:05 Welcome – **Dr. Szabolcs Rózsa**, Dean, Budapest University of Technology and Economics, Faculty of Civil Engineering

9:05-9:10 Conference opening – **Dr. László Pásztor**, DSc, Director, HUN-REN ATK, Institute for Soil Sciences

9:10-9:30 Keynote speaker: **Prof. Tomáš Dostál** – Soil and water conservation, Czech Technical University, Czech Republic

Oral presentations: 12 minutes each +3 minutes for questions

9:30-10:30 Section 1: Recent developments in soil science and soil health (chair: Nándor Csikós)

9:30-10.30

1) **Tibor Tóth**, Szilárd Szabó, Tibor Novák, Szabolcs Czigány, Mihály Kocsis, András Makó, Bence Gallai, Mátyás Árvai, János Mészáros, Kitti Balog – Evaluation of four classification levels of Soil Taxonomy, Hungarian classification and WRB in terms of biomass production and their use for management zoning in a salt-affected alluvial plot (HUN-REN ATK TAKI, Hungary)
2) **Grant A Campbell** – Exploring the potential of underutilised plant species for improving soil health in Sub-Saharan Africa (University of Aberdeen, United Kingdom) - online

3) **Vladimir Ćirić**, Dragana Marinković – Soil data collection as initial steps for digital decision support systems in field production in Vojvodina (Novi Sad University, Serbia) - online
4) **Elemér László**, Dhikra Aouatef Benmansour, Péter Bodnár, Magdolna Szilágyi, László Palcsu – Strontium isotopes reveal terroir signatures in wine (HUN-REN ATOMKI, Hungary)

10:30-11:00 Coffee break

11:00-12:30 Section 2: Advances in soil biology (chair: Tünde Takács)

1) **Borbála Biró**, Zsolt Kotroczó – Plant-growth-promoting or -regulating rhizobacteria and analysis of soil-microbiom as potential monitoring tools of soil-health (MATE University, Hungary)
2) Csilla Almási, Viktória Orosz, Timea Tóth, Ibolya Demeter, István Henzsel, Zsolt Bogdányi, Tamás András Szegi, Mostafa M. Mansour, **Marianna Makádi** - The role of sewage sludge compost in the phosphorus cycle (IAREF, Hungary)
3) **Katalin Bereczki**, Attila Benke, Endre Tóth, Melinda Megyes, Kristóf Korponai, Tibor Szili-Kovács, Gábor Illés, Károly Márialigeti – Evaluation of the structure and respiration activity of soil bacterial communities in three Hungarian forest stands (Sopron University, Hungary)
4) **Tibor József Novák**, Áron Béni, Evelin Juhász, Costa Gumisirya, Soma Horváth, Botond Buró, István Kocsis, Zsolt Sándor, Andrea B. Kovács – Spatial and temporal variations in the abundance and composition of the soil microbiome in healthy and degraded soils in Hungary based on PLFA markers (Debrecen University, Hungary)
5) **Viktor Szentpéteri**, Zoltán Mayer, Lívia László, Katalin Posta – Host-Mycorrhiza compatibility results in varying stress resilience in tomato against drought and heat (MATE University, Hungary)
6) **Anandyawati Anandyawati**, Syaiful Anwar, Dwi Andreas Santosa, and Zainal Muktamar – Implications of soil fauna diversity and abundance on land use age gradients in horticultural agricultural systems for soil health (IPB University, Indonesia; Bengkulu University, Indonesia) - online

12:30-13:30 Lunch

13:30-14:30 Section 3: Conservative agriculture (chair: Eszter Tóth)

1) **Abdulrahman Maina Zubairu**, Anita Takács, Boglárka Anna Dálnoki, András Sebők, Caleb Melenya Ocansey, Miklós Gulyás – Characterization of controlled pyrolysis and traditional drum kiln biochar, and their agronomic evaluation (MATE University, Hungary; UNIMAID University, Nigeria)
2) **K Sanjith** – Reducing soil degradation in tea plantations through soil organic matter management: A 25-year study from the Nilgiris (UPASI, India)
3) **Lizana Flores G. Shelly**, La Scala Junior Newton – Loss of vegetation and CO_2eq emissions as indicators of soil degradation in different biomes of Peru - São Paulo State University "Júlio Mesquita Filho" (UNESP University, Brazil)

4) **Sándor Horváth**, Gabriella Horváth, Gemma Gabriella Horváth, István László Papp, Gáborné Horváth – Soil ventilation - a new way to revitalization (WOODTECH PLC, Hungary)

14:30 - 15:30 Section 4: Monitoring and modeling soil processes (chair: Ágota Horel)

1) **Seyedehmehrmanzar Sohrab**, Brigitta Szabó, László Pásztor, András Makó, Gábor Szatmári – Bias correcting bulk density observations in the Hungarian Soil Information and Monitoring System (HUN-REN ATK TAKI, Hungary)
2) **Zsolt Kozma**, Tamás Ács, Bence Decsi, Máté György – Soil hydraulic aspects of a regional water balance modelling effort in the Tisa River Basin (BME University, Hungary)
3) **Ronald András Kolcsár**, Piroska Kassai, Péter Braun, Kinga Farkas-Iványi, János Mészáros, Michael Strauch, Cordula Wittekind, Mikołaj Piniewski, Christoph Schürz, Natalja Čerkasova, Brigitta Szabó – Stakeholder-driven multi-objective optimisation of water retention measures in a small Hungarian catchment (HUN-REN ATK TAKI, Hungary)
4) **Ignacio Domenech-Carretero**, Gema Guzmán, José Alfonso Gómez – Quantifying the effects of soil management on sediment dynamics using WaTEM/SEDEM in a Mediterranean small catchment under olive cultivation (IAS-CSIC, Spain)

15:30 - 16:00 Short presentations (Chair: Zsófia Bakacsi)

PICO presentations – 3-4 minutes each

1) **Ubaid Munawar Mir**, Shah Murzata Mushtaq, Khurshid Ahmad Sofi, Iqbal Jeelani, Mansha Manzoor – Soil quality indices for assessing the impact of forest soil health in urban forest division Srinagar
2) **Fredy F. Rivas Yupanqui**, Lizana Flores Giuliana S. – Critical phosphorus levels in maize grown in soils with contrasting remnant phosphorus and buffering capacity in the Mantaro Valley, Peru
3) **B Nivetha**, M Srinivash, P Murugesan, K Sanjith – Developing an organic foliar nutrition strategy to reduce soil degradation in tea cultivation in South India
4) **Amit Kesarwani**, Suraj Kumar – Enhancement of chlorophyll content as SPAD value and spike production in wheat crop under foliar feeding of urea and micro nutrients
5) **Fahad Amjad**, Muhammad Zain – Machine learning approaches for optimizing cover crop selection to enhance soil carbon sequestration and reduce degradation
6) **Muhilan Gangadaran**, Bagavathi Ammal Uma, Sankar Ramasamy, Dharumarajan Subramanian, Mummadi Thrivikram Reddy, Hemavathi Manivannan – Geospatial assessment and kriging-based mapping of soil fertility in agricultural lands of Karaikal district, Puducherry, India

16:00 – 16:55 Coffee break and Poster section

Poster presentations and a **free discussion** at the poster exhibition.

Posters:

1) **Jeancy Ntuka Luta**, Alasca Ekuya Lombolu, Paul Mafuka – Restorative approaches to degraded urban-rural land in the city-province of Kinshasa and its reuse for agricultural production (University of Kinshasa, Democratic Republic of Congo)
2) **Ariba Shahab** – Integrated mobile pyrogasification and biochar enhancement for low-carbon, resilient NET ZERO agriculture
3) **Hassan El-Ramady**, József Prokisch – Can nanotechnology be a solution against global water crisis? Towards promising approach for saving water under climate change
4) **Ashenafi Nigussie** – Effects of bio-slurry and inorganic nitrogen fertilizer rates on wheat yield components, yield, and soil properties (Ethiopian Institute of Agricultural Research based at Wondo Genet Agricultural Research, Ethiopia)
5) **Arous Ali**, Ouaar Djilali, Kaci Zakia, Dahmene Thoraya, Kelkouli Nouredine – Influence of livestock manure types (poultry and rabbit manure) on soil improvement for the preservation of natural resources in Algeria
6) **Raj Sharma**, Neha Kumari – Conservation agriculture and regenerative tillage practices: A pathway to soil health restoration and sustainable crop production
7) **Waqar Ahmed Pahore**, Muhammad Taqi Mirza, Amna Saleem, Arsalan Baigal, Kainat – A critical review on impacts of microplastic pollution on physico-chemical properties of soil
8) **Raghvendra Kumar Kushwaha**, Rishi Pratap – Soil physical, chemical, biological properties and recent soil health advances
9) **Manrique-Córdoba**, C. Álvarez-Alonso, E. Martínez-Sabater, Pérez-Murcia, M.D., S. Sánchez-Méndez, F.J. Andreu-Rodríguez, L. Orden, Sáez, J.A., Moral, R., Bustamante, M.A. – The agronomic application of compost and compost extract derived from agro-industrial wastes in lettuce cultivation
10) **João Pedro Coumendouros Scott** – Multi-isotopic tools to assess impact of vegetation changes on nitrogen and carbon cycles of Brazilian Highland soils
11) **Zafirah Zainal Abidin**, Mohd Hadi Akbar Basri, Muhammad Zhafiran, Noorsuhaila Abu Bakar – Effects of POME rates and NPK fertilizer combuinations on growth, yield, shelf life, and soil chemical properties of cucumber (*Cucumis sativus* L.)
12) **Muhammad Zhafiran Bin Zamri**, Mohd Hadi Akbar Basri, Zafirah Zainal Abidin, Noorsuhaila Abu Bakar – Influence of palm oil mill effluent (POME) amendment on growth, physiology and soil chemical properties under *Mucuna bracteata* cultivation
13) **Lucia Toková**, Lenka Botyanszká, Peter Šurda, Natália Botková – Effect of polystyrene on radish (*Raphanus sativus* L. var. *Sativus*) growth in Chernozem
14) **Dana Elhottová**, Kajan Grodecká Lucie, Hobza Roman, Matějů Ldislava – Benefits and risks of human sludge composting as an alternative fertilizer to mitigate soil degradation
15) **Shabir Muhammad** – Indigenous arbuscular mycorrhizal fungi associated with zinc and copper in rice-cultivated soils of southern, central, and northern Khyber Pakhtunkhwa
16) **Sherwan Yassin Hammad**, Mahrokh Shafiei, Ledianë Durmishi, Gábor Milics – Hyperspectral site-specific weed detection as a strategy to mitigate herbicide-induced soil degradation

17) **Noorsuhaila Abu Bakar**, Muhammad Syahren Adzahar, Mohd Hadi Akbar Basri, Zafirah Zainal Abidin, Muhammad Zhafiran Zamri – Optimising grain corn productivity through nitrogen management strategies
18) **Dominika Lassu**, Márk Rékási, Orsolya Szécsy, Péter Ragályi, Mónika Molnár – Biochar from sunflower seed husk for the improvement of degraded sandy soil
19) **Anand Chaurasia**, Piyush Saxena, Shivam Kumar – Mycorrhizal-mediated soil quality improvement under conservation agriculture in the Indo-Gangetic Plains of India
20) **Veronika Gergócs-Winkler**, Norbert Flórián, Bettina Kelemen, Sándor Attila Pabar, Tünde Takács – Soil fauna-mediated effects of plant residues on soil health in agricultural systems
21) **Bouzar-Essaïdi Khaled** – Diversity and ecological role of soil arthropods in a cork oak (*Quercus suber*) forest ecosystem: A case study from the Tacheta-Zougagha state forest, Aïn-Defla, Northern Algeria
22) **Sara Gaida**, Fillipo Vaccari, Youssef Amor, Iteb Boughattas, Hanem Grissa, Chaima Alaya, Mohamed Banni, Edoardo Pugliesi, Sabrine Hattab – Short-term organic amendments differentially shape microbial communities in soil and earthworm guts under contrasting management
23) **Sándor Attila Pabar**, Zsolt Kotroczó, Borbála Biró, Tünde Takács – Sensitivity of labile and stable carbon fractions to soil regeneration practices
24) **Mónika Márkus**, Balázs Madarász, Barnabás Kovács, Levente Kardos, Zsolt Kotroczó – Organic under-vine mulching for terroir stability: Enhancing soil buffering capacity in Tokaj Vineyards
25) **Éva Pénzes,** Viktor Tóth, Richárd Császár, Márton Pólya – Results of a long-term trial with soil bacterial preparations (2016-2025)
26) **Daljit Singh Karam**, Arifin Abdu, Mohd Hakeem Mohd Ibrahim – Potential of silica-rich biochar as a soil amendment for regenerative agriculture
27) **Nafeesh Muhammad**, Deo Kumar, Krishnanand Yadav – Sustainable soil water management and conservation
28) **Dilkhush Meena** – Role of conservation agriculture on crop productivity under changing climate scenario
29) **Rania Amedjekouh**, Leila Soudani, Khadidja Attou, Meriem Bouzroura – Medicinal plant-based approach to phytoremediation for the sustainable conservation of heavy metal–contaminated agricultural soils: A case study of the Wilaya of Tiaret, Algeria
30) **Somsavath Thongphanit** – Regenerative Agriculture and its effect on soil physical characteristics
31) **Costa Gumisiriya**, Evelin Kármen Juhász, Rita Kremper, Áron Béni, Andrea Balla Kovács – Investigation of long-term effects of agrotechnical factors on the soil microbiome under winter wheat and corn
32) Enas Soliman, Medhat E. El-Seedy, Ola A. El-Gamal, Yasmin Abdullatif, **Mostafa M. Mansour** – Evaluation of biodegradable hydrogels for restoring degraded sandy soils
33) **Andres Felipe Rodriguez Vasquez**, Yolanda Rubiano, Andres Javier Peña – When climate leads the soil: projected shifts in soil moisture regimes and their impact on degradation in the Colombian Altillanura

34) **Malek Abidli**, István Waltner, Ágota Horel – Hydrology of urban surfaces: Water retention capacity of common mulch types
35) **Dragana Đorđević**, Sanja Sakan, János Mészáros, Zsófia Bakacsi, Eszter Tóth, Márton Dencső, Tibor Zsigmond, Sofija Miljković, Ágota Horel – Level of harmful elements in the grassland of central Serbia – Levač area (Rekovac)
36) **Cristina Álvarez-Alonso**, María Dolores Pérez-Murcia, Natalia Manrique-Córdoba, F. Javier Andreu, Enrique Agulló, Silvia Sánchez-Méndez, Aurelia Pérez-Murcia, Concepción Paredes, Raúl Moral, María Ángeles Bustamante Muñoz – A long-term study of the use of organic amendments from decentralised composting systems: effects on soil quality
37) **Tibor Zsigmond**, Andor Bódi, János Mészáros, Dragana Đorđević, Sanja Sakan, Ágota Horel – Analysis of soil moisture and vegetation dynamics in Serbian and Hungarian grasslands
38) **Andor Bódi**, Tibor Zsigmond, Ágota Horel – Soil moisture and surface temperature patterns across adjacent land use types
39) **Aiman Achemrk** – Spatial probabilities of soil salinity risk and recovery under hydroclimatic variability: A transition-based machine learning approach
40) **Mohd Hadi Akbar** – Sampling bias in soil CO_2 flux measurements in oil palm peat plantations
41) **Agim Leonard Chimaobi**, Ogu Christian – Evaluation of geotechnical properties, moisture retention characteristics and erodibility of selected degraded soils in Imo State Southeastern Nigeria
42) Unenmunkh Ganbold, Tibor Tóth, Viktória Labancz, András Makó, Hilda Hernádi, **Gyöngyi Barna** – Effect of an anionic surfactant on some soil physical properties
43) **Milena Mitova**, Eli Pavlova-Traykova – Erosion risk evaluation and assessment of the effectiveness of hydrotechnical facilities in mountainous watershed
44) **Monica Shree Chandramohan**, Peter Šurda – Hydrophilic biochar application to enhance soil hydraulic functioning and combat soil degradation
45) **Gyöngyi Barna**, Hanna Czinege, Mihály Pethe, Károly Hoffman, Tibor Novák, Tibor Tóth – The effect of trampling on some soil physical properties
46) **Mahrokh Shafiei**, Ledianë Durmishi, Sherwan Yassin Hammad, István Waltner, Györgyi Gelybó – Monitoring soil moisture dynamics in the southeast of Hungary using Soil Moisture Active Passive (SMAP) satellite data and the standardized soil moisture index (2016–2023)
47) **Mariem Dahmouni**, E. Abdennour, M. Hachicha – Soil characterization and modeling of water and solute dynamics – Case of irrigated perimeters El Haouareb, Merguellil-Kairouan, Tunisia

16:55-17:00 Conference closing, final remarks

Abstracts of oral presentations

Keynote speaker:

Soil and water conservation

Tomáš Dostál

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Soil erosion is widely recognized as one of the most severe forms of soil degradation. A significant proportion of eroded soil particles is subsequently transported into watercourses and reservoirs, where it exerts numerous adverse effects on water quality, aquatic ecosystems, and reservoir functioning.

The first essential step in soil and water quality conservation is therefore the quantification of erosion and sediment transport processes. A range of methods has been developed for this purpose; however, each of them exhibits specific limitations with respect to reliability and accuracy. For instance, the most widely applied approach, the Universal Soil Loss Equation (USLE), describes a fundamentally event based process while employing a long term average and continuous modelling framework. Moreover, the parameterization of erosion processes remains challenging, despite the availability of detailed and comprehensive input data catalogues.

The second key step involves the definition of tolerable soil loss limits that do not compromise soil productivity, water quality, or ecosystem integrity, nor induce adverse secondary effects. This raises the question of how such tolerable soil loss thresholds should be defined and which potential socio economic consequences may arise from their implementation.

Section 1: Recent developments in soil science and soil health

(chair: Nándor Csikós)

Evaluation of four classification levels of Soil Taxonomy, Hungarian classification and WRB in terms of biomass production and their use for management zoning in a salt-affected alluvial plot

Tibor Tóth[1*], Szilárd Szabó[2], Tibor József Novák[3], Szabolcs Czigány[4], Mihály Kocsis[1], András Makó[1], Bence Gallai[5], Mátyás Árvai[1], János Mészáros[1], Kitti Balog[1]

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In a salt-affected alluvial plot, increased biomass is associated with increasing elevation and decreasing salt concentration. All four levels of three classification systems, the Soil Taxonomy (ST), the Hungarian classification (HU) and the WRB were evaluated in a 100 m regular grid of 85 profiles for their applicability for biomass estimation (using 10-year average NDVI as proxy) and their correlation with ground elevation. NDVI values reflecting soil formation chronology (from the least to the most developed soils) were found on the first (least detailed) level of the classification systems. Detailed levels 3 and 4, HU performed the best in terms of class separability, WRB showed the most homogeneous classes, HU provided the closest correlation with elevation; while ST operated with the lowest number of classes, and, consequently, had a lower level of homogeneity and weaker correlation with elevation. Both HU and WRB performed well in most aspects, but the latter showed greater homogeneity. WRB had twice as many classes as HU and four times as many compared to ST; thus, their homogeneity increased accordingly. Furthermore we compared the polygon alignment derived from the three systems, relative to the pattern of elevation and mean NDVI in order to delineate potential management zones. We described the polygon alignment qualitatively and through the use of landscape metrics. Additionally, we evaluated number of classes and polygons, and delineated potential management zones based on environmental variables. The polygons became increasingly fragmented at levels 2, 3 and 4, where isolated single raster cell polygons dominated the plot in each classification: 96% in WRB, 73% in HU and 70% in ST, compared to the total number of polygons. Landscape metrics proved that ST exhibited the best north–south orientation (the orientation of highs/lows), length, perimeter, area, aggregation and interspersion/juxtaposition of polygons. HU showed an intermediate performance, while WRB had the least satisfactory alignment with the north–south orientation, length, perimeter and area, as well as patch cohesion and aggregation of polygons. After analyzing the scatterplot of elevation versus mean NDVI, and also elevation versus long-

term NDVI range, we noted a cutpoint of 95.47 m, which separated the more productive and less variable zone from the lower lying less productive less certain zone, given its periodical precipitation-related waterlogging.

Exploring the potential of underutilised plant species for improving soil health in Sub-Saharan Africa

Grant A Campbell

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Soil degradation remains a critical barrier to the development of sustainable agriculture across Sub-Saharan Africa (SSA), with widespread declines in soil fertility, structure and biodiversity impacting food security and climate resilience. As part of the interdisciplinary CROSSROADS-SSA project, this oral presentation evaluates the potential of underutilised plant and crop species across SSA, examining how they can contribute to soil health restoration within low-input and climate-vulnerable farming systems.

Drawing on a structured synthesis of peer-reviewed literature as well as experiences from recent fieldwork conducted in Ethiopia, the presentation explores a range of species and functional traits associated with improving soil health. These include nitrogen fixation, phosphorus mobilisation, deep rooting systems, organic matter inputs, and ground cover that reduces erosion. Evidence is assessed across diverse agroecological contexts, with particular attention to relevance for smallholder farms and agroecological systems where access to external inputs is limited.

The findings highlight considerable diversity among underutilised species, many of which deliver multifunctional benefits for soil structure, nutrient cycling and erosion control while also supporting on-farm biodiversity. This research contributes to a growing body of evidence supporting soil health and biodiversity-based approaches to soil degradation in SSA. Through identification of species with relevant soil-improving functions, this presentation provides a practical framework to prioritise candidate species for future field trials and participatory research, supporting the scaling of context-specific, climate-resilient soil management strategies.

Keywords: Underutilized plants, soil health, biodiversity, sustainable agriculture, phosphorous mobilizing, nitrogen fixing, carbon sequestration, food security, Sub-Saharan Africa

Soil data collection as initial steps for digital decision support systems in field production in Vojvodina (Serbia)

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Soil represents one of the most important sources of information for understanding field variability, assessing production potential, and supporting site-specific crop management. The development of an effective digital decision support system (DSS) in field crop production begins with reliable and well-structured soil data collection. Creating an initial soil data collection begins with sampling and analyzing key physical and chemical properties. These parameters provide the foundation for creating spatially explicit databases that can be integrated with geographic information systems, remote sensing data, weather observations, and crop management records. Their purpose in soil science is to support decision-making in crop management by providing up-to-date data on soil quality, nutrient status and dynamics. A digital twin that monitors real-world data, identifies patterns, synthesizes predictive information by simulating future scenarios in the real environment, also relies on soil data.

This study aimed to unify and harmonize legacy soil data from different sources in order to enable their use as a structured GIS database, integrated with Sentinel 2 and SoilGrids. Over one million soil data (such as pH value, organic matter content, available phosphorus and potassium, soil texture, water retention…), along with pedotransfer function, were used for the soil mapping and assessment of regional nutrient distribution, estimation of cation exchange capacity and development of a 250-m resolution map of soil water availability. The obtained harmonized soil database, resulting in digital maps, should be core of the future decision support systems, which can be built upon them. Establishing a robust soil information base is a necessary first step toward the successful implementation of digital tools in field production, enabling data-driven management and supporting the transition toward more sustainable and efficient agricultural systems.

Strontium isotopes reveal terroir signatures in wine

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The 87Sr/86Sr isotope ratio is a robust tracer of geological origin in wines. This study investigates strontium isotopic variability across soil profiles, grapevine tissues, and wines from major Hungarian wine regions, including Tokaj, Szekszárd, and Eger, with additional comparison to international samples.

Tokaj wines exhibit relatively high and variable 87Sr/86Sr ratios (~0.7092–0.7103), reflecting complex volcanic and sedimentary geology, while wines from Szekszárd and Eger show lower and more homogeneous values (~0.7080–0.7088), consistent with less radiogenic substrates. Soil profile data reveal strong depth-dependent variability, with increasing isotopic ratios toward deeper layers, indicating dominant bedrock control. Grapevine tissues closely match intermediate soil values, suggesting uptake from an integrated root zone, whereas wines preserve this signal with minor modification during vinification.

Global comparisons (0.706–0.711) confirm that regional differences in 87Sr/86Sr are primarily governed by geology rather than climate, and that Hungarian wine regions occupy distinct isotopic domains. The absence of temporal trends in historical Tokaj wines further supports the long-term stability of the strontium isotopic fingerprint.

These results demonstrate that wine 87Sr/86Sr ratios reflect an integrated soil–plant system controlled by lithology and water uptake, providing a reliable tool for terroir characterization and geographical origin assessment.

Section 2: Advances in soil biology

(chair: Tünde Takács)

Plant-growth-promoting or -regulating rhizobacteria and analysis of soil-microbiom as potential monitoring tools of soil-health

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Plant growth-promoting rhizobacteria (PGPR) and other plant growth-regulating beneficial microorganisms (PGR) generally exert positive effects in the soil–plant–microbe–environment system. The increased use of such biofertilizers is particularly recommended under the conditions of environmental stress. Several types of PGPR and other beneficial microorganisms are known, including those that can replace or reduce the need for inorganic NPK fertilizers. Their application is part of a "bioeffective" approach, coming from the EU-funded BIOFECTOR project. The main mechanisms involved may include: (i) obligate and associative nitrogen-fixing microorganisms associated with legumes and monocotyledonous plants; (ii) phosphorus-mobilizing bacteria and fungi; and (iii) other beneficial microbes that can improve nutrient-use efficiency (NUE) and water-use efficiency (WUE) through specific hormone production. All industrial biofertilizer strains currently in use originate from the so-called "cultivable" fraction of various soil microorganisms. However, novel and up-to-date methodologies now use molecular tools to monitor the entire soil microbiome. This raises the question of how conventional and modern monitoring approaches estimate soil functioning. Is microbiome analysis suitable for identifying and understanding the actual effects of these beneficial PGPR microorganisms? Which microbial groups could be most effectively recommended for assessment, depending on differences among soils and/or major agricultural crops? The lecture will present how these beneficial microorganisms can be considered in soil health monitoring and agricultural practice.

This work was supported by the Research Excellence Programme of the Hungarian University of Agriculture and Life Sciences.

The role of sewage sludge compost in the phosphorus cycle

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The treatment of wastewater and the utilization of the by-products of these processes are an important part of the circular economy. The sewage sludge, as a result of water purification, could be used as a material for plant nutrient supply and/or soil-improving products. Sewage sludge composts (SSCs) usually have high phosphorus (P) content while the P sources for agriculture are limited and expensive. The city of Nyíregyháza, Hungary with 120,000 citizens has a well-planned water treatment plant operated by Nyírségvíz Ltd., which, in cooperation with the Research Institute of Nyíregyháza, IAREF, University of Debrecen developed a municipal SSC in 2003. At that time, a small-plot experiment was started with this compost product containing 40% (m/m) of sewage sludge, 25% (m/m) of straw, 30% (m/m) of rhyolite and 5% (m/m) of bentonite, applied at the rates of 0, 9, 18, 27 t ha−1 in every third year. This long-term experiment is a good place to study the accumulation effects/processes in soil and plants as rye, rye with hairy vetch and maize. Focusing on P cycle, our main questions are:

- Could this SSC product increase the P content of the soil?

- Could the plants utilize the P content of the SSC?

- What is the role of soil microbes in the P cycle of the SSC treated soil?

We concluded that, addition of SSC is not just a simple source of P, but it improves soil health through increasing pH, organic matter, nutrient content, and microbial activity. Also, some elemental ratios have an important role in the regulation of soil enzyme activities. Therefore, our findings underscore the potential of well-planned SSC applications to improve the fertility of ploughed, acidic sandy soil, taking into account the theory of circular economy.

Evaluation of the structure and respiration activity of soil bacterial communities in three Hungarian forest stands

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Understanding the effects of various forest management practices on the soil microbiome is very important, as it plays a decisive role in soil multifunctionality. Our research aimed to reveal the composition and activity of soil bacterial communities in two mixed pedunculate oak forests (one clear-cut during the study period and one already in the regeneration phase) and in one black locust forest over a period of 4 years. The bacterial community composition was revealed by amplicon sequencing of the 16S rRNA genes on the Illumina MiSeq platform. The MicroResp™ system was used to evaluate the catabolic activity pattern of soil sample bacterial communities. At the phylum level, Acidobacteriota, Actinomycetota, Pseudomonatoda, and Verrucomicrobiota were the taxa with high relative abundance in the investigated three stands. Our results revealed that differences in the bacterial community structure among individual stands were due to differences in the relative abundances of members of the Acidobacteriota and Actinobacteriota phyla. On the edaphic side, soil pH was the most influential parameter determining the composition of the bacterial community. As for catabolic activity, our results showed that citrate utilisation of soil microbial communities was the dominant factor in the development of inter-stand variance. Our studies suggest that the dominant physical and chemical properties of soils have a greater effect on the structure and function of forest soil bacterial communities than the forest type composition and stand structure.

Spatial and temporal variations in the abundance and composition of the soil microbiome in healthy and degraded soils in Hungary based on PLFA markers

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One of the most important indicators of soil health or degradation is the composition of the soil microbial community and the amount of living microbial biomass. Since most microbial communities are extremely sensitive to changes in environmental factors (moisture content, temperature, pH, substrate quality and quantity), microbial biomass can also change relatively quickly within extremely wide limits. One of the most effective methods for characterizing the composition and quantity of the living microbiome is the identification of soil phospholipid fatty acid markers and their assignment to functional microbial groups. The low diversity and abundance of microbiomes result in limited nutrient cycling and low-quality functioning soils. However, little information is available on the values of what can be considered a healthy amount of microbial biomass, depending on the soil type, season, and physical-chemical characteristics of the soils, and at what amount we evaluate the soil as biologically degraded. In our study, Hungarian soils samples from different land cover and land use conditions, with different seasonal distributions, from different soil types, and soil depths were analyzed for PLFA microbial markers.

Our findings show that besides high seasonal and annual variability share of functional groups, and the relative rank of soils with different biological activity remains relatively stable. Anyway, highly active soils are always those with perennial vegetation and dense belowground phytomass (roots). In case of Chernozems with identical physico-chemical characteristics, season and soil depth grasslands soils show up more than 10 times higher total PLFA markers (>220 nmol/g) than conventionally cultivated soils (<20 nmol/g). Pairwise comparison on forested and grassland soils revealed 2x higher microbial biomass in grassland (>650 nmol/g) compared to forest on identical soil and climatic conditions during the vegetation period. Organic poor forested Arenosols in dry hot season still showed up higher microbial biomass based on PLFA (70-90 nmol/g), than conventionally cultivated Chernozems.

To assess soil health through PLFA markers, it is necessary to expand the available reference database on degraded and healthy Hungarian soils.

Host-Mycorrhiza compatibility results in varying stress resilience in tomato against drought and heat

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As a consequence of global climate change, extreme weather events are becoming increasingly frequent. One promising environmental friendly solution in eliminating these abiotic stresses can be the use of arbuscular mycorrhizal (AM) fungi. The first and crucial step towards effective practical application is however the investigation of host–mycorrhiza compatibility.

We compared seven AM fungi isolates in their ability to enhance the resistance of tomato to drought and heat stress, as well as combined drought and heat shock, and observed variation in the effectiveness of the different AM fungal strains. Considering all measured parameters (biomass, photosynthetic activity, stress indicators and ROS eliminating enzimes) two fungal strains, *F. mosseae* and *S. constrictum* performed exceptionally under both stress conditions.

F. mosseae increases root biomass under heat and combined stress. Mycorrhizal plants maintained significantly higher relative water content accumulated more phosphorus and showed lower stress marker levels under stress conditions. In parallel, the expression of several phosphate transporter gene was upregulated under stress conditions, suggesting that *F. mosseae* induces enhanced phosphate transporter activity, which may contribute to stress alleviation.

The specific effect of *S. constrictum* strain on tomato heat stress response was examined using transcriptomic and bioinformatic approaches. The elevated H_2O_2 levels induced by heat shock was significantly less pronounced in mycorrhizal plants supported also by the increased expression of ROS eliminating enzime genes. Functional analysis of DEGs revealed enhanced metabolite mobilization between root and shoot in mycorrhizal plants, as well as the activation of hormonal signaling pathways, particularly auxin and jasmonate, induced by the AM fungus under heat shock.

Acknowledgement: This research was supported by the National Research, Development and Innovation Office, grant number OTKA142974; Flagship Research Groups Programme of the Hungarian University of Agriculture and Life Sciences and the EKÖP-MATE/2025/26/K university research Scholarship Programme of the Ministry for Culture and Innovation from the source of the National Research, Development and Innovation Fund.

Keywords: Arbuscular mycorrhizal fungi, Heat Stress, Drought stress, Stress mitigation

Implications of soil fauna diversity and abundance on land use age gradients in horticultural agricultural systems for soil health

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Conventional intensive farming practices in horticultural systems can degrade soil's physico-chemical and biological properties, biodiversity, and ecosystem functions, ultimately threatening soil health. Soil fauna, as a sensitive biological indicator, is one of the first components affected by land use changes and intensive agricultural management. This study aims to compare the diversity and abundance of soil fauna in horticultural farming systems based on land use age gradients, as well as to evaluate the impact of land use age on soil physico-chemical properties and the relationship between soil mesofauna communities and soil characteristics. Soil and fauna samples were taken from different land uses, including forest, shrubland, and horticultural land, categorized by land use age gradients: <5 years, 5–10 years, 10–15 years, 15–20 years, and >20 years. Soil fauna were collected using pitfall traps, and data were analyzed by measuring abundance, diversity index (H'), evenness (E), species dominance, and by using paired t-tests and Pearson's correlation. The results revealed a total of 6,594 individuals from 19 orders, with Poduromorpha (Collembola) being the most frequently encountered suborder. The highest abundance of soil fauna was found in horticultural land aged 10–15 years, while the lowest abundance occurred in horticultural land aged 5–10 years. The highest diversity index was observed in shrubland, whereas the lowest was recorded in horticultural land aged >20 years. The highest evenness index was found in shrubland, while the lowest was in horticultural land aged 10–15 years. Species dominance was highest in horticultural land aged 10–15 years and lowest in shrubland. Furthermore, soil fauna diversity showed a significant positive correlation with organic carbon content and invertase enzyme activity, indicating that soil fauna play a crucial role in maintaining soil health and ecosystem functions.

Section 3: Conservative agriculture

(Chair: Eszter Tóth)

Characterization of controlled pyrolysis and traditional drum kiln biochar, and their agronomic evaluation

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In this research, the effect of pyrolysis temperature (300, 400, 500°C) on the standard biochar and locally made biochar (LBC, which was made with newly devised method of Bababe using a drum kiln.) characteristics. The objective of this object was to characterize the various biochars, evaluate their fertilizer value and toxicity according to the IBI threshold. Using R Studio, Dplyr, car, agricolae, ggplot2, and writexl were used to carry out data processing and statistical analysis, post-hoc comparison, visualization, and data export, respectively. The temperature of pyrolysis had a great influence on all the parameters. There was a reduction in biochar yield of 34.3 (300°C) to 28.5 (500°C). The values of electrical conductivity and salt content were higher with rise in temperature; BC300 and BC500 recorded the highest values, BC400 was intermediate and LBC lowest. All pyrolyzed biochar were highly alkaline (pH 10.26-10.57; BC400 highest), and LBC was almost neutral (7.84). The maximum carbon level was obtained with BC 300-400 (56.8-56.9 %) and decreased at BC500 (44.1%), and LBC intermediate (49.35%). BC400 is the most suitable in terms of fertilizer value to be generally used in agriculture, BC500 is most suitable for carbon sequestration and remediation, and BC300 is best at the potassium supply. LBC is a low-cost, low-salinity and high concentrations of volatile micronutrient material and has a variety of applications; it is especially compatible with fertilizer coating or blending systems, especially on soils sensitive to salt, where application rates are significantly lower (<10 t ha^{-1}) and this limits the amount of agronomic risk (e.g. Mo contaminant loading). Nevertheless, the high levels of molybdenum in all biochars are the main limitation, and they require better feedstock choice or remediation measures. These results point to the fact that even though conditions of pyrolysis play a strong role, the paramount factor of biochar safety is the composition of feedstock

Reducing soil degradation in tea plantations through soil organic matter management: A 25-year study from the Nilgiris

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This study presents a longitudinal analysis of soil organic matter (SOM) dynamics in the major tea-growing regions (Ooty, Coonoor, Kollakambai, Kotagırı, and Kundha) of the Nilgiris district, Tamil Nadu, India. Soil samples were systematically collected from representative tea estates over a 25-year period (2000-2025) and subjected to standardized laboratory analysis. The objective was to quantify spatiotemporal variations in SOM content, elucidate driving factors, and assess the long-term sustainability of regional soil management practices.

The results demonstrate significant regional disparities in SOM concentrations, strongly correlated with altitudinal gradients and associated bioclimatic factors. Estates in Kotagiri exhibited the highest and most stable SOM levels (7.0-15.0%), indicative of robust nutrient cycling, and favourable microclimatic conditions for potentially sustainable organic management protocols. This was closely followed by the high-elevation region of Kundha (>13.0%). In contrast, intermediate levels were observed in Kollakambai (2.6-5.2%) and Ooty (<13.0%), while Coonoor recorded the lowest SOM values (4.0-7.0%), suggesting heightened mineralization rates or suboptimal organic input regimes.

Given the critical role of SOM as a master indicator of soil health governing cation exchange capacity (CEC), microbial biomass, aggregate stability, water retention, and the long-term mineralization of nitrogen and other essential nutrients, these findings have profound implications for the sustainability of Nilgiri tea production. Regions with declining SOM are at risk of negative feedback loops involving soil degradation and yield instability.

This study underscores the necessity for continuous SOM monitoring and the development of region-specific, cost-effective soil stewardship strategies. We advocate for the adoption of precision organic amendment practices and improved agronomic management to augment soil organic carbon stocks, thereby ensuring the ecological resilience and economic viability of this premier tea-growing ecosystem.

Keywords: organic matter, soil health, sustainable cultivation, long-term assessment

Loss of vegetation and CO_2eq emissions as indicators of soil degradation in different biomes of Peru

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Soil degradation is closely linked to land-use change and vegetation loss, processes that directly affect carbon fluxes, soil structure, and ecosystem stability. In Peru, increasing deforestation and the intensification of agricultural activities have contributed to significant alterations in CO_2 dynamics and to the deterioration of soil environmental quality. This study aimed to analyze the relationship between vegetation loss, CO_2eq emissions and removals, and climatic variables from 2021 to 2024, assessing their implications for soil degradation processes. Independent emissions data from the Climate TRACE platform were integrated with climatic information and annual deforestation records derived from remote sensing. Analyses were conducted at national and biome scales, focusing on the Agriculture and Land Use and Forestry sectors. The results revealed marked temporal variability in emissions. National total emissions increased from 18.18 Mt CO2eq in 2021 to 21.67 Mt CO2eq in 2024 in the agricultural sector, while the forestry and land-use sector exhibited strong fluctuations, ranging from net removals of –114.11 Mt CO_2eq in 2022 to high positive emissions of 442.05 Mt CO2eq in 2024. A clear association was observed between vegetation loss and increasing CO2eq emissions. Cumulative deforestation in the Amazon biome reached more than 1,021,000 hectares by 2024, coinciding with a progressive decline in annual precipitation from 1583 mm in 2021 to 1372 mm in 2024. These trends were accompanied by a substantial rise in emissions in Amazonian departments such as San Martín, Loreto, and Ucayali, which shifted from important carbon sinks in 2022 to major emission in 2024, with values exceeding 180 Mt CO_2eq in some regions. In the agricultural sector, synthetic fertilizer application (21.68 Mt CO_2eq) and enteric fermentation (21.65 Mt CO_2eq) were identified as the main emission sources, together accounting for approximately 57.8% of agricultural emissions. These activities, combined with land conversion, increase soil vulnerability to erosion, organic matter loss, and reduced biological activity. The findings demonstrate that quantitative monitoring of vegetation dynamics and greenhouse gas emissions provides essential indicators for understanding soil degradation processes. Integrating environmental data at multiple scales offers valuable insights into the interactions between land-use change and soil health.

Soil ventilation - a new way to revitalization

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Soil ventilation is a robust new technical solution for drastically reducing of soil compaction. During the process, 12 bar of air is pressed into the soil at a depth of 80+ cm, which causes the soil particles to move and increases macroporosity. As a result of treatment, surface water seeps deep into the soil and can be stored even during periods without precipitation. The treatment cuts the hair roots of the plants, as a result of which intensive root development begins. The effect of treatment can be felt for about 4-5 years. The technology is successful in any arable and woody culture. It breaks through the plowshare. It also intensifies soil life.

In the framework of international cooperation, we examined alternatives for revitalizing contaminated and degraded soils, as part of which we planted field protection tree plantations combined with soil ventilation.

Soil compaction is a significant problem in both agricultural and urban soils. Soil ventilation is a new approach to this problem. Revitalizing agriculturally overused soils is a significant challenge for farmers. Partial revitalization of such degraded soils is successful by planting tree rows, which can also help to change the microclimate of the area at a rapid pace. Soil cultivation methods without surface disturbance are experiencing a renaissance in Europe. Soil ventilation is a new alternative among no-till technologies.

Section 4: Monitoring and modeling soil processes

(Chair: Ágota Horel)

Bias correcting bulk density observations in the Hungarian Soil Information and Monitoring System

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Bulk density (BD) is a key physical soil property that strongly influences soil functions, ecosystem services, and hydrophysical behavior. However, previous assessments have shown that BD observations in the Hungarian Soil Information and Monitoring System (SIMS) contain inconsistencies that limit their reliability for scientific and applied use. This study aims to correct BD values in SIMS using advanced pedotransfer functions (PTFs) developed from the Hungarian Detailed Soil Hydrophysical Database (MARTHA) combined with environmental covariates representing soil-forming factors.

We implemented and compared multiple modeling approaches, including multiple linear regression, generalized additive models (GAM), Cubist, random forest (RF), and artificial neural networks (ANN). Model performance was evaluated using 5 times repeated 10-fold cross-validation. Among the tested methods, the RF-based PTF proved to be the best-performing PTF (RMSE = 0.099, and NSE = 0.539) and was used in SIMS to predict, and thereby, bias-correct the original BD values across SIMS profiles while also quantifying associated prediction uncertainty.

The resulting harmonized dataset includes profile and layer identifiers, depth intervals of soil horizons, corrected BD values, and uncertainty estimates. This information was also added to the corrected dataset to support end users in using the corrected BD values appropriately. The adjusted dataset and the developed codes are freely available on Zenodo (https://zenodo.org/records/16926945) and GitHub (https://github.com/Mehrsoh/Soil-BD-Correction), respectively. The corrected BD dataset provides a more reliable basis for soil-related analyses and is recommended for applications in soil science, environmental modeling, and sustainable land management. Beyond national relevance, the dataset supports broader continental and global efforts related to soil health monitoring and land degradation neutrality.

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Keywords: bulk density; machine learning; pedotransfer functions; bias correction; uncertainty quantification; soil monitoring

Soil hydraulic aspects of a regional water balance modelling effort in the Tisa River Basin

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Soils have a distinctive role in the water cycling. In a non-linear way soil hydrological properties influence surface and subsurface flow accumulation, prolonged water availability for vegetation, and aquifer storage on various spatial and temporal scales. Therefore, adequate soil information is essential, when making water balance calculations.

Here, we present a case study from the Danube River Basin (DRB) to illustrate how a regional scale distributed parameter hydrological model utilizes soil information. The introduced Community Water Model (CWatM) is capable of simulating surface water and groundwater processes, including river discharge, actual evapotranspiration and storage in snow, reservoirs, soil and groundwater, at daily time step over multiple decades, with a 1 arcmin spatial resolution and with varying land cover conditions.

The introduced implementation of the CWatM for the DRB utilities the Mualem-van Genuchten parametrization for the moisture retention curve and the hydraulic conductivity curve of the EU-SoilHydroGrids 3D database (7 soil depths for the top 2 m).

In our presentation we introduce (i) the general approach with which the CWatM simulates subsurface water movement processes, (ii) the representation of soil information in the model, (iii) the scaling coefficient-based approach followed during the model calibration, (iv) certain calculation results with special attention to soils and (v) results of a sensitivity analysis on soil and other applied parameters.

We conclude with some practical considerations for possible future directions both for the actual regional model improvement and for the soil database directions.

This work was supported as part of DANUBE WATER BALANCE, an Interreg Danube Region Programme project co-funded by the European Union.

Keywords: hydrological modelling, Community Water Model, CWatM, Danube River Basin, EU-SoilHydroGrids

Stakeholder-driven multi-objective optimisation of water retention measures in a small Hungarian catchment

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In the recent decade, as a result of the growing frequency of extreme weather events water retention has become a critical challenge in both agriculture and environmental protection. Natural/Small Water Retention Measures (NSWRMs) have emerged as one of the key tools against these climate change-induced negative effects. The role of NSWRMs in improving soil moisture, groundwater recharge, and water quality, reducing runoff and erosion, and enhancing landscape resilience is significant.

In present study stakeholders of different sectors, namely: agriculture, water management and nature conservation were interviewed. Their localized expertise helped us to identify those measures viable within the environmental and socio-economic context of the study area. Together with these experts, sets of sector specific objectives - deemed to be most important for their respective areas - were also selected.

We used process-based hydrological model coupled with Pareto-optimization to find the optimal combination of these measures within the study area for each of the three sectors. When soil moisture content, sediment load, flow stability, and operational savings are also taken into account, the following measure implementations are recommended: applying minimum tillage on 58% of the cropland area, converting 39% of the cropland to grassland, and establishing grass-shrub erosion control strips on 1% and grass-shrub riparian buffers on a marginal extent (0.1 ha) of the arable land area. This implementation scheme could be regarded as an inter-sectoral compromise solution. The low soil quality of the slopes incentivizes farmers to substitute crop production with a management that has lower input requirements. Results indicate that changing soil management to minimum tillage is a viable option as well. Grass-shrub buffer strips and erosion control strips however are not preferred solutions by farmers who rely on EU CAP area-based support. Their implementation could be encouraged by introducing support for non-productive investments.

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Quantifying the effects of soil management on sediment dynamics using WaTEM/SEDEM in a Mediterranean small catchment under olive cultivation

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Understanding how soil management influences sediment production, redistribution and export in Mediterranean olive orchards is essential to assess long-term soil sustainability. In this study, WaTEM/SEDEM was run in a small vertisol catchment in southern Spain to evaluate how soil management practices could affect annual sediment dynamics, and to examine the correspondence between simulated erosion-deposition patterns and SOCstock. Model calibration using five contrasting hydrological years yielded strongly divergent transport capacity coefficients (ktc under dry conditions = 24 m; ktc under wet conditions = 61 m), whereas the integrated calibration (ktc = 54 m) provided the most balanced statistical performance (NSE = 0.74, RSR = 0.51, PBIAS = -11.72 %). Scenario analysis showed that while changes in C factor produced large variations in total sediment production (87.3-312.8 $t \cdot yr^{-1}$), their effect on annual sediment yield was comparatively modest (56.6-74.3 t·yr-1), indicating that most mobilised sediment is redistributed internally rather than exported. A comparison between soil redistribution and SOCstock, based on the integrated calibration, revealed statistically significant differences in SOCstock among modelled classes (all pairwise at least got Mann-Whitney $p \leq 10\text{-}15$), demonstrating qualitative agreement between simulated redistribution and observed topsoil (0-20 cm) SOCstock variability. These results indicate that soil management practices primarily govern internal sediment redistribution, emphasising the relevance of ground cover practices for mitigating on site degradation. The study demonstrates the suitability of WaTEM/SEDEM for analysing sediment dynamics in Mediterranean olive systems while emphasising the need to consider model limitations and hydrological variability when interpreting sediment dynamics.

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Keywords: modelling, olive grove, mediterranean agroecosystems, soil redistribution, soil management scenarios

Abstracts of short (PICO) presentations

(Chair: Zsófia Bakacsi)

Soil quality indices for assessing the impact of forest soil health in urban forest division Srinagar

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Urban forest soils play a crucial role in sustaining ecosystem functions, carbon sequestration, and environmental resilience in rapidly urbanizing regions. The present investigation (2021-2023) aimed to quantify and spatially map the Soil Quality Index (SQI) of the Urban Forest Division, Srinagar, to evaluate forest soil health and support sustainable urban forest management. Soil samples collected from multiple forest blocks were analyzed for key physical, chemical, and biological properties, revealing considerable spatial variability in soil characteristics and ecosystem functioning across the study area. An integrated SQI was developed using Principal Component Analysis (PCA) combined with weighted factor analysis to identify the most sensitive soil indicators and determine their relative contribution to overall soil quality. Four principal components explained 73.5% of the total variance, with microbial biomass carbon, available potassium, and cation exchange capacity emerging as the most influential variables governing soil quality. Indicator weighting factors ranged from 0.15 to 0.37, with the first principal component contributing the highest weight to SQI computation. The computed SQI values were subsequently integrated into a geospatial framework to generate soil quality maps, enabling spatial visualization of soil health conditions and identification of priority management zones within the urban forest landscape. The developed SQI-GIS approach provides a reliable decision-support tool for policymakers and forest managers to monitor soil health, prioritize restoration interventions, and implement sustainable land-management strategies for urban forest ecosystems.

Keywords: Soil Quality Index; Urban Forestry; PCA; Geospatial Mapping; Soil Health

Critical phosphorus levels in maize grown in soils with contrasting remnant phosphorus and buffering capacity in the Mantaro Valley, Peru

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In agricultural soils of the Mantaro Valley (Junín, Peru), phosphorus (P) bioavailability is often limited due to inherent soil properties, which constrains fertilizer efficiency and maize (Zea mays L.) productivity. In this context, the determination of critical P levels in soil and plant tissues is a key tool for optimizing fertilization recommendations and improving nutrient management.

The objective of this study was to determine critical phosphorus levels in soil (Olsen P) and plant tissue (inorganic foliar P, Pi) in soils with different remnant phosphorus (Prem) contents, and to assess their relationship with soil buffering capacity. A greenhouse experiment was conducted using a completely randomized design with a factorial arrangement (6×2), including six P rates (0, 80, 160, 320, 640, and 1280 mg kg^{-1}) and two contrasting soils from Huancas and El Mantaro. Critical levels were estimated using regression models, considering 90% of maximum biomass production.

The results revealed significant differences in critical P levels between the two soils. The El Mantaro soil showed a Prem of 5.2 mg L^{-1}, with critical levels of 10.315 mg kg^{-1} for Olsen P and 90.474 mg kg^{-1} for foliar Pi. In contrast, the Huancas soil, with a Prem of 13.2 mg L^{-1}, presented critical levels of 17.997 mg kg^{-1} for Olsen P and 129.66 mg kg^{-1} for foliar Pi. These differences reflect the influence of soil buffering capacity on P availability and crop response to fertilization.

The findings demonstrate that remnant phosphorus is a robust indicator of P dynamics in soil and should be considered when defining phosphorus fertilization strategies. Furthermore, this study provides quantitative thresholds that contribute to improving phosphorus use efficiency and support soil health assessment in Andean agricultural systems.

Developing an organic foliar nutrition strategy to reduce soil degradation in tea cultivation in South India

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The global agricultural sector is increasingly transitioning toward sustainable systems that protect environmental health and long-term soil productivity. In South India, organic tea cultivation reflects this shift by replacing synthetic fertilizers with traditional bio-formulations. However, even organic systems often rely heavily on soil-applied nutrients, which can contribute to nutrient imbalances, leaching losses, and gradual soil degradation. Identifying alternative nutrient delivery strategies that reduce dependence on soil inputs is therefore essential.

Foliar nutrition offers a viable alternative by supplying nutrients directly to the plant canopy, minimizing soil loading and associated degradation processes. Despite its potential, the lack of a scientifically validated organic foliar schedule remains a key limitation for tea growers.

To address this gap, a study was conducted by the UPASI Tea Research Foundation to develop an effective foliar-based nutrient strategy for organic tea cultivation. The experiment evaluated traditional bio-formulations—Panchakavya, Ecochem, and Bio-phos—applied alone and in combination with organic mineral supplements such as potassium magnesium (K-Mag) and polyhalite. A conventional foliar treatment (urea + muriate of potash) served as a control.

The trial was carried out at the UPASI Glysdale Farm using a randomized block design over 12 months. Key parameters, including green leaf yield, shoot growth, mite incidence, and leaf quality, were assessed.

Results from the first nine months showed that 3% Panchakavya and 2% Ecochem produced yields of 1726 kg/ha and 1725 kg/ha, respectively—approximately 5% higher than the conventional treatment. Bio-phos recorded the lowest yield (1598 kg/ha). Notably, mineral supplements alone did not improve yield, highlighting the importance of bio-active formulations in nutrient mobilization.

These findings demonstrate that bio-formulation-based foliar nutrition is an effective alternative to soil-dependent fertilization, reducing nutrient buildup, leaching, and overall soil degradation while sustaining productivity.

Enhancement of chlorophyll content as SPAD value and spike production in wheat crop under foliar feeding of urea and micro nutrients

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Micronutrient deficiency is widespread in many Asian countries due to the calcareous nature of soils and imbalanced application of fertilizers. Enrichment of wheat-based dietary products is essential for remedying malnutrition as wheat grown on calcareous soils is generally inherently low in vital micronutrients. Hence, an experiment was conducted at Tarai region of Uttarakhand, i.e., Pantnagar to study impact of foliar feeding in different wheat cultivars chlorophyll content and other yield attributes. The SPAD value recorded at 60 and 75 days after sowing (DAS). Six foliar nutrition treatments were selected viz. 2% elemental sulphur (ES), 2% urea (U), 0.5% Zn EDTA (ZE), 1% KCl (K), a combination of ES +U + ZE + K and without foliar spray treatment with four popular bread wheat cultivars namely HD 3226, HI 1544, DBW 187 and PBW 1 Zn. The foliar application was done at stem elongation and milking stage. The experiment was laid in strip plot design with three replications. Other recommended practice followed as per standard guidelines at state level. There was a gradual increase in SPAD values after the first foliar spray which might be attributable to an increase in chlorophyll quantity in leaves. The result indicated that 2% urea spray led to a significant increase in SPAD values (22.6) and chlorophyll content ((2.08 mg/g).) followed by all nutrient combinations (22.2). Variety PBW 1 Zn recorded higher SPAD values and chlorophyll due to more plant nitrogen content. The maximum number of spikes/m² and length of spike were recorded in 2% urea spray (324.6/m² and 12.3 cm, respectively) which was statistically at par with 0.5% Zn EDTA (319.6/m²) and 1% KCl spray (319.0/m²). Even the 0.5 % Zn EDTA recorded an increase of 2.7% fertile spikelets/spike compared to no foliar spray (15.5). Foliar feeding found one of the ways to supply adequate and sufficient quantity of nutrients to the developing seed. Stimulating effect of foliar nutrients on chlorophyll and yield attributes showcased an important role in maintenance of balanced plant physiology.

Machine learning approaches for optimizing cover crop selection to enhance soil carbon sequestration and reduce degradation

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Due to poor agricultural practices, there is increasing global soil degradation, which threatens our world's food supply and contributes to climate change through the release of carbon stored in soils into the atmosphere. Planting cover crops is one of the best biotic strategies for regenerating depleting soil organic carbon (SOC) and reducing soil degradation processes such as erosion, compaction, and nutrient leaching. However, how well each cover crop will perform is based on factors unique to that location (e.g., soil texture, climate, previous crop rotation, and management history) and the goals of the farmer, meaning that the selection of a combination of cover crops suited to an individual field or farming system is a very intricate, multi-dimensional decision that cannot be addressed using traditional methods of agronomic practice alone on a large scale. Machine Learning provides a new way to look at the challenges that face the integration of high dimensional heterogeneous data (remote sensing imagery, soil sensor data, weather data, historical field trial results) into site-specific predictive cover crop recommendations. This article reviews and synthesizes all of the ML methodologies related to cover crop selection and SOC sequestration modeling and assesses their predictive abilities against traditional agronomic models as well as proposing a strategy for implementing ML decision support at farm and landscape scales. The results show that ensemble tree based methods (Random Forest, XGBoost) and deep learning models (LSTM, CNN) significantly outperform traditional regression methods for predicting SOC response to cover cropping based on $R^2 > 0.85$ within well characterized locations. Additionally, we highlight key data/knowledge gaps and transferability of models and provide direction for research at the intersection of AI and soil science.

Keywords: machine learning, cover crops, soil organic carbon, soil degradation, random forest, deep learning, precision agriculture, carbon sequestration, decision support systems, agroecology

Geospatial assessment and kriging-based mapping of soil fertility in agricultural lands of Karaikal district, Puducherry, India

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Proper soil thematic maps are essential for developing effective soil nutrient strategies. This study aimed to demarcate soil nutrient properties and spatial variability across the Thirunallar region of Karaikal District through a digital survey, adopting a toposheet and base map from Sentinel 2 satellite data for sample collection in each grid (320-meter interval) at 0-15cm depth. The soil data were fitted into model and layer maps were generated using ArcGIS (v 10.8.2) considering the Kriging function under geostatistical method. The results revealed that soils were in the acidic to alkaline range (5.18 - 8.93), exhibited less saline (0.035 - 3.502 dS m^{-1}), and were low to high in SOC (0.24 - 1.41%), respectively. The available N ranged from low to high (142.80 - 739.20 kg ha-1), while the range was medium to high for available P (15.33 - 98.44 kg ha-1) and low to high for available K (90.18 - 493.42 kg ha-1). Sulphur was reported to be in the medium to high range (9.94 - 99.67 mg kg-1). Exchangeable properties were sufficient, as were micro-nutrient (Fe, Mn and Cu) levels, except for Zn. The coefficient of variation was reported to be high in soil EC (103.36%) and low for pH (10.87%). The efficiency of quantification with respect to Root Mean Square Error provided explained variance and residuals in the derived model, and the majority of soil properties were best fitted for the spherical model. Semivariogram modelling indicates a strong spatial dependency (SpD) level. The anticipated dataset for each parameter showed the lowest RMSE, which accounted for soil EC and SOC (0.524; 0.154). Thus, integrating spatial analytical data will provides better regional soil management practices, optimum fertilizer use and future sustainable practices.

Abstracts of poster section

Restorative approaches to degraded urban-rural land in the city-province of Kinshasa and its reuse for agricultural production

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In the urban-rural interface of Kinshasa, Democratic Republic of the Congo (DRC), specifically at the Kimwenza site, intensive market gardening is threatened by severe soil degradation and acidification caused by the overuse of chemical fertilizers. This study evaluates the efficacy of restorative soil management techniques to improve soil fertility and agricultural productivity. Through a participatory approach involving 80 market gardeners in field schools, we implemented an integrated strategy combining the use of locally produced biochar with micro-dosing mineral fertilizers. The goal is to replace excessive fertilizer application with precise techniques that improve soil structure and nutrient retention. Field results demonstrate significant restorative capacity. Biochar application acted as a soil conditioner, raising soil pH by 1.5 units without lime, which mitigated acidification. Agronomically, the combined biochar and micro-dose technology increased the yield of key crops (amaranth, okra, and eggplant) by 53% compared to conventional peasant practices. Furthermore, biochar's high retention capacity allowed for a 70% reduction in costs related to purchasing organic matter. These results confirm that combining biochar with precision fertilization provides a cost-effective alternative to reduce soil degradation while ensuring the sustainable intensification of peri-urban agriculture in tropical ecosystems.

Keywords: Soil restoration, biochar, micro-dosing, urban agriculture, Kinshasa

Integrated mobile pyrogasification and biochar enhancement for low-carbon, resilient NET ZERO agriculture

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England's transition to net-zero agriculture is constrained by a growing challenge: increasing volumes of organic residues such as poultry litter, slurry solids, and digestate fibre that are costly to manage, emissions-intensive, and underutilised as valuable resources. Simultaneously, livestock and mixed farms face tightening environmental regulations, rising fertiliser costs, and volatile energy prices. While biochar offers significant potential to improve soil carbon storage, nutrient efficiency, and climate resilience, adoption has remained limited due to high capital costs, logistical barriers, and uncertainty around carbon accreditation and agronomic performance. This innovation delivers a transformative circular farming solution by converting farm residues into high-value, carbon-negative inputs through mobile pyrogasification and nutrient-enhanced biochar production. By enabling on-farm processing, the system eliminates transport challenges and creates a scalable, distributed model for sustainable residue management. The innovation integrates mobile thermochemical conversion, heat co-generation to reduce farm energy demand, advanced biochar upgrading, and a digital twin platform that optimises performance, supports carbon verification, and guides application strategies.

The solution will reduce greenhouse gas emissions, improve soil health, enhance nutrient retention, and create new revenue opportunities through carbon removal credits and value-added biochar products. Through real-farm demonstrations, lifecycle assessment, and farmer-led trials, the project will establish a commercially viable pathway to accelerate England's agricultural decarbonisation while strengthening farm productivity, resilience, and rural economic growth.

Can nanotechnology be a solution against global water crisis? Towards promising approach for saving water under climate change

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In the twenty-first century, many challenges face the world including climate change and scarcity of fresh water. Concerning climate change, it is an unstoppable and irreversible natural process. Changing in climate may back to human activities through emissions of greenhouse gases. It is reported that, half of the global population will face problems in getting access to enough, safe and clean drinking water by 2025. To overcome the global water crisis, it is needed to provide sufficient, clean and safe water for all people. Climate change is proposed to increase drought stress in several zones all over the world, and water stress as well. Therefore, combating climate change should be a multi-front approach rather than a single-front one. Nanotechnology has several attributes that can support efforts for mitigation of climate change. In this regard, applied nanotechnology could be the most promising strategy to mitigate both climate change and global water crisis, being the latest and highly advanced technology. An urgent need is necessary for new nano-technological innovations for more integrated water management using unconventional water sources. This could be achieved by enhancing the water use efficiency, supporting stressful plants under water stress, and removing the pollutants from wastewater as well as applications of nanosensors. Therefore, the main aim of this study is to develop a nano-approach to mitigate water stress towards saving water through direct and indirect strategies. Concerning the benefits of this approach, it is expected to be a significant on the different fields including nano-farming, environmental protection and economic sectors.

Effects of bio-slurry and inorganic nitrogen fertilizer rates on wheat yield components, yield, and soil properties

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Maintaining soil fertility and enhancing food production on smallholder farms in Ethiopia remains a major challenge due to severe nutrient depletion caused by continuous cropping with minimal external nutrient inputs. In this context, a field study was conducted on Nitisols over two consecutive cropping seasons (2022–2023) across four locations to evaluate the effects of combining bio-slurry with inorganic nitrogen (N) fertilizer on selected soil chemical properties, wheat yield, and economic feasibility. The experiment consisted of eleven treatments comprising sole and integrated applications of liquid bio-slurry, dry bio-slurry, vermicompost, and nitrogen fertilizer from urea. Treatments were arranged in a randomized complete block design with three replications. The results showed that the integrated use of bio-slurry with inorganic fertilizer significantly improved soil chemical properties, wheat yield, yield attributes, and overall economic profitability. The combined treatments increased grain yield by 84-102% compared to the untreated plot, with the highest yield (3835.2 kg ha^{-1}) achieved with 50% N from urea and 50% N from liquid bio-slurry. Specifically, 75% N from urea combined with 25% N from liquid bio-slurry produced the highest grain yields in the Hula and Basoliben districts, while 100% N from urea supplemented with 25% N from liquid and dry bio-slurry provided the maximum yields in the Welmera and Ejere districts, respectively. In conclusion, integrated application of bio-slurry and inorganic fertilizer enhances soil chemical properties, improves wheat yield and its components, and offers a promising approach for sustainable intensification of smallholder wheat production in Nitisols of the study areas and similar agro-ecologies.

Keywords: Bio-slurry, nitisols, nitrogen, vermicompost, wheat

Influence of livestock manure types (poultry and rabbit manure) on soil improvementfor the preservation of natural resources in Algeria

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Soil health refers to the ability of soil to function as a living system over the long term, capable of ensuring plant biomass productivity compatible with the long-term maintenance of the ecological functions of natural or cultivated ecosystems, as well as related processes, contributing to the preservation of natural resources such as air, water, and biodiversity in their quantitative and qualitative dimensions, and to the health of plants, animals, and humans by promoting the physiological processes involved in their self-defense systems. The goal of our work is to make the soil more active and valuable for agricultural producers, because fertile, healthy soil offers significant biodiversity and increased availability of nutrients such as nitrogen, phosphorus, and sulfur, which, when properly balanced, promote crop productivity and profitability. We have therefore amended the soil through the extensive use of organic fertilizers, mainly livestock manure (rabbit and poultry). The incorporation of these fertilizers has contributed to crop development, significantly improving yield and production quality. The results showed that the treatments adopted improved the various parameters tested. The results obtained showed that the most favorable physical property values were measured in the manure treatment. Compared to the control, the lowest results were recorded in the control soil without manure input.

Conservation agriculture and regenerative tillage practices: A pathway to soil health restoration and sustainable crop production

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Conservation agriculture and regenerative farming approaches are increasingly recognized as effective strategies for maintaining soil health, improving productivity and ensuring long-term sustainability of agricultural systems. These approaches emphasize minimal soil disturbance, efficient resource use and ecological restoration to enhance soil functions and ecosystem services. However, the widespread adoption of these practices remains limited due to insufficient understanding of their integrated benefits, particularly regarding tillage management and regenerative soil restoration techniques. In this study, relevant scientific literature was analyzed to evaluate the role of conservation agriculture practices and regenerative techniques in improving soil health and sustainable crop production. The study focused on key management practices such as conservation or reduced tillage, residue retention, crop diversification, cover cropping and the application of organic amendments and biofertilizers as regenerative techniques. The analysis indicated that these practices significantly improve soil physical, chemical and biological properties by enhancing soil structure, increasing soil organic carbon, stimulating microbial activity and improving nutrient cycling. Conservation tillage reduces soil erosion and moisture loss, while regenerative techniques promote carbon sequestration, biodiversity, and longterm soil fertility. These improvements collectively contribute to enhanced crop productivity, resilience to climate variability and better environmental quality. Overall, the findings suggest that integrating conservation agriculture with regenerative soil management practices provides a holistic pathway for restoring soil health and strengthening agroecosystem sustainability. Therefore, adopting conservation tillage along with regenerative techniques can serve as a practical and climate-smart strategy for sustainable agricultural production and long-term food security.

Keywords: Conservation agriculture, Conservation tillage, Regenerative agriculture, Carbon sequestration.

A critical review on impacts of microplastic pollution on physico-chemical properties of soil

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The widespread utilization of plastics has resulted in considerable environmental issues, especially as microplastics have surfaced as a significant pollutant in the realm of agriculture. While prior research has recorded the buildup of microplastics across various ecosystems, this review specifically emphasizes agricultural soils as a crucial endpoint for these pollutants. In contrast to other reviews, we explore the mechanisms by which microplastics become integrated into soil matrices and the ensuing effects on soil health and crop yield. We investigate the environmental origins, fate, and toxicity of microplastics in agricultural contexts, underscoring distinct pathways through which these substances infiltrate the soil, including the use of plastic mulches, irrigation with contaminated water, and the application of organic amendments such as compost and sewage sludge. This review not only consolidates existing knowledge but also highlights critical gaps in our understanding of how microplastics interact with soil characteristics, microbial ecosystems, and agricultural crops. These interactions are vital for tackling food safety issues and assessing risks to human health due to potential bioaccumulation and biomagnification. Moreover, our findings are intended to stimulate policy development and practical measures, suggesting methods for the agricultural sector to mitigate microplastic pollution. Tackling microplastic pollution in agriculture is crucial not just for safeguarding food security but also for protecting human health and preserving environmental integrity. This review makes a distinct contribution by offering a framework for future research and action, steering stakeholders towards comprehensive solutions for this urgent global challenge.

Soil physical, chemical, biological properties and recent soil health advances

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Soil is one of the key components of terrestrial ecosystems. It plays a vital role in the regulation of plant growth, retention of water and nutrients, and microbial activities. The physical, chemical, and biological properties of soil need to be understood to increase agricultural productivity. The physical properties of soil that have been discussed in this chapter include particle density (2.60–2.70 Mg/m^3), bulk density (1.0–1.6 Mg/m^3), porosity (0.30–0.60), void ratio (0.3–2.0), and specific volume. The other important physical properties of soil discussed in this chapter are texture, structure, and air porosity. The chemical properties of soil that have been analyzed in this chapter include pH, electrical conductivity, organic carbon, and available macronutrients such as nitrogen, phosphorus, and potassium. The biological properties of soil have been analyzed through soil respiration, microbial biomass carbon, and enzymes such as urease and dehydrogenase. The results indicated that the texture of the soil varies from sandy loam to clay loam. The presence of more organic carbon in the soil was responsible for increased microbial activity and nutrient supply. The pH levels, ranging from slightly acidic to neutral, also impacted nutrient supply and microbial diversity. The results also indicated that enzymatic activity was positively related to organic matter and microbial biomass, reflecting better conditions in organic farming. New developments in soil science, precision agriculture, biofertilizers, remote sensing, and soil health monitoring techniques have also helped in better understanding and managing soil quality. Overall, this study reflects the strong association between various properties of the soil, emphasizing that integrated soil management techniques are necessary for better soil health, crop productivity, and sustainable agriculture.

Keywords: soil health, soil properties, soil health, fertility, nutrient availability, characteristics

The agronomic application of compost and compost extract derived from agro-industrial wastes in lettuce cultivation

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In recent years, the rise of the circular economy and increasingly stringent European regulations on organic waste management have driven the emergence of decentralized composting models, such as agro-composting, as an effective and local strategy for managing and valorising the wastes generated by the agro-industrial sector. This biological process enables essential nutrients to be recovered on site, producing a sanitised end product with fertilising properties. This helps to reduce dependence on chemically synthesised mineral fertilisers and minimises the environmental impact associated with their production and use.

This study aimed to evaluate the agronomic effects of four composts and their respective aqueous extracts, sourced from various agro-industrial sectors, compared with one farmyard manure and two commercial soil improvers when applied as fertilisers to a lettuce crop. The trial was conducted in a growth chamber under controlled temperature and relative humidity conditions. Parameters indicative of plant health were evaluated, including canopy cover (CANOPY) and leaf chlorophyll index (SPAD), as well as final crop yield.

The results showed that most of the evaluated composts and their extracts promoted greater vegetative growth and higher yields than the control treatment without fertilization and the conventional inorganic fertilization. These findings demonstrate the agronomic potential of agro-industrial composts as a sustainable and viable alternative to conventional fertilisers for horticultural production, particularly lettuce cultivation. This opens the door to new waste management models within the framework of the circular economy.

Keywords: compost, compost extracts, agricultural waste, agro-industrial waste, nutrients, lettuce.

Multi-isotopic tools to assess impact of vegetation changes on nitrogen and carbon cycles of Brazilian Highland soils

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The stable isotopes 13C and 15N in soil allow to assess current and past vegetations and their input in biogeochemical processes and C and N cycles. The 15N signatures reflect microbial processes and N losses by leaching, ammonia volatilization and nitrous oxide emissions. The 13C isotope records shifts of soil organic matter (SOM) sources, allowing prediction of changes in soil ecosystem functions that are difficult to measure directly. This study was conducted in a hilly area of Campos do Jordão, São Paulo State, Brazil, with about 1900 m elevation. Two soil profiles, P1 – Mollic Umbrisol (Dystric) under humid subtropical forest, and P2 – Umbrisol (Loamic, Dystric) under pasture, were sampled up to 1.0 m depth. Stable isotopes 13C and 15N, C/N ratio, total soil nitrogen (TN) and carbon (TC) were analyzed. P1 exhibited higher TC and TN (11.55 ± 0.67%; 0.82 ± 0.16%) values than P2 (2.98 ± 1.86%; 0.15 ± 0.11%), with a stabilized C/N ratio (between 13 and 15), characterizing a preserved ecosystem. Values of 15N increased with depth (0.69 to 5.14‰), indicating a closed cycle with gradual variation in microbial activity; and the surface soil values of 13C show a C3 forest as dominant source of SOM. P2 showed lower values of TC and TN, and wider C/N ratio (16 to 31), which indicates a state of N cycle in which the exportation by plants exceed inputs. Surface 15N enriched values (3.92‰) suggests an open nutrient cycle prone to higher losses, and shift in 13C values from deep layers (-29.96‰) to surface soil (-18.64‰) reflects the replacement of original forest ecosystem by current C4 grasslands. The isotopic data differentiated the preserved and degraded system, revealing changes in nutrient dynamic and vegetation coverage history. P1 maintained a healthy nutrient reserve and stable microbial cycling, while P2 showed evidences of nutrient depletion and biological instability. These results highlight the usefulness of the stable isotopes 13C and 15N as tools in the establishment of baselines for works monitoring soil health and degradation.

Effects of POME rates and NPK fertilizer combinations on growth, yield, shelf life, and soil chemical properties of cucumber (*Cucumis sativus* L.)

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Oil palm generates substantial biomass waste, primarily Palm Oil Mill Effluent (POME). Raw POME poses environmental risks such as soil clogging and water pollution, but its treated form offers a sustainable fertilizer alternative to reduce dependency of inorganic fertilizer. However, effectiveness of integrating POME with chemical fertilizers in cucumber cultivation remains unclear. This study evaluated the combined effects of POME and NPK on the growth, yield, post-harvest quality, and soil chemical properties of cucumber (*Cucumis sativu*s L.) using a randomized complete block design with nine treatments. Results showed that integrated POME–NPK applications significantly influenced stem diameter, root development, yield, and fruit weight loss. Notably, 3 g NPK + 300 ml POME (T7) achieved comparable performance to farmer practice 6g NPK (T1) while using 50% less inorganic input. These findings demonstrate that treated POME may partially substitute chemical fertilizers while maintaining crop performance with reduced inputs levels.

Influence of palm oil mill effluent (POME) amendment on growth, physiology and soil chemical properties under *Mucuna bracteata* cultivation

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Palm oil mill effluent (POME) is a major by product generated during palm oil processing and may pose environmental challenges if not properly managed. However, POME contains substantial organic matter and nutrients that can be beneficial when applied as a soil amendment. This study evaluated the influence of POME application on plant growth, physiological performance, and soil chemical properties under *Mucuna bracteata* cultivation. The experiment was conducted at Ladang 15, Faculty of Agriculture, Universiti Putra Malaysia using a Randomized Complete Block Design (RCBD) with eight treatments and three replications. Treatments consisted of different combinations of POME (0, 50, 100 and 150 mL) and NPK Blue fertilizer (15:15:15) rates (0, 5 g and 10 g). Growth parameters measured included plant height, leaf number, leaf area, stem diameter, and fresh and dry biomass of shoots and roots. Physiological performance was evaluated using photosynthesis rate measurements, while soil chemical properties including soil pH and electrical conductivity were also analysed. The results indicated that POME application significantly improved plant height, leaf number, leaf area and plant biomass compared with the control. Treatments combining POME with reduced NPK fertilizer often showed comparable performance to full NPK fertilization. Soil pH was not significantly affected and electrical conductivity remained within acceptable ranges. The findings suggest that POME can be utilized as a sustainable organic amendment to enhance the growth and physiological performance of *Mucuna bracteata* while reducing dependence on inorganic fertilizers.

Effect of polystyrene on radish (*Raphanus sativus* L. var. *Sativus*) growth in Chernozem

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Ecological research has traditionally focused on plant and soil responses to climate change; however, increasing attention is now being directed toward anthropogenic stressors such as plastic pollution. Microplastics can disrupt soil ecosystems by altering microbial communities, reducing the abundance of beneficial organisms, and weakening soil structure, thereby affecting water and nutrient cycling. They may also directly impair plant performance by limiting growth and photosynthetic efficiency, although their long-term effects remain insufficiently understood. This study examined the effects of three common plastics—HDPE, PS, PVC—on radish growth and soil aggregate stability in Chernozem soil. Microplastic particles (<400 μm) were incorporated into the soil at a concentration of 5% and allowed to stabilize for 14 days. Subsequently, radish (*Raphanus sativus* L. var. *sativus*) plants were cultivated under controlled conditions across three microplastic variants and a control, each with five replicates. The results indicate that PS contamination significantly increased both dry biomass (DB) and fresh biomass (FB), (by ~40% and ~40%, respectively) compared to the control. This effect corresponded with higher maximum photochemical efficiency of photosystem II (Fv/Fm) in the PS variant. In contrast, HDPE and PVC variants showed a declining trend in biomass production. These findings suggest that PS contamination may enhance photosynthetic performance and biomass production, potentially acting as a growth stimulator in Chernozem soils. This effect is likely associated with alterations in soil physical properties, particularly improved aggregate stability. Measurements showed that PS increased the stability of water-stable microaggregates, possibly due to micropore formation, which enhances water retention and availability to plants. Furthermore, PS appears to promote a more stable soil structure and a balanced pore system, supporting root development and soil aeration.

Keywords: microplastics, polystyrene, radish, Chernozem, biomass, water-stable microaggregates

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Benefits and risks of human sludge composting as an alternative fertilizer to mitigate soil degradation

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Soil degradation, especially agricultural, is associated with the loss of soil organic matter, among other things, as a result of the separation of animal and plant production and their intensification. The lack of manure and compost leads to the search for alternative sources. One option is human sludge in the form of sewage sludge, which carries a wide range of pollutant residues, or sludge from composting toilets (CT). The use of composted sludge from CT has great potential in circular waste management, which returns nutrients and organic matter to the soil, saves drinking water resources and does not use disinfectant chemicals. Our investigation focuses on sludge from Forest kindergartens (FKG) which are significant CT users in the Czech Republic. Due to the lack of support in legislation, the options for dealing with this type of compost are very limited. To enable the safe use of this type of compost for improving soil properties, more detailed information on the achievement of compost sanitation is needed. We compared indicators of sanitation effectiveness of sludge from CT from FKG using microbiome analyses and cultivation methods. Pilot results showed that metagenomic analyses of sanitation effectiveness were consistent with legally required cultivation tests. Furthermore, the metagenomic analysis indicated not only presence of undesirable but also potentially beneficial microorganisms for soil application purposes. Preliminary results also showed that attention needs to be paid to the phytopathogens in backfill material used for CT operation.

Keywords: Human sludge compost, soil organic matter, microbiome, indication of sanitation process

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Indigenous arbuscular mycorrhizal fungi associated with zinc and copper in rice-cultivated soils of southern, central, and northern Khyber Pakhtunkhwa

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Arbuscular mycorrhizal fungi (AMF) play a pivotal role in nutrient acquisition and soil health in rice-based agroecosystems, yet comprehensive studies on their spatial distribution and interaction with soil micronutrients across contrasting agro-ecological zones remain limited. This study investigated AMF spore density, root colonization, soil physicochemical properties, and micronutrient dynamics (Zn and Cu) in the rhizosphere of rice across three major rice-growing districts of Khyber Pakhtunkhwa, Pakistan: Swat, Peshawar, and Dera Ismail Khan. A total of 100 rhizospheric soil and root samples were collected during 2023–2024 and analyzed using standard wet sieving, staining, and atomic absorption spectrophotometry methods. AMF spore density (39.04 ± 3.18 spores 20 g^{-1} soil) and root colonization ($62.4 \pm 1.7\%$) were highest in Swat, followed by Peshawar and Dera Ismail Khan, with significant inter-district differences ($p < 0.05$). Enhanced AMF activity in Swat was associated with higher soil organic matter (1.9%), balanced micronutrient availability, and moderate lime content, whereas lower activity in Dera Ismail Khan corresponded with reduced organic matter and elevated lime levels (8.5%), indicative of limited microbial activity. Pearson correlation analysis revealed a strong positive relationship between spore density and root colonization ($r = 0.856$, $p = 0.001$), while Zn and Cu exhibited contrasting regulatory effects on AMF sporulation and colonization. Mass multiplication of native AMF using maize proved effective for inoculum production, achieving an average of 60 spores per 20 g soil and 58.7% root colonization. Generally, AMF dynamics in rice are primarily governed by soil organic matter, lime content, and micronutrient balance rather than direct antagonistic effects, highlighting the importance of site-specific soil fertility management to maximize mycorrhizal activity and sustain rice productivity.

Hyperspectral site-specific weed detection as a strategy to mitigate herbicide-induced soil degradation

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The increasing reliance on herbicides in modern agriculture has raised significant concerns regarding soil degradation, including negative impacts on soil microbial activity, biodiversity, and long-term soil health. Conventional weed management practices typically rely on uniform herbicide application, which often leads to excessive chemical inputs and unnecessary exposure of non-infested areas. This not only increases production costs but also contributes to soil contamination and ecological imbalance. Therefore, innovative approaches that enable targeted weed management are essential to support sustainable soil management. This study investigates the potential of hyperspectral sensing combined with machine learning to support site-specific weed management as an alternative approach to reduce herbicide application and mitigate soil degradation. The research focuses on the discrimination of *Ambrosia artemisiifolia*, a highly invasive weed species, from maize and sunflower crops using high-resolution spectral reflectance data. A controlled pot experiment was conducted, where hyperspectral measurements were collected across multiple growth stages using an ASD FieldSpec spectroradiometer (350–2500 nm). Spectral data were preprocessed to remove noise and analyzed using Principal Component Analysis (PCA) and Random Forest classification. Different classification scenarios were evaluated, including weed-versus-crop and pairwise species discrimination. The results demonstrated that hyperspectral reflectance captured clear differences among plant species, particularly in the visible, red-edge, and near-infrared regions. PCA revealed that the first two components explained the majority of spectral variance, highlighting strong redundancy in hyperspectral data while providing partial species separation. However, machine learning significantly improved classification performance. Random Forest achieved high accuracy in detecting *Ambrosia artemisiifolia*, with classification accuracy reaching approximately 86% against maize and 90% against sunflower. The findings confirm that hyperspectral sensing combined with machine learning provides an effective framework for precise weed detection. By enabling targeted herbicide application, this approach can significantly reduce chemical input, thereby contributing to improved soil health and more sustainable agricultural practices. This study highlights the potential of integrating advanced sensing technologies into site-specific weed management systems as a strategy to mitigate soil degradation. **Keywords:** soil health, hyperspectral data, site-specific weed management, herbicide reduction, and precision agriculture.

Optimising grain corn productivity through nitrogen management strategies

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Increasing food demand for livestock feed has led to greater nitrogen (N) fertiliser application to maximize grain corn (*Zea mays* L.) productivity. However, excessive application of commercial urea can increase nutrient losses and contribute to soil degradation. The use of enhanced fertiliser such as slow release or coated urea has the potential to improve N management while sustaining grain yield. Nevertheless, the optimum application rates of coated urea under field conditions remains limited. Therefore, field experiments were conducted to evaluate the effectiveness of coated urea compared with commercial urea fertiliser on the growth and yield performance of grain corn. The research was arranged in a randomised completely block design (RCBD) with four replications. Four fertiliser treatments including reduced N rates using coated urea and compared with the standard commercial fertiliser as a control treatment. Growth and yield performance were measured to observe the response of grain corn to reduced N input under coated fertiliser. The results showed that grain yield obtained from coated urea was comparable to the yield obtained from standard practice. Notably, a 25% reduction in N application through the coated urea produced similar yield to the standard practise. These findings indicate that coated urea can maintain yield productivity while reducing fertiliser input in large scale grain con production. In summary, the application of coated urea offers an alternative approach for sustainable grain corn production by reducing N losses and minimising soil degradation without compromising yield performance. The study highlights the potential of enhanced fertiliser as effective strategy for supporting sustainable agriculture production under intensive grain corn production.

Biochar from sunflower seed husk for the improvement of degraded sandy soil

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The efficient utilization of agricultural and industrial waste streams for biochar production offers a promising approach to mitigating soil degradation problems. As the sunflower oil industry is a major and continuously expanding global sector, it is important to find ways to utilize its by-products, such as seed husks, to produce sustainable bioenergy and other useful products. One such promising method is the conversion of sunflower seed husks into biochar, which could enhance the fertility, water retention and productivity of degraded soils.

The primary long-term objective of our research was to develop specific soil amendments utilizing sunflower seed husk biochar, sewage sludge compost and composite products (co-composted biochar and organic waste) to improve degraded or low-quality soils.

First, the biochar produced by pyrolysis of sunflower seed husks was comprehensively characterized using a complex methodological approach that included physicochemical, biological, and ecotoxicological analyses. Subsequently, microcosm experiments were conducted using calcareous sandy soil treated with different combinations of biochar (15 and 30 t ha^{-1}), sewage sludge compost (20 t ha^{-1}), and biochar–compost composites. The composite products were produced via co-composting of sewage sludge and biochar at rates between 1% and 5%. The aim of the study was to evaluate the effects of these amendments on degraded sandy soil and to identify the most effective treatments for future field-scale applications.

Our results demonstrated that the applied biochar had a positive direct and indirect influence on the sandy soil. However, the efficiency of applying biochar, compost, and their composite in calcareous sandy soil varied greatly depending on the applied combinations used and the duration of the treatment. The composite product was most effective at higher biochar concentrations, as evidenced by microbiological activity, water-holding capacity, and plant growth tests.

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Mycorrhizal-mediated soil quality improvement under conservation agriculture in the Indo-Gangetic Plains of India

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The Indo-Gangetic Plains (IGP) of India represent one of the most intensively cultivated agricultural regions in the world, yet long-term conventional tillage, residue removal, and excessive input use have led to progressive soil degradation, declining biological activity, and reduced water-use efficiency. Conservation agriculture has been increasingly promoted in this region to restore soil health and ensure sustainable agricultural development. This abstract focuses on the role of mycorrhizal fungi in enhancing soil quality under conservation agriculture practices in the Indo-Gangetic Plains.

Reduced tillage and crop residue retention, central to conservation agriculture, create favorable conditions for arbuscular mycorrhizal fungi by maintaining hyphal continuity and increasing organic carbon availability. Enhanced mycorrhizal colonization improves nutrient acquisition—particularly phosphorus—in cereal-based cropping systems dominant in the IGP. Additionally, mycorrhizal hyphae and associated glomalin production contribute to soil aggregation, leading to improved soil structure, higher water infiltration rates, and greater resistance to erosion and compaction.

Recent advances in soil biology and monitoring techniques have enabled the assessment of mycorrhizal diversity, soil biological indicators, and their interactions with soil physical and hydrological processes in this region. Integrating biological measurements with soil water movement modeling provides a comprehensive understanding of how conservation practices influence soil functioning under semi-arid to sub-humid climatic conditions.

This region-specific focus highlights mycorrhizal fungi as key drivers of soil health restoration in the Indo-Gangetic Plains. Strengthening soil biological processes through conservation agriculture offers a practical and scalable pathway for improving soil quality, enhancing climate resilience, and supporting sustainable agricultural productivity in one of India's most critical food-producing regions.

Soil fauna-mediated effects of plant residues on soil health in agricultural systems

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Adding plant residues to agricultural soils is a common management practice used to improve soil chemical and physical properties. Among other benefits, it increases soil organic matter content and thereby promotes crop growth. However, these positive effects are mediated largely by soil biota, microorganisms and soil fauna, while the specific role of soil fauna in these processes remains less well understood.

We investigated the contribution of soil-dwelling microarthropods to nutrient cycling and plant performance in barley-grown soils amended with plant residues and mineral fertilisers. To address this, we established mesocosm experiments using two soil types in which barley was grown in defaunated or faunated soils. In the first year, soils were amended with or without plant residues; in the second year, soils received mineral fertiliser or no fertiliser. Throughout the experiment, we measured soil and leachate nitrate and ammonium concentrations, soil carbon content, plant growth and yield, microbial activity, and microarthropod abundance.

In the first year, soil microarthropods played a significant role in nutrient cycling in the presence of crop residues: nitrate leaching was lower and soil nitrate concentrations were higher in faunated mesocosms than in defaunated ones. In addition, crop yield and microbial activity were higher in the presence of soil fauna. In the second year, mineral fertilisation had the strongest effect on plant growth. The influence of soil fauna was most evident in microbial activity and in soil nitrogen and carbon dynamics, both of which were modified by fertilisation. Under fertilised conditions, microbial activity was higher in the presence of soil fauna than in their absence. Microbial functional profiles also differed consistently between faunated and defaunated soils, regardless of fertilisation: in the absence of microarthropods, microorganisms showed stronger responses to amino acids, whereas in their presence they responded more strongly to sugars. Under fertilised conditions, soil fauna also reduced nitrate leaching.

Our study demonstrates that soil-dwelling microarthropods play an important role in stimulating soil microbial activity and, consequently, regulating nutrient cycling and plant growth in soils amended with plant residues.

Diversity and ecological role of soil arthropods in a cork oak (*Quercus suber*) forest ecosystem: A case study from the Tacheta-Zougagha state forest, Aïn-Defla, Northern Algeria

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Forest soils represent dynamic ecosystems where soil fauna plays an essential role in organic matter decomposition, nutrient cycling, and the maintenance of soil fertility. Soil arthropods are particularly important components of soil biodiversity and are widely used as indicators of soil biological activity and ecosystem functioning.

This study aims to characterise the physico-chemical properties of soils and to provide a preliminary inventory of soil arthropod communities in a cork oak (*Quercus suber*) forest located in the Tacheta-Zougagha State Forest (Aïn-Defla region, northern Algeria). Soil sampling was conducted in February 2023 using a random sampling design along a measuring transect. Soil samples were collected from depths ranging from 0 to 40 cm using a shovel, and each sample was placed in a separate bag to ensure proper transport and conservation.

The extraction of soil microarthropods was carried out using the Berlese–Tullgren funnel method, a widely used technique that separates organisms from the soil through gradual drying and heating. The soil samples were placed on a mesh screen positioned over a funnel connected to a collection bottle containing a preservative solution. A 70-W lamp placed approximately 25 cm above the samples was used to create a temperature and humidity gradient, forcing the organisms to migrate downward into the collection container over a period of five days.

Preliminary observations indicate that soil arthropod abundance is higher in the upper soil horizons and varies according to local environmental conditions. These findings highlight the ecological importance of soil arthropods in maintaining soil biological fertility and ecosystem functioning in Mediterranean cork oak forests. Further studies integrating soil fauna inventories with broader forest biodiversity assessments would contribute to a better understanding of the ecological dynamics of these ecosystems.

Keywords: Soil arthropods, soil biodiversity, forest soil, biological fertility, cork oak forest.

Short-term organic amendments differentially shape microbial communities in soil and earthworm guts under contrasting management

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Biochar and compost are widely recognized as soil amendments used to improve soil fertility, yet their short-term effects on soil and earthworm-associated microbial communities under controlled conditions remain insufficiently explored. This study examined the short-term effects of eucalyptus wood–derived biochar (2%, 20 g kg^{-1} soil), compost (1%, 10 g kg^{-1} soil), and their combination (2% biochar + 1% compost), in the presence of the earthworm *(Lumbricus terrestris)*, over a 14-day laboratory microcosm incubation using organically and conventionally managed soils. Physicochemical properties, six enzymatic activities, bacterial functional diversity, and 16S rRNA gene amplicon sequencing were assessed in both soil and earthworm gut samples. Microbial alpha and beta diversity, as well as microbial abundance, were also evaluated. The results indicated that biochar and compost amendments were associated with increased soil organic matter across treatments, while compost application was linked to a decrease in soil pH in both soil types. Amendment-specific responses were observed for soil enzymatic activities. Alpha and beta diversity analyses suggested higher bacterial diversity in organically managed soil. Co-occurrence network analysis indicated more interconnected microbial associations in conventionally managed soil. Multivariate analyses showed a clear separation of treatments based on microbial, enzymatic, and physicochemical parameters, with organic matter, pH, and enzymatic activities contributing to the observed variability. Spearman correlation analysis further suggested interactions between microbial diversity, enzymatic activity, and soil properties. Overall, this short-term microcosm study highlights early biological responses of soil and earthworm-associated microbial communities to biochar and compost amendments and provides a basis for future long-term studies.

Sensitivity of labile and stable carbon fractions to soil regeneration practices

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The ongoing degradation of arable soils, largely driven by the decline of soil organic matter (SOM), poses a significant challenge to sustainable agriculture. As SOM is fundamental to soil functionality, identifying reliable indicators of soil improvement is essential. This study evaluates the effectiveness of regenerative soil management practices and compares indicators suitable for monitoring short- and long-term changes in soil quality.

A three-year field experiment was conducted using minimum tillage, mineral amendments to enhance soil physical properties, and organic practices such as cover cropping and mulching. Soil chemical properties were analyzed, including Total Organic Carbon (TOC), labile carbon fractions (Permanganate Oxidizable Carbon – POXC, Dissolved Organic Carbon – DOC, NaOH-soluble fulvic acids), as well as easily extractable glomalin-related soil protein (EE-GRSP). Crop productivity was also assessed.

Minimum tillage showed a pronounced time-dependent effect, increasing surface TOC by 17.58%, NaOH-soluble humic acids by 40.85%, and POXC by 77.75% over three years. Mulching and cover cropping further enhanced specific carbon fractions and yield performance. Among the indicators, labile carbon fractions (DOC, POXC) proved most sensitive for short-term changes, whereas TOC, EE-GRSP, and NaOH-soluble humic substances were more suitable for long-term monitoring.

These findings highlight the importance of combining multiple SOM indicators to assess soil regeneration and support the development of effective soil conservation monitoring systems.

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Organic under-vine mulching for terroir stability: Enhancing soil buffering capacity in Tokaj Vineyards

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Soil plays a fundamental role in the sustainability of viticulture and in maintaining site-specific stability, particularly under changing climatic conditions. Soil biological activity and organic matter dynamics are key drivers of soil buffering capacity, which regulates water and nutrient cycles and mitigates environmental stress. The aim of this study was to investigate whether the application of natural mulching materials can enhance soil buffering capacity and biological activity in vineyard systems of the Tokaji borvidék.

Field experiments were conducted in four vineyards with contrasting soil types, where under-vine applications of wool mulch and alfalfa hay were evaluated. Baseline soil conditions were assessed prior to treatment establishment, followed by a two-year monitoring period focusing on changes in soil organic matter and biological activity. Soil organic carbon content showed a slight but increasing trend over time, indicating gradual improvement in soil quality.

Labile carbon fractions proved to be strongly site-dependent; however, a reduction in variability was observed in the upper soil layer (0–10 cm), suggesting a trend toward system stabilization. No significant effects were detected in deeper layers (30–60 cm) within the observed period. Measurements of fluorescein diacetate (FDA) enzyme activity revealed particularly high values under alfalfa mulch in the topsoil, while wool mulch also supported active soil biological processes.

These results indicate that natural mulching represents a promising soil-conserving management practice to enhance soil biological activity and buffering capacity, thereby contributing to the long-term maintenance of soil quality and site stability in viticulture.

Results of a long-term trial with soil bacterial preparations (2016-2025)

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This study summarizes the findings of a ten-year field experiment (2016–2025) evaluating the agronomic effects of soil inoculant bacterial preparations under Hungarian field conditions. Soil bacterial products, classified as yield-enhancing biostimulants, are known to stimulate plant growth, increase yield, and improve certain quality parameters. To verify these effects in a long-term, controlled setting, a joint trial was conducted by the National Food Chain Safety Office (Nébih) and the Professional Association of Hungarian Soil Protection Bacteria Producers and Distributors. As stated in the poster, "the aim was to compare the results of plots treated with microbiological preparations with those of the untreated and standard control plots." The experiment was carried out in Baranya County (Szalánta) on Ramann-type brown forest soil, using a replicated randomized block design with 4–6 replications. Across two experimental cycles, nine crops were tested, including corn, spring barley, soybean, winter rapeseed, winter wheat, sunflower, and winter barley. Treatments included multiple commercial soil inoculant products, two untreated controls, and a standard control receiving +50 kg/ha nitrogen. After each harvest, crop residues were treated with stubble-decomposing microbial preparations. Across all crops and years, treated plots consistently outperformed the untreated controls. The average yield increase across nine crops was 15.28%, with the highest improvement in corn (31.6%) and the lowest in spring barley (9.1%). In most cases, yields also exceeded those of the nitrogen-supplemented standard control. Significant differences were observed particularly in winter rapeseed and winter wheat. Quality parameters measured until 2020 also improved: crude protein content increased in spring barley (P5%), and oil content increased in winter rapeseed (P1%).

Potential of silica-rich biochar as a soil amendment for regenerative agriculture

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Biochar is a carbon rich material produced from organic residues such as forestry by-products, animal manures, and agricultural wastes through gasification or pyrolysis at temperatures between 300–600 °C under oxygen-limited conditions. Numerous studies have highlighted the potential of biochar as an effective soil amendment in both agricultural and forestry systems, particularly for improving soil fertility, enhancing nutrient retention, and increasing soil carbon sequestration.Asia generates approximately 600–800 million tons of rice straw annually, while global production is estimated at 800–1000 million tons. In addition, worldwide annual production of rice husk and rice bran is about 120 million tons and 76 million tons, respectively. Rice husk is partially utilized as fuel in rice mills for paddy drying; however, large quantities of rice residues are commonly burned in the field. Farmers often adopt residue burning as a low-cost and convenient management practice, with the perception that it contributes to soil nutrient cycling. Nevertheless, prolonged and widespread burning of rice residues leads to severe air pollution and increased greenhouse gas emissions.

Sustainable crop production therefore requires improved strategies for rice residue management. Converting rice husk into biochar presents a promising solution by simultaneously addressing waste management, environmental pollution, and soil degradation. Rice husk biochar is rich in silica, which enhances its adsorptive capacity, improves nutrient retention, and contributes to better plant structural integrity and water-use efficiency. While rice husk biochar has been increasingly applied in agricultural soils, its adoption in forestry plantations, particularly in Malaysia, remains limited.

This study aims to evaluate the potential of silica-rich rice husk biochar as a soil amendment for both agricultural and forest soils, with emphasis on improving soil quality, enhancing sustainable productivity, and reducing reliance on chemical fertilizers in support of conservation and regenerative land management practices.

Keywords: Rice husk biochar; Silica-rich biochar; Soil amendment; Sustainable agriculture; Regenerative land management

Sustainable soil water management and conservation

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Sustainable management and conservation of soil moisture in water are important for enhancing agricultural productivity, meeting environmental challenges, and providing climate variability. However, as noted in the introduction, the challenges facing sustainable management and conservation in some developing regions are attributed to increased incidences of water scarcity, land degradation, and random rainfall patterns. Consequently, these factors adversely affect agricultural productivity by impacting crops in these regions. Therefore, this study had a purpose or objective to analyses viable options in effective management of soil moisture in water to improve agricultural productivity. Sustainability in managing and conserving surface as well as groundwater can be attributed to a number of factors.

The methodology used in doing the research includes an evaluation of practices used in soil and water conservation, such as mulching, contouring, cover cropping, conservation tillage, and rainwater harvesting. Data were collected through field observation and an evaluation of secondary data. From the results obtained, it is clear that integrated practices in soil and water have positive effects in terms of retaining more moisture in the soil, minimizing loss, and increasing yield and sustainable management and conservation of soil waters can be promoted for the attainment of a sustainable system of agriculture, natural resources, and climate-resilient soils.

Keywords: Soil water conservation, Sustainable agriculture, Soil moisture management, Climate resilience, Productivity

Role of conservation agriculture on crop productivity under changing climate scenario

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Conservation agriculture (CA) plays a crucial role in sustaining and enhancing crop productivity under changing climate scenarios characterized by rising temperatures, erratic rainfall, and increased frequency of extreme weather events. The core principles of CA –minimum soil disturbance, permanent soil cover, and diversified crop rotations – help improve soil health, water-use efficiency, and system resilience. Reduced tillage conserves soil moisture, lowers fuel and labor costs, and minimizes soil erosion, which is especially important under intense rainfall and drought conditions. Retention of crop residues as mulch moderates soil temperature, reduces evaporation losses, enhances soil organic carbon, and improves nutrient cycling, thereby supporting stable crop growth even under climatic stress. Crop diversification and rotations interrupt pest and disease cycles, enhance biodiversity, and improve nutrient-use efficiency, leading to more stable yields. Over time, CA systems increase soil aggregation and infiltration, reduce runoff, and improve root growth, enabling crops to better withstand heat and water stress. Additionally, conservation agriculture contributes to climate change mitigation by sequestering carbon in soils and reducing greenhouse gas emissions through lower tillage and optimized input use. Overall, conservation agriculture offers a climate-smart, sustainable approach that enhances crop productivity, improves resource-use efficiency, and strengthens the resilience of farming systems in the face of climate variability and change.

Medicinal plant-based approach to phytoremediation for the sustainable conservation of heavy metal–contaminated agricultural soils: A case study of the Wilaya of Tiaret, Algeria

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Soil pollution in agricultural systems represents a major environmental issue, requiring sustainable and eco-friendly solutions. Phytoremediation, using medicinal plants, offers a promising alternative for soil decontamination. The objective of this study is to evaluate the potential of medicinal plants in the phytoremediation of polluted agricultural soils by analyzing their ability to absorb, accumulate, or stabilize contaminants, with a specific application to the context of the Wilaya of Tiaret, Algeria.

A contaminated agricultural soil was first analyzed to determine its initial composition in heavy metals (Pb, Zn, Fe, Cd, etc.). Medicinal plant seeds were then cultivated in this contaminated soil. After plant growth, further analyses were conducted on both the soil and the harvested plant tissues, allowing the assessment of the plants' capacity to absorb and accumulate heavy metals. The results showed that the tested plants exhibit a significant ability to accumulate heavy metals in their tissues. A reduction in the concentration of certain elements was also observed in the soil, confirming the potential of these species for the phytoremediation of contaminated agricultural soils.

Keywords: Pollution, heavy metals, medicinal plants, phytoremediation.

Regenerative agriculture and its effect on soil physical characteristics

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Regenerative agriculture (RA) has emerged as a critical solution to the global crisis of soil degradation. As the foundational habitat for millions of microorganisms and the primary source of global food and nutrition, maintaining soil health is essential. While soil physical characteristics encompass a wide range of properties, this research focuses specifically on water infiltration rate (hydraulic conductivity), compaction and decomposition rate of soil organisms. These three parameters serve as the most direct indicators of soil structural recovery and are the primary physical constraints limiting yield in non-regenerative systems. The research utilizes a comparative analysis of different land parcels, including tilled with non-tilled and fertilized with non-fertilized plots, and mixed organic and inorganic fertilizers by measuring how these different managements impact the soils physical stressors. This study investigates whether regenerative techniques can effectively restore soil viability and sustainability. The data gathered regarding these physical parameters will serve as evidence to determine the potential for the widespread adoption and proliferation of regenerative agriculture in future farming systems.

Investigation of long-term effects of agrotechnical factors on the soil microbiome under winter wheat and corn

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Agrotechnical factors are agricultural practices and techniques applied to optimise crop production and soil management. These practices greatly impact the overall soil health. Studying the effect of these practices in long-term field experiments helps to understand their cumulative impacts on various soil parameters, including soil microbial biomass and its community. This study specifically investigated the long-term effect of conventional and reduced tillages and mineral NPK fertiliser treatments on the soil microbiome under winter wheat-corn rotation. The study was undertaken at the long-term polyfactorial field experiment established in 1991 at Látókép research station belonging to the University of Debrecen. Soil samples were collected from plots where corn and winter wheat were grown during the spring of 2024 specifically under winter wheat-corn rotation. The treatments included NPK fertilisation (160 kg ha^{-1} N, 60 kg ha^{-1} P_2O_5, 90 kg ha^{-1} K_2O) and a control (without fertiliser) and three tillages (plough, strip, ripper). Each treatment was replicated three times. The soil microbial biomass and its community comprising of Gram-positive bacteria, Gram-negative bacteria, Actinomycetes, Arbuscular mycorrhizal fungi (AMF) and saprophytic fungi was determined by Phospholipid Fatty Acid analysis. Results from this study indicate that microbial biomass was higher in wheat soil than in corn soil under both NPK treated and control plots. NPK fertilisation reduced AMF and Gram-negative bacteria, with a more pronounced effect in corn than wheat. In contrast, actinomycetes, Gram-positive bacteria and saprophytic fungi increased with NPK fertilisation, with a more pronounced effect in wheat than corn. Reduced tillages (strip and ripper) showed a higher microbial biomass and community composition in both crops. These findings suggest that soil management practices differentially influence soil microbial structure and its suitability for microbial life.

Keywords: Soil microbial biomass, tillage, NPK fertilization

Evaluation of biodegradable hydrogels for restoring degraded sandy soils

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Biodegradable hydrogels based on polysaccharides such as chitosan, pectin, proteins, and acacia gum have attracted increasing attention as sustainable natural materials for improving the physical and hydrological properties of sandy soils, and mitigating its degradation. Sandy soils are highly affected by degradation processes, including water loss, nutrient leaching, poor structure, and reduced fertility. The incorporation of eco-friendly natural hydrogels represents an effective strategy to face these challenges by enhancing soil health and restoring its functional properties. In this study, several natural polymer-based hydrogels were synthesized and characterized using scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), fourier transform infrared spectroscopy (FTIR), and specific surface area measurements (EBT). Then a pot experiment cultivated with rocket plants was conducted to evaluate the performance of the synthesized hydrogels by measuring some parameters such as swelling capacity, water-holding capacity (WHC), water retention, and soil moisture characteristic curve (SMCC).

The results indicate that, the hydrogel-amended soil improved plant growth due to better soil water content. Hydrogels based on pectin (PcH), protein (ProH), acacia gum/bentonite (ABH), and chitosan/gelatin (CGH) showed superior performance compared to the untreated treatment. These hydrogels effectively functioned as water reservoirs, which have a swelling capacity reaching 766% after 5 hours (h) in ProH and 819% after 24 h in PcH. In addition, it recorded the highest WHC by 19.99 and 20.16% for ProH and PcH, respectively, which will reflect on reducing the irrigation frequency. The SMCC showed an increase in volumetric water content under suction ranges of 0–800 cm for all synthesized hydrogels, especially for ProH, and ABH. In conclusion, these hydrogels could help in reducing the degradation of sandy soils by increasing organic carbon content, improving soil structure, and enhancing soil water retention, thereby supporting long-term soil health and sustainability.

When climate leads the soil: projected shifts in soil moisture regimes and their impact on degradation in the Colombian Altillanura

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The Altillanura region in the Colombian Orinoquía is a strategic agricultural frontier, yet the accuracy of its soil moisture regime (SMR) classifications—critical for land use planning—remains largely unverified. Current SMR estimations in Colombia rely on climatic zonations (e.g., Caldas-Lang) that assume a direct correlation between regional climate and soil water dynamics, without explicit modeling of the soil moisture control section (SMCS) or temporal water dynamics as defined by Soil Taxonomy. This study aimed to quantify the uncertainty in SMR estimation for the Meta department's flat highlands by integrating in-situ soil monitoring, the Newhall simulation model, and climate change projections.

Ten reference sites were selected across the study area (~745,000 ha) using conditioned Latin Hypercube Sampling. At each site, soil physical properties (texture, bulk density, water retention curves) were analyzed to calculate the SMCS depth and available water capacity (AWC). Continuous soil volumetric water content was monitored using CS616 sensors at three depths (Oct 2023–Oct 2024). SMRs were determined from observed data and compared against those simulated by the Newhall model using CHIRPS precipitation and ERA5 temperature data. Model performance was assessed via contingency tables and Cohen's Kappa coefficient. Finally, SMRs were spatially modeled for historical (1991-2010) and future (2081-2100, SSP5-8.5) scenarios.

Preliminary results indicate discrepancies between observed and modeled SMRs, with the Newhall model showing a tendency to overestimate dry periods, leading to a moderate agreement ($\kappa > 0.7$). Spatial projections suggest a potential shift towards more xeric conditions (Ustic regimes) in parts of the Altillanura under climate change scenarios. These findings highlight significant uncertainties in current SMR estimations, stemming from both the limitations of climate-only models and the critical need for local SMCS characterization. The research underscores the importance of integrating hydropedological approaches and in-situ monitoring to improve soil classification, inform sustainable agricultural expansion, and mitigate land degradation risks in this vulnerable savanna ecosystem.

Hydrology of urban surfaces: Water retention capacity of common mulch types

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Rapid urbanization has significantly altered natural hydrological processes by increasing impervious surface cover, leading to reduced infiltration, enhanced surface runoff, and elevated urban heat stress. Nature-based solutions, such as mulching in urban green spaces, offer a potential strategy to mitigate these impacts by improving water retention and regulating soil moisture dynamics. This study investigates the water retention capacity of commonly used organic and inorganic mulch materials under controlled laboratory conditions.

Ten mulch types (eight organic and two inorganic) were tested at three thickness levels (2, 4, and 6 cm) using a standardized saturation–drainage experimental setup. Water retention was quantified as both absolute storage and thickness-normalized retention efficiency (mm/cm), allowing direct comparison across materials and depths.

Results show that material properties are the primary driver of retention performance. At 2 cm, retention efficiency ranged from 0.63 to 2.07 mm/cm; at 4 cm, from 0.42 to 1.49 mm/cm; and at 6 cm, from 0.36 to 1.66 mm/cm. Organic mulches consistently outperformed inorganic materials across all thicknesses. Bark pine exhibited the highest efficiency at shallow depth (2.07 mm/cm) but declined with increasing thickness (0.92 and 0.71 mm/cm), indicating rapid saturation. In contrast, leaves maintained relatively high retention across all depths (~1.27–1.66 mm/cm). Inorganic materials such as white marble showed consistently low performance (~0.69–0.45 mm/cm). Retention capacity further emphasized that straw and pine needle mulches retained up to ~336% of their dry mass, while inorganic mulches such as lava rock (~12%) and white marble (~4%) showed minimal storage capacity.

While increasing mulch thickness increased total water storage, retention efficiency declined systematically, indicating diminishing returns beyond ~4 cm. Overall, the findings demonstrate that mulch selection is more critical than thickness alone. High-porosity organic mulches act as effective interception layers, capable of temporarily storing rainfall and reducing short-term runoff. This study provides a quantitative basis for integrating mulch into water-sensitive urban design.

Keywords: urban hydrology; mulch; water retention; infiltration; runoff; green infrastructure

Level of harmful elements in the grassland of central Serbia – Levač area (Rekovac)

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Within the framework of the bilateral Hungarian-Serbian project "Soil health indicators and their relation to soil physical, chemical characteristics, and plant indices" of the 2024/2026 project cycle, investigations were conducted on the content of harmful and hazardous elements (As, B, Ba, Cd, Co, Cr, Cu, Ni, Pb, and Zn) in the grassland soil of central Serbia, in the Levač region, near the municipality of Rekovac. In addition to the total content of the investigated elements, sequential extraction was performed to separate the easily soluble fraction, the fraction associated with Fe and Mn oxides, the fraction associated with organic matter and sulfides, and the fraction associated with the crustal structure.

Sequential extraction procedures are usually applied to assess element association with the different solid phase components in soils. The data obtained from the analyses of the fractions supply information about the mobility, pathways or bioavailability of elements and any potential hazard to the environment using the optimized BCR procedure. Element concentrations were determined using an iCAP-6500 Duo inductively coupled plasma optical emission spectrometer (ICP/OES), Multi-Element Plasma Standard Solution 4, Specpure® (1000 µg/mL), containing Li and B, and Arsenic Plasma Standard Solution, Specpure® (As 1000 µg/mL). Accuracy was evaluated by analysing the sediment reference material BCR-701 (for Cd, Cu, Cr, Ni, Pb and Zn), for the three-step sequential extraction procedure.

Measured concentrations of harmful elements, except for Co and Cu in two samples, are significantly below the prescribed national limit values. Elevated concentrations of Co in soil, slightly above 9 mg kg3, are proven to be of geological origin and/or due to their retention by the clay layer. In two samples a slight increase in Cu content was found, but still around the limit value defined by the Law on limit values of polluting, harmful and dangerous substances in soil of the Republic of Serbia. Although the proportion of the easily soluble fraction of Cd is high in all samples, the total Cd content does not exceed the MAQ.

A long-term study of the use of organic amendments from decentralised composting systems: effects on soil quality

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In recent years, there has been a shift in organic waste management models towards localisation and decentralisation of processes. In this context, novel composting models have emerged, such as community composting, decentralised urban composting and agrocomposting, capable of managing organic waste fluxes, such as the organic fraction of separately collected municipal waste and wastes from agricultural, livestock and agro-industrial activities, from the perspective of the circular economy. Nevertheless, the potential consequences arising from the utilisation of this novel type of compost remain an area of research that has received comparatively little attention. The objective of this study is to undertake a long-term investigation into the consequences for soil quality resulting from the application of compost derived from these new composting models. In order to achieve this objective, a two-year experiment was conducted, utilising diverse soil-compost mixtures from the various models in a greenhouse setting. These mixtures were watered on a weekly basis, with the objective of maintaining moisture levels at 50% of the soil's maximum water-holding capacity. Destructive sampling was conducted at six-month intervals in order to ascertain the physico-chemical and chemical parameters of the various amended soils, as well as to monitor temperature and humidity within the greenhouse. The comprehensive results obtained demonstrate an increase in the contents of organic matter and nutrients in the soil, particularly phosphorus, in the compost-amended soils, as well as an enhancement in soil biological quality. The findings indicate that composts obtained from these novel sources have not only improved soil fertility, but also its biological quality. Consequently, the utilisation of these materials over an extended period can guarantee soil fertility and increase the circularity and sustainability of agricultural systems.

Analysis of soil moisture and vegetation dynamics in Serbian and Hungarian grasslands

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Understanding the spatial and temporal variability of soil moisture is crucial for managing grassland ecosystems, particularly under changing climatic conditions. This study investigates the relationship between soil water content (SWC), soil physical and chemical properties, and vegetation indices to evaluate the consistency between ground-based measurements and satellite-derived data.

Data collections were carried out in 2025 at two research sites, one in Rekovac (Serbia - SR) and the other in Balaton Uplands (Hungary - HU) with two separate campaign events in summer and fall. A systematic approach was implemented across 32 (HU) and 35 (SR) sampling points per site, where in-situ soil water content (SWC; Hydrosense II, Campbell Scientific) and soil temperature were recorded. These measurements were complemented by soil sampling for laboratory analysis of pH, SOC, total nitrogen, and phosphorus. Vegetation dynamics were evaluated across three hierarchical scales: leaf-scale (L) NDVI (PlantPen NDVI 310) and chlorophyll (Apogee MC100), canopy-scale (C; tripod-mounted NDVI and PRI sensors; Meter Group), and farm-scale (F; NDVI or green chlorophyll index - GCI; Sentinel-2 satellite imagery), enabling a comprehensive multi-scale analysis of grassland health.

The results showed a clear separation between the study sites and the sampling periods, reflecting distinct environmental and phenological states. The first HU sampling campaign showed the most distinct separation, primarily driven by leaf-scale chlorophyll and soil temperature variables. While higher SWC was observed at both sites during the autumn campaign, spectral data did not exhibit a strong correlation with soil moisture. However, a strong positive correlation was found between NDVI data retrieved from the different measurement scales ($r > 0.77$; $p < 0.05$). A negative correlation was observed between Sentinel-2 GCI and leaf-scale CCI values ($r = -0.47$; $p < 0.05$). Farm and canopy scale NDVI exhibited significant inverse relationships with SOC and total N, showing correlation coefficients ranging from -0.71 to -0.55.

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Soil moisture and surface temperature patterns across adjacent land use types

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Soil moisture and surface temperature are strongly influenced by land use and topographic position, yet their combined spatial patterns within small catchments are rarely characterized at fine resolution. The objective of this study was to characterize spatial patterns of soil moisture and surface temperature across a forest and two topographically distinct vineyard plots located on a hillslope. The three study sites were located in the following order: top of the hill (with appr. 8% inlcine) was the forest, below it the upper vineyard (UV), and below the other or the lower vineyard (LV). Each site represented by 15 sampling points arranged along the slope gradient, yielding 45 measurement locations in total per measurement occasion. At each sampling point, volumetric soil water content (SWC) was measured using a Campbell HydroSense II portable sensor, alongside surface temperature. The sampling design allowed for comparison across land use types as well as along the topographic gradient. Within the vineyard sites, measurements were taken both in the inter-row and row (under vine) positions to capture small-scale spatial variability. Sampling was conducted on two occasions (12 March and 9 April 2026).

Results revealed significant differences in SWC and surface temperature among the study sites. The UV showed the highest mean SWC (29.2 ± 5.1%), followed by the forest (24.3 ± 5.4%), while the LV recorded the lowest values (19.1 ± 4.8%). SWC differed significantly between each vineyard and the forest ($p < 0.001$), whereas no significant difference was detected between the two vineyard plots ($p > 0.05$). Surface temperature followed an inverse pattern, with the forest showing markedly lower values (mean 10.1°C) compared to both the upper (15.8°C) and lower (16.2°C) vineyards; while all pairwise temperature differences were significant ($p \leq 0.012$). Within both vineyard sites, the inter-row position consistently retained more moisture than the row position (upper vineyard: 30.7% vs. 27.7%; lower vineyard: 21.1% vs. 17.1%), indicating that micro-topographic and vegetation structural effects contribute to within-site variability. A significant decline in mean SWC between the two sampling dates (25.9% in March vs. 22.4% in April; $p = 0.010$) reflected seasonal drying trends across the research site.

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Spatial probabilities of soil salinity risk and recovery under hydroclimatic variability: A transition-based machine learning approach

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Soil salinization is a major constraint to sustainable agriculture in arid and semi-arid regions, driven by complex interactions among hydroclimatic variability, groundwater processes, and land management practices. Although remote sensing and machine learning have improved the spatial prediction of soil salinity, limited attention has been given to the probabilistic dynamics of salinity transitions and their associated uncertainty under changing climatic conditions.

This study presents an integrated framework combining Support Vector Regression (SVR), entropy-based transition matrices, and pixel-wise probabilistic modeling to analyze soil salinity dynamics over a 25-year period (2000–2025) in the semi-arid Sehb El Masjoune region (Morocco). Multi-source datasets, including Landsat imagery, topographic and climatic variables, and 233 field soil samples, were used to produce annual salinity maps. The SVR model demonstrated strong predictive performance ($R^2 = 0.76$), enabling a reliable spatial representation of salinity patterns.

To move beyond static mapping, salinity classes were analyzed using a Markov-based transition framework conditioned by hydroclimatic regimes derived from the Standardized Precipitation Index (SPI). These transitions were integrated into a probabilistic projection model to simulate spatial trajectories of salinity under sequences of wet, normal, and dry years. Key indicators were derived, including the probability of exceeding critical salinity thresholds (≥32 and ≥64 dS/m), representing degradation risk, and the probability of recovery toward low salinity levels (≤8 dS/m). Results reveal a structured spatial organization of soil salinity processes, with persistent hotspots in topographic depressions expanding during dry periods, while wet conditions promote only partial and temporary recovery. Uncertainty analysis highlights higher prediction variability in transitional zones, indicating areas requiring targeted monitoring. Additionally, drought simulations show increased probabilities of salinity exceedance under prolonged dry conditions, reflecting heightened vulnerability to hydroclimatic stress.

Overall, this framework provides a dynamic and spatially explicit tool for assessing salinity risk, recovery potential, and supporting adaptive land management under climate variability.

Monitoring and modeling soil processes

Sampling bias in soil CO_2 flux measurements in oil palm peat plantations

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Large-scale conversion of tropical peat swamp forests to agricultural plantations is a major contributor to carbon dioxide (CO_2) emissions in Southeast Asia. However, emission estimates remain uncertain due to limitations in sampling frequency, spatial variability, and insufficient understanding of site-specific peat controls. This study evaluates the accuracy of CO_2 flux estimation in oil palm peat systems by integrating automated and manual chamber measurements.

High-frequency soil CO_2 flux data were collected over six months using automated chambers recording hourly emissions in an oil palm plantation in Malaysian Borneo. Measurements covered key microforms: Palm Base (PB), Harvest Path (HP), Frond Pile (FP), Drain (DR), and Inter-row (IR). Diurnal patterns from automated data were compared with monthly manual chamber measurements collected over six years at the same site to assess biases associated with infrequent sampling.

Sampling bias varied across microforms, with the highest variability in Harvest Paths (-18 to 24%), followed by Palm Bases (-13 to 11%), Drains (-10 to 9%), and Frond Piles (-5 to 3%). When scaled using microform area weighting, corrected annual emissions ranged from 36–53 Mg CO_2 ha^{-1} yr^{-1}. Water table depth and temperature showed positive relationships with CO_2 flux, though responses differed by microtopography.

These results emphasize the need to account for diurnal variability and spatial heterogeneity. Integrating automated high-frequency data with long-term manual measurements improves the accuracy of emission estimates in oil palm peat ecosystems.

Evaluation of geotechnical properties, moisture retention characteristics and erodibility of selected degraded soils in Imo State Southeastern Nigeria

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Soil degradation in southeastern Nigeria, as in many tropical regions, occurs due to the weakening of soil physical structure under high rainfall intensity. This study investigated the geotechnical properties, moisture retention characteristics, and erodibility of degraded soils from Akaeze, Ishiagu, Okigwe, and Umulolo. Soil samples were collected, prepared, and analyzed using standard procedures. Soil texture varied from loam to sandy clay loam. Soils from Okigwe recorded the highest sand fraction (654.00 g kg^{-1}), which corresponded with high saturated hydraulic conductivity (Ks = 2.01 cm hr^{-1}). Geotechnical analysis showed that shear strength ranged from 70.92 to 76.11 kN m^{-2} in Okigwe and Ishiagu. Clay activity ranged from 1.64 to 1.88 in Okigwe and Akaeze, respectively, suggesting the presence of minerals prone to volume changes. Hydrologically, the soils exhibited low moisture retention capacity. Okigwe recorded the lowest plant-available water (90 g kg^{-1}) but the highest slaking index (1.47), indicating that soil aggregates are highly susceptible to collapse upon wetting. Erodibility indices, including KPn and erosion ratio (ER), ranged from 0.25 to 0.40 t ha^{-1} MJ^{-1} mm^{-1} and 49.17 to 78.72%, respectively, across the locations. These results indicate high soil fragility and susceptibility to erosion. Therefore, management strategies should focus on improving soil structure through organic amendments and moisture conservation practices to reduce erosion risk and enhance soil stability.

Effect of an anionic surfactant on some soil physical properties

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Surfactants are widely used in herbicides, pesticides, cleaning products, and even soil remediation. They can also enter the soil with wastewater and pesticides. The biodegradable anionic surfactant sodium cocoyl isethionate (SCI) was added to different soil samples that differed in texture, organic carbon content, acidity, and salinity. This surfactant is often used in cosmetics and personal care products and is commercially available. In this study, we investigated how SCI can modify the physical and chemical properties of soils.

Seven soils with different properties were treated with three different concentrations of the surfactant suspension (0.5%, 1%, and 1.5%) at a soil-to-surfactant ratio of 1:10. The samples were then dried at room temperature, sieved through a 2 mm sieve, and the following tests were conducted: particle size distribution, pH, electrical conductivity, slake test (using the SLAKES application), microaggregate stability and hygroscopic water content (according to Sík; hy1). In the Solonetz soil, neither pH nor electrical conductivity showed significant differences between treatments, but this was the case for the other soil types. The highest aggregate stability was observed in the slake test in the acidic Luvisol A horizon; in level B, the aggregate stability (also determined in the slake test) increased with increasing surfactant concentration. Overall, the average total hygroscopic water content of the tested samples decreased significantly with increasing surfactant concentration.

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Erosion risk evaluation and assessment of the effectiveness of hydrotechnical facilities in mountainous watershed

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Variations in annual and seasonal precipitation, often characterized by heightened intensity, combined with land-use changes and limited implementation of erosion control activities, are primary contributors to the elevated erosion intensity observed in numerous areas of Bulgaria.

In this study the Universal Soil Loss Equation (USLE) is used to evaluate potential soil erosion risks within a torrential mountainous watershed, and also it was assessed the effectiveness of hydrotechnical facilities. It was established that territories with high erosion risk (over 100 t/ha y) cover 20% of the catchment area. Territories with low erosion risk occupy 17%, followed by 14% of territories with low to moderate risk. The remaining distribution is between very low, moderate to high and moderate potential risk, with 10%, 4% and 3% respectively. The result showed that the main objectives of the constructed system have been fulfilled - strengthening the torrential bed and retaining a significant volume of sediment.

Hydrophilic biochar application to enhance soil hydraulic functioning and combat soil degradation

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Soil degradation remains a critical constraint to sustainable land management, particularly through the loss of soil structure, reduced infiltration capacity, and declining water retention. Biochar has emerged as a promising amendment; however, its effectiveness is often limited by hydrophobicity and variability in physicochemical properties. This research addresses these limitations by investigating engineered hydrophilic biochar designed to optimize soil–water interactions.

The study evaluates the effects of hydrophilic biochar on key soil hydraulic properties, including infiltration dynamics, water retention characteristics, and unsaturated hydraulic conductivity. Controlled laboratory experiments and field-based assessments are used to quantify how biochar surface functionalization and pore architecture influence water movement and storage across different soil textures. Emphasis is placed on linking biochar physicochemical properties with measurable improvements in soil hydraulic performance.

Preliminary results demonstrate that hydrophilic biochar significantly enhances soil moisture retention and promotes more uniform water distribution, while reducing preferential flow and surface runoff risks. These improvements suggest strong potential for mitigating drought stress and improving water use efficiency. Furthermore, biochar amendment contributes to soil structural stability and provides a conducive environment for microbial activity, supporting soil biological processes and nutrient cycling.

This research contributes to conservation agriculture and soil health improvement by integrating material engineering with soil hydrology. It also supports advances in monitoring and modeling soil water processes by providing parameter insights for biochar-amended systems. The findings highlight hydrophilic biochar as a scalable and climate-resilient solution to reduce soil degradation and improve sustainable soil management practices.

Keywords: Hydrophilic biochar, Soil hydraulic properties, Soil degradation, Water retention, Sustainable soil management, Soil health

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The effect of trampling on some soil physical properties

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One consequence of overgrazing is that excessive trampling by animals leads to soil compaction, which disrupts the soil's water, air, and nutrient management. In this study, we investigated the effects of trampling in Hortobágy in July 2025: on three different plant communities: salt meadow, closed steppe on loess, and annual salt pioneer sward. The following soil parameters were measured: moisture content, field infiltration with a MiniDisc Infiltrometer, electrical conductivity, pH, compaction assessment with pocket push-cone penetrometer, additionally we also determined the number of species and plant cover.

Trampling reduced the pore volume between solid particles in the soil due to compaction. As expected, the hydraulic conductivity was higher in not trampled areas on closed steppes on loess and annual salt pioneer sward. The opposite was observed on salt meadow, which may be due to the cracked nature of the soil. In the case of closed steppes on loess and annual salt pioneer swards, the penetration value was higher in trampled areas, clearly demonstrating the effect of regular animal passage. As the moisture content of the soils differed in the three habitats, the wettest annual salt pioneer swards showed the least resistance, as wet soil offers little resistance to pressure.
We found that trampling reduced the number of plant species. Further consequences may include reduced plant growth and the formation of increasingly waterlogged patches.
If trampling causes adverse changes that are contrary to the objectives of land users (grazing livestock and nature conservation), such as reduced grass yield for livestock, or the disappearance of valuable species for nature conservation, then intervention is necessary and the impact of trampling must be reduced, for example by fencing off the trampled area or relocating livestock.

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Monitoring soil moisture dynamics in the southeast of Hungary using Soil Moisture Active Passive (SMAP) satellite data and the standardized soil moisture index (2016–2023)

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Soil moisture is a critical component of soil health, influencing microbial activity, nutrient cycling, plant water availability, and overall ecosystem functioning. In agricultural regions such as Békés County, southeastern Hungary, understanding seasonal and inter-annual soil moisture variability is essential for sustainable land management and adaptation to increasingly frequent drought events under a changing climate. This study utilized NASA's Soil Moisture Active Passive (SMAP) satellite product (SPL3SMP_E, ~9 km resolution) to monitor surface soil moisture dynamics over Békés County from 2016 to 2023. Monthly composites were generated using Google Earth Engine, and the Standardized Soil Moisture Index (SSI) was calculated to characterize wet and dry anomalies relative to the long-term baseline. Spatial and temporal analyses were performed to identify seasonal patterns and inter-annual variability across the study period. Results revealed a clear seasonal pattern, with positive SSI values (wet conditions) concentrated in winter and early spring months (November–February) and persistent negative anomalies (dry stress) during summer, particularly in July and August. Among the study years, 2022 showed the most severe and spatially uniform drought anomaly across the entire county, while 2016 exhibited the strongest wet conditions. These findings demonstrate the value of freely available satellite-based soil moisture products for long-term monitoring and highlight the growing drought risk in this agriculturally important region of Central Europe.

Keywords: Soil moisture, SMAP, SSI, Drought monitoring, Soil health and Remote sensing

Soil characterization and modeling of water and solute dynamics - Case of irrigated perimeters El Haouareb, Merguellil-Kairouan, Tunisia

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Water scarcity and soil salinization are major challenges affecting irrigated areas in Central Tunisia, particularly in the El Haouareb perimeter (Merguellil–Kairouan). This study aims to characterize soil properties and simulate water flow and solute transport under irrigated conditions using numerical tools. HYDRUS-1D and COMSOL Multiphysics, were applied to simulate water dynamics and salt movement in a stratified soil profile. It was conducted on an instrumented soil profile. A 2 m soil column was reconstituted and fitted with sensors to monitor water content, tension, temperature and electrical conductivity. An internal drainage test was performed on this monolith. Model outputs were compared to observed data to assess their performance. Simulation results were compared with observed data to evaluate model performance. HYDRUS-1D results showed a good agreement between simulated and measured water and salt profiles, with slight underestimations at certain depths. Similarly, COMSOL simulations demonstrated strong correlations with observed soil moisture and salinity values, confirmed by high coefficients of determination (R^2). Both models proved effective in reproducing soil water and solute dynamics under current conditions. They also provide valuable tools for predicting future scenarios related to increasing salinity and water scarcity. These findings contribute to a better understanding of soil–water processes in irrigated systems and support decision-making for sustainable water and soil management in arid regions.