Alternatives to Reduce Soil Degradation

ARSD 2024

Alternatives to Reduce Soil Degradation

Book of abstracts

7 May 2024, Budapest, Hungary

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Alternatives to Reduce Soil Degradation (ARSD2024)

Book of abstracts

International conference and TUdi project workshop on

7 May 2024, Budapest, Hungary

edited by

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3) Mostafa M. Mansour (IAREF Nyíregyháza, Hungary) Nanocarbon is a promising alternative for enhancing organic carbon storage in sandy soils
4) Andrea Balláné Kovács (UD, Hungary) Examining the impacts of intensive and reduced tillages and NPK fertilization on the microbial biomass and community of the soil
5) Borbála Bíró (MATE, Hungary) Meta-analysis of bioeffector soil-inoculations for improving soil-fertility and health
6) Péter Futó (Albitech Biotechnological Ltd., Hungary) Investigating the effect of biological soil crust forming microalgal cultures on soil in erosion-prone croplands and vineyards
7) Géza Tuba (MATE Research Institute of Karcag, Hungary) Effect of soil conditioning on the yields of maize and grain sorghum in Karcag

13:00-13:50 Lunch (sandwiches will be provided)

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2) Alaa El Hariri (MATE, Hungary) Determination of soil shear strength by remote sensing
3) Ahmed Elawad Eltayeb (MATE, Hungary) Investigating the spectral behaviour and load bearing of soil
4) Klára Pokovai (HUN-REN ATK TAKI, Hungary) Proximal sensing for evaluating plant performance in field experiments
5) Nándor Csikós (HUN-REN ATK TAKI, Hungary) Temporal and spatial dynamics of productivity in Eurasian black soils: trends between 2001 and 2021

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Posters:

Section 1: Identifying and reducing soil degradation – actions in TUdi Project

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2) Gyöngyi Barna (HUN-REN ATK TAKI, Hungary) Effect of land use on the macroaggregate stability, based on the Hungarian Soil Structural Database (HunSSD)
3) Márton Dencső (HUN-REN ATK TAKI, Hungary) Effect of different tillage methods on soil carbon and nitrogen cycle
4) Jose Antonio Muñoz Sánchez (IAS-CSIC, Spain) Assessing the prairie strip efficiency in sediment reduction from small catchment experiments using a sediment connectivity model improved with the inclusion of a probabilistic approach to trapping efficiency by prairie strips (***on-line***)
5) Adrás Bidló (University of Sopron, Hungary) Examination of the organic carbon stock of the soil of beech stands due to determining factors

Section 2: Soil amendments, Plant and Soil Health (chair: Márk Rékási)

6) Tsvetina Paparkova (Inst. Soil Sci. Nicola Pushkarov, Bulgaria) Influence of biological products on soil physical parameters in beans cultivation
7) Lucia Toková (IH SAS, Slovakia) Determination of the biochar effect on pore size distribution derived from the soil water retention curves
8) Orsolya Szécsy (HUN-REN ATK TAKI, Hungary) Soil microbial activity correlates with texture in Hungarian soils
9) Zoltán Dévény (CSFKI) Effects of land use change on soil organic matter
10) Malek Abidli (MATE) The importance of water-retaining mulches in urban environments
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12) Tibor Aranyos (IAREF Nyíregyháza, Hungary) Effect of sewage sludge compost amendment on soil and yield parameters
13) Csilla Almási (IAREF Nyíregyháza, Hungary) Some parameters of P cycle in a sewage sludge compost experiment
14) Viktória Orosz (IAREF Nyíregyháza) The potential of aqueous sewage sludge compost extract against maize pathogens
15) Nóra Szűcs-Vásárhelyi (HUN-REN ATK TAKI, Hungary) Soil safety investigation opportunities of military areas through the example of a Hungarian barrack's territory
16) Béla Pirkó (HUN-REN ATK TAKI, Hungary) Mitigating soil nitrate contamination and agricultural ammonia emission: the role of controlled-release nitrogen fertilizers
17) Eszter Tóth (HUN-REN ATK TAKI, Hungary) How can different agrotechnical methods influence soil NH_3 emissions after urea fertilization? A laboratory study
18) István Henzsel (IAREF Nyíregyháza) Long-term effects of traditional organic matter applications in acidic sandy soil

Section 3: New technologies in soil science – Artificial intelligence and proximal sensing

19) Mehjubin Kizhisseri (ELTE, Hungary) Integrating remote sensing and field measurements of spatiotemporal analysis of soil and vegetation parameters in different land use types
20) Tibor Zsigmond (HUN-REN ATK TAKI, Hungary) Investigation of changes in plant health using ground truth measurements and remote sensing
21) Krasimir Kostenarov (Bulgaria) Use of TUdi SEST tool to improve soil health

17:00-17:10 Conference closing

Abstracts of oral presentations

Section 1

Identifying and reducing soil degradation – actions in TUdi Project

(chair: Ágota Horel)

A field guide for evaluation of erosion risk in olive orchards guiding on best choices for soil conservation and restoration

[1]José Alfonso Gómez; [1]Ignacio Domenech-Carretero; [2]María Auxiliadora Soriano; [3]Gema Guzmán

[1]Agronomy Department, Institute for Sustainable Agriculture (IAS-CSIC), Córdoba, Spain; [2]University of Córdoba, Córdoba, Spain; [3]IFAPA, Granada, Spain

Olive is one of the dominant crops in the Mediterranean basin, although is also an expanding crop in other areas of the World with similar climate type. Olive trees are cultivated in arid and semi-arid areas, and this has resulted in a management strategy oriented towards limited vegetative ground cover to improve water availability for the crop. This fact, combined with cultivation in sloping areas and periodic high-intensity rainfall events, has led to high erosion rates in many olive-growing areas. The proposed field guide is based on a dual approach integrating erosion risk estimation from basic farm and management features, according to simplified RUSLE factors combined with erosion symptoms. With this approach, this tool aims to achieve these objectives:

1. To provide a standardized tool valid across multiple environments and cropping conditions to evaluate water erosion risk in olive cultivation.
2. To develop an educational tool to provide training on prevention of water erosion in olive orchards valid for any stakeholder and orienting them to the best technologies for soil conservation and restioration based on their own appraisal of their farm.

The database construction for Chinese team and the soil and fertilizer management in an agroforestry system of Loess Plateau in China

Roushui Wang

Beijing Forestry University, Beijing, China

I: Based on the main typical agro-ecosystems, the long-term observation stations and farmers / farms in Central Europe were screened, the database structure was designed, all available data were evaluated, and data standards were defined. Design database structure, collect and sort out all farms and long-term test data on both sides, and establish a data platform. Taking the long-term experimental observation station and farmer farm in typical ecosystem type area as the research object, together with the corresponding task group of the European side, the data acquisition scheme is designed, the database structure design method is unified, and the database integrated management system is constructed according to the consistent data acquisition protocol, and the typical agricultural ecosystem information network management platform is established.

II: Uneven soil moisture and nutrient distribution before and after intercropping limits apple cropping system productivity in the western Shanxi loess area. To address the problem, a field experiment was conducted between 2020 and 2021 to investigate the effects of different water and fertilizer management practices on soil moisture, nutrients, root distribution, and overall benefits of the intercropping system during the crop replacement period. The experiment involved two irrigation methods: drip (D) and flood (M) irrigation, three irrigation levels included: rain-fed without irrigation (W_0), 50% (W_1), and 80% (W_2) of field capacity(Fc) , three fertilizer treatments included: no additional fertilizer application (F_0), 375 (F_1), 750 kg·hm^{-2} (F_2), and control (CK) without irrigation and fertilization. The soil water content (SWC) decreased after the crop replacement. Besides, nitrate nitrogen (NN), ammonium nitrogen (AN), and organic matter (OM) contents in all treatments increased, whereas total phosphorus (TP) content decreased. The soil layer with crop roots moved downward after crop replacement, and partial fertilizer productivity (PFP), irrigation water use efficiency (IWUE), and water use efficiency (WUE) under both irrigation treatments were decreased. Principal component analysis showed that the W_2F_2 treatment had the highest combined benefits both irrigation treatments during the crop replacement period. According to our results, to optimize the benefits of apple-crop intercropping, drip irrigation with complete water supply and flood irrigation with incomplete water supply are recommended during crop replacement. In addition, an upper irrigation limit of 80% Fc with 750 kg·hm^{-2} fertilization is recommended for optimal water and fertilizer regulation.

Open and accessible TUdi Meta-database of long-term monitored farms and experiments associated with the EU project partners.

Zsófia Bakacsi, Béla Pirkó, Anita Szabó, Eszter Tóth

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

The TUdi Meta-database contains information on 15 types of soil degradation threats (which threats were identified based on the results of the questionnaire-based survey among the TUdi partners) such as Soil Organic Matter decline, Salinization/Sodification, Soil compaction, Erosion (water/wind), Drought, Soil water holding capacity, Flooding, Ponding, Saturation for long time, Nitrate leaching, Low soil biodiversity, Excessive soil P accumulation, Soil nutrient depletion, Unbalanced nutrient availability (for healthy food production), Acidification, Weak soil structure, Surface sealing, Leaching/Runoff of pesticides.

Within an observation site, several degradation threats are typically observed, this is why the meta-database contains different experiments within the same site. Experiments to investigate the impact of farming on soil processes can be divided into 10 types within the TUdi Meta-database, such as Fertilization, Tillage, Irrigation, Plant protection, Land management (eff. of parcel sizes, boundary effects, riparian zone etc.), Cover crop, Erosion, Soil structure, Soil microbiology, Soil mezofauna, Soil macrofauna.

There may be overlaps in the soil processes tested in each experiment (2–3 processes are common in one experiment). The lead partner of the experiment determines which is the main process to be tested when the experiment is set up.

Surface erosion, Runoff, Suspended sediment, N-Leaching, Groundwater quality, Biodiversity, and Nutrient balance are the commonly monitored processes in different countries. As stated in the TUdi project proposal, the UK and New Zealand partners do not have their long-term experiments in targeted land use types that could be linked to the TUdi Meta-database.

The management of soil erosion in the hill country of New Zealand

Alison Bailey

Lincoln University, Lincoln, New Zealand

New Zealand occupies a land are of 26.8 million hectares. Two thirds of the land mass is hilly and mountainous terrain. Agricultural and horticultural land occupies about 46% of the land area. Plantation forestry covers a further 6%.

New Zealand soils are diverse. The New Zealand Soil Classification identifies 15 Soil orders. Brown soils are the dominant (43%), followed by Podzol (13%), Pallic (12%), Pumice (7%), and Allophanic Soils (5%). These are mature soils with well-developed topsoil and subsoil horizons. The other 10 soil orders make up the remaining area (20%). Many New Zealand soils are inherently susceptible to erosion with high rainfall, soft lithology, and steep topography. New Zealand comprises about 39% flat to undulating land (7° slopes), 36% rolling to hilly land (7–25°), and about 25% steep to very steep land (>25°). The steeper hilly and mountain lands are particularly prone to erosion by mass movement especially rainfall triggered shallow landslides, but also slumps, gully, surface and streambank erosion.

The dominant soil order, brown soils are found primarily in the hill country and underlie much of New Zealand's sheep and beef production. They have a low soil pH and low natural fertility addressed with aerial top dressings of lime and phosphorus based fertiliser. There are also problems of hillslope erosion. For sheep and beef the impacts of erosion and phosphate runoff are a major concern.

This paper explores the range of vegetation types and species that have been used to control erosion and funding available. Space planted poplars and willows are widely used in grazed hilly and mountainous areas to control landslides, slumps, gully and streambank erosion. Maintaining good groundcover is key to reducing surface wind and also water erosion. Afforestation is used in the worst eroding areas.

Impact of cover crop diversity on soil resilience and recovery

Csilla Hudek; Helen Grant; John Quinton; Ian Dodd; Nick Ostle

University of Lancaster, Lancaster Environment Centre, Lancaster, United Kingdom

A laboratory experiment was established to evaluate the sensitivity of soil responses to both dry/wet cycles and passive warming.

Cover crop species as monocultures and multi species mixtures were grown in PVC containers for 12 weeks in a walk-in growth chamber mimicking predicted climate winter scenarios. Drought was imposed by ceasing watering until the plants no longer extracted water from the soil and re-watered (to prevent plant death) after „complete" soil water extraction.

CO_2 gas fluxes were measured continually with an EGM-5 portable CO_2 gas analyser. Soil moisture and temperature was recorded before measuring the gas fluxes as well as plant height and surface cover. The containers were weighed with an analytical scale after irrigation and right before the next irrigation to calculate relative water losses.

Root traits were determined by excavating the entire root system of the plants at the end of the experiment. Soil samples were collected from the rhizosheath to measure the soil microbial community composition using EcoPlates.

The CO_2 gas fluxes result showed significant differences between the treatments and the control plants both for monocultures and the species mixtures. This trend was also detected for the above and below ground plant biomass.

Experimental estimation of erodibility factors on agricultural soils

[1]David Zumr; [1]Martin Neumann; Jan Devaty; Michal Vrana; Tomas Dostal;
[2]John S. Schwartz

[1]Czech Technical University in Prague, [2]University of Tennessee in Knoxville

The article describes a method for determining the erodibility of non-cohesive agricultural soils by measuring the critical shear stress using the „Jet Erosion Test" (JET). The measurement was carried out with a modified mini-JET device. The device is very suitable for on-site measurements as it is small and light, requires a relatively small amount of water and can be operated by a single person. The principle of measuring the critical shear stress of the soil is based on monitoring the erosion rate caused by the impact of a jet of water with known kinetic energy. The erosion parameters of the soil, such as the critical shear stress and the erodibility coefficient, can be calculated based on the evolution of the erosion craters.

All mini-JET experiments were carried out on test sites near Řisuty (central Czech Republic).

A large variability of soil parameters was observed, which is characteristic for agricultural topsoils. Nevertheless, the determined values of the erodibility coefficient are comparable with the previously published values and can therefore be used for implementation in the physically based soil erosion models. Based on the tests carried out, it can be concluded that the mini-jet method is practicable for agricultural soils.

Underground Engineers vs. Dinosaur Loads – Fighting soil degradation

[1,2]Gunther Liebhard; [2]Stefan Strohmeier; [2]Marton Toth; [2]Andreas Klik; [1]Peter Strauß

[1]Institute for Land and Water Management Research, Federal Agency for Water Management, Petzenkirchen, Austria, [2]Department of Water, Atmosphere and Environment, University of Natural Resources and Life Sciences, Vienna, Austria

Soil degradation through overexploitation and poor management is a pressing problem for agricultural soils. A major soil degradation threat is soil compaction, where the soil structure is degraded by a crushing of aggregates. The threat of compaction due to poor management is increasing, as agricultural vehicles are becoming continuously bigger, with modern agricultural vehicles exerting a pressure load on the ground comparable to that of sauropods. The decreased porosity and connectivity of soil pores affect all soil functions through impaired infiltration capability, hydraulic conductivity, water storage capacity, and air permeability. Technical approaches to alleviate compaction, particularly in the subsoil, are limited, energy-intensive, and may be harmful to the soils' structure stability. Therefore, it is the preferable way to prevent subsoil compaction and to improve the load-bearing capacity of the soils. This is best done by soil organisms, which act as underground engineers. In this study, we are investigating two soil conservation strategies in their effect to make soils more resilient to soil compaction. The first strategy aims to consolidate the topsoil in order to protect deeper soil layers from compaction. In the second strategy, no-tillage in combination with intensive cover crops are used to improve soil life and alleviate compaction through root growth. We investigate the effects on soil structure parameters across the soil profile down to 50 cm soil depth. The soil samples from two sampling campaigns in Autumn 2023 and Spring 2024 at two sites are analysed for several soil structure parameters, including bulk density, penetration resistance, organic carbon content, aggregate stability, percolation stability and hydraulic conductivity. First results show that the strategies are effective in stabilizing the soil structure down to around 30 cm soil depth. The two conservation agriculture systems protect the subsoil with differing penetration and resistance profile compared to conventional management, though. Further ongoing analyses on microbiological activity will help to reveal the processes involved in soil stabilization.

Keywords: compaction, soil penetration resistance, aggregate stability, resilience, conservation agriculture

Abstracts of oral presentations

Section 2

Soil amendments, plant and soil health

(chair: Márk Rékási)

Effect of different conventional and non-conventional tillage systems on the soil moisture content

[1]István Sojnóczki; [2]János Nagy; [2]Csaba Bojtor; [2]Árpád Illés; [2]Adrienn Széles

[1]Kerpely Kálmán Doctoral School, University of Debrecen, Debrecen, Hungary;
[2]Institute of Land Use, Engineering and Precision Farming Technology, Faculty of Agricultural and Food Sciences and Environmental Management, University of Debrecen, Debrecen, Hungary

Tillage practices have changed significantly over the past decade. Systems based on traditional practices have been replaced by more biologically based farming systems. These practices have been boosted by the stimulation of various scientific advances and the expansion of technological possibilities. Other incentives include the need to adapt to adverse climatic conditions and the site-specific measurement results of precision agriculture. These point to the differences in soil across the field and reveal its heterogeneity. The tillage system experiment was set up in the eastern region of Hungary at Nádudvar (47°25'49.3 "N 21°12'33.5 "E) on chernozem soil type in 2016. Each plot is further divided into 4 parts and different tillage systems are used in these plots. Soil moisture content was measured with moisture sensors in 2021 and 2022 to evaluate the effects of different tillage systems on the soil moisture level. The largest difference was measured between conventional and mulch tillage at a depth of 25 cm, where mulch tillage resulted in 18.07 v/v% higher soil moisture, and at a depth of 35 cm, the difference was 18.42 v/v% in April. Overall, in the 2021 growing season, the soil moisture content was significantly higher in all soil layers examined at the phenological stages important for early and maize development. Altogether, in the extreme dry year of 2022, when rainfall during the growing season was 80 mm below the long-term average, the biological tillage had the most favourable effect on soil moisture in all examined depth zones and months. In the more favourable year of 2021, significantly higher soil moisture was measured in the deeper soil layers in the plots of the no-tillage system compared to the conventional system. In the extremely dry year of 2022, this effect was observed in the deeper zone of 35 cm. Based on our results the biological tillage system can serve as a mitigation against agricultural drought.

Plowing induced short-term changes in stabilized soil organic matter in an arable chernozem

[1,2]Thulfiqar Al-Graiti; [1,2]Gergely Jakab; [1,2]Zoltán Szalai

[1]Department of Environmental and Landscape Geography, Eötvös Loránd University, Budapest, Hungary;
[2]Geographical Institute, HUN-REN Research Centre for Astronomy and Earth Sciences, Budapest, Hungary

Soil organic matter (SOM) refers to soil fertility. Studies suggest that SOM is degraded in arable soil due to intense cultivation. The present work aims to study if soil organic carbon (SOC) concentration and SOM compositions change by soil management (fertilization, different crops) or with time in cultivated topsoil. The investigated cropland is a Chernozem and part of a long-term experiment at Martonvásár (47.331196 N, 18.789660 E), Hungary, comparing the effects of different fertilizations to the no fertilization (control) under varied crops, including maize, wheat, and diculture. Soil was sampled during the summer (22/08/2018) and spring (23/04/2019) to study SOC and total nitrogen (N) concentration besides SOM compositions in bulk soil and two soil organic carbon (C) pools. These two C pools were mineral phase-associated organic matter (slow pool) and aggregate-associated organic matter (fast pool). SOM compositions were estimated using Fourier transform infrared (FTIR) spectroscopy, and the total C and N were measured using the Elementar vario MACRO cube CHNS elemental analyzer. Treatments (NPK (nitrogen, phosphorus and potassium); NPK+manure; and control or no fertilization) and crops did not, but soil C pools affected SOM composition. A higher SOC concentration and recalcitrance of SOM were found in the slow pool. In contrast, a high percentage of amide N and polysaccharides were found in the fast pool regardless of crops and fertilization. It demonstrates the slow pool's importance as a fundamental C protection route in arable soil. Seasonally, there was a change in SOM composition as an increase in the recalcitrance of SOM in summer compared to spring was found in the slow pool. Furthermore, SOM compositions were changed in the fast pool. These short-term changes in stabilized SOM come from a change in soil aggregate stability due to plowing. It manifests the negative effects of plowing on SOM stability and the importance of preserving soil aggregate stability to ensure soil health in arable Chernozem.

Nanocarbon is a promising alternative for enhancing organic carbon storage in sandy soils

[1,2*]Mostafa M. Mansour; [2]Marianna Makádi; [1]Enas Soliman

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[2]Research Institute of Nyíregyhaza, IAREF, University of Debrecen, Nyíregyháza, Hungary

Soil degradation is a 21st century global problem that is unquestionably severe in the arid and semi-arid regions. It significantly reduces the stocks of total soil organic carbon (OC), which is considered an indicator to evaluate land degradation. Among these are sandy soils, which cover 900 million ha worldwide. There are extensive areas of sandy soils under cultivation, but they have a low water holding capacity, a high infiltration rate, and runoff, and their fertility is often low and dependent on the levels of OC applied through traditional sources and practices. Recently, using nanotechnology in agriculture has become fashionable as it has the potential to produce organic nanoparticles (ONPs) to reduce the degradation of sandy soils by enhancing their chemical, physical, and biological properties. Among several bio-polymers, polysaccharides have exhibited great promise in agricultural applications due to their sensitivity to biodegradation, environmentally friendly nature, and low cost. The suggested types of ONPs were protein-polysaccharide, pectin, and chitosan linked with polyvinyl alcohol, which are considered alternatives organic matter sources. Besides, these natural polymers could be used as slow-release fertilizers loaded with N, P, and K elements. The application of ONPs can improve the properties of sandy soils by sustaining OC content and consequently increasing crop productivity.

Keywords: soil degradation, sandy soils, organic carbon storage, organic nanoparticles.

Examining the impacts of intensive and reduced tillages and NPK fertilization on the microbial biomass and community of the soil

Andrea Balláné Kovács; Evelin Juhász; Áron Béni; Rita Kremper

Faculty of Agricultural and Food Sciences and Environmental Management, University of Debrecen, Debrecen, Hungary

The study investigated the impact of different tillage methods and NPK fertilization on soil chemical parameters and soil microbial biomass (based on PLFA analysis) and activity in a 30 years old experiment. The tillage methods included plowing, ripper, and strip techniques, while fertilization treatments consisted of no fertilization (control) and NPK application. Results showed that in plots with strip tillage higher soil organic carbon, nutrient content, microbial biomass, and enzyme activity were measured, followed by plots with ripper tillage and then plowed tillage. Fungal, and bacterial biomasses were notably higher in strip and ripper tillages compared to plowed tillage. Among the investigated tillages the strip tillage was identified as the most favourable for enhancing the soil microbial biomass and increasing the fungi-to-bacteria ratio in Chernozem soil. The long-term use of NPK fertilizers significantly decreased the microbial biomass of the soil and altered the microbial communities, particularly reducing fungi and Gram-negative bacteria. The „stessfactor number", the ratio of cyclopropyl PLFAs precursors to cyclopropyl PLFAs indicated the highest bacterial stress in fertilized plowed soil.

Meta-analysis of bioeffector soil-inoculations for improving soil-fertility and health

Borbála Biró

Department of Agro-environmental Studies, Hungarian University of Agriculture and Life Sciences (MATE), Budapest, Hungary

The Bioeffectors (BEs) comprise plant growth-promoting microorganisms and active natural substances that promote plant nutrient-acquisition, stress resilience, growth, crop quality and yield. The treatments might be part of the sustainable agricultural practices if applied it properly, for considering biotic and abiotic parameters in various soil-plant-microbe systems.

Unfortunately, the effectiveness of BEs, particularly under field conditions, appears highly variable and poorly quantified. During an EU-funded BIOFECTOR project a random model meta-analyses tools were used to summarize the effects of 107 BE treatments on the performance of major crops with a focus on phosphorus (P) nutrition, over five years. There were 94 controlled pot and 47 field experiments involved under different geoclimatic conditions, with variable stress levels. The study design is based on a common standardized protocol of BE application, which applies to all experiments conducted within the project to reduce sources of variability.

The results shown an average growth/yield increase by 9.3% (n=945), with substantial differences between crops (tomato>maize>wheat) and growth conditions (controlled+nursery+field). Among environmental stress, the application could be more productive. BE effectiveness profited from manure and other organic fertilizers, increasing soil pH and presence of abiotic stresses (cold, drought/heat or salinity).

Application of BEs can save fertilizer resources in the future, but the efficiency of BE application highly depends on cropping systems and environments.

Investigating the effect of biological soil crust forming microalgal cultures on soil in erosion-prone croplands and vineyards

[1,2,3]Péter Futó; [4,5]Balázs Madarász; [6]György Zsigrai; [3]Gábor Bernát; [1]Máté Futó; [4,5]Gergely Jakab; [1]Zoltán Daoda; [1]József Kutasi

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Climate-related land degradation and desertification pose significant threats to around half of EU member states. In Hungary, wind and water erosion affect 2.3 million hectares of land. Preserving and improving soil quality is hence vital in the agriculture. Biological soil crusts are a community of closely coexisting microorganisms, including algae, cyanobacteria, lichens and mosses in the upper layer of the topsoil. Despite their low biomass fraction in the enviroment, their impact on soil is considerable. The biological soil crusts have diverse roles in the ecosystem, including promoting microbial communication, improving soil structure and hydrological properties, and increasing resistance to erosion, thus indirectly contributing to the settlement of higher order vegetation. These soil crust are capable to thrive and form colonies in drought-ridden areas. In our study, we aimed to investigate the effect of applying biological soil crust forming microalga cultures in sloping arable land and vineyards. The technology was based on filamentous soil crust forming *Klebsormidium bilatum* microalgal culture developed by Albitech Biotechnological Ltd. During our investigation we studied the effect of algal inoculation on soil degradation by artificial rainfall simulation, carried out soil moisture, aggregate stability, macro- and microporosity, and soil crust structural tests. Our findings indicate that the application of algal cultures had beneficial effect on the properties of the soil, as demonstrated by the increase in stable aggregates and porosity. Additionally, the establishment of the algae dominated biological layer led to a reduction in water erosion soil loss.

The project was supported by MKI-2018-00034 grant and the National Multidisciplinary Laboratory project NKFIH-872 of the National Research, Development and Innovation Office, Hungary.

Effect of soil conditioning on the yields of maize and grain sorghum in Karcag

Géza Tuba; Györgyi Kovács; Loujainne Seddik; József Zsembeli

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Nowadays, instead of classical soil reclamation, more and more emphasis is placed on soil conditioning, which means the use of industrially produced yield-enhancing substances that have a favourable effect on the physical, chemical, and biological properties of the soil. These agents mostly do not contain nutrients, but they facilitate their discovery and uptake by plants and increase resistance to environmental stress effects.

At the Research Institute of Karcag MATE, within the framework of a long-term soil cultivation experiment, we set up plant a field experiment with three replications to investigate the effect of the soil conditioner Explorer S 10 on the yield of maize and grain sorghum as indicator crops in 2023. The Explorer biostimulator contains algae extract and 10% sulphur. According to the manufacturer, it stimulates the activity of enzymes involved in mineralization and promotes root growth and resistance to climatic stress. In our experiment, 150 kg ha^{-1} of MAP fertilizer (18 kg N, 78 kg P) was incorporated into the soil with a TopDown field multi-cultivator. The soil conditioner was applied at a dose of 150 kg ha^{-1} in one operation with sowing. The maize hybrid P9718E (Waxy) was sown at the end of April. The grain sorghum hybrid Zádor was sown at the end of May.

In the case of both indicator plants, we experienced a statistically significant yield increase as a result of the treatment. The maize plots treated with the soil conditioner yielded an average of 6.9 t ha^{-1}, while the control plots yielded 6.1 t ha^{-1}. In the case of grain sorghum, the yield was slightly below the expected level, the average yield of the treated plots was 5.5 t ha^{-1}, and that of the control plots was 3.9 t ha^{-1}.

Abstracts of oral presentations

Section 3

New technologies in soil science – Artificial intelligence and proximal sensing

(chair: János Mészáros)

Photoacoustic systems for measuring surface-atmosphere exchange flux of gases

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Measuring surface-atmosphere exchange flux of gases (including greenhouse gases and various nitrogen compounds) is an important task in environmental science. Monitoring instruments have to meet highly challenging requirements, either their accuracy and time resolution is not sufficient, or they require frequent maintenance, which cannot be provided at most environmental monitoring sites. Laser spectroscopy based instruments have the potential to fulfil these requirements. Photoacoustic (PA) spectroscopy is a subclass of optical absorption spectroscopy, and it has been successfully applied in industrial, environmental, and medical applications. The method is highly sensitive, selective, and the robust set-up enables construction of automatic instruments with low maintenance requirement.

Ammonia (NH_3) is a significant air pollutant due to its serious environmental impact. The primary sources of ammonia include animal husbandry, manure treatment, and crop production. Since the early 20^{th} century, there has been a substantial conversion of inert atmospheric nitrogen (N_2) into ammonia using the Haber-Bosch synthesis, primarily for fertilizer production. However, it has been demonstrated that the overall efficiency of applied nitrogen fertilizer is less than 50% on a global scale.

Ammonia loss from fertilizers mainly occurs through volatilization from soil and stomatal emissions by foliage. Ambient ammonia concentrations are relatively low, and existing ammonia monitoring instruments do not fully meet all environmental monitoring requirements. To address this, a mid-infrared laser-based photoacoustic (PA) instrument has been developed. This instrument can measure ammonia in the parts per billion (ppb) range with a time resolution of a few seconds.

A long-term measurement campaign began on 19 March 2024, in a crop field in Kartal, Hungary. The campaign combines the PA instrument with a CSAT-3 ultrasonic anemometer. The focus is on measuring ammonia emission fluxes, especially after the application of N-fertilizers, using the relaxed eddy covariance method. This approach involves simultaneous measurements of ammonia concentration differences between upstream and downstream airflows and the vertical wind velocity. The main goal of these investigations is to determine ammonia loss from fertilized crops, providing valuable information for mitigation purposes.

Determination of soil shear strength by remote sensing

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When a vehicle moves on terrain, the soil is subject to excitation stresses from the tractive element. These stresses might lead to the failure of the soil beneath the tractive element, the case that either ends with the sinkage of the tractive element into the soil, or the slippage of the vehicle due to the failure of the soil layer resulting from shearing, and in some cases the two failures occur simultaneously. The moisture content is a major factor that influences the mechanical properties of a soil. The mechanical properties of a soil at different moisture contents are needed for studying the performance of a vehicle. Having the soil mechanical properties at different moisture contents measured by laboratory work, these results can be linked to the color of the soil, upon having the color measured using a spectrophotometer. The project work is concentrated on finding the soil color at different moisture contents using visible range spectrophotometer. Three soil types were tested, ending up with color-moisture equations. Having a measured color value – n ew record of a tested soil type – inserted in its color-moisture equation, will end up with the predicted moisture, that based on it, the shear strength value of the soil can be identified (an example on 1 soil type will be given). The performed work is laboratory work, considering that relating the color to the strength of the soil is a new study. Dealing with the soil as a visually homogeneous material, will serve in simplifying the study case. Even though the work is pure laboratory work, but it is also worth mentioning that in the field of geotechnical and civil engineering, finding the moisture from the color of the soil might be beneficial, by reaching moisture results faster than relying on traditional methods, as gravimetric method. The empirical work was done at the Department of Vehicle Technology, Hungarian University of Agriculture and Life Sciences (MATE).

Investigating the spectral behaviour and load bearing of soil

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The principal objective of this study project is to clarify the complex interactions among the soil's moisture content, load-bearing ability, and spectral properties. By using the Bevameter, the load-bearing capacity data demonstrated a decrease in its value with increasing the soil moisture content. Spectral examination using a spectrophotometer revealed a consistent decrease in colour reflectance as moisture levels increased, which is attributed to the absorption and scattering of light at the particle's level. The work findings, which indicate a relationship between the load-bearing capability and spectral behaviour, are critical to a deeper understanding of soil behaviour aiming to optimize a vehicle's performance. These deep realizations drawn from the study results play a crucial role in directing the development of design parameters and operating strategies for off-road vehicles traversing a variety of terrains, ultimately leading to increased levels of operational efficacy and efficiency. Furthermore, these research findings have far-reaching consequences for land and soil management methods, going well beyond the domain of vehicle performance. We propose that future research projects should investigate a wider range of soil types with different environmental factors. This will increase the knowledge regarding understanding soil behaviour under a variety of conditions.

Proximal sensing for evaluating plant performance in field experiments

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Proximal sensing is used for a variety of purposes including quantifying spatial and temporal changes in plant growth and development. Such instruments are used in our institute enabling us to carry out integrated studies of the soil-plant system. Root electrical capacitance (CR*) measurement provide valuable data on the size and activity of the root system. Ceptometer (eg.: Accupar LP-80) estimate leaf area index (LAI) based on the above and below canopy photosynthetically active radiation (PAR). Plant canopy analyser (PCA, LI-COR LAI-2200 C) assess LAI by measuring light intensities in the blue range. Chlorophyll concentration meter (Apogee Instruments MC-100) calculates leaf chlorophyll content (Chl) from the ratio of leaf transmittance at 931 nm to transmittance at 653 nm. All data collection is done in-situ, and in stop-and-go mode to provide measurements representing plant status at a specific point in time. However, the temporal dynamics of agricultural production systems can be followed by regular monitoring of plant parameters, as these methods are nondestructive, they can be repeated without damage to the stand.

Root capacity, LAI and chlorophyll content of five winter wheat varieties were measured at flowering over three years in organic farming in Martonvásár, Hungary from 2021 to 2023. Collection of these data by CR*, LP-80 and MC-100 instruments were able to show differences between varieties, so these tools can be used to nondestructive whole-plant phenotyping. The linear regression of the measured values on grain yield varied by varieties: CR* R^2 0.67–0.72, LAI R^2 0.36–0.92 and LAIxChl R^2 0.34–0.82. However, regression with grain yield has potential to predict grain yield at flowering time.

Spatial sampling of LAI was performed by LAI-2200 C in the Józsefmajor experimental site for highlighting any soil or agrotechnic-related unevenness, if present. Winter oat stands were at the flowering stage in the mouldboard plough and the no-tillage treated plots on campaign measurement day in May 2020. LAI of the crop canopy was significantly different. However, visualization of LAI magnitude of the sample points did not show any spatial pattern.

In the future, we plan to extend spatial temporal monitoring studies to further experiments or to study natural plant populations.

The project was funded by the NKFIH, No. FK-137617.

Temporal and spatial dynamics of productivity in Eurasian black soils: trends between 2001 and 2021

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Black soils serve critical roles in sustaining global environmental and social systems, significantly contributing to food production and carbon balance within the earth-atmosphere system. Understanding the dynamics of black soil productivity and land cover changes, alongside other environmental factors, is essential for comprehending global processes and formulating timely responses. Our study utilized extensive remote sensing datasets spanning from 2001 to 2021 to investigate environmental shifts in Eurasian black soils, focusing on productivity and environmental variables. Our analysis reveals notable productivity increases in Chinese and Mongolian black soils, juxtaposed with substantial declines observed in vast areas of Kazakh black soils. Interestingly, Russia and Ukraine, countries with extensive black soil coverage, exhibit both declining and increasing productivity trends, indicative of the intricate interplay between environmental conditions and agricultural practices in these regions. Our findings emphasize the predominant influence of climatic factors on productivity trends, while also highlighting the significant contribution of cultivation technology in specific areas. This underscores the complex relationship between environmental dynamics and agricultural strategies, shaping productivity outcomes across diverse geographical regions. Furthermore, climate change drives land cover transformations in black soil areas, with the most alarming trend being the net loss of croplands, particularly evident in drying regions such as Kazakhstan and Russia, albeit with scattered spatial patterns across Eurasia.

Abstracts of poster presentations

Section 1

Identifying and reducing soil degradation – actions in TUdi Project

Effect of land use on the macroaggregate stability, based on the Hungarian Soil Structural Database (HunSSD)

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In 2016, we started the development of a national representative database of typical Hungarian soils, focusing mainly on the physical, structural and physico-chemical properties of soils, the HunSSD. In this publication, we investigated the stability of macroaggregates and their relationship with other soil properties. We tested the effects of land use, comparing salt-affected soils with not salt-affected soils.

We explored 60 soil profiles and collected disturbed and undisturbed soil samples from all soil horizons (257). Land uses were grassland, arable, forest, orchard/vineyard.

Basic soil properties were determined according to Hungarian standards: particle size distribution was determined by sieve-pipette method; soil organic matter (SOM) by Turin method; SOM quality by Hargitai method; cation exchange capacity (CEC) values were determined by modified Mehlich method ($BaCl_2$), while macroaggregate stability was measured by wet sieving (Eijkelkamp).

Regression analysis was used to calculate: which soil properties are the most important determinants of macroaggregate stability. For salt-affected soils, the <<CEC – Sum of base cations>> values, the humus quality index Q (according to Hargitai) and the clay content are the most important. On the contrary, for not salt-affected soils, organic matter (SOM) and calcium carbonate content are the most dominant parameters

The research was funded by Hungarian National Research, Development and Innovation Office Foundation (Grant No. OTKA K134563), the Sustainable Development and Technologies National Programme of the Hungarian Academy of Sciences (FFT NP FTA), and by the TUdi project (EU Horizon 2020 grant agreement no. 101000224).

Comparison on conventional and new techniques to determine aggregate stability

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Structure is a unique property of soils, and aggregate stability is the most commonly determined indicator for soil structure. Unfortunately, there is no general consensus regarding the best method for the determination of this parameter; and our objective was to compare the performance of four methodological approaches.

The Hungarian Soil Structural Database (Hun-SSD) contains different soil profiles representative for Hungary, and their physical, hydro-physical and chemical properties.

The aggregate stability was determined with four different methods:

- macroaggregate stability with wet sieving (Eijkelkamp),
- macroaggregate stability with laser diffraction method (Malvern Mastersizer 3000),
- microaggregate stability according to the Vageler structure factor,
- microaggregate stability with laser diffraction method (Malvern Mastersizer 3000).

We proved that laser diffraction is a good tool to determine either macroaggregate, or microaggregate stability. We compared the results between different soil types. In case of forest soils the humus-rich A horizon has much higher macroaggregate stability, than the leached A layer, however microaggregate stability does not decrease the same extent. In the case of Chernozem soils, the land-use (mainly tillage) has deteriorating effect either on macro-, or on microaggregate stability.

The research was funded by Hungarian National Research, Development and Innovation Office Foundation (Grant No. OTKA K134563), the Sustainable Development and Technologies National Programme of the Hungarian Academy of Sciences (FFT NP FTA), and by the TUdi project (EU Horizon 2020 grant agreement no. 101000224).

Effect of different tillage methods on soil carbon and nitrogen cycle

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Disruption in carbon and nitrogen balance of soils is a current issue world widely, due to intensive agricultural production. Soil tillage practices alter soil carbon and nitrogen cycle, thus they affect crop production efficiency as well.

In this study, we investigated the effect of conventional mouldboard ploughing (MP) and conservational shallow cultivation (SC) and no-tillage (NT) methods on selected soil health indicators at the long-term tillage experiment of the Józsefmajor Experimental and Training Farm (Hungary). To evaluate the conventional and conservational methods, we determined soil organic carbon (SOC), total (N_{tot}) and mineral nitrogen contents (NO_3–N, NH_4–N) in the top 20 cm layer. We also present greenhouse gas intensity indexes (GHGI) for each treatment, showing the ratios of annual total GHG emissions to the annual yields from 2015 to 2020.

There was higher SOC and Ntot content under conservational treatments (SC and NT) compared to the conventional MP. Vertical heterogeneity of chemical parameters in the upper 20 cm was observed under SC and NT treatments, but not under MP. The results showed that carbon and nitrogen accumulation occurred in the top 10 cm layer of the soil under the conservational methods, but in lower depth, this effect was not significant. GHGIs were the highest under NT, and uniformly lower under SC and MP.

In general, conservational treatments caused major accumulation of carbon and nitrogen in the soil, although the GHG emission increased under NT treatment, in addition to the lowest yield values. No major carbon and nitrogen accumulation was observed under the conventional MP, with the lowest GHG emission and high yield values. The advantage of the SC treatment is the accumulation of carbon and nitrogen in the soil with high annual yield values, but the disadvantage of this treatment is the increased GHG emission.

The research was funded by the Sustainable Development and Technologies National Programme of the Hungarian Academy of Sciences (FFT NP FTA) and supported by the EJP SOIL-Carboseq project (H2020 – 862695).

Assessing the prairie strip efficiency in sediment reduction from small catchment experiments using a sediment connectivity model improved with the inclusion of a probabilistic approach to trapping efficiency by prairie strips

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Prairie strips are vegetative barriers placed at the end of the catchment, or in several places along runoff path runoff and sediment in agricultural landscapes. This study uses an alternative approach incorporating a probabilistic approach to barrier efficiency to appraise the effectiveness of vegetative barriers from small catchment experimental studies. This study uses published experimental data from the USA involving 12 catchments with single and multiple prairie strips in row crops small catchments model. The hypothesis is that using an improved connectivity model, with the incorporation of a probabilistic approach to efficiency in sediment reduction by a vegetative barrier, it will be possible to appraise the effectiveness of multiple vegetative barriers in different landscape positions using experimental data from the catchment outlet. The results show that our approach captures the differences in barrier effectiveness under different prairie strip designs, individual, double, or triple aggregated during the study period of 7 years (r^2=0.74). The analysis at the event scale proved a large variability in sediment efficiency (0 to 100%). This large variability is partly inherent to the dynamic changes in the catchments (rainfall, ground cover, vegetation growth, etc.) but also spatial variability among catchment and individual events (e.g., strip breaching, etc.). Our results imply this improvement is useful for analyzing long-term effectiveness trends of the prairie strips, although the interpretation of effectiveness at individual events has still been difficult. Improvement in the model analysis, coupling the connectivity model with the model prediction of absolute runoff and sediment losses, and better incorporation of field conditions in both models can be a viable strategy to improve the approach presented in this paper. This allows the appraisal of prairie strips efficiency at different landscape positions using data from the catchment outlet in a relatively straightforward manner.

Examination of the organic carbon stock of the soil of beech stands due to determining factors

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Due to global climate change, the focus is on the ability of carbon fixing, especially in the beech forest ecosystems of Hungary. The importance of beech is highly related to nature conservation and economic point of view, while it is a native tree species with high production capacity. We can easily estimate the amount of tree biomass, but we do not know enough about soil organic carbon.

Therefore, our research aimed to collect as much data as possible on the amount of organic carbon stored in the soil in these native forest stands.

During the research, 40 beech stands were investigated. The soil samples were collected from a 1-meter depth. On loessy or sandy bedrock, the depth was 110 cm. In the case of rocky structure, samples were taken from 0–40 cm depth. Dendrometrical parameters were also recorded on the sampling sites (tree species, diameter, etc.). Moreover, litter samples were taken and analyzed.

The soil pH was 5.17 on average. The humus content varied between 0.16 and 15.65% because it decreased with depth close to the bedrock. The average organic carbon stock was 6.39 C t ha^{-1}. There is a weak relationship between individual soil parameters. No correlation was found between soil pH and soil organic carbon. A weak correlation was found between soil physical properties (percentage of leachable particles (silt + clay) and soil organic carbon.

The research was made in the frame of the project TKP2021-NKTA-43 which has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary (successor: Ministry of Culture and Innovation of Hungary) from the National Research, Development and Innovation Fund, financed under the TKP2021-NKTA funding scheme. Some of the tools used during the research were acquired within the framework of the "Investigation of the conditions for the cultivation of wood biomass - GINOP-2.3.3-15-2016-00039" project.

Abstracts of poster presentations

Section 2

Soil amendments, plant and soil health

Influence of biological products on soil physical parameters in beans cultivation

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The influence of the biological products on soil physical parameters were studied within the experiments with growing of broad bean fields on Fluvisol (sandy loam) in the village Negovan, Sofia region and on Luvic Chernozems (silty clay loam) in the village Obraztsov Chiflik, Ruse region. The studied variants under beans cultivation were: non-treated (control), 2 biological preparations („Naturalis", based on *B. Bassiana* ATCC 74040 and bio-fertilizer SoftGuard with chitosan) applied independently and combined, and 3 selected active strains of the entomopathogenic fungus *B. Bassiana* – 339,538,730. The sampling was conducted in May and October the same year, before and after vegetation. The investigation was carried out on the undisturbed soil samples taken with rings from the surface 0–5 and 15–20 cm and on bulk soil. The water retentions at low suctions (pF 0.4–2.5) were determined on undisturbed soil cores in the process of draining by suction type apparatus and on fine earth samples by pressure membrane apparatus and water vapor adsorption method. The saturated hydraulic conductivity was determined by falling head method on undisturbed soil cores. The studied indicators were water retention characteristics, bulk density, total porosity, aeration capacity, water stability of soil aggregates. The obtained data after the first year of the experiment showed a decrease in the water stability of the aggregates in the surface 0–5 cm soil layers of treated variants of both soils. This effect was expressed differently for the studied products in both soils. Nevertheless the water retention did not change and even increased in variant treated with active strains of the entomopathogenic fungus *B. Bassiana* 339. The subsoil compaction in the Luvic Chernozem was more pronounced in treated variants. The coarser Fluvisol has better water conductivity and aeration properties than the finer Luvic Chernozem was also negatively influenced by the applied products. These results are preliminary and can be influenced also by the extremely dry conditions during 2023 year. The experiment will be continue in 2024 year.

Determination of the biochar effect on pore size distribution derived from the soil water retention curves

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This study reports determination of the effect of biochar with concentration of 1.5% based on its size fractions on pore size distribution (PSD) obtained from the soil-water retention curves (SWRCs). Biochar for this experiment was produced from the Swedish biomass willow variety (*Salix viminalis x schwerinii var*. Tordis), by pyrolysis process at the temperature of 300 and 520 ºC with limited air access. Then, biochar particles were separated into two size fractions as follows: <125 μm and 125μm – 2 mm. Soil pore diameters (d) calculated from SWRCs are often used to divide pores sizes into different categories. The slope C(h) curves indicates that the majority of soil porosity values were within the range 0.2 up to1000 μm. We observed larger C(h) values in the range 1 up to 100μm in the biochar amended soil associated with the greater proportion of large pores and creation of structural porosity. Overally, the biochar addition led to a significant increase of the volume of large pores (d > 10 μm) and micro storage pores (d 0.2–10 μm). In the contrast the volume of micro residual pores (d 0.02–0.2 μm) decreased after the biochar was applied. The results also show that the smaller biochar size fraction (<125 μm) had larger impact on the volume changes in micro storage pores from 15 up to 29% vol. due to the better incorporation in to the soil compared to the bigger size fraction.

Soil microbial activity correlates with texture in Hungarian soils

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Enzyme activity of soils can be a good reference for the state of soil microbial abundance. The significance of enzyme activities in the dynamics of material cycles in the soil is extremely great, regarding either synthesis or decomposition processes. There is lack of comparative soil biology studies conducted on different soil types in Hungary. A nation-wide sampling campaign is therefore very useful in the evaluation of the microbial state of Hungarian soils.

This research is based on a nation-wide soil sampling survey, during which more than a hundred soil samples were taken in Hungary. Bulk samples (0–30 cm surface layer) were collected from a representative part of the sampling parcels. After the measurement of the Arany yarn number, soil texture classes were determined. Microbial state of the soils were evaluated through enzyme activity tests and a respiratory test. The aim of the research was to find correlations between the measured microbial parameters and the texture of the soil in this heterogenous group of natural soil samples.

Three methods were used for the evaluation of the microbial activity: substrate induced respiration (SIR) method, sucrose (invertase) enzyme activity test and fluorescein-diacetate (FDA) enzyme activity test. These tests provide information on the soil's microbial activity, on the carbohydrate metabolism processes and also on soil respiration, as the most important indicator of soil biological activity. According to the results, correlations could be detected between soil texture and the measured microbial parameters.

The research was funded by TDR project (KEOP-6.3.0/2F/09-2009-0006).

Effects of land use change on soil organic matter

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Degraded soils by intensive cultivation need to be restored for climate change mitigation and adaptation furthermore it is perfect to help make soils healthier. The research focused on three land use types (native grassland, arable land, and abandoned arable land) on the same Chernozem. The organic carbon (SOC) was investigated in soil fractions and the bulk soil. Methods of spectroscopy also analysed the components of the organic matter. SOC content of the topsoil (0–30 cm) increased significantly due to cultivation stop (2.2%) compared to the cropland (1.8%) but was far below that of the grassland (3.3%). The increase was more remarkable for the mobile SOC fraction (aggregates), although the proportion of more easily oxidised organic compounds was higher in this fraction than in the mineral phase fraction. Cultivation intensity was proportional to the aromaticity of the soil organic matter, indicating increased decomposition under arable land. Cultivation significantly reduced the spatial heterogeneity of the soil of arable land. Overall, the 12 years of lack of cultivation were insufficient time to refill the SOC in the mineral phase and none in the fraction of the aggregates. Aggregate stability was higher in topsoil than in subsoil for both grassland (82%) and abandoned arable land (70%) than in subsoil (48 and 49%). There was no significant difference in aggregate stability between topsoil and subsoil of arable land (56 and 58%).

Keywords: climate change, land use change, soil organic matter, ancient grassland, cultivation, soil health, subsoil

The importance of water-retaining mulches in urban environments

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Due to the expansion of urban areas in the 20th and 21st centuries to accommodate the increasing urban population, the covering of urban surfaces has become an important element in the cities' landscapes, which influence local climate conditions and its environmental system. Lately, mulch, which originally was a material used generally in agriculture practices, has become a promising tool that helps mitigate urban heat effects and fosters the environmental sustainability of urban areas.

The study of the mulches in urban areas emphasizes the importance of taking into consideration multiple factors such as surface permeability, water retention capacity, and material composition when optimizing the mulch performance for urban heat island mitigation. The aim of the study was to investigate different mulch types and thickness layers and their effects on soil water retention. During the experimentat, a range of mulches were taken into consideration, including inorganic mulch (Lava rocks and white marble) and organic mulch (Straw and bark pine). Each type of mulch was investigated in triplicates with different thicknesses of 2 cm, 4 cm, and 6 cm mulch layers. The bark pine mulch's water retention capacity effect showed a linear pattern through the different thicknesses: the higher the mulch thickness is, the higher the capacity effect was. An interesting phenomenon was observed for the lava rocks mulch where the higher the thickness was, the lower the capacity effect was observed. The highest overall water retention of 2.23 mm cm^{-1} was measured for the mulch lava, and the lowest for the straw (0.55 mm cm^{-1}). Our results indicate that 2 cm mulch thickness is the best option among the investigated mulch types, deeper layers provide better moderation, but beyond certain thresholds, the benefits decline.

The results of this study improve our understanding of urban surface dynamics by showing that different mulch thicknesses can have a considerable impact on surface water and temperatures.

Revision of maximum nitrogen application rates adapted to farmers' conditions in farm-scale experiments

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The aim of our research is to review the Appendix 3 of FVM (Nitrate) Directive 59/2008 (IV.29.), i.e. the maximum amount of nitrogen (N_{max}) (kg ha^{-1}) that can be applied.

The research demand, namely the initiative to increase the maximum N value, came from the farmers. Funding was provided by the Ministry of Agriculture. The National Chamber of Agriculture and KITE Zrt. proposed farmers to be involved in the experiment.

The series of experiments for food security and agri-environmental purposes was set up under farm conditions at national level in 2020, on 30 fields of 10 farms for 4 years, with 4 different treatments, soil and plant sampling, taking into account farmer data.

Soil samples to a depth of 2 m were taken in the farms before the experiment to assess the nitrate profile. The fertilization log, including the nutrient amount applied per treatment and yield data, was collected in each experimental year for calculating annual N balance and nitrogen use efficiency (NUE) values.

The 4 treatments in the on-farm Nmax experiments were: A) Pro Planta (PP) minimum NPK level; B) Present Nmax + PP maximum PK level; C) New N_{max} + PP maximum PK level; D) Farming practice. The cost-effective and environmentally friendly PP recommendations were thus present in three of the four treatments. The present Nmax values were based on the current regulation, whereas new Nmax values were calculated according to the farmers' requests.

In the year 2023, thanks to the advanced agro-technology used in the farms, the high yielding varieties and hybrids, and the favourable agro-climatic conditions, the average yields of the experiments were above the national: maize 12.5; winter wheat 7.2; sunflower 2.7; winter barley 7.8; grain sorghum 9.1 t ha^{-1}.

It can be concluded that in 2023, a year with more favourable precipitation, both cereals and catch crops were able to take up more nitrogen from the soil on average than in a drought year, so that the NUE values were mostly either optimal (around 0.8) or well above 1.0, which indicates a soil depleting practice.

Keywords: N fertilizer, field experiment, nitrogen balance, nitrogen use efficiency, sustainable agriculture

Effect of sewage sludge compost amendment on soil and yield parameters

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In the future, sandy soils will play an important role in sustainable agricultural production due to the growing global population and urbanization. However, the harmful effects of climate change and intensive land use can lead to decrease the content of soil organic matter. The use of composted organic waste as organic fertilizer is becoming increasingly popular in agriculture. Sewage sludge compost contains considerable amounts of organic matter and essential nutrients for plants, so it can be considered as an alternative soil improvement material.

The research work was carried out in the sewage sludge compost long-term experiments at the Research Institute of Nyíregyháza, IAREF, UD in Hungary. The characteristic soil type was Dystric Lamellic Arenosol. The applied compost contained the followings components (m/m%, dry matter): sewage sludge (40%), straw (25%), bentonite (5%) and rhyolite (30%).

Our aim was to study the effect of sewage sludge compost amendment on soil and yield parameters in 2022. Our results confirmed, that the long-term application of sewage sludge compost into the soil significantly increased the organic matter content and pH, and improved the nutrient supply of sandy soil. The positive changes in soil parameters had a favourable effect on plant development and yield, which is also supported by the results of NDVI (normalized difference vegetation index) measurements.

This study confirmed, that the environmentally sustainable agricultural practices are important in preserving soil quality, in which soil organic matter management plays a significant role. Replenishment of sandy soil with organic matter can be achieved through the agricultural utilization of sewage sludge compost, thus improving the properties of the soil.

Some parameters of P cycle in a sewage sludge compost experiment

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Sewage sludge compost (SSC), due to its high organic matter and phosphorous (P), is considered a promising soil conditioner that could be used as a low-cost source for P. The plant-soil-microbe interactions enhance the availability of soil P to plants. This study aims to investigate the long-term impact of regular SSC application on some elements of P cycle in a small-plot experiment which has been established in Nyíregyháza since 2003 on an Arenosol soil. It consists of four treatments in five replicates, wherein the SSC was ploughed every three years at a rate of 0, 9, 18, and 27 t ha^{-1}. Surface soil samples were collected at two physiological stages of the rye crop in 2023 for the analysis of soil and plant parameters. Results showed that higher available P levels compared to the control plot resulted in higher biomass and P utilization efficiency of the rye plant. Acid and alkaline phosphomonoesterases work at different soil pH and their activities also contribute to the forms of the soil available P. Furthermore, the principal component analysis confirmed that total P, ammonium lactate P_2O_5, and acid phosphomonoesterase were the main parameters of P cycle elements, resulting in the differences among the SSC treatments. It can be suggested that, high total P of SSC increases the total and plant available P content of the soil, proving the important role of SSC in plant P supply. Moreover, it indicates that soil microbes have a significant role in the availability of soil P.

The potential of aqueous sewage sludge compost extract against maize pathogens

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The goal of the "Healthy Soil and Food Mission" of the European Union is to reduce the amount of pesticides, plant protection products, and chemical substances by 50% by 2030. Composts have been used in agriculture for a long time but the water extract of compost has come into focus in the last decades and they utilization seems to be an excellent way to reduce the chemicals in agriculture. These extracts can be used for nutrient supply and suppress certain plant diseases especially those caused by soil-borne pathogens.

Aqueous extract was prepared from sewage sludge compost (SSC) and was applied in a small-plot field experiment on sandy soil. Test plant was maize (*Zea mays* ‚SY Torino'). The soil was directly infected b before sowing with three maize pathogens (*Aspergillus flavus*, *Fusarium graminearum* and *Rhizoctonia solani*). The application time of SSC extract was also tested by applying it at two different times: two weeks before sowing or at the time of sowing. In the control plots, the compost extract was applied without pathogen infection. The investigated parameters were plant height, plant number, vegetation index, green mass, healthy and infected grain yield.

The results indicated that the SSC extract beneficially affected maize plants in the control plot (without pathogen infection) resulting in greater plant height and vegetation index. The aqueous SSC extract had different effects against the applied pathogens. The infection with *Rhizoctonia solani* had a strong negative effect on the maize causing most infected crops. A double amount of healthy grain yield was recorded in the control plots compared to the infected one whereas 70% of the crop was infected and 30% was healthy. The infection with both *Aspergillus flavus*, and *Fusarium graminearum* were suppressed to a greater extent where the signs of disease were observed in 50% of the crop in these cases, in the provocational experiment. Based on the results we recommend the eco-friendly use of the SSC aqueous extract in agriculture to reduce chemicals applied to combat soil pathogens.

Keywords: sewage sludge compost, aqueous extract, pathogens, maize, yield

Soil safety investigation opportunities of military areas through the example of a Hungarian barrack's territory

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A key to the sustainable use of our soils is to avoid and mitigate the threats that cause soil degradation, to develop an appropriate legislative framework and to effectively remediate already contaminated sites.

Pollution in the soil from a disaster has a serious impact on both the environment and humans. It would be necessary to use tools and methods for in situ assessment of soil conditions in the affected area and to integrate them into disaster management procedures. A number of studies have demonstrated the usefulness of non-destructive sampling and ecotoxicological testing in soil contamination investigations. The risk assessment methods used in disaster management practice are based on 'classical' chemical analytical tests, which are time-consuming and costly, and may also involve high individual risk in the case of possible radiation contamination. Rapid decision making is particularly important in disaster situations, and a rapid procedure for in situ assessment of the damage site, complemented by interpretation of soil health data, would be needed to ensure that individual risk is minimised. The combination of proximal soil sensing (PSS) and ecotoxicology could provide a new, optimised approach to soil safety.

For the measurements we used in situ applicable PSS instruments in the designated military sample area. The detection of soil radiation was performed by means of airborne remote sensing using an unmanned aerial vehicle (uav) mounted radiation measuring device. The potentially toxic element content was measured using a hand-held X-ray fluorescence spectrometer (PXRF). Ecotoxicological tests, soil column and microcosm experiments were set up to investigate soil ecosystem sensitivity.

Through our research we aim to contribute to the development of the methodology for damage classification, thus supporting the operational work of the management and enforcement units at each level of the disaster management organisational structure. Our research results aim to demonstrate that high individual risk can be minimised when detecting radiation in hazardous areas. Furthermore, we intend to propose improvements to the methodology of ecological risk assessment of soil testing for disaster management in complex contamination incidents.

The research was funded by the National Research, Development and Innovation Fund of the National Defence Subprogramme of the Cooperative Doctoral Programme of the Ministry of Innovation and Technology.

Mitigating soil nitrate contamination and agricultural ammonia emission: the role of controlled-release nitrogen fertilizers

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Soil contamination is a significant factor that can disrupt the natural functions of soil, consequently affecting soil health. Nitrate, a characteristic pollutant derived from agricultural activities, raises specific concern. Due to excessive or improper use of fertilizers, nitrate can infiltrate deeper soil layers, potentially reaching groundwater due to its mobility. The threshold-exceeding presence of nitrate in groundwater poses a risk to human health, highlighting the importance of preventing its mobilization and leaching from the topsoil. On the other hand, nitrate is also a vital nutrient for plants in their mature stage and plays a crucial role in the nitrogen cycle. Therefore, in agricultural practices, the objective is to enhance the efficiency of nitrogen fertilizers and retain nitrogen in the topsoil, near the root zone, in a readily absorbable form. Controlled-release nitrogen fertilizers offer a promising solution to meet this demand.

Our research team conducted multi-year experiments to evaluate the nitrogen use efficiency of urease-inhibitor fertilizers compared to traditional urea. In the experiment, the effect and use of urease-inhibitor fertilizer were investigated, considering nitrate leaching and ammonia volatilization. Experiments were conducted across various soil types, employing different agricultural techniques and test crops, and utilizing varying fertilizer doses.

The poster showcases a specific phase of the experiment, focusing on the impact of inhibitor fertilizers alongside cereal crops (winter wheat, triticale). These fertilizers were applied either as a single dose (100%) or split-dose application (60–40%) at the currently maximum nitrogen dose (N_{max}) and an increased nitrogen dose (new N_{max}) tailored for the specific site, crop, and nitrogen supply level. Utilizing data from two years (2021–2022), differences in nitrogen utilization, agricultural ammonia emissions, and nitrate leaching compared to conventional urea fertilizer are presented across different soil types (Arenosol, Chernozem) and nitrogen doses (120, 150 kg ha^{-1}, 170, 210 kg ha^{-1}, respectively).

The poster highlights the risk of nitrate leaching and outlines variations in nitrogen balances for each treatment. Based on experimental findings, a combination of application methods and fertilizer types that minimize soil risk while maximizing yield is summarized.

Keywords: controlled-release fertilizers, NUE, nitrate leaching risk, agricultural practice, soil health

How can different agrotechnical methods influence soil NH_3 emissions after urea fertilization? A laboratory study

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We set up laboratory experiments on sandy soil and chernozem soil in 30x30 cm containers (h=15 cm) to investigate NH_3 emission after urea fertilization. We studied 7 different treatments as follows: (i) control (C) – no urea was added, (ii) 150 – 150 kg ha^{-1} N active agent as urea fertilizer, spread on soil surface, (iii) 180 – 180 kg ha-1 N active agent as urea fertilizer, spread on soil surface, (iv) 150i – 150 kg ha^{-1} N active agent as urea coated with urease inhibitor, spread on soil surface, (v) 180i – 180 kg ha^{-1} N active agent as urea coated with urease inhibitor, spread on soil surface, (vi) 150b – 150 kg ha^{-1} N active agent as urea fertilizer, incorporated in 10 cm depth, (vii) 180b – 180 kg ha^{-1} N active agent as urea fertilizer, incorporated in 10 cm depth. We set up soil water content for both soil types for the values of field capacity (pF 2.3), which was about 14–18 V% in the case of sandy soil, and 39–40 V% in the case of chernozem. We measured soil NH_3 emission in 5 replicates per treatment with Picarro G2103 gas analyzer; once before fertilizer was added to soils and 11 times after the fertilization event during a two-week long period. In the case of sandy soil the 150b and 180b treatments reduces most effectively NH_3 emissions, with the magnitude of emissions in these treatments being comparable to the control treatment. In the case of surface spreading, (without inhibitor coat), an increase of 30 kg ha^{-1} of active ingredient resulted in a significantly detectable difference in soil NH_3 emissions. The NH_3 emission values measured in the experiment on chernozem soil were two orders of magnitude lower than on sandy soil, but no significant difference between treatments was observed.

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Long-term effects of traditional organic matter applications in acidic sandy soil

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Organic matter has a key role in soil fertility. To maintain its level stable, traditional organic amendments such as farmyard manure (FYM), straw manure (SM), and green manure (GM) have been applied for centuries on agricultural fields. Long-term experiments are valuable for studying the accumulation effects, if any, of the applied soil amendments. In the 95 years old Westsik's crop rotation long-term experiment of the Research Institute of Nyíregyháza, IAREF, University of Debrecen, the effects of the aforementioned amendments are investigated in 15 crop rotations (CRs) with or without low doses of N, P, and K fertilizers, comparing the changes in soil and plant properties to the results of the fallow CR. According to the Principal Component Analysis (PCA) of the basic soil chemical parameters, the normalized difference vegetation index (NDVI) values at the flowering stage, and yield of potato in 2022, the main factors differentiating the CRs on PC1 were AL-K_2O and AL-P_2O_5, while Mn and Mg were on PC2. The results showed that CR10 and CR11, the FYM-treated CRs with the highest available P and K content in the soil, were very far from the other CRs, while CR1, CR7, and CR15 (the fellow, rye, and green manure, respectively, all without chemical fertilizers) were found on the opposite side of the graph. The findings proved that among the classical soil amendments, stabilized and complex FYM or FYM + fertilizers can lead to higher P and K levels of soil in the long-term, as key effect parameters, while other organic amendments without chemical fertilizers can't increase the P and K levels of acidic sandy soil. Our findings indicated the significance of complex and stable organic materials for improving soil.

Abstracts of poster presentations

Section 3

New technologies in soil science – Artificial intelligence and proximal sensing

Integrating remote sensing and field measurements of spatiotemporal analysis of soil and vegetation parameters in different land use types

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This study is a part of the ongoing research work at the Institute of Soil Science. It aims to evaluate the spatiotemporal changes in soil water content, temperature, and vegetation indices (NDVI and leaf chlorophyll content) across various land use types (cropland - sunflower, forests and grasslands) using a combination of field measurements and remote sensing data. The research site is, located in a small catchment area in Balaton Uplands, Hungary. The site experiences a continental condition with notable soil erosion issues due to the agricultural activities on medium to steep slopes.

The field measurements were conducted during the vegetation period of 2022 and focused on the soil physical and chemical parameters, and vegetation indices of NDVI and leaf chlorophyll content. Field measurements were collected in 4 or 5 points along a transect per land use type. The remote sensing data were obtained from Sentinel-2 (S2) satellites were obtained and analyzed using the QGIS software in order to derive the vegetation indices; NDVI and Chlorophyll content.

The meteorological data was also obtained from nearby rain gauges and a meteorological station, which showed a lower rainfall in the region in 2022 compared to previous years, which impacted the soil moisture and overall plant parameters.

Field measured vegetation indices also indicated differences in the overall productivity plant health among the different land use types. For example; cropland exhibited higher NDVI values, while forests showed higher leaf chlorophyll content compared to other land use types. The study also included the correlation between the field measured data and remote sensing data, to demonstrate the effectiveness of remote sensing in the estimation of plant parameters, mainly in agriculture. Field and S2 retrieved NDVI data were similar for the grassland, however, field NDVI measurements were consistently higher for cropland and forest compared to S2 data. We found that lower leaf chlorophyll values did not correlate well with S2 data, while higher values showed strong correlation.

In conclusion, there need to be an integrated approach in analysis of soil and vegetation indices for more sustainable agriculture practices. Also, longer time-data series are needed for more concise results, such as comparison with years where no extreme rain deficiency is occurring.

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Keywords: soil parameters, remote sensing, vegetation indices, chlorophyll, NDVI, plant health

Investigation of changes in plant health using ground truth measurements and remote sensing

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Diverse information on plant health is an important factor in soil-plant-water system research. Remote sensing is a common method for researchers to correctly account for the spatial and temporal variability of vegetation status and plant health, where ground-based measurements can improve the reliability of data. The aim of the present study was to investigate plant response to changes in environmental parameters (e.g. heat or water stress) using ground truth measurements and remote sensing.

The study area was in Balaton Uplands, Hungary. Three different land use types (grassland, cropland, and vineyard with different inter-row management) were investigated. For the vineyard we had three different inter-row managed study sites (i.e. perennial grass, cover crop, and tilled inter-row). The field monitoring system is working since 2020. The monitoring system collected Soil Water Content (SWC) data at each land use types, while Normalized Difference Vegetation Index (NDVI), Photochemical Reflectance Index (PRI) and Photosynthetically Active Radiation (PAR) data was collected at the vineyard. Hand-held NDVI, PRI and Leaf Area Index (LAI) was measured every two weeks during vegetation period since 2021. Satellite data were collected in each vegetation period between 2020 and 2023, including all retrievable bands (e.g. B2–B12) that allowed us to calculate different vegetation indices.

Land use types and the underlying soil physical and chemical parameters have a strong influence on plant growth and development. We found the highest overall NDVI values in the vineyard samples, and the lowest in grassland. Strong correlation was observed between field measured and satellite based NDVI values (r=0.9). PRI values for all land use types were most strongly correlated with the Red Edge bands (e.g. r=0.65 for grassland, r=0.69 for Cropland, r=0.70 for vineyard cover crop. PCA analysis showed that the cover crop and grassed inter-row did not, but most other land use types grouped distinctly.

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Use of TUdi SEST tool to improve soil health

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One of its main objectives ot TUdi project is to develop a socioeconomic soil restoring supporting toolkit (SEST) for management and analysis of socioeconomic data for the needs of farmers and policymakers. The SEST aims to fill the knowledge gap about the economic impact of soil restoring strategies and improved fertilisation practices by enabling (i) farmers to evaluate the economic impact of different soil-restoration mechanisms and (ii) policymakers to draw policy and governance solutions based on user data. To achieve this the SEST is planned in 3 modules:

Management Operational Tool (MOT):

- Gross margin calculation
- Break-even point calculation
- Business plan generation

The MOT, as the first part of the 3-stage workflow cycle, allows the farmers to form an understanding of the stage of their farm via a wide range of proven tools.

Cost-Benefit Analysis Tool (CBAT):

- Partial Budget
- Single-period full CBA
- Dynamic CBA

The second tool (CBAT) in the workflow cycle focuses on the task of analysing the data, the results, and the alternative strategies for soil restoration available strategies.

Simulation Environmental Tool (SET):

- Optimisation
- Life cycle analysis

The third tool (SET) in the cycle defines the final solution over what should and could lead to better results in terms of reaching better soil quality.