BRITISH SOCIETY OF SOIL SCIENCE

Soil Science Society of Ireland
Cumann Eolaíocht Ithreacht na hÉireann

The British Society of Soil Science and the Soil Science Society of Ireland

Annual Conference 2023

Soil Management and Monitoring

Monday 4 and Tuesday 5 December 2023

Assembly Buildings Conference Centre, Belfast, Northern Ireland

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Annual Conference Programme

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10:30am - 10:45am – Introduction to the Conference – Brian Ervine (DAERA)

10:45am - 11:30am – Soil Nutrient Health Scheme in Northern Ireland - Rachel Cassidy (AFBI)

11:30am - 12:15pm – Benchmarking Soil Health Across Europe: Rachel Creamer (WUR) *[BSSS Invited Lecture]*

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13:15pm - 15:20pm – Policy Session: Soil Monitoring and Management

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2. Hannah Binner – *Update on the status of urban soils in the south of Ireland*
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4. Felicity Crotty – *Investigating soil health during conflict*

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4. Ruth Wade – *FixOurFood: The impact of regenerative farming on soils in Yorkshire*

Nutrient and Water Management *(Ground Floor Conference Room)*

1. Isobel Lloyd – *Greenhouse gas fluxes from winter wheat fertilised with treated and untreated pig slurry*
2. Rebecca Hall – *Geospatial modelling of soil phosphorus fractions and sorption indicators from heterogeneous landscapes*
3. David Clarke – *Crop Simulation Modelling to Support Precision Nitrogen Management*

4. Xiaoxia Cao – *Municipal Solid Waste Compost and Wastewater Recovered Struvite as a Chemical Fertiliser Replacement in Irish Grasslands: Spatiotemporal Impacts on Soil Phosphorus*

16:15pm - 17:15pm - Oral Presentation Session 3:

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17:15pm - 17:30pm – Closing Remarks from Paul Hallett (BSSS) and Suzanne Higgins (SSSI)

Speaker Biographies

Sallie Bailey – Scottish Government

Dr Sallie Bailey, FICFor is Deputy Chief Science Advisor for Scottish Government for environment, natural resources and agriculture and leads the Science Advice Unit, bringing scientific & evidence to the centre of decision-making in government. Previously, she's held leadership roles in the state forestry sector; as regional manager for Forestry and Land Scotland, in environmental regulation as Conservator for South Scotland; and, in the Forestry Commission (GB) advising Government with provision of science and evidence to inform policy development (including soils, water, biodiversity, protected species and natural capital). She has worked with UK Government's Statutory Nature Conservation Agencies promulgating use of spatial data and GIS. Following completion of her PhD at the University of Nottingham, she completed a post-doctorate at Stanford University on forests and ecosystems in the tropics of Costa Rica, arid ecosystems of Nevada and the Rocky Mountains, Colorado.

Rachel Boulderstone – Department for Environment, Food and Rural Affairs (DEFRA)

Rachel Boulderstone has led the Soil and Contaminated Land team for the Department for Environment, Food and Rural Affairs since 2019. Her team is developing policy to improve and protect soil in England from further degradation and to deliver key ecosystem services and to help achieve wider environmental benefits. Rachel's extensive experience as a policy advisor within Defra has covered a wide range of areas, including waste management, rural development, flood management, sustainable drainage systems, inland waterways and environmental targets. Rachel has worked on numerous primary legislation, including the Flood and Water Act 2010, the Agricultural Act 2020 and more recently, the Environment Bill.

Rachel Cassidy – Agri-Food and Biosciences Institute (AFBI)

Dr. Rachel Cassidy is a catchment scientist in the Agri-Food and Biosciences Institute (AFBI), Belfast. Rachel is currently leading the Soil Nutrient Health Scheme project taking place in Northern Ireland. Her areas of expertise lie in:

- Monitoring of diffuse contaminants in agricultural catchments.
- Catchment hydrology
- Critical source area modelling using LiDAR elevation models.
- Hydrogeology and near-surface geophysics.

- Agricultural pressures on freshwater systems

Mary Cleary - Department of Agriculture, Food, and the Marine (DAFM)

Mary grew up on dairy farm in Co. Wexford. Mary has a keen interested in agriculture and the environment which led her to study Agri-Environmental Sciences in UCD. Mary joined the Department of Agriculture, Food, and the Marine in 2022, working in the Nature and Land Use Division in Johnstown Castle, Wexford as part of the Agricultural Inspectorate team. Previous to this role Mary worked in Teagasc, as a research technician on Agri-SOC and the National Agricultural Soil Carbon Observatory (NASCO). Mary's current work in DAFM involves the design and implementation of the National Soil Sampling and Analysis Programme along with National and EU Soils policy.

James Cooke – Welsh Government

James Cooke leads the Peatland, Soil and Agricultural land Use Planning team within the Environmental Sustainability Directorate of Welsh Government. James has led on the development of the National Peatland Action Programme since 2019. His wider team covers a wide range of evidence, policy and technical advice including the Soil Policy Evidence Programme, development of a Soil Policy Statement for Wales, and representing soils through the planning systems in Developments of National Significance and mineral extraction cases.

Rachel Creamer - Wageningen University

Prof. Dr. Rachel Creamer is chair of the Soil Biology Group at Wageningen University. Rachel has worked as a soil pedologist for the last 25 years, specialising in soil quality, soil biological indicator assessment and soil classification. She has coordinated various national and European (H2020 – LANDMARK) research projects and published over 50 papers and a book. Rachel's expertise is currently focussed on soil indicator development, linking soil and land based measurements to ecosystem functions. She currently coordinates the European funded BENCHMARKS project on monitoring soil health across Europe.

Brian Ervine – The Department of Agriculture, Environment and Rural Affairs (DAERA)

Brian Ervine is Head of Environmental Farming at DAERA

Jim Hodgson - Department of the Environment, Climate and Communications (DECC)

Dr. Jim Hodgson PGeo, is a Senior Geologist in Geological Survey Ireland specialising in geophysical surveys. He manages the Tellus programme, a national ground geochemical and airborne geophysical project mapping the soils, rocks and waters of Ireland. A former Vice-President of the Institute of Geologists of Ireland he is active in research concerning radon risk mapping, geomagnetism and peat mapping. He is currently the co-project manager on the Terra Soil project a collaborative research project with Teagasc investigating nutrients, trace elements and soil texture variation across the northern half of Ireland.

John Gilliland – Agriculture Horticulture Development Board (AHDB)

Recently appointed to the EU's Soil Mission Board and a special advisor to the UK's Agriculture Horticulture Development Board (AHDB), John Gilliland, is a willow and livestock farmer from N. Ireland. He is also the Professor of Practice in Agriculture and Sustainability at Queens University Belfast; and chair of the innovative, EIP-Agri funded, farmer led, carbon farming project, ARC Zero. John chaired the UK's Rural Climate Change Forum, reporting directly to the Secretary of State of DEFRA, London, and supporting the UK at COP15 in Copenhagen. Alongside this, John chaired the writing of the N. Ireland Sustainable Land Management Strategy which led to the recent opening of N. Ireland's Soil Nutrient Health and LiDAR Scheme, which is a World first and an investment of £45m to baseline all fields' soil, trees and hedges in N. Ireland.

David Wall - Teagasc

David Wall is a Research Officer at Teagasc and he is also the editor of Teagasc nutrient recommendations for agricultural crops. His research interests include:

- Improving the precision of fertiliser advice
- Predicting soil nitrogen supply through soil N mineralization

- Soil phosphorus dynamics and plant and animal P nutrition
- Nutrient cycling and sustainability of farming systems
- Soil pH and lime –interactions with nutrient efficiency
- Organic manure management
- Remediating heavy metal contamination in soils and produce

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Cranfield University ***[Exhibitor]***

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Nutrient Management: Oral Abstracts

Municipal Solid Waste Compost and Wastewater Recovered Struvite as a Chemical Fertiliser Replacement in Irish Grasslands: Spatiotemporal Impacts on Soil Phosphorus

By **Xiaoxia Cao[1],** Paul N. Williams[1], William O'Neill[1], Yingjian Xu[2]
1. Queen's University Belfast
2. GoldenKeys High-Tech Materials Co., Ltd., Guizhou, China

Phosphorus is an essential but non-renewable mineral resource and a primary limiting factor for crop production. Intensive agriculture has resulted in a high demand for phosphorus fertilizers in farmland. However, the economic and social factors associated with the scarcity of phosphorus fertilizers, coupled with their price and non-renewability, have become a growing concern. Additionally, eutrophication resulting from phosphorus leaching has also become a major environmental management priority. Consequently, the utilization of alternative phosphorus resources has become a popular global topic. Municipal solid waste (MSW) compost and struvite are two types of phosphorus resources derived from solid waste and wastewater, respectively. This study aims to evaluate the feasibility of using amendments from different phosphorus sources (MSW compost and struvite) for the complete or partial replacement of mineral phosphorus fertilizers (Triple superphosphate) in high-yielding Italian ryegrass. In addition, the study investigates the patterns of phosphorus leaching from these materials over time and with depth in soil profiles. A mesocosm trial (22.5 cm *42 cm, 20 kg soil per pot) was conducted with the application of full chemical fertiliser, 25% MSW compost+75% chemical fertilizer, full MSW compost, 25% struvite+75% chemical fertilizer, and full struvite based on a balanced phosphorus level for two years. Additionally, a soil incubation study was carried out for 12 months using the same treatments, but with 17 different soils collected from across the Island of Ireland. The results found that the complete struvite replacement and 25% reduction of phosphorus fertilizer by MSW compost/struvite could maintain comparable grass yields and soil phosphorous availability compared with the full chemical fertilizer treatment ($p < 0.0001$). Though there were no differences in total grass silica through all treatments, higher concentrations of total phosphorous and potassium were found in the 100% MSW compost treatment, leading to increased nutrition for livestock. The phosphorus availability in the surface soil during the 2nd year is the lowest (12.3 mg/kg), which was due to nutrient leaching. The duration of cultivation had a significant and negative impact on soil phosphorus availability, whereas soil depth showed a significant positive effect on it. Furthermore, significant spatial and temporal interactions were observed for phosphorus availability in the soil across all treatments ($p < 0.0001$). These findings can provide direction for future research on the utilization of MSW compost/struvite as a substitute for chemical fertilizers. However, it is essential to prioritize addressing the issue of nutrient leaching and improving phosphorus utilization efficiency when applying any type of phosphorus.

Presenting time: 5 December 2023, 16:00

Keywords: Nutrient leaching; Olsen P; Soil depth; Compost; Struvite.

Funded by: Natural World Products Ltd., Golden Keys High-Tech Materials Co., Ltd., China Scholarship Council

Presenting time: 5 December 2023, 16:00

Crop Simulation Modelling to Support Precision Nitrogen Management

By **David Clarke**
Cranfield University

Soil properties can vary within a field as much as they do across a region. This variation interacts with crops causing spatial and temporal variation in yields and nutrient demand. Site specific management accounting for this spatial variation can significantly improve economic outcomes and reduce losses of nutrients to the environment and form the basis for precision agriculture. Determining the optimal management strategy to account for this variation remains a key challenge. It is not possible to evaluate all the possible soil, crop and management interactions across many seasons and across areas of defined spatial variability through conventional field experiments. Currently spatial management decisions are driven mainly by economics, with precision agriculture tools and methods based on yield and economic return, with little consideration on the externality to the environment. Crop simulation models (CSM) bring together soil and plant process models, describing changes in system states in response to weather or management. Their application in scenarios exploring and managing spatial and temporal yield variability is limited and CSM are currently not widely used to inform on-farm management decisions. A systematic review highlighted a key barrier to the application of CSM to support precision agriculture. was the high spatial resolution of soil properties information required for accurate spatial parametrisation. We overcame this barrier by using a whole-farm yield map data set for Morley Farms, Norfolk, UK, analysed using a fuzzy c means clustering algorithm to identify areas of homogenous yield performance across farm. A linear regression model using soil apparent electrical conductivity and soil particle size was used to generate spatially explicit soil water retention parameter. CSM were then calibrated and validated against yield maps, satellite data and long-term experimental data. These validated models were run using historic weather data with incremental nitrogen management strategies. Optimal N strategy was determined using simulated yield and simulated N leaching risk probabilities allowing for site specific management that considered the economic and environmental performance. Multiple crop simulation models were used to provide consideration for model uncertainty. This study demonstrates the potential of using CSMs to support precision agriculture by providing a framework for developing and using CSM tools that consider the economic and environmental performance of site-specific management decisions.

Funded by: CENTA - NERC

Presenting time: 5 December 2023, 15:45

Geospatial modelling of soil phosphorus fractions and sorption indicators from heterogeneous landscapes

By **Rebecca Hall**
Geological Survey Ireland

Digital soil mapping of phosphorus (P) pools at regional scale can be used to inform policy and land management strategies in agri-environmental systems. However, linking an element that is predominantly managed by fertiliser and organic inputs to regional scale geochemistry can be problematic. This study used a geological survey of the northern half of Ireland at ≤4 km2 resolution to map total P (ICP aqua regia), available P (Morgan' P) and Legacy P pools (ICP aqua regia and Mehlich-3 P).

Spatial modelling was used to map P interactions with total and available aluminium (Al) (ICP aqua regia and Mehlich-3 Al), as predefined sorption indicators. With the aim to develop agri-environmental digital soil mapping approaches to link soil P sorption dynamics to geological controls that can assist with regional, catchment and national-scale modelling for policy development.

Bioavailable P showed no spatial continuity in Kriged variogram output and was regulated by fertiliser inputs which mask any underlying geological processes. Subsequently, making this exploration method redundant in highly managed landscapes. Available Al concentrations (Mehlich-3 Al) are however regulated by underlying geology and have a significant negative correlation with bioavailable P indices. Areas of high Al concentrations (≥ 702.5 mg kg-1) are dominant in the study area and show mainly low P index values (3 mg L-1), however, potential legacy P pools were indicated. Whereas areas of low Al concentrations (≤ 697 mg kg-1) show moderate to high P concentrations which could identify areas where P is likely to remain in solution phase and being a risk to local watercourses. Therefore, using Available Al as a sorption indicator can identify areas of high P fixation and low soil P retention in soils, and using sorption dynamics in geospatial modelling could benefit targeted management approaches.

Key Words: Phosphorus; Digital Soil Mapping; Phosphorus sorption indicators; Kriging; interpolation; Soil Index

Funded by: Geological Survey Ireland

Presenting time: 5 December 2023, 15:30

Greenhouse gas fluxes from winter wheat fertilised with treated and untreated pig slurry

By **Isobel Lloyd**
University of Leeds, Centre for Ecology and Hydrology, Rothamsted Research

The use of livestock waste as an organic fertiliser contributes significantly to agricultural greenhouse gas (GHG) emissions; GHGs are emitted from organic manures during storage and spreading. There is an urgent need to develop new technologies to treat livestock waste to improve nutrient utilisation and minimise environmental impacts. This study quantified GHG emissions (CO2, N2O, CH4) from winter wheat amended with organic and inorganic fertilisers. In March 2022 a randomised block experiment was established for a winter wheat crop with three treatments: (i) inorganic fertiliser (IF), (ii) pig slurry (PS), and (iii) treated pig slurry (TPS) which had been nitrogen (N)-enriched via plasma induction. Each treatment received the same amount of available N (220 kg N ha-1). Fluxes of biogenic GHGs were measured every two hours continuously over an 83-day period between March and June 2022 using automated chambers with collar extensions. Total CO2-equivalent emissions were highest from TPS, followed by PS and IF. Cumulative N2O-N fluxes were significantly greater from TPS (1.14 g N m-2) compared to PS (0.33 g N m-2, P=<0.05) and IF (0.13 g N m-2, P=<0.05). This could be attributed to TPS having a higher proportion of fine solids and a higher N content than IF and PS, making it more accessible to soil microorganisms for transformation to N2O. The largest peaks in N2O-N emission were observed following TPS application and concentrations remained elevated for five days post-application before returning to pre-fertilisation levels; N2O-N emissions also peaked following PS application but were comparatively lower in magnitude. Cumulative CH4-C fluxes were significantly greater from PS (0.053 g C m-2) compared to TPS (-0.023 g C m-2, P=<0.05) and IF (-0.017 g C m-2, P=<0.05). CH4-C fluxes peaked immediately after the application of PS and concentrations remained elevated for one day post-application before returning to pre-fertilisation levels.

During slurry storage, CH4 is first produced and dissolved into PS, then volatilised and emitted on application to land. IF contains no carbon source for CH4 production and the plasma induction process of TPS production results in no CH4 production during storage, explaining the lack of CH4-C emission after the application of these two treatments. CO2-C emissions were not influenced by the type of fertiliser (P=>0.05) and CO2-C emissions from all treatments followed a characteristic diurnal pattern. No significant differences were observed between the wheat yields (t ha-1) of the three treatments. Our results provide a near-continuous record of CO2-C, N2O-N, and CH4-C emissions from a winter wheat crop amended with organic and inorganic fertilisers over a three-month period. Greater CO2-equivalent emissions relative to the yield of the TPS treatment suggest more should be done to improve the emissions output of the product following field application to reduce its environmental impact. Alongside this, GHG emissions from all treatments during storage should be measured to provide a more complete assessment of the GHG balance.

Presenting time: 5 December 2023, 15:15

Funded by: This work was supported by the Leeds-York-Hull Natural Environment Research Council (NERC) Doctoral Training Partnership (DTP) Panorama under grant NE/S007458/1

Presenting time: 5 December 2023, 15:15

Nutrient Management: Poster Abstracts

Silicon nano-biostimulants alleviate cadmium toxicity in bayberry (Myrica rubra) by modulating rhizosphere soil metabolites and microbial community

By **Temoor Ahmed**

Xianghu Laboratory, Hangzhou, 311231, China

Chinese bayberry (Myrica rubra), a cultivated fruit crop in southern China for over 7000 years, is rich in phytochemicals with antioxidant, anti-tumor, and anti-diabetic activities. Heavy metals, including cadmium (Cd), pose a global threat to agricultural crops and human health. Physicochemical methods for Cd remediation often involve toxic compounds that harm the soil ecosystem. Nano-enabled techniques provide a sustainable platform for heavy metals remediation and enhancing crop resilience. Here, we investigated the potential of biologically synthesized (bio)-SiNPs in effectively alleviating Cd toxicity in bayberry plants by modulating biochemical properties, soil metabolites and microbiome.

Bio-SiNPs are synthesized by cell-free cultural filtrate of a rice rhizosphere bacterial strain Chryseobacterium sp. strain RTN3 and are found spherical in shape with a size range of 15–47 nm. The Soil application of 250 mg kg^{-1} bio-SiNPs improved antioxidant enzymes (ascorbate peroxidase +42.4%, peroxidase +41.2%, superoxide dismutase +35.3%), photosynthesis, and nutritional efficiency (N, P, Si, Fe, K+, Ca^{2+}) of bayberry plants, while reducing acropetal Cd translocation by 42.3%. The 16S rRNA metagenome sequencing revealed that bio-SiNPs reshaped the bacterial community (Proteobacteria, Chloroflexi, Actinobacteriota, and Acidobacteriota). GC-MS based soil metabolomic analysis showed altered metabolite profiles involving amino acid, fatty acid, and sugar metabolic pathways, suggesting perturbed C and N metabolism consistent with bacterial community structure results. Overall, our findings demonstrate that bio-nanoremediation is a highly efficient and sustainable approach to enhance food production and security.

Funded by: Xianghu Laboratory, Hangzhou, 311231, China

Presenting time: 5 December 2023, 14:45 – 15:15

P - 1

Measuring soil N_2O emissions from different crop nutrient management strategies

By **Elisabeth Appleton,** Dafydd Elias, Simon Oakley, Ross Morrison, Alex Cumming, Hollie Cooper, Morag McCracken, Sarah Hulmes, Lucy Hulmes, Richard Pywell & Niall McNamara
UK Centre for Ecology and Hydrology

Large-scale application of nitrogen-based fertilisers to agricultural soils is required to support crop productivity. However, an excess of applied nitrogen in the soil impacts the surrounding environment by leaching and leads to the emission of nitrous oxide (N2O), a particularly potent greenhouse gas. We are measuring N2O emissions from a variety of nutrient management strategies that might reduce dependency on synthetic nitrogen-based fertilisers or directly reduce microbial N2O production. As a result, we aim to identify strategies that reduce the environmental impacts of applying nitrogen-based fertilisers whilst maintaining crop productivity.

In particular, we are investigating the use of clover under-sowing, the timing and number of synthetic nitrogen applications, nitrification/urease inhibitors, biochar and digestate. To evaluate these, we are running a series of plot-scale arable experiments using an automated roving greenhouse gas chamber system (Skyline 2D) in conjunction with a Picarro G2508 which provides high frequency measurements of N2O, CO2 and CH4. This allows us to measure greenhouse gas fluxes from up to 36 plots at multiple daily timepoints across the crop lifecycles, producing a high spatial and temporal resolution dataset. Additionally, we measure a variety of soil metrics at each plot, including the available soil nutrients, soil moisture and temperature. This poster will provide an overview of these field experiments, the technology used and our plans for further experiments.

Keywords: Nitrous Oxide (N2O), greenhouse gas emissions, nitrogen-based fertilisers, crop nutrient management, environmental impacts, climate mitigation, technology

Funded by: NERC and BBSRC

Link to Poster

Presenting time: 5 December 2023, 14:45 – 15:15

P - 3

Yield response field trail to reduce the application rate of CAN fertilizer used for babyleaf spinach crops, Dorset (UK)

By **Ellie Barbrook**
University of Reading

Babyleaf spinach has a short growing period (24- 60 days), this is a novel factor in relation to nitrogen (N) cycle inhibitor (NCI) research. Extensive work has already been conducted on optimal NCI and synthetic N fertiliser use in cereal systems. NCIs are an effective solution to reducing nitrate leaching and gaseous emissions from soil, without reducing crop yields. A field trail was established to examine the interactive effects of N fertiliser application rate (early in the season: 0, 108, 144, 180, 216 Kg N ha-1 later in the season: 0, 45, 60, 75, 90 Kg N ha-1) and nitrification inhibitor (NI) application (nitrapyrin (2-chloro-6-(trichloromethyl) pyridine). Nitrapyrin acts through copper chelation, inactivating the ammonia monooxygenase enzyme which is responsible for catalysing NH4+ oxidation during nitrification. The objective of this trial is to determine whether a reduction in N fertiliser application can be achieved without losing marketable yield, whilst quantifying the efficacy of NIs as a tool for reducing N losses from soil.

The field trail consisted of five rates (in triplicate) of calcium ammonium nitrate (CAN), which were applied to 70m lengths of 1.6m wide spinach beds, 30m of which had an application of nitrapyrin 4-7 days prior to fertilisation. The field trial was replicated three times during the growing season (March-October): early (May), mid (July) and late (September). Soil samples were taken before sowing the spinach crop and after harvest to test for soil total N&C, pH, NH3 and NO3- . Plant samples were taken 1 day before harvest to test for total N&C in addition to yield data (kg/ha) from each Spinach bed. NH3 and N2O emissions were measured using semi-open and static chambers, respectively. NO3- leaching was also measured using porous pots (installed by Wessex Water) to take soil pore water samples.

Synthetic N fertiliser is required for sufficient marketable yield of babyleaf spinach crops, not applying fertiliser resulted in 0 Kg/m2 marketable yield of spinach. Organic amendments are not viable for commercially grown babyleaf spinach due to this crop being classed as ‘ready-to-eat’, meaning it cannot come into contact with amendments which could contain pathogenic micro-organisms responsible for causing foodborne illness. In addition, there was no significant loss of yield between the highest and lowest application rates. This informed the babyleaf spinach grower to reduce their rate of N fertiliser application by 37% and 27% in early and mid-growing seasons, respectively. Future research will be conducted using a combination of urea and CAN fertiliser application rates with urease inhibitors (UIs) and NIs, with an aim of further reducing fertiliser application rates without losing marketable yield.

Keywords: nitrification inhibitor, nitrapyrin, fertiliser, nitrogen losses, crop yield, field trail

Funded by: Waitrose CTP

Presenting time: 5 December 2023, 14:45 – 15:15

Evaluation of Double Eagle Wonder Black (Organic Fertilizer) on performance of wheat and cauliflower

By **Sabina Devkota**
Nepal Agricultural Research Council

The Productivity or fertility of the soil is determined by the amount of organic matter content in the soil as it controls most of the soil's physical, chemical, and biological properties. There are several organic fertilizers available in the market but the quality of the products is not assured. The study was conducted from November to March 2020 and in 2021 in RCBD with 8 treatments each to study the response of different compositions of organic fertilizer(Double Eagle Wonder Black) on yield attributes and soil parameters of cauliflower and wheat-based cropping systems. In wheat, the significant thousand grain weight was obtained from FYM 10 t/ha which is similar to the application of 600 kg wonder black per ha. Application of 50% recommended dose of chemical fertilizer and farm yard manure also produces an equal effect that of wonder black application and full dose of NPK, FYM, and control. In cauliflower, the average curd diameter, the average curd depth of cauliflower was significantly influenced by the application of 30 t FYM/ha which is similar/at par with the 50% wonder black and 50% FYM and 50% RDF.

The yield and biomass were significantly influenced by the application of a full dose of RDF which is similar/at par with 50% wonder black and 50% FYM. In cauliflower, soil parameters like soil pH and soil potassium content were obtained significantly higher from the application of 30 t FYM/ha which is similar to the application of 50% wonder black and 50% FYM whereas in wheat, soil parameters like soil pH, organic matter, nitrogen, phosphorous and potassium were not significantly influenced by the application of NPK, FYM and wonder black organic fertilizer. However, there is no serious decline in soil pH after the application of wonder black. In this way wonder black together with FYM and RDF produce better result rather than the sole application of wonder black organic fertilizer and it is also helpful to enrich soil organic matter and nitrogen content though the results were non-significant.

Presenting time: 5 December 2023, 14:45 – 15:15

P - 5

Grain P concentration as an indicator of fertilizer requirements in winter wheat

By **Stephan Haefele**
Rothamsted Research

Available phosphorus management is a continuous task in wheat-based systems of the UK, balancing between enough P application to support high yields and not too much application to avoid damaging losses to the environment. Although the Olsen P method with corresponding threshold values is well established, the method does have a considerable uncertainty interval and the response on different soil types can vary. Therefore, grain P concentration and corresponding threshold values were proposed as a new method for P management. We used data from three longterm experiments managed by Rothamsted Research (Broadbalk, Exhaustion Land, Saxmundham) to investigate the relations between grain yield, grain P concentration, and Olsen P values in winter wheat crops over the last 30 years.

Our results show that maximum grain P concentrations in high yielding years are lower than in low yielding years, indicating a dilution effect through high assimilate transfer to grains. A threshold of not more than 0.25% grain P was indicated in our experiments above which no further significant yield response occurred. And an Olsen P threshold value of 15 mg P per kg soil seemed to be sufficient to avoid P deficiency even in highest yielding seasons for winter wheat in the investigated trials. However, the analysis also indicated that current grain and straw P concentration values of winter wheat, used for field specific P balances, are outdated and need adjustment. Using such data would help to finetune field specific P management for optimized crop P supply and minimized P losses to the environment.

P - 7

Assessing alternative tests for Irish Soils to replace the SMP buffer test for Lime Determination

By **Fionan Mackessy,** Eoin McCarthy, Patrick Quille
Department of Biological and Pharmaceutical Sciences, Munster Technological University Kerry

Soil pH can be considered a master variable that will affect the chemical (nutrient availability), biological (soil microbial growth rates) and physical properties (structure) of soil. Over time soils tend to become more acidic. The rate at which this happens can be exasperated by weather conditions and agronomic activity, particularly the application of intensive chemical fertilisers. The increase in soil acidity has resulted in a high requirement for lime applications. Lime acts as a soil conditioner which can control the acidity of the soil by neutralising the acids from fertilisers, slurry, and high levels of rainfall. The determination of lime requirement at field scale is a fundamental test to assess the health of a soil and to provide recommendations to improve its fertility.

Currently the SPM (Shoemaker-McLean-Pratt) buffer test is the standard test in Irish labs since 1965, to determine soil pH and to give a lime recommendation, however this buffer contains two known carcinogens, potassium chromate and nitrophenol. As a result, laboratories have a temporary derogation to use this buffer, so a dependable substitute to estimate the amount of lime is required. This study is designed to create an affective and accurate alternative test for Irish soils that does not involve hazardous chemicals to replace the SMP buffer test.

68 soil samples were collected across Ireland, with varying pH levels, clay content, cation exchange capacity (CEC), organic matter levels, and under different agronomic practices. The soil samples were further categorised according to their organic matter and clay content. Several different lime requirement tests including buffer tests; Modified Mehlich buffer, The Santa Maria (TSM) buffer, Adam-Evans and the Sikora buffers were investigated, along with the Ca (OH)2 titrations method, and compared to the SMP buffer test. Additionally, results from all these tests were compared to a lime incubation to test for true accuracy. Correlations and linear regression analysis were utilised to compare the accuracy and usefulness of the tests to themselves and as a raw predictor of lime requirement individually.

Keywords: Lime requirement, Soils, CEC, Soil pH

Funded by: MTU postgraduate bursary scheme

Presenting time: 5 December 2023, 14:45 – 15:15

P - 9

The influence of soil structure on phosphorus dynamics

By **Patricia Roche**

South East Technological University, University College Dublin

Soil pore structure influences root penetration and hydrologic processes, and hence, exerts influence on nutrient dynamics. The influence of structure on the availability and release of legacy soil phosphorus (P) stores is not fully understood. Consequently, there are limited options available to improve mining of P reserves, and current recommendations are based predominantly on soil chemistry. The hypothesis of the present research is that poor soil structure impedes change in P index and mobilisation of P reserves. While poorly structured soils may be more difficult to change chemically, structural improvements could allow a more effective manipulation of indices. The influence of soil structure on mobilisation and availability of phosphorus is being examined through a pot trial.

The aim is to study the influence of contrasting soil structures on build-up and draw down of soil P, across low to high P indices. Soil of varying soil test Morgan's P values (2.5 – 10 mg/l) was collected, air dried, and sieved. Each soil was packed into pots at three different bulk densities (1.2, 1.4, and 1.6 kg/m3), to reflect good, average, or poor soil structures. Perennial ryegrass was sown and rooting was allowed to establish over a 6 month period to encourage structural development. After the priming period (2022), baseline measurements of soil test P (Morgan's) were taken in Spring 2023. Treatments of draw-down and build up rates of P will be applied over two years. Soil P is measured annually to detect trends in P build-up or drawdown. Herbage measurements will be taken at intervals typical to grazing rotations of 21 to 28 days throughout the growing season, to allow P balance to be calculated. Soil physical quality will be assessed at the conclusion of the trial in 2025. Intact soil cores will be extracted from each pot and soil water retention curves will be measured. Porosity, hydraulic parameters, and physical quality (SPQ) will be calculated. It is anticipated that the results of this work will indicate if structural variations influence the manipulation of Morgan's soil test P levels and mobilisation of P reserves.

Funded by: South East Regional Development Fund

Presenting time: 5 December 2023, 14:45 – 15:15

P - 11

Overcoming barriers to the adoption of intercropping in the UK

By **Tom Sizmur[1],** Jerry Alford[2], John Hammond[1], Martin Thorsoe[3], Imelda Uwase[1], and Shamina, Imran Pathan[4]

1. University of Reading
2. The Soil Association
3. Aarhus University, Denmark
4. University of Florence

Conventional cropping systems result in the deterioration of soil quality and declines in aboveground biodiversity. There is an urgent need to change soil management practices to adopt more sustainable yet productive systems. Intercropping is when two crops of different species are grown together in the same field at the same time. Intercropping can enhance biodiversity, maximise land productivity, and optimise biogeochemical cycles in agroecosystems. However, intercropping is adopted by very few UK arable farmers. We held a workshop with UK conventional and organic farmers and other stakeholders to conduct a SWOT (Strengths, Weaknesses, Opportunities, and Threats) assessment of intercropping in the UK. The most important strength identified was 'the opportunity to improve farm biodiversity and resilience'. The most important weakness identified was 'the need for separation and a market for the product'. The most important threat identified was 'the lack of knowledge to get it right'. The most important opportunity identified was 'an increase in grain protein content and a reduction in nitrogen use'.

The LEGUMINOSE project aims to reduce the barriers to intercropping by conducting applied scientific research. 20 on farm trials will be established across the UK to compare legume and cereal intercrop mixtures with their respective monocultures. Field trials have been established on the University of Reading research farm. The overarching objectives of the trials are to determine whether legume/cereal intercropping could (i) reduce the use of pesticide (agrochemicals) by suppressing weed, pest and soil borne pathogens and improving beneficial species; (ii) improve soil fertility by increasing below ground biomass and thus C sequestration and reduce GHG emissions and (iii) increase yield of main crop.

We will specifically aim to attribute the yield benefit (land equivalent ratio) that intercropping makes to the supply of nitrogen, or to other factors. Our focus is on combining wheat crops with legumes and we select legumes that have previously performed well in our prior field trials (Faba Beans and Lupin) and an emerging UK crop (Soybean). We have designed the trials to provide data that will enable farmers to decide how much less nitrogen they need to apply to a wheat crop to achieve milling quality grain when the wheat crop is intercropped with a legume. Measurements will comprise crop yield and quality parameters (e.g. N content of grain), nitrogen losses (N2O emissions and NO3- leaching) and soil physical, chemical, and biological properties that underpin soil health (e.g. soil structure, nutrient availability, organic matter, and microbial activity). The poster will provide a full details of the trial designs for the purpose of obtaining feedback from peers. We will also present the results of preliminary trials conducted in 2022-23.

Presenting time: 5 December 2023, 14:45 – 15:15

P - 11

Keywords: Nitrogen Use Efficiency; Intercropping; Wheat; Legume; Leaching; GHG emissions; Soil Fertility

Funded by: This project has received funding from the European Union's Horizon Europe Research and Innovations programme under GA No 101082289 and is supported by the United Kingdom Research and Innovation under the Horizon Europe Guarantee [Grant Numbers 10039837 and 10057156]

Link to Poster

Presenting time: 5 December 2023, 14:45 – 15:15

P - 13

Using soil microorganisms to improve the fertiliser capacity of anaerobic digestate

By **Christina Van Midden**
Cranfield University

Introduction

Anaerobic digestate (AD) is a nutrient rich slurry by-product derived from biogas production, often used as a fertiliser due to its high nitrogen content. However, nitrogen losses from its application can lead to major environmental issues. Novel strategies are needed to keep the nitrogen from the digestate in the soil. Materials high in organic carbon are known to stimulate microbial immobilisation of nitrogen in their biomass. AD has a low content of organic carbon, so the aim of this project was to investigate the suitability of adding high organic carbon materials with varying decomposition rates to the digestate to stimulate microbial nitrogen uptake.

Methodology

Incubated soil was amended with digestate at 45m3/ha at a rate equivalent to 250kgN/ha, and with additional carbon at 12kg C/m3, as either glycerol, straw, woodchip or biochar. Soils were sampled 0, 30, 90 and 150 days after application and nitrogen immobilisation was measured by available soil nitrogen and microbial biomass carbon and nitrogen contents. A second study was carried out to investigate the effect of carbon addition rate, with 12, 24 and 36kgC/m3 of carbon in the form of glycerol added to digestate, applied at a rate equivalent to 250kgN/ha. Soils were sampled at 0, 7, 14, 30 and 50 days after application.

Results and discussion

Study 1: Although glycerol significantly increased microbial biomass during the first month, it did not cause significant nitrogen immobilisation. However, the quantity of nitrogen within the microbial biomass was higher following glycerol than for other treatments. The straw treatment resulted in a significant increase of nitrogen immobilisation (at 120μg N/g dry soil) after three months of incubation. Neither woodchip nor biochar stimulated nitrogen immobilisation. These results suggest that mixing a moderately labile organic carbon amendment into AD has the potential to reduce nitrogen losses following AD application through microbial immobilisation.

Study 2: The addition of glycerol significantly increased microbial biomass for a month after application with the two higher doses resulting in similarly a greater and longer lasting effect. Soil available nitrogen decreased throughout the study and remained at lower concentrations than the digestate only control treatment by the end of the study. These results show that increasing carbon rates results in higher levels of microbial nitrogen immobilisation due to more carbon available to microorganisms. However, 36kgC/m3

digestate did not result in increased growth compared to 24kgC/m3 digestate, as either nitrogen (or other essential nutrients) became the limiting factor for microbial growth instead of carbon. This demonstrates that increasing dose is only effective at increasing microbial nitrogen immobilisation up to a certain concentration.

Conclusion

Carbon addition into digestate results in microbial growth and nitrogen immobilisation, but this is dependent on the carbon being relatively labile and therefore available for microorganisms to utilise. The rate of carbon addition is important, with 24kgC/m3 of liquid digestate found as optimal to trigger microbial immobilisation.

Keywords: Biogas residue, microorganisms, anaerobic digestate, nitrogen immobilisation, high organic carbon amendment

Funded by: BBSRC and Future Biogas Ltd

P - 15

Identifying windows for slurry spreading based on soil moisture deficit

By **Sara Vero**, Lizy Abrams

Dept. of Land Sciences, South East Technological University, Walton Institute, South East Technological University

Land spreading of livestock slurry and farmyard soil water is commonly used to dispose of waste products and to recycle nutrients within the agricultural system. The Nitrates Directive specifies a 'closed period' in which spreading is prohibited, with the objective of avoiding runoff of nutrients to watercourses, and to align with the growing season. Within this closed period, weather and ground conditions may occur in which spreading is relatively low-risk, and conversely, high-risk conditions may occur within the open period. In the present study, available days for land spreading were calculated based on combinations of closed period, soil moisture deficit, and weather rules for twenty weather stations and three soil drainage classes. Full analysis of the results is ongoing; results from weather stations in the most intensive area of dairy farming in the south-east of Ireland are presented here. Application of the closed period rules in addition to weather restrictions rather than a wholly weather-based system significantly reduced spreading days on well-drained soils, but showed minimal difference on poorly drained soils. For well-drained soils there commonly occurred c. 50 additional days per year of viable spreading conditions based on weather rules, whereas poorly-drained soils obtained an additional c. 29 days.

Within November and December well-drained soils exhibited an average of 17 days per month of spreadable conditions, whereas poorly-drained soils only 5. Crucially, large inter-annual variability in conditions occur. A gridded prediction system, similar to weather-based blight and fire alerts could be considered as a means to implement spreading guidelines, and could be coupled with field-scale soil nutrient analyses to identify optimal locations. This work is currently in development. In summary, the preliminary results of this research suggest that well-drained soils may have the potential to receive slurry or soiled water under suitable weather conditions in the current closed period, whereas the regulations appear to work adequately on poorly drained soils.

Funded by: VistaMilk

Presenting time: 5 December 2023, 14:45 – 15:15

P - 17

Tracing the mineralization rates of C, N and S from cysteine and methionine in a grassland soil: A 14C and 35S dual-labelling study

By **Deying Wang**
University of Warwick

Sulphur-containing amino acids (i.e. Cysteine (Cys) and methionine (Met)) constitute an important proportion of the soil organic sulphur. However, detailed information regarding the microbial transformation of Cys and Met at a molecular level remain poorly characterized. To trace the fate of carbon (C) and sulphur (S) derived from Cys and Met in an agricultural grassland soil, a14C and 35S dual-isotopic labelling approach was adopted. We also investigated whether their mineralization was affected by manipulating C (added as glucose), nitrogen (N), phosphorus (P) and S (added as NH4NO3, KH2PO4 and K2SO4) availability in soil solution.

Our results showed that over a 7-day incubation period, 67.2–89.2 % of the 14C derived from Cys and Met was respired as 14CO2, 2.7–19.5 % had been immobilized in the soil microbial biomass; while the recovery of 35S in soil solution ranged from 6.4 to 9.9 %, with the reminder retained in the soil microbial biomass. Overall, our results indicated that soil microbial communities possess a high capacity to utilize Cys and Met. Furthermore, using the 14C and 35S dual-labelling technique, we found that C and S derived from Cys and Met were microbially mineralized and immobilized at different rates, indicating that the cycles of these two elements were temporally decoupled at the molecular level. The addition of glucose-C increased 14CO2 respiration from Cys and Met after 7 d, while in comparison inorganic N, P and S addition had less effect on 14C and 35S partitioning.

Key words: Dissolved organic sulphur, Nutrient availability, Radioisotope tracers, 14C tracer, 35 tracer, Grassland soil

Funded by: University of Warwick, Bangor University

Link to Poster

Presenting time: 5 December 2023, 14:45 – 15:15

Soil Carbon: Oral Abstracts

National trends in arable top-soil organic matter over 40 years from the UK Countryside Survey

By **Laura Bentley**
UK Centre for Ecology and Hydrology

Soil organic matter (SOM) represents the largest store of terrestrial carbon and is vital for soil health, food production, and the hydrological and ecological functioning of our ecosystems. This resource has been progressively eroded from British arable soils with 11% of arable soil organic matter lost between 1978 and 2007. The restoration of SOM for soil function and health and the potential for carbon sequestration in arable soils have prompted significant academic, practitioner and policy interest in Great Britain (GB), but uncertainty remains about the feasibility of increasing and sustaining greater amounts of SOM in arable soils at a national scale. Using recent data from GB's longest running national monitoring survey (the Countryside Survey 1978-2022) we report for the first time on the responses of arable soils to changing environment and management over the last 20 years at a national scale, in the context of multi-decadal trends. This dataset is produced from over 5000 15cm soil cores collected from 1978 onwards, including over 1700 from across GB between 2019 and 2022. We established a representative sample of GB soils across 400 1km survey squares, selected as a random-stratified sample by land class. Within each 1km square, five sites were randomly selected for the collection of soil cores. Broad habitat was mapped in the field for the entire 1km square. Soil cores were used to determine SOM and organic carbon concentration and stocks, calculated using loss on ignition and bulk density. These same sites have been repeatedly surveyed since the establishment of the Countryside Survey in 1978 using identical survey methods, allowing us to monitor the status and trajectory of natural resources in GB, controlling for land use and habitat change. Using this data, we show the first signs of recovery in arable soil organic matter, carbon concentrations and stocks, which have all increased significantly for the first time. We observed a positive upward trend in topsoil SOM (0-15cm) since 2007 with an accrual rate of 0.35 t ha-1 yr-1, which is consistent with the reported potential of land management interventions that have occurred in GB since 2007 to maintain and increase degraded soil carbon stocks. Topsoil carbon concentrations increased by 0.13 g kg-1 yr-1 over the same period. Observed changes in arable topsoil carbon stocks equated to an increase of 0.76 Mt C yr-1 when scaled to all arable land in GB, from 2007 to 2021, equivalent to 2.8 MtCO2 yr-1. Whilst uncertainty remains about the stability of these carbon stocks and whether this increase constitutes genuine additional carbon sequestration, our findings suggests that future policy intervention, through management options, can help restore topsoil organic matter over decadal timescales with anticipated benefits for a wide range of soil functions, including crop productivity.

Funded by: NERC

Presenting time: 5 December 2023, 16:30

Sequestering soil organic carbon by planting hedgerows in agricultural landscapes

By **Pippa Chapman,** Sofia Biffi, Guy Ziv
University of Leeds

Agricultural intensification has resulted in the decline and loss of semi-natural habitats, including hedgerows, and in the amount of soil organic carbon (SOC) stored in soils, contributing to a decrease in farmland biodiversity and a large carbon (C) debt in soils. To mitigate the effects of habitat loss on biodiversity, landscape corridors, such as hedgerows, have been promoted as a tool in conservation policies. In addition, the SOC debt represents an opportunity for hedgerows to sequester SOC i.e. removal of carbon dioxide (CO2) from the atmosphere and storing it in soil under hedges. SOC sequestration is seen as a major part of climate mitigation strategies and large-scale ecosystem restoration, and could play a critical role in meeting the Paris climate change agreement. The UK Committee on Climate Change proposed that to achieve net zero by 2050 hedgerow length will need to increase by 40%, which equates to ~190,000 km of newly plants hedgerows across England, with an interim goal of a 20% increase by 2035. However, little is known about how the UK is progressing towards reaching these planting goals. Moreover, there is a lack of information on the amount of C stored in hedgerow soils and on the rate at which C is sequestered in soil beneath hedgerows over time since planting. In our study, seventy-eight hedgerows across six different pedo-climatic conditions in England were classified into four age categories. Soil organic carbon (SOC) stocks were quantified at 10 cm intervals for the top 50 cm of soil beneath hedgerows and in adjacent grassland fields. In addition, we examined the distribution of SOC among particle-size fractions to investigate how hedgerow planting may influence SOC dynamics by affecting the quality and long-term stability of SOC. We found higher SOC stocks beneath hedgerows than adjacent fields for all age categories and hedgerows stored on average 40% more SOC in the top 50 cm of soil compared to adjacent fields and 30% more SOC in the top 30 cm of soil. The average additional SOC stock beneath hedgerows was 40.9 Mg C ha-1 at 0-50 cm depth, or 6.1 Mg C km-1. We used the SOC sequestration rate for 37 year old hedges to show that if England were to reach its goal of a 40% increase in hedgerow length, 6.3 Tg of CO2 will be sequestered and stored in the soil over 40 years (9.9 Tg with aboveground biomass). We also found that it was the light particulate organic matter fraction that increased significantly as a result of planting hedgerows. Our results indicate that hedgerows, together with their supporting and provisioning ecosystem services, can help contribute to net-zero targets. However, hedgerow planting rates in public agri-environment schemes will need to increase markedly if we want to meet this target.

Funded by: BBSRC, ESRC, NERC, Defra, Scottish Government and Research England Policy Support Fund

Presenting time: 5 December 2023, 16:15

Soil mineralogy, litter quality and microbial community controls on the formation of mineral associated organic matter

By **Dafydd Elias**
UK Centre for Ecology and Hydrology

Soil organic matter (SOM) is the largest terrestrial carbon (C) pool and its preservation is crucial for climate change mitigation. Traditionally, the stability of SOM in soils was thought to be a function of the chemical recalcitrance of the input biomass. However, recent evidence suggests that most SOM is microbial in origin and that physical protection of organic matter from decomposer organisms, through protective sorption to mineral surfaces controls the persistence of SOM in soils. Mineral associated organic matter (MAOM) is an important pool for long-term soil C storage. However, the influence of soil mineralogy and interactions with the quality of aboveground litter inputs on the formation of MAOM is unclear. We hypothesized that soil mineralogy would control the rate of MAOM formation due to variability in surface area and reactivity. In addition, we also hypothesized that high quality litter with low C:N ratios would form MAOM more efficiently, promoting higher microbial carbon use efficiency (CUE) (and thus formation of microbial residues). To test our hypotheses, we conducted a laboratory microcosm incubation with a standard agricultural soil amended with common soil minerals (Kaolinite, Montmorillonite and unamended soil control). Soils were incubated under standardised temperature and moisture conditions, with two surface applied 13C labelled litters of contrasting qualities (White Clover – low C:N and Winter Wheat - high C:N) and a no litter control. During the incubation, turnover of litter derived C by microbial respiration was quantified by δ13CO2 analysis and microcosms were destructively harvested after 4 months. The amount of litter derived C stabilised as MAOM, remaining as particulate organic matter (POM) and assimilated into microbial biomass was quantified by δ13C analysis and soil microbial communities were characterised. Soil mineralogy strongly influenced the efficiency of MAOM formation, with Montmorillonite amended soils respiring less litter derived C and stabilising more as MAOM. High quality litter was respired more rapidly across all soils. However, the effect of litter quality on the efficiency of MAOM formation was dependent on soil mineralogy with low quality litter transferred to MAOM more efficiently only in Montmorillonite amended soils. Litter addition also caused taxonomic shifts in soil bacterial communities with high C:N litter addition associated with shifts toward more oligotrophic taxa. This suggests that although input of high C:N litter may decrease the CUE of individual microbial community members, it may also lead to a shift towards specialised functional groups with higher CUE. Taken together, our findings demonstrate that soil mineralogy is an important control on the rate of MAOM formation and that litter-microbial interactions may determine the effect of litter quality on MAOM.

Keywords: Soil carbon, mineralogy, litter quality, MAOM, microbial communities

Funded by: BBSRC

Presenting time: 5 December 2023, 17:00

The response of soil respiration to long-term nutrient inputs and soil tillage in an improved grassland ecosystem

By **Jonathan Holland,** Alan Gordon, Dario Fornara
AFBI

This study investigates how soil respiration is affected by long-term additions of organic and inorganic nutrients and by soil tillage. We use data from a long-term grassland experiment established in 1970 in Northern Ireland. The eight different nutrient treatments include: (1) control (no N added), (2) inorganic fertiliser (NPK: 200 kg N ha−1 year−1), cattle slurry at three application rates (3) 50, (4) 100 and (5) 200 m3 ha-1 year−1, and pig slurry at the same three application rates (6) 50, (7) 100 and (8) 200 m3 ha-1 year−1. Static automated chambers were installed by end of 2016 to measure soil respiration. In September 2019 half of the experimental plots were cultivated and reseeded with a multi-species sward mixture. Data from this long-term experiment show how the nutrient fertilisation treatments have influenced soil respiration of a typical temperate grassland in North-western Europe. The pig slurry application had greater cumulative CO2 flux than cattle slurry, but there was no consistent or significant effect of slurry rate on CO2 flux. From October to March there was much smaller difference in CO2 flux between the treatments. Correlation of CO2 flux with the soil organic carbon was evaluated.

These findings suggest that slurry type has a strong influence on soil respiration, however there is a paradox as the rate of slurry application does not appear to be related with soil CO2 flux. During the period immediately after the plots were ploughed there was significantly greater soil respiration from the permanent pasture plots than the reseeded plots which raises questions regarding the net C loss from the tillage of grasslands. This study seeks to improve understanding of the dynamics of grassland C as a source/ sink and to explore what short-term soil CO2 flux can inform us about long-term changes in soil carbon accumulation.

Keywords: Carbon fluxes, Grassland, management practices, Ploughing, Tillage, slurry, nutrient management

Funded by: DAERA (Department of Agriculture, Environment and Rural Affairs), Northern Ireland

Presenting time: 5 December 2023, 13:45

Degraded arable soils in England: How much manure to restore?

By **Jonah Prout**
Rothamsted Research

Using SOC/clay as an indicator, we estimate that 40% of arable soils in England and Wales are currently degraded. So, there is a clear need to optimise organic soil amendments and management to meet multiple milestones within the next 30 years to restore the environment and increase the resilience of food production to changing climate conditions. We have used a subset of the National Soil Inventory of England and Wales (n = 642) and the Rothamsted Carbon turnover model (RothC) to model the rates of organic matter which would be needed to increase degraded arable soils across England to a minimum threshold of SOC/clay = 1/13. We assumed a constant crop and residue scenario at each site and calculated the amount of farmyard manure (FYM) required to increase the SOC stock to the target level in 10 to 50 years. We found that close to three quarters of the modelled soils could be restored within 20 years respecting the loading limit for FYM application in nitrate vulnerable zones (170 kg N ha-1 yr-1), which cover 55% of England.

To put the results into context of the croppable area of England, we scaled the carbon stock deficits up (based on proportions within the dataset) and assessed whether there was enough FYM at this scale. Estimates of the amount of cattle FYM applied to arable land in England suggested that there was enough to restore soils which were close to the threshold (SOC/clay between 1/13 and 1/16) within 50 years. For soils further from the threshold (< 1/16), there were insufficient quantities of cattle FYM for restoration across the area in this timeframe. We looked at cattle FYM in the first instance, however, there is scope to include other sources of FYM and other organic amendments with respective constraints on application. Mixed farming systems and accounting for the amount of FYM applied to grassland and through grazing could also provide opportunities for soil restoration.

Keywords: soil organic carbon, soil clay, FYM, land use, carbon sequestration, organic amendments, land degradation, land restoration, soil health

Funded by: BBSRC

Presenting time: 5 December 2023, 14:00

ADAPTForRes: Partitioning Soil Respiration in Irish Forests for Better Climate Models

By **Blair Ruffing,** Ken Byrne
University of Limerick

Sustainable forest carbon (C) sinks increase resilience against disturbance and projected climate variability when overseen by ongoing adaptive management strategies (Liu, 2011). This project aims to identify the factors influencing resiliency in Irish forests through the evaluation of soil C budgets at three contrasting forest types within the national forest estate (coniferous forest on mineral soil, native woodland on mineral soil, and coniferous forest on peat soil). As forest ecosystems contain approximately 86% of all terrestrial aboveground organic carbon (C) and approximately 73% of all belowground terrestrial C (Intergovernmental Panel on Climate Change [IPCC], 2019), these areas have a significant effect on global C cycling. Depending on the unique balance between photosynthetic activity and total ecosystem respiration (sum of aboveground plant respiration and belowground soil respiration), forest ecosystems can act as either sources or sinks of carbon dioxide (CO2) (Ojanen et al., 2012). The importance of soil respiration measurements and the work of partitioning soil respiration into its autotrophic and heterotrophic components cannot be understated. It is critical to the understanding of the processes that drive soil carbon and nutrient cycling processes in forest ecosystems and can help to identify the relative contributions of living biomass and soil organic matter to ecosystem respiration. As the study sites for this project differ in ways such as age, soil type, management practices, and species composition, valuable insights can be made regarding the effect that this variability can have on respiration rates and subsequent implications for efforts to mitigate climate change. Since the start of fortnightly data collection in November 2022, the lowest average total ecosystem respiration rates have been observed in the native woodland on mineral soil (0.17 g (CO2) m2 hour-1)) where the lowest value of 0.15 g (CO2) m2 hour-1 was observed in February 2023 and the highest value of 0.40 g (CO2) m2 hour-1 was observed in November 2022. The highest average total ecosystem respiration rate was in the coniferous forest on mineral soil (0.25 g (CO2) m2 hour-1) with the lowest value of 0.17 g (CO2) m2 hour-1 taken in February 2022 and the highest value of 0.46 g (CO2) m2 hour-1 taken in November 2022. Like previous studies, the heterotrophic flux contributed more to total ecosystem respiration than the autotrophic flux.

Keywords: Litterfall, coarse woody debris, fine root turnover and distribution, C stock estimation, moss-derived carbon, and organic matter physical fractionation data are also collected to support the understanding of soil respiration and C dynamics in contrasting Irish forest types. This information will be used to develop accurate models of carbon and nutrient cycling in forests and to better predict the impacts of environmental change on these critical ecosystem processes.

Funded by: Department of Agriculture, Food and Marine

Presenting time: 5 December 2023, 14:15

Modelling CO2 and CH4 fluxes from a Rewetted Irish Peatland Previously Drained and Forested with Sitka Spruce

By **Amey Sudhir Tilak**[1], Kenneth Byrne, Matthew Saunders

University of Limerick [1], Vrije Universiteit, Kytalyk Carbon Cycle Research, University of Zurich and Trinity College, Dublin

The northern peatlands were drained and converted into forestry, agricultural lands and grasslands resulting in decreasing their carbon sequestration potential and increasing CO2 fluxes to the atmosphere. To mitigate this impact, drained forested peatlands are rewetted to increase the anoxic conditions that promote carbon sequestration. The limited field scale studies on rewetted forested peatlands highlighted the importance of environmental factors (peat temperatures, pH, litter quality, plant and microbial composition and groundwater levels) that regulated CO2 and CH4 fluxes from peat to the atmosphere. Almost all the field scale studies have limited duration (3-5 years) of environmental data in addition to discontinuous groundwater measurements. Also, very few field scale studies possess long-term (20+ years) continuous groundwater measurements at a daily scale.

In absence of these long-term field measurements, a process-based computer model known as Peatland VU calibrated and validated against field measured data for testing different hypothesis. This study utilizes the field collected data from a rewetted Irish peatland previously drained and forested with Sitka Spruce. This site was forested in the 1980s, while vegetation clearing and drain blocking occurred in 2011 and 2013 respectively. The CO2 and CH4 monitoring conducted in different microsites (Eriophorum-Sphagnum, Eriophorum, Cladonia mosses and brash) from August 2014 to September 2015 and March 2014 to July 2015 respectively, along with quantification of environmental parameters (moisture, temperature, groundwater levels, leaf area index, pH, bulk density, and C:N ratio). The vegetation monitoring throughout the study period showed that the Eriophorum vaginatum increased its canopy size and spatial extent on the rewetted areas. The growth of this aerenchyma vegetation on the rewetted areas has important implications for CH4 emissions. The field measured CO2 and CH4 fluxes (2014-2015) from the Eriophorum vaginatum microsite used for calibrating and validating the Peatland VU model. A model spin-up for 20+ years (1990-2013) was conducted to stabilize the carbon pools before proceeding to calibrate and validate the model. After model spin-up, calibration, and validation, the model will be used to test the following hypothesis: effect of brash (easily decomposable litter) addition on resulting CH4 fluxes and its different pathways (plant transport, ebullition, and diffusion) subjected to 20+ years of daily groundwater data varying from 0-10 cm and 20-40 cm of the peat surface. The authors will present the model outputs with respect to the carbon pool stabilization, calibration, validation, and hypothesis testing scenarios.

Keywords: Drained forested peatlands; rewetted forested peatlands; plant transport; ebullition; diffusion; Peatland VU; Eriophorum vaginatum; CO2 fluxes; CH4 fluxes; calibration and validation.

Funded by: Irish Environmental Protection Agency (EPA)

Presenting time: 5 December 2023, 16:45

Estimating the soil carbon stocks on Welsh farms

By **Non Williams**
Farming Connect

Agriculture is responsible for approximately 10% of the United Kingdom's greenhouse gas emissions. However, farming systems also have the capability to sequester carbon from the atmosphere. Soils may sequester or release carbon depending on several factors, such as land use, management practices, soil type and climate. Changes in soil carbon stock occur gradually over several years, and accumulation over time will reach an equilibrium, which makes quantifying a common baseline a challenge. Nevertheless, estimating the carbon stocks of our agricultural soils provide useful baseline figures to benchmark against and compare with future measurements. Furthermore, there is much interest in the role of soils in climate change mitigation by farmers, researchers and policy-makers.

Here, we focus on a multi-year project aimed at estimating the carbon stock of Welsh agricultural soils. In Year One, detailed soil testing on seventeen farms (a combination of red meat and dairy) was conducted following a commonly used methodology (i.e., using soil organic carbon concentration and field bulk density values) in order to a) estimate the soil carbon stock of multiple fields (n=5) from seventeen varying farming systems, and b) investigate the degree of variability in soil carbon stock within a single farming system, as well as between different farming systems. This novel pan-Wales study explored farms of varying soil and field types. Selected field types for comparison included permanent pasture, hay or silage, grass reseed and grazing only. Working directly with the farmers, specific management and historical data were gathered for each field to aid with interpreting the results.

The results showed that the average soil carbon stock (for the 0-50 cm soil profile) varied between 119.8 t/ha and 137.5 t/ha for the different field types listed above. At the conference, we will present the findings in detail, discussing the differences in soil organic matter and organic carbon, as well as soil carbon stocks at different soil depths, varying field types, and between farms. Analysis conducted post abstract submission will enable us to better understand the significance of the differences in soil carbon stock between farms and fields. Furthermore, to consider the effect of differing factors, e.g. soil type, land use and management on the results.

This ongoing project is a three-year study, whereby we aim to use the wealth of knowledge within the farming and scientific communities to reduce the gap between experimental research and practical application within the agricultural industry in relation to soil carbon. By the conference, the study will be in its second year, whereby additional farms will have been recruited to participate.

The Welsh Government is committed to reaching net zero emissions by 2050. The findings of this work will be of relevance to this challenge.

Funded by: Welsh Government

Presenting time: 5 December 2023, 14:30

Soil Carbon: Poster Abstracts

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Long-term manure application enhances organic carbon and nitrogen stocks in Mollisol subsoil

By **Muhammad Mohsin Abrar**, Syed Atizaz Ali Shah
University of Agriculture and Engineering, Guangzhou, China

Subsoils contain half of the total soil organic carbon (SOC) that is supposed to be relatively more persistent than that present in the topsoil. Improving SOC and total nitrogen (TN) stocks in croplands is crucial to mitigate climate change and ensuring food security. However, our insight into how the management practices and climatic variables influence stocks of SOC and TN, and crop grain yields in the soil profile is limited. In this study, we assessed the long-term impacts of mineral and manure fertilizers on SOC and TN stocks at soil profile levels (up to 100 cm), and cropping system (wheat–maize–soybean) grain yields.

Results indicated that in the top 0–40-cm layers SOC and TN stocks were the highest in manure plus mineral fertilizers (MNPK) compared with control, that is, non-fertilized control (CK). Conversely, compared with NPK, sole application of manure (M) clearly increased SOC stocks by 19%, 40%, and 39% and TN stocks by 51%, 105%, and 116% in 40–60, 60–80, and 80–100 cm, respectively ($p < 0.05$). Moreover, Pearson correlation revealed that climate variables, that is, mean annual temperature (MAT) affected both SOC and TN stocks in 0–40-cm layers only of the soil profile. Our findings implicated that the sole application of manure (M) is vital to augment SOC and TN sequestration, particularly in the subsurface layers. However, trade-offs between SOC and TN sequestration and crop yields should also need to be considered while making recommendations for SOC and TN stocks maintenance and increasing crop productivity in terms of management strategies.

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Link to Poster

Presenting time: 4 December 2023, 12:15 – 13:15

Mechanisms of Soil Binding Exudate Release and Their Role in Plant-Soil Interactions

By **Jumana Akhtar**
University of Bristol

Plants play a pivotal role in the global carbon cycle, releasing up to 40% of their carbon into the soil. This carbon allocation has been implicated in soil processes, including the formation of rhizosheaths. Rhizosheaths are specialised structures believed to play a crucial role in plant-soil interactions, particularly in enhancing drought tolerance and water retention capacities. Rhizosheaths are formed through a complex interplay of root hairs and adhesive root exudates that effectively entangle soil particles and contribute to the mitigation of soil erosion (Price, 1911; Pang et al., 2017).

Certain polysaccharides commonly found in the plant cell wall, such as xyloglucan and complex gums, possess soil binding properties. Recent investigations have further identified cell wall-like polysaccharides, including xyloglucan, heteroxylan, and arabinogalactan protein (AGP) epitopes, in the exudates released from the roots of agriculturally significant crops such as wheat, barley, and maize (Akhtar et al., 2018; Galloway et al., 2017).

Differences in the composition of exudates that lead to an increased release of carbon from the roots of root hairless mutants in barley when compared to wild-type roots. The exudates from hairless roots are less effective at binding soil compared to those released by barley plants with root hairs. However, the precise underlying mechanisms governing the release of soil binding exudates remain elusive (Galloway et al., 2022).

To gain deeper insights into this exudate soil-binding mechanisms, our study capitalises on the a wide array of root hair mutants available in Arabidopsis thaliana. We employ a novel centrifuge assay to assess the adhesion strength of Arabidopsis roots to identify mutants with adhesive phenotypes. These mutants are likely to exhibit alterations in root hairs, cell wall composition, and transporter activities, all of which may significantly influence the process of exudate release (DeBaets et al., 2020; Eldridge et al. 2021).

To elucidate the composition and release mechanism of exudates in these mutants, we will collect exudates for a soil binding assay (Akhtar et al., 2018) and use immunohistochemical methods to dissect the exudate composition of substrate-adhesion mutants. Through comprehensive comparison of the quantitative and spatial release patterns of exudates in both soil and agar, the role of root hairs in soil aggregation and the function of exudates in soil binding will be characterised.

This comprehensive investigation into the mechanisms of soil binding exudate release and their contributions to plant-soil interactions will significantly enhance our understanding of carbon allocation in plants and unlock new avenues for research on sustainable agriculture and ecosystem management. Leveraging insights from targeted gene approaches using Arabidopsis, we aim to inform the development of drought-resistant and soil-beneficial crop species in the future. Ultimately, our findings will have promising implications for

enhancing drought tolerance, mitigating soil erosion, and refining water retention strategies in various plant species, and foster more resilient and productive agricultural systems.

Keywords: soil aggregation, root exudates, soil properties, soil erosion, soil carbon, polysaccharides

Funded by: Leverhulme Trust

P - 23

Fibre crop work in The Centre for High Carbon Capture Cropping

By **David Clarke**
NIAB

The agricultural sector in the UK has been set the target of Net-Zero greenhouse gas emissions by 2040. The Centre for High Carbon Capture Cropping aims to help growers increase the carbon captured on their farms through diversifying arable and forage rotations. This will help build resilience into farming systems which is vital in an industry vulnerable to the effects of climate change. Across all trial sites and throughout the project, soils are being sampled to assess physical, chemical and biological properties at depths 0-30 cm and 30-60cm.

Plant and root samples are being measured to calculate above and below ground biomass. Baseline soil data has been collected for all trial sites, flax and hemp shoot and root samples have been collected and are being assessed. Results so far are in line with anticipated deep and wide root systems; this highlights the view that fibre crop root biomass can contribute to carbon capture and potential soil sequestration.

Funded by: DEFRA

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The relevance of subsoil in the study of soil carbon storage

By **Lizzie Foley**
Free University of Bolzano

Studies on soil C dynamics to date focus mainly on topsoil, even though a large proportion of soil C is stored in subsurface soils. These deeper layers of the soil profile are thought to be dominated by C that has formed mineral-associations and has a much longer turnover time than its labile counterpart. Understanding the efficacy of this could be critical in the development of practices aimed to mitigate climate change by increasing carbon storage in agricultural soils. The aim of this study is therefore to explore differences in soil C fractions in topsoil and subsoil in agricultural soils, to gain an understanding of how carbon cycle dynamics change along the soil horizon. For this purpose, soil samples at 0-30 cm and at 30-60 cm were collected from four apple orchards in Northern Italy. Soil samples were analysed for the labile C fractions (dissolved organic carbon (DOC), humic and fulvic acids (HA/FA), hot water extractable carbon (HWEC), permanganate oxidisable carbon (POXC), particulate organic matter (POM)) and the stable fraction (mineral-associated organic matter (MAOM)). Preliminary results indicate that soil samples taken from deep layers contained significantly lower concentrations of all labile C fractions (DOC, HA/FA, HWEC, POXC and POM). Concentrations of C across all of the labile fractions measured are significantly lower at all sites, with certain fractions (HWEC and POMC) measuring up to 3 times lower in deeper soil layers, than in topsoil. This suggests that concentrations of labile C fractions are higher in the topsoil, in line with the general understanding of the share of C across the soil horizon. However, when examining the stable C fraction (MAOM), preliminary results show the proportion of stable (MAOM) to labile (POM) C in the subsoil samples to be significantly higher than in the topsoil, with MAOM making up ~73% of C in subsoil samples, and just ~61% in topsoil samples. The results of this study highlight the importance of subsoil in the study of soil C storage, as indicated by the larger proportion of the longer-lived, stable C fraction: MAOM. Furthermore, it underlines the importance of identifying and quantifying carbon fractions at different sampling depths and understanding the associated turnover rates. This will facilitate a deeper comprehension of carbon cycle dynamics within these environments and will in turn will provide important insight into the relevance of subsoil when studying carbon dynamics in agricultural ecosystems.

Keywords: Carbon sequestration, carbon fractions, soil carbon storage, subsoil, apple orchards

Funded by: PNRR, Südtiroler Apfelkonsortium

Presenting time: 4 December 2023, 12:15 – 13:15

P - 27

Soil carbon dynamics in regenerative agricultural practices – evidence from a new Rothamsted long-term experiment

By **Marcelo Valadares Galdos**
Rothamsted Research

It is widely agreed that increasing and maintaining soil carbon in agricultural systems has benefits including removing CO2 from the atmosphere, increasing the capacity of crops to withstand extreme climatic events, improving the capacity of soils to provide nutrients for crop growth, and a range of other ecosystem services. Over the last decades, changes in climate, land use and management have resulted in soil degradation including erosion, compaction, and a decline in soil carbon content in agricultural systems. The Large-Scale Rotation Experiment (LSRE), a new addition to Rothamsted's long-term trials, was designed to address current challenges for agricultural production, expanding the range of outcomes beyond crop yields, to include environmental and economic sustainability, climate resilience and global warming mitigation potential. The LSRE was established in 2018 at the Rothamsted Research Harpenden site on a silty clay loam soil. The experiment is comprised of four management factors, as follows: (1) three rotations, (2) two intensities of cultivation, and two approaches to (3) crop protection and (4) crop nutrition. Three crop rotations (3-year, 5-year and 7-year) with winter wheat, winter oilseed rape, spring barley, spring field beans, sugar beet, linseed and grass/clover ley were included in the design. Each crop phase was either cultivated using conventional inversion tillage or reduced tillage. Half of the main plots were designated as 'smart crop protection' (SCP), with the following practices: growing cultivar mixtures, spraying to pest and disease thresholds, delaying drilling to control weeds and companion cropping, following the principles of Integrated Pest Management. The other half of the plots were managed following conventional crop protection approaches. The nutrition factor comprised either a standard mineral fertilization or this standard approach but with the addition of organic amendments, applied either as a living mulch and/or green compost. Soil samples were collected in each subplot at three depths (0-23cm, 23-60cm and 60-100cm) at the beginning of the experiment (2018), in 2021 and in 2023. Samples were analysed for total carbon and nitrogen, Olsen phosphorus, pH, bulk density and cation exchange capacity. Soil carbon physical fractionation, including mineral associated organic matter carbon (MAOC-C), and particulate organic matter carbon (POM-C). Soil chemical and physical properties were also analysed by soil spectroscopy using a Mid-Infrared spectrometer. Apparent electric conductivity (ECa) data over the whole experiment was obtained by using an Electromagnetic inductance (EMI) probe. Preliminary results indicate that total soil carbon content and soil carbon fractions were influenced primarily by cultivation and organic amendments, but the magnitude of the effect varied according to system diversity and crop protection methods.

Funded by: BBSRC

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Agroforestry for ammonia abatement and reducing greenhouse gases

By **Kaisa Ilmari**
Forest Research and the University of Edinburgh

To address the increasing pressures on land management due to climate change, food insecurity and biodiversity loss, agroforestry has been proposed as a key method to create more sustainable agricultural systems that meet the goals for both ecological protection and socioeconomic development. Trees on farmland deliver a myriad of ecosystem services that not only benefit the farmer but also the surrounding environment. Tree shelterbelts are a type of agroforestry system where trees are incorporated within and around farming infrastructure, crops and livestock and their purpose is to shelter the land from harmful weather conditions as well as increase the biodiversity, carbon storage and capture of pollutants, primarily ammonia originating from livestock housing and manure management.

However, there is limited evidence on the response of soil properties, specifically carbon balances, soil nitrogen content and greenhouse gas fluxes, in tree shelterbelts under an increased ammonia load from livestock farming. This MSc project shows that the increase of ammonia at the shelterbelt edge increases soil ammonium content, nitrous oxide emissions and acidity. There is a significant decreasing trend with these parameters with increasing distance up to 150 meters from the source of ammonia. These findings provide further evidence for the benefits of shelterbelts as the trees intercept the ammonia from spreading to nearby natural habitats, preventing eutrophication and acidification. On the other hand, the soil carbon and total nitrogen stock, carbon dioxide emissions and methane sink are increased at the interior of the shelterbelt due to the forest edge effects. This supports the design of agroforestry systems where the trees are planted in multiple long rows to create an ecosystem that can improve the carbon storage of the farming landscape as the carbon stock was found to be higher in the interior of the shelterbelt compared to adjacent grassland. Additionally, the shelterbelt took up more methane and thus created a stronger methane sink compared to the grassland. However, the shelterbelt had higher carbon dioxide emissions and there were no significant differences in soil organic carbon content between the two sites, highlighting the need to continue monitoring agroforestry sites to gain a better understanding of the full ecosystem services associated with the management practices.

Nonetheless, due to the co-benefits for ammonia abatement, shelter for livestock and potential for improved carbon storage, shelterbelts, and agroforestry systems in general, will have a crucial role in the paradigm shift in the agricultural sector that increases the climate change mitigation potential and adaptation capability of our food production systems without compromising food security.

Keywords: Agroforestry, ammonia, carbon storage, climate change mitigation, greenhouse gases, livestock farming, shelterbelts

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Application of Digital Soil Mapping Techniques for Prediction of Soil Carbon Stocks in South Korea: Towards Carbon Neutrality

By **Yun-Gu Kang**[1], Jun-Yeong Lee, Jae-Han Lee, Jun-Ho Kim, Taek-Keun Oh*

Chungnam National University[1], Department of Bio-Environmental Chemistry, College of Agriculture and Life Science, Daejeon 34134, South Korea

Spatial distribution information and quantitative assessments of soil carbon stocks at the national level are essential for achieving carbon neutrality and mitigating climate change. However, estimating soil carbon stocks through soil surveys necessitates substantial labor, time, and cost. Therefore, there is a growing interest in statistical methods, such as digital soil mapping. This study employed digital soil mapping techniques to estimate the soil carbon stocks in agricultural land across South Korea at depths of 0-30 cm and 0-100 cm. For the implementation of the spatial distribution map, a total of 933 soil samples were surveyed and utilized in this study. To derive the spatial distribution map of soil carbon stocks, we considered 22 environmental factors with a 30 m × 30 m grid resolution as parameters. Among these factors, 10 parameters were related to soil characteristics (e.g., texture and drainage), while 6 parameters each were related to terrain (e.g., slope and normalized difference vegetation index) and climate (e.g., precipitation and average temperature) of South Korea. The estimated mean value of soil carbon stocks was higher at a depth of 0-30 cm (27.81 ton C ha-1) compared to the soil at a depth of 0 - 100 cm, which was evaluated at 21.61 ton C ha-1. Confidence levels for the estimation results were 10% and 14% at depths of 0 - 30 cm and 0 - 100 cm, respectively. The findings of this study are expected to provide the information for achieving carbon neutrality and mitigating climate change.

Keywords: Carbon storage, Digital soil mapping, RandomForest, Scale effect, Soil map, Soil survey, Spatial variability

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Different Sampling Protocols Produce Different Soil Organic Carbon Estimates

By **Christopher Lakey**[1] Rosalinda Morrone[1], Nicky Knox[1] , Jacqueline McGlade[1,2,3], James Spalding[1], Kevin Morris[1]

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In addition to improving soil health and nutrient density of foods, there is increasing interest among farmers and landowners in the UK and globally to increase soil carbon sequestration as a negative emissions technology to deliver "net-zero" outcomes and generate revenues from the Voluntary and Compliance Carbon Markets.

Historically, soil field sampling combined with chemical and physical laboratory analyses have been used to quantify stocks of soil carbon. The majority of soil carbon projects rely on this approach to provide baseline measurements of soil carbon. Repeated field measurements, at intervals of up to five years, are then used to determine the rate of change. The volume of carbon credits available to place in a carbon registry are calculated from the rate of change in the volume of the stock (tonnes per hectare), converted to volume of carbon dioxide equivalent (tCO2e).

There is a clear need for precision and robustness in the data that are used to underpin soil carbon crediting systems. However, no internationally agreed standard exists for how and where soil samples should be collected, statistically analysed or verified. As a result, different sampling designs are being deployed to determine soil carbon without regard to their underlying statistical assumptions or behaviours. There is also little understanding or appreciation within the carbon markets of the extent to which the choice of sampling protocol and sample location can affect soil carbon estimates and their subsequent valuation.

This study investigated the influence of different in-field sampling protocols on estimates of soil carbon within three fields located on an organic farm in Devon, UK. The protocols tested include simple random, stratified, conditional Latin hypercube, W, and grid sampling. Three neighbouring fields, each approximately 3 ha were sampled over a period of two days. A total of 105 samples were collected, comprised of seven samples per sampling method per field; the soil organic carbon (SOC) results from the laboratory analyses were examined using a range of statistical methods.

Comparisons of the mean SOC derived from the different protocols showed significant differences, varying by up to 16%, the equivalent of a within-field difference of 197 tonnes CO2-e. The results also confirm that SOC can vary significantly over short length scales.

To deliver robust and reliable estimates of SOC stocks and changes over time, sampling approaches thus need to be able to capture and account for spatial and temporal variability

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across short length scales. For greater transparency, protocol dependent characteristics, biases and limitations should also be reported.

Given the dependence on baselining and measurement of soil carbon stocks, GHG (greenhouse gas) removals and carbon sequestration, greater levels of transparency and reporting of data quality and sources of uncertainty is necessary. A variation of 16% between methodologies, as detected in this study, is very problematic for the rapidly expanding Compliance and Voluntary Carbon Markets. We therefore recommend that there needs to be greater transparency about the sampling protocols used in determining soil carbon measurements and that potential errors arising solely from the sampling approach are considered to ensure carbon estimates are as precise as possible.

Keywords: soil carbon, soil sampling, carbon removals, sample protocol, method comparison, SOC measurement

P - 35

Responses of microbial carbon metabolism and function diversity in heavy metal contaminated soil after washing with biodegradable chelators

By **Hanqing Lin**, Shirong Zhang, Guiyin Wang
University of Reading

In the quest for sustainable soil remediation, the use of biodegradable chelators has gained recognition, offering an eco-friendly alternative to traditional methods. This research explores the impact of biodegradable chelators, such as iminodisuccinic acid (IDS) and N, N–bis (carboxymethyl) –L–glutamic acid (GLDA), on the removal of cadmium (Cd), lead (Pb), and zinc (Zn) from soil.

The study reveals that GLDA and IDS can remove 25-75% of these heavy metals, enhancing the total value of carbon utilization by soil microorganisms. Moreover, the chelators significantly alter the ratio of carbon utilization by microorganisms in paddy soils. Carbohydrates, carboxylic acids, and amines/amides are the preferred carbon sources during the biodegradable chelator washing process. This research recommends the use of biodegradable chelating agents like GLDA and IDS as eco-friendly alternatives to traditional EDTA, ensuring effective remediation while preserving soil microbial function.

Key words: Heavy metal pollution, Biodegradable chelators, Soil remediation, Microbial community, Carbon metabolism, Functional diversity, Contaminated soil

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Revealing the influence of cover crops on soil microbial functionality in apple orchards

By **Rita Raja Noto**
Free University of Bolzano

Cover crops are a valuable source for feeding microorganism and micro-meso fauna and impact thus fundamental biogeochemical cycles in agricultural ecosystems promoting particularly carbon (C) sequestration. This study aims to assess the influence of various cover crop mixtures (Hühnerauslauf: mixture of low-growing grasses, Südtirolmix: contains a high proportion of legumes) on soil microbial functionality. The research unfolds across six distinct apple orchards located in South Tyrol, Italy each characterized by different agronomic practices, and is conducted in close collaboration with local farmers. Soil samples have been collected thrice yearly (spring, summer and autumn) at two depths (0-30, 30-60 cm). Soil microbial functionality has been investigated by determining soil respiration and selected enzyme activities. Preliminary findings suggest a distinct difference in soil respiration between topsoil and subsoil during the first two samplings (spring and summer). As expected, respiration levels are higher in the topsoil. Further, we did not find any significant differences in soil respiration among cover crop mixtures. Nonetheless, we are analysing the samples collected in autumn expecting differences among cover crop mixtures. The same occurs to the enzyme activities mainly related to the C cycle, which are being analysed. Understanding the effects of cover crops mixtures on the soil biological functions will help us to develop the base for agroecological based practices that promote C sequestration.

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C-cycling in grazed wetlands: effect of cattle and an antiparasitic drug in soil carbon stocks

By **Melisa Olivelli**
IIIA-CONICET-Universidad Nacional de San Martin, Argentina

Over the last 150 years enormous amounts of carbon have been lost from soil due to land use change. The carbon lost from soil has had a dramatic impact on the amount of carbon in the atmosphere and has escalated climate change. The World Health Organization (WHO, 2018) states antibiotic (AB) resistance as "one of the biggest threats to global health" (O'Neill, 2016 Review on AMR). When livestock are treated, ABs and other veterinary drugs can enter soils generating an enhancement of C-cycling in soils, contributing to GHG emissions and climate change. Issues of veterinary drugs use and land degradation conflate in Argentina, where wetlands are being exploited to support livestock production. This has led to wetland degradation and the influx of antibiotics and antiparasitics into the wetlands (Peluso et al., 2023, Environ. Res., 226, 115692). While there are many reports on soils stress, leading to C loss caused by AB inputs, no information was found for the widely used antiparasitic, Ivermectin. On a previous study we also analysed the environmental presence of ivermectin in three different soils from farms located in Delta del Parana, Argentina. Results indicated that all soils had ivermectin and its mobility in the environment was related to water soluble organic matter.

The aim of this work was to study the effect of cattle and ivermectin concentrations on C-cycling in soils with different hydrological regimes. In-field GHG emissions were measured in two different locations to evaluate the effect of livestock in soil carbon. GHG emissions were collected every 15 days, during 6 months, using a static chamber model and GC-MS was used for determination of CO2 and CH4. Mesocosms experiments were instated to investigate soil-ivermectin interactions in redox changing conditions, including the fate and potential bioavailability of the compound; and GHG emissions. Hydrological regime was simulated maintaining soil water up to 60% or 100% of the soil water holding capacity (WHC). Ivermectin was added to the soil in an environmentally relevant concentration (500 ppb) and systems were maintained for 3 months. GHG emissions were collected every 15 days. Samples were taken each month: organic matter was fractionated in soluble, free-labile and occluded-labile (water and heavy liquid fractionation, respectively). For partitioning of the contaminant, ivermectin was determined (HPLC-MS) in the soluble fraction (water extraction) or in the total soil fraction (solvent extraction).

Results indicated that the presence of ivermectin, enhanced the mineralization of organic matter and ivermectin mobility. Over time, the water soluble fraction increased in all soils treated with ivermectin indicating rapid degradation of organic matter. This led to an increase of GHG emissions. Mesocosms results evidenced the influence of these type of veterinary drugs in wetland soils and provide insight into the linkages between ivermectin bioavailability and the pressure antiparasitics exert on soil C stocks. Field GHG emissions indicated that livestock had a more negative effect on soil C when the soil was drier and in

more degraded environments where biogeochemical cycles are diminished. Establishing these linkages is novel and will support better livestock management.

Keywords: C-cycling, wetlands, grazing, soil carbon, GHG emissions, ivermectin, veterinary drugs.

Funded by: CONICET

Link to Poster

Impact of Climate-Smart Agriculture on Soil Organic Carbon Stocks in Cocoa Farming in Soubré, Cote d'Ivoire

By **Olufisayo Onawumi**[1], Youssouf Toure, Olorunfemi Akanbi
Forestry Research Institute of Nigeria[1]*, Pan Africa University of Life & Earth sciences*

Fertilizers in cocoa farms for the purpose of carbon sequestration, incentives are required. Production of cocoa has long been regarded as a factor in forest loss and an environmental problem. Researchers are looking into cocoa sustainability systems, especially agroforestry systems, as a way to slow global warming by storing carbon. However, the majority of agroforestry research has focused on cacao yield and forest management, and little is known about soil organic carbon (SOC) reserves. We conducted a study in the South West Region (NAWA) of Cote d'Ivoire to compare and quantify soil organic carbon stocks in agroforestry, organic fertilizer use, and traditional cocoa farming. In accordance with standard soil testing procedures, soil samples were collected at three different depths: 0–15 cm, 15 – 30 cm, and 30 -45 cm. In comparison to plantations where farmers did not practice sustainability programs, SOC was found to be higher in plantations where farmers did. In contrast to farmers who grow conventional cocoa, those who intercrop cocoa with shade trees (both fruit and non-fruit) on their plot are more likely to benefit from soil carbon credits. Growing shade trees and using organic fertilizers would help farmers growing sustainable cocoa trap more carbon. To encourage the planting and maintenance of shade trees and the use of organic.

Funded by: PAN Africa University of life & Earth sciences

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Root exudation effects on soil nutrient availability and litter decomposition in a mature English Oak Woodland; a mechanistic evaluation of climate change impacts

By **Johanna Pihlblad[1],** Liz Hamilton[1], Emma J Sayer[2], Iain P Hartley[3], Sami Ullah[1]

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2. Lancaster University

3. University of Exeter

With a warmer climate plant exudation rate of labile compounds into the soil, like carbohydrates, organic acids and amino acids are increasing and changing in quality. These changes will have cumulative effects on the soil nutrient availability, microbial community, and decomposition processes determining the fate of soil C.

Here we present data from a 6-month field experiment in a mature oak woodland located in Staffordshire, England, where we supplied a daily delivery of artificial root exudation cocktails of different concentration and quality mimicking observed changes in root exudation regimes under a future climate scenario (Birmingham Institute for Forest Research Free Air Carbon dioxide Enrichment). Exudation solutions were mixed weekly by combining two sugars, four amino acids and four organic acids commonly found in root exudates to three treatment levels: a baseline concentration of C and N (5% of estimated forest NPP), increased CN ratio, double baseline concentrations and a water control. The exudates were delivered by an Automated root exudation system (ARES) at the rate of 0.29 L/day through 24 drip points over a 1 m2 area with a blocked treatment design (n=4). We assessed soil respiration and nutrient availability continuously throughout the field experiment, whereas microbial biomass, enzymatic activity, and decomposition rates of soil, oak leaf, and root litter was assessed at the termination of the experiment after 6 months.

We hypothesise that the changes in exudation regimes will increase enzymatic activity in the soil and decomposition rates of the litter disproportionately favouring release of nutrients (N and P) to balance the stoichiometry of the microbial biomass. By investigating the relationship between plant exudation change with a changing climate and soil microbe, nutrient and decomposition response we aim to inform on driving mechanisms of the soil C balance in a future climate.

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Assessing soil C in urban forest environments

By **Jay Ryan**
University of Adelaide

Soil carbon (C) is a larger and more stable C storage pool than terrestrial biomass. Some trees are very effective in transferring C from the atmosphere to the soil, particularly soil under canopy. As a consequence, in environments containing a variety of trees, the distribution of soil C is patchy at the 1-10 m scale making it challenging to quantify at the larger scales relevant for carbon sequestration accounting. The aim of this study was to develop and test a process for assessing soil C in such environments. An initial set of 53 soil cores was collected in open spaces across the Waite Arboretum in Adelaide, Australia, which contains over 800 different tree species across 27 ha of parkland. Conventional soil C analysis indicated.

Variation in C concentration of the 0-10 cm soil layer through the 2-5% range with an average soil C concentration of 3.19%, considerably higher than the range of 1-2.5% in adjacent topsoils under agricultural management. A reliable model to predict soil C concentration from mid-infrared (MIR) spectra from further soils collected in the Waite Arboretum was developed using partial least squares regression (PLSR). Follow-up sampling targeted 144 soils collected in a radial pattern under and close to tree canopies and the soil C values obtained from MIR-PLSR prediction of these soils confirmed the open-space average (3.19%) is a substantial underestimate, with higher average values at half canopy (7.47%) canopy edge (5.10%) and twice-canopy distance (3.84%) for twelve selected trees of different species. Importantly, the elevation in under-canopy C concentration varied substantially from tree to tree.

This study highlights the challenge posed in assessing soil C in urban forest environments, confirms soil C storage is varies with tree species and demonstrates the value of using mid-infrared prediction in tandem with traditional chemical analyses for assessing soil C.

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Rail Network Regolith Soil Formation and Implications for Carbon Storage

By **Justin Thomas**, Astley Hastings, Jon McCalmont
University of Aberdeen

The rapid expansion of the UK rail network in the mid 19th Century had a profound effect not only on the cultural landscape of the nation but also the physical landscape through which they were driven. From the opening of the first passenger service in 1825, gangs of navvies created over 10,000km of routes by 1850 across the country and the network continued to expand to over 30,000km by the 1920s. The construction of track beds, embankments, cuttings and tunnels impacted the area within and often adjacent to the land owned by the rail companies. The foundation materials used were selected on cost and availability, promoting the use of line excavated rock and soil, local waste products such as clinker and ash, and rubble from local quarries. The effect was to create an anthropogenic regolith in narrow transport corridors across the country. Although the network has shrunk, particularly in the 1960's, Network Rail today run some 16,000km of route covering over 50,000 ha of land. To better understand the potential for carbon sequestration on Network Rail land, this study looks at the development of railway soils since construction and their carbon content. For ease of sampling, soil cores have been collected from the many thousands of kilometers of disused rail tracks in England, Scotland and Wales, their carbon content measured and potential controls on soil development and carbon storage assessed.

We find that thin humic rich soils have developed away from the track bed as vegetation has developed but that typically this is no more than a few centimetres. Carbon stocks are universally low irrespective of local bedrock, soil, structural type or location. There is a clear decrease in carbon with depth particularly into foundation material. As the soils on embankments and cuttings have developed over a relatively short period of 150 years, this work provides an insight into the morphology of soil formation and its carbon sequestration.

Link to Poster

Presenting time: 4 December 2023, 12:15 – 13:15

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Crop diversification and soil management legacy alter soil microbial traits that govern carbon and nutrient processing

By **Imelda Uwase,** Liz Baggs, Kate Buckeridge, Tim George, Eric Paterson
University of Reading

Background and objective

Crop diversification is one of the promising sustainable approaches to reduce the adverse environmental effects associated with conventional agriculture. Intercropping is a diversification practice of growing multiple crops simultaneously in the same field. Intercropping can modify the structure and activity of soil microbial communities, but whether intercropping modifies soil microbial functionality supporting agricultural productivity remains largely unexplored. This laboratory experiment investigated the responses of microbial functional traits associated with carbon and nutrient cycling and acquisition, such as carbon use efficiency (CUE), soil extracellular enzyme activities (EEA), and microbial catabolic diversity, to barley-pea intercropping growing in soils with contrasting soil management legacies. Physiological assays of these microbial characteristics indicate the potential for soil organic matter (SOM) retention and decomposition, highlighting their crucial role in maintaining the balance of carbon and nutrient retention and release within soils.

Methods

Plants in combination (barley-pea, barley-barley, pea-pea) were grown in soils with a history of conventional and sustainable management for 50 days under controlled laboratory conditions. Microbial CUE was estimated by the 13C isotope tracing method. Fluorometric assays were used to determine the potential activities of extracellular hydrolytic enzymes involved in C cycling (β-glucosidase (BG) and cellobiohydrolase (CBH)), N cycling (β-1,-4-Nacetylglucosaminidase (NAG) and leucine aminopeptidase (LP)) and P cycling (acid phosphatase (AP)). Microbial catabolic diversity was estimated using MicroRespTM.

Results

Microbial CUE was unaffected by intercropping treatment, but soil enzymatic activity and microbial catabolic diversity were responsive. Compared to the average of barley and pea monocrops, barley-pea intercropping reduced the potential activities of CBH, NAG and AP but increased those of BG in conventionally managed soils and LAP in sustainably managed soils. Intercropping altered microbial substrate utilisation profiles and increased microbial catabolic diversity relative to barley and pea monocrops. Soil management legacy had stronger effects on microbial traits than crop combination. Regardless of crop combination, sustainable management enhanced microbial CUE, soil enzyme activities and microbial catabolic diversity relative to conventional management practice.

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Conclusion

The results support the hypothesis that intercropping and management practice affect carbon and nutrient cycling processes in soil through differential effects on microbial functional traits. These findings show that barley-pea intercropping modifies the catabolic abilities of soil microbial communities to decompose various organic substrates while maintaining the efficiency of soil microbial communities to utilise these substrates for their growth and metabolic activities. Moreover, the results emphasize the predominant role of soil management (legacy) in shaping these microbial traits, surpassing the effect of crop combination. These findings imply that intercropping and sustainable management practice alter the balance between the release and retention of carbon and nutrient in soils, potentially favouring retention.

Keywords: Crop diversification; cereal-legume intercropping; Sustainable soil management; Carbon use efficiency; Hydrolytic enzyme activity; Microbial functional diversity; Substrate utilisation profile, MicroRespTM

Funded by: The Gatsby Charitable foundation

Link to Poster

Presenting time: 4 December 2023, 12:15 – 13:15

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Leys, organic amendments and reduced tillage lead to carbon accumulation in farmland soils: A rapid evidence assessment

By **Catriona Willoughby**[1], Pippa Chapman, Guy Ziv
University of Leeds[1], University of York

There is a growing policy interest in promoting soil carbon accumulation, with evidence-based quality assurance carbon codes already developed in the UK for woodland and peatland. However, much of the land in the UK is agriculturally managed, and while the carbon sequestration rates associated with the implementation of individual farm management practices have been investigated, the potential sequestration rate associated with adopting multiple management practices is poorly understood. Furthermore, results may be confounded by soil and climate heterogeneity. It is therefore necessary to enhance our understanding of which farm management practices are most effective in promoting soil carbon accumulation for different UK pedo-climates. This study aimed to review the evidence base for the soil carbon benefits of various farm management practices from the scientific literature. We carried out a rapid evidence assessment of published academic literature from the UK and areas of Europe with a temperate climate, using "carbon", "soil" and "agriculture" as keywords. We extracted data pertaining to carbon content, carbon stocks and carbon sequestration rates, climate, soil properties, organic amendments, tillage depth and soil sampling depth.

To date, data from 35 studies have been analysed, from which 452 carbon accumulation rates were extracted. The rates represented eight agricultural management practices: agroforestry, alternative cropping, cover crops, grassland management, leys, organic farming, organic amendments and tillage depth. There was an imbalanced spread of management practices considered in studies investigating carbon accumulation in farming systems, with 35 % of studies focused on tillage and 20 % focused on alternative cropping. Significant differences were found between the treatment groups ($H(7) = 48.51$, $p = <0.01$). The carbon accumulation rates between different treatment groups suggest that organic amendments and leys have the greatest potential for enhancing carbon accumulation rates in agricultural soils (mean accumulation of 0.23 and 0.25 t C ha -1 respectively). Cover crops and alternative cropping had the smallest effect upon carbon accumulation rates (mean accumulation of -0.6 and - 0.04 t C ha -1 respectively). We found that tillage depth was a key driver of soil carbon loss, with mean annual losses of - 2.4 t C ha -1 in farming systems with deep tillage compared to those with zero tillage. The median length of the studies included was 9 years; this affected our calculated carbon accumulation rates as in shorter (1 - 20 year) studies (which most often considered agroforestry and alternative cropping), rates of accumulation were much higher than in longer (> 20 year) studies, which focused on the addition of organic amendments. The evidence shows that reducing tillage depth, including ley periods in arable crop rotations and application of organic amendments were the most promising management practices for increasing soil organic carbon stocks. There are limits to the amount of carbon that can accumulate in farming systems in the long term, and the capacity

of farmers to maintain crop yields while enacting carbon-friendly management practices is a key consideration for future work in this area.

Link to Poster

Presenting time: 4 December 2023, 12:15 – 13:15

Soil Health: Oral Abstracts

Developing a soil monitoring framework for Scotland

By **Nikki Baggaley,** Allan Lily, Ken Loades
James Hutton Institute

New policies on climate, nature, and agricultural reform are placing ever greater emphasis on the need for monitoring, reporting, and verification (MRV) of changes in soil properties and condition, both in the UK and internationally. However, there are many different sampling and analytical methods used to assess soil health and condition and it is not known if they are comparable with each other or how accurately they reflect the soil health attributes.

Over the years there have been many reviews and reports written around suitable soil indicators with no real attempt to implement a soil monitoring scheme nationally. Work from the National Soil Inventory of Scotland resampling in 2007-9 assessed potential soil health indicators for Scottish soils but there are many research questions that still need to be answered for the development of a soil monitoring framework. Questions include how data from different sampling campaigns, and methods, can be integrated to provide a robust picture of changes in soil health over time and also the need to match indicators to different soil types and land uses.

The presentation will summarise current work on developing a soil monitoring framework for Scotland beginning with a review of potential indicators used within existing national, European, and sector specific datasets and how these can form the basis for assessing change in Scotland's soils. Specifically, we will focus on an analysis of data on soil carbon stocks, soil hydrological properties, and observations of soil erosion. This will include results from analysis of the European data sets (LUCAS and BioSOIL) as well as the National Soil Inventory of Scotland (NSIS) and soil hydrological properties from SoilBIO, an Innovate UK funded project containing soil physical data from across the UK.

Key Words: Soil Health, Monitoring, National Framework

Funded by: Scottish Government

Presenting time: 5 December 2023, 13:45

Comparative geochemistry of urban soils in the south of Ireland

By **Hannah Binner**[1,2], J. Weatherill1[2] and M.E. McNamara[1,2]
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2. Environmental Research Institute, Ireland.

Urban soils are prone to accumulating metals over time. This is caused by the proximity of urban soils to roads and industry, among other sources. In Europe, many urban areas show metal enrichment linked to anthropogenic activity. The public are in contact with urban soils on a regular basis. This potentially has adverse effects on human health, especially in locations with enrichment of metals that are systemic toxicants, such as As, Cd, Cr, Hg and Pb. Despite this, most European countries lack dedicated policy on urban soils. In Ireland, data on urban soil metals exist for only two urban centres (Dublin and Galway), both of which show anthropogenic enrichment of metals. Cork city is an ideal target for study of urban soil metals because its history includes over 200 years of industrial development, and its urban parks include former brownfield and industrial sites. Here, we measured concentrations of urban soil metals for ten sites in Cork city using a portable XRF (X-ray fluorescence) analyser. In addition, ten sites in County Wexford were sampled in the same way to serve as a reference for a potential geochemical baseline for Irish soils. Our results show that at all ten Cork sites, Pb is highly enriched in soils, with concentrations up to ten times greater than natural background levels. Fe, Mn and Zn are moderately enriched at each of the ten Cork sites, with concentrations typically between two to five times natural background levels. Metal concentrations are systematically higher at sites in the Cork city centre compared to suburban sites. In County Wexford, Pb is also high to moderately enriched at nine of the ten sites. As, Ti and Zn are moderately enriched at each of the ten Wexford sites. In Wexford County, urban soils closest to the urban centres of major towns generally show higher metal concentrations compared to less urbanised areas. Although the urban soils in Wexford are overall lower than those in Cork, the patterns of metal enrichment are similar to those seen in urban soils elsewhere in Europe.

Future EU policy is essential for the assessment of urban soils and for the remediation of contaminated sites. This research has already helped to inform the Geological Survey of Ireland and the Government of Ireland Department of the Environment, Climate and Communications to help facilitate the implementation of data-driven legislation, through conducting an evidence review for soil policy in Ireland, funded by the EPA Ireland. It is anticipated that a relevant soil policy will come into effect in the coming year, which will aid the assessment and remediation of contaminated urban soils across Ireland.

Keywords: urban soil, geochemistry, metals, PTEs, Irish soil

Funded by: iCRAG (SFI Research Centre for Applied Geosciences) and GSI (Geological Survey Ireland)

Presenting time: 5 December 2023, 14:00

A review of useful soil health indicators for Scottish agricultural soils

By **Rose Boyko**, Paul Hargreaves, Christine Watson
Scotland's Rural College (SRUC)

The maintenance of a sustainable and productive soil is of significant importance to meet future net zero targets and food security demands. The benchmarking and analysis of soil health is often measured through the three pillars of soil indicators: chemical, physical and biological. Prior to this research, an investigation into the indicators best adapted to the Scottish pedo-climate (Northern European, maritime, temperate) had been limited. The aim of this research was to source any routinely used indicators from research from similar systems which could provide a bespoke set of soil health indicators for Scotland. Using a Scopus database search of "temperate, soil, quality and indicators" from the year 2000 to present, papers were grouped into those that were (a) directly relevant to the Scottish climate and vegetation/agri systems, (b) some relevance, and (c) not directly relevant. Of those directly relevant papers, the most cited and prevalent indicators were chemical, followed by physical, then biological, which had the fewest variety and regularly cited indicators. Of the directly relevant papers, the most cited chemical indicators were soil organic matter (SOM) (67.9%), pH (58%), total/available phosphorus (48.1%), total nitrogen (43.2%), available potassium (38.3%), "other soil chemical characteristics" (35.8%), and micronutrients (29.6%). Other chemical characteristics included methods that may be useful outside of the top indicators such as C:N, cation exchange capacity, and conductivity, among others. Of the directly relevant papers, the most cited physical indicators were "other soil physical characteristics" (48.1%), bulk density (37%), penetrometer resistance (14.8%), soil aggregates (13.6%) and soil structure (including VESS) (4.9%). Other physical indicators that may be useful included: macro, micro and ultra micro porosity, water holding capacity, and soil colour, among others. Of the directly relevant papers, the most cited biological indicators were microbial biomass (29.6%), nematodes (6.2%) and earthworms (1.2%). All other biological indicators fell below 1% of all indicators: PCR, macro, bacterial and microbial counts, indicator enzymes, nematode and microarthropod indices and diversity, and teabag decomposition rate, among others. Vegetation yield or quality was a suggested indicator to be taken into consideration, as 59% of directly relevant papers utilised these. Additional vegetation indicators may include root biomass and structure, plant height, enzyme activities, field position, litter depth, bare soil, and root health ratio. As SOM is a significant indicator and currently of high interest in research, automated sensors are suggested for Scottish uptake for routine analysis.

The use of automated sensors in the field still appears to be at the development stage, with the main focus being the quicker analysis of samples once collected. These include soil colour, visible, near or infra-red spectroscopy, laser-induced breakdown spectroscopy, inelastic neutron scattering and diffuse reflectance. The use of biological indicators has scope for development, improvement and uptake according to the literature for use as soil indicators. This research established that easy and novel indicators in all categories of soil

Presenting time: 5 December 2023, 15:15

health needs further investigation for incorporation into routine assessments with established criteria for good, moderate and poor health related to particular soils and use.

Funded by: RESAS (Scottish Government)

Presenting time: 5 December 2023, 15:15

Linking soil health measured by enzyme activity and oak tree health

By **Luci Corbett**
University of Reading

Acute oak decline (AOD) is an emerging disease that affects mature native oak trees in the UK. Although visible symptoms such as vertical black weeping stem bleeds and sometimes the presence of the buprestid, Agrilus biguttatus, exit holes are diagnostic, the causes of decline syndromes are complex and involve multiple factors. Although much progress on understanding the causes of AOD has been made, all the factors and their interactions are not yet fully understood, but it involves both biotic and abiotic factors.

Environmental predisposition factors such as drought and nitrogen deposition are abiotic drivers thought to be placing oak trees under stress, rendering them susceptible to attack by opportunistic biotic factors. Previous work has shown that soil nutrient status between AOD symptomatic and non-symptomatic trees, differs. This suggests that changes in the soil microbial activity rates that mediate biogeochemical processes, may either contribute to, or result from, the progression of oak decline.

Potential microbial activity can be measured using assays for specific enzymes, which act as catalysts in microbially mediated biogeochemical processes in soil (for example recycling plant-available mineral nutrients; decomposition and stabilization of leaf and root litter-derived carbon) to give an indication of soil health and wider ecosystem function. When analysed in oak rhizosphere soils these sensitive indicators have already been shown to be affected by changes in environmental conditions such as drought and nutrient stress and may be able to give early warning of, or indicate susceptibility of a tree to AOD.

A 4 year study is underway and is in its 2nd year at Writtle, Essex where soil health and oak tree health are being monitored using soil enzyme activity and phenotypic features in a cohort of 30 trees with varying degrees of AOD symptoms.

Soil health is being assessed by measuring potential enzyme activity using fluorometric assays in rhizosphere and bulk soils. Hydrolytic enzymes, related to the decomposition and nutrient cycling of carbon, nitrogen and phosphorous, namely B-Glucosidase, N-Acetyl Glycosaminidase (NAG), Leucine Amino Peptidase (LAP) and Phosphatase (P) will be determined. Other soil chemical indicators such as pH, nitrate and ammonium (KCl extraction), available P (Mehlich extraction) and labile C (hot water extraction) are being determined in both Spring and Autumn. Key results from the mid-point of the study where relationships between soil enzyme activity and tree health will be presented.

Key words: Acute oak decline (AOD), Enzyme activity, Fluorometric assay, Phosphatase, B-Glucosidase, N-Acetyl Glycosaminidase (NAG), Leucine Amino Peptidase (LAP), Soil health, Ecosystem function, Labile C

Funded by: Forest Research

Presenting time: 5 December 2023, 15:30

Investigating soil health during conflict

By **Dr Felicity Crotty**[1,2], Rebecca Smith[2], Dr Olena Melynx[3], Prof Nicola Cannon[2], and Prof Mark Horton[2].

1. Agriculture and Land Team, Ricardo Energy & Environment, Harwell
2. Royal Agricultural University, Cirencester
3. Sumy National Agrarian University, Ukraine

The military invasion of Ukraine in February 2022 has led to large areas of farm land becoming degraded, possibly contaminated and in general of poor soil health. This war degradation can be from obvious causes like mines and bomb craters but can also be due to compaction (from tanks travelling over the land in unsuitable conditions), chemical pollutants (like diesel or heavy metals from shelling) or even just leaving the soil bare which can lead to erosion. As farming during wartime is ongoing, assessment of soil health and remediation should also be immediate and ongoing. Using UK military sites, we investigated the impact of bombing on soil whilst in the UK, to pilot the methods to be implemented in the Ukraine as part of Royal Agricultural University's collaboration with Sumy Agrarian University. Bomb crater dimensions will be impacted by trajectory and size of bombs as well as the type of shell and possible contamination this could cause. Soil samples were taken from military areas on Salisbury Plain and soil physical and chemical measurements were taken to understand what contamination may have occurred. Recently bombed areas were sampled alongside a range of historic craters.

Results show that signs of military activity are still detectable in soil, in both recent and older samples. Farmers need to know the level of soil degradation that has occurred on their land, both in terms of human health and quality of food within the supply chain, but also to understand what crop yields to expect and look at ways to improve them. This is important both in terms of crop health but also for sustainable agriculture. During restoration activity of conflict zones, the emphasis is on decontamination rather than considering the long-term use of the area. To restore farmland to achieve sustainable farm management and a return to high yielding crops the overall soil health needs to be considered and this concept and the necessary methods to achieve this is far greater than just the remediation phase.

Keywords: Soil Health, Contamination, Bombturbation, Restoration, Soil Health Assessment

Presenting time: 5 December 2023, 14:30

Development of soil health benchmarks for managed and semi-natural landscapes across Great Britain

By **Christopher Feeney**
UKCEH

Efforts to improve soil health require that target values of key soil properties are established. Currently, no agreed targets exist but providing population data as benchmarks is a useful step to standardise soil health comparison between landscapes. We exploit nationally representative topsoil (0-15 cm) measurements to derive soil health benchmarks for managed and semi-natural environments across Great Britain. In total, 4,587 soil organic matter (SOM), 3,860 pH, 2,908 bulk density (BD), and 465 earthworm abundance (EA) data points were used to assess soil health at national scale. As soil properties are sensitive to site-specific characteristics, data were stratified by habitat, soil type, and mean annual precipitation, with benchmarks defined as the middle 80 % of values in each distribution. This process yielded 135 unique benchmarks. Unsurprisingly, the biggest differences in SOM, pH and BD benchmarks can be seen when comparing carbon-rich soils between the arable & horticulture (4.5-11.2 % SOM; pH 5.2-7.7; 0.85-1.35 g cm-3) and upland wetlands (20-96 % SOM; pH 4-5.3; 0.06-0.3 g cm-3) habitats. Medium loamy-textured soils are the most common soil type for which EA data were reported, and the greatest average (17) and range (3-36) of recorded counts occurred on modified / improved grassland with this soil type. Shallow mineral soils tended to be the most alkaline with the lowest BD (bucking the usual trend of BD increasing with pH), which reflects the dominance of calcareous rendzina soils that are resistant to compaction. Normalising benchmark ranges by medians revealed soil health indicator benchmark widths increased in the order: pH then BD, SOM and EA, whilst width generally increased with decreasing land management intensity. Arable and horticulture and improved grassland exhibited among the narrowest benchmarks for SOM, pH and BD, yet the widest EA benchmark, suggesting additional drivers impact biological indicators compared to physical and chemical indicators. Woodlands exhibited among the widest pH and SOM benchmarks, reflecting the diversity of woodland types and management intensities.

Upland wetlands had the widest BD benchmarks, an important consideration when determining carbon stocks. According to the most recent UKCEH Countryside Survey years (2007 and the ongoing 2019-23 campaign), East Anglia currently possesses the most disproportionate amounts of soils with indicator values outside the benchmarks. This includes the highest proportions of below typical SOM (19.2 %), above typical BD (17.4 %) and pH (39.1 %), and the smallest proportions of above typical SOM (2.4 %), and below typical BD (5.8 %) and pH (2.3 %). This is revealed even after land use, soil type and rainfall have been considered, which underscores just how urgently soil health needs to be improved here. We have developed a new webtool (https://connect-apps.ceh.ac.uk/soilhealth/) to communicate our results to the public, with the intention of encouraging landholders to compare their soil's health against our benchmarks and determine whether they need to improve management locally.

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Key words: Soil organic matter, pH, Bulk density, Earthworm abundance, Ecosystem services, Land use, Land management, National monitoring

Funded by: Natural Environment Research Council (NERC) award number NE/R016429/1 as part of the UK-SCAPE programme delivering National Capability

Presenting time: 5 December 2023, 14:15

Impacts of mineral-based construction and demolition waste on soil functions and ecosystem services

By **Dr Angeliki Kourmouli**, Carly Stevens, John Quinton
Lancaster Environment Centre

Over half of the world's population live currently in urban areas with future projections estimating an increase to 68% by 2050, with an additional 1.2 million km2 of land converted to urban areas by 20301. Poor practice or malpractice in the construction industry, lack of established processes and lack of practitioners to undertake surveys assessing soil health prior to a development, as well as laws and policies loopholes are key factors in soil loss during construction. Over 90% of the soil coming from construction and demolition sites is considered inert and thus no threat to humans and the environment, but millions of tonnes of soil are being disposed of in the landfill2. Moreover, there are policies in place advising multiple recovery pathways for construction soil (eg. agricultural and ecological improvement schemes)3 that should take precedence, however, the most widely used recovery pathway is for civil engineering purposes.

Urban soils are often overlooked but they play a major role in humans' lives as the loss of soil functions can have not only disastrous consequences (eg. loss of soil's water infiltration function can cause increase flooding risk) but also huge financial repercussions. Construction inadvertently impacts soil health and functionality, due to soil loss, compaction, sealing, contamination, soil carbon loss, and soil biodiversity loss. The current approach for assessing the effects of a development on land and soil is restricted to the protection of biomass soil function for food, fibre and timber production4. The structural resilience of soils to damage when they are moved and reused is also considered in the context of protecting the same functions. Other soil functions that are important in local and national context (such as the hydrological function), as well as carbon storage and soil biodiversity in the global context of maintaining healthy ecosystems and mitigating climate change, are completely ignored.

The aim of this study is to assess the impact of three major mineral-based construction materials (concrete, brick and plasterboard) on soil multifunctionality and ecosystem services under future climate events. The materials were mixed with soil in 6 different addition treatments (5, 10, 20, 30, 40, and 50% material addition) and were maintained for 5 months in three different moisture contents (10, 25 and 50%). Soil moisture, total carbon and nitrogen, microbial biomass carbon and nitrogen, ammonium and nitrate, nitrogen mineralisation rate as well as microorganism community structure and abundance were measured on the first and the last day of the experiment, whereas soil respiration was measured on day 1, 15 and 30 and thereafter once a month until the end of the experiment.

References

1 https://www.worldbank.org/en/topic/urbandevelopment/overview.

2 Defra (2021) ENV23 - UK statistics on waste data.

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3 Environment Agency (2021) – Guidance on waste suitability for deposit for recovery

4 IEMA (2022) – A new perspective on land and soil environmental impact assessment

Funded by: UKRI

Presenting time: 5 December 2023, 15:45

FixOurFood: The impact of regenerative farming on soils in Yorkshire

By **Ruth Wade**
University of Leeds

We must continue to produce food to meet the demands of our increasing population but our current agricultural practices are degrading the environment, causing soil quality decline, water pollution, greenhouse gas (GHG) emissions and biodiversity loss. 33% of UK soils are assessed as degraded where 3 m tonnes of topsoil is eroded each year, with intensive agricultural practices associated with the loss of 60% of soil carbon. Furthermore, agriculture is responsible for 10% of UK's GHG emissions, over 50% of methane emissions and 75% of N2O emissions.

Regenerative farming seeks to address the historic global decline in soil stocks and fertility, carbon and nitrogen sequestration, terrestrial biodiversity and water quality, as well as offer increased agricultural productivity with social benefits. We present current opinions, opportunities, activities and challenges associated with regenerative agriculture with exemplars from Yorkshire in the North of England. Combinations of practice-based options such as mixed crop cover, novel livestock-crop rotations, greater crop diversity and reduced tillage, are being trialled at the University of Leeds farm to quantify the impacts of the regenerative farming practices on soil quality, crop production, GHG emissions and profit. This work aims to determine the impact of regenerative farming changes on whole-life cycle GHG emissions, long-term profitability and environmental sustainability.

Key words: Regenerative farming, soil health, reduced tillage, mixed cropping, herbal leys

Funded by: UKRI

Presenting time: 5 December 2023, 16:00

Soil Health: Poster Abstracts

Cumulative effect of PGPR and L-tryptophan on the growth and yield of bitter gourd

By **Muhammad Zaid Azhar**
University of Agriculture Faisalabad

The use of chemicals to enhance plant growth and yield is unsustainable and has led to over-reliance on harmful substances that harm the soil health, environment and threaten human health as well. The chemical fertilizers result in the acidification of soils or the change in pH of soil, reduced organic matter content, reduced beneficial microbes, stunted growth of plants, and damaged soil crust leading to release of greenhouse gases. A more sustainable, alternative approach needs to be adopted in the future keeping soil health under check while enhancing plant growth. The use of plant growth promoting rhizobacteria and plant growth regulators can be very impactful. A pot trail was conducted during the period of September-December 2022, to evaluate the "cumulative effect of PGPR and L-tryptophan on the growth and yield of bitter gourd". The experiment consisted of two factors: as- Factor A: seed coating (with PGPR and L-TRP, solely and in combined form) T1: control (coating with uninoculated media), T2: PGPR, T3: L-TRP (10-4M), T4: PGPR+L-TRP , Factor B: soil application (of PGPR and L-TRP, solely and in combination, 30ml each) T5: control (water application), T6: PGPR, T7: L-TRP (10-4M), T8: PGPR+L-TRP. All the treatments were replicated three times in a completely randomized design (CRD). Recommended dose of fertilizers was used, and soil application of the treatments was done at the flowering stage.

Maximum results of number of branches 1.6-fold, number of leaves (33.32%), number of fruits (45.08%), fresh weight of fruit (112%), nitrogen (1.65%), and potassium (0.81%) was observed with the combined soil application of treatments as compared to control, while the combined application of treatments as seed coating resulted in high chlorophyll value (28.83%), and enhanced root length (126%) as compared to control. The lowest results among the treatment were observed in T3; seed coating of PGR, while the lowest values of all parameters were observed in control. So, the overall results reveal that, combined soil application of PGPR and PGR (L-TRP) was the best for achieving the higher growth and yield and hence can be adopted in future considering the food demand and soil health.

Presenting time: 4 December 2023, 15:20 – 16:00

P - 2

Microbial and Metabolite-based indicators for soil health

By **Michaela Bartley**
Atlantic Technological University Sligo

Healthy soils are essential in achieving climate neutrality, reversing biodiversity loss, providing healthy food and safeguarding human health. Yet, despite decades of soil research, and the production of advanced databases for land use type and soil properties (e.g. Corine land use and Tellus mapping programme), we still do not have adequate measures of soil that marry to provide an overall assessment of soil health. The newly launched Environmental Protection Agency (EPA) funded MMeSH project (Microbial and Metabolite indicators for Soil Health) aims to address this using a combined lipidomics, metabolomics, and genomics approach and comparing this with existing land use, soil type and geochemical Tellus datasets and maps. Specifically, we will use advanced mass spectrometry- and nuclear magnetic resonance-based techniques combined with taxonomic and functional gene metagenomics provide the most detailed characterisation of soil microbial biodiversity and metabolic activity of soils in Ireland. To validate new 'omics'-based indicators for soil health, we will use a suite of biological and chemical tests, including soil pH, phosphorous, potassium, and minor element composition, total soil organic matter (SOM), soil respiration, autoclaved-citrate extractable (ACE) protein.

Funded by: EPA, GSI

Presenting time: 4 December 2023, 15:20 – 16:00

P - 4

Soil health scorecard: a practical framework to monitor soil health on farm

By **Amanda Bennett**
AHDB

Any soil management intervention may affect soil health, including drainage, cultivations, crop rotation (length and diversity of species), liming and use of mineral and organic fertilisers. Farmers and land managers looking to better understand their soils and the consequences of management can measure and monitor a range of physical, chemical and biological properties. The soil health scorecard provides an integrated framework for these measurements; it can facilitate a routine soil health check, help identify constraints to production, and support farmers and agronomists when evaluating changes in farming systems or soil management practices.

Benchmarks (threshold values) for a core set of soil health indicators were developed and validated as part of a five-year levy-funded programme of research and knowledge exchange*. Indicators on the soil health scorecard were selected through co-design with farmers and tested on a range of mineral soil types in cropping and lowland grassland systems. They include both in-field assessments (visual evaluation of soil structure and earthworm counts) and laboratory analyses from topsoil samples (pH, extractable nutrients, soil organic matter, microbial respiration and potentially mineralisable nitrogen). Where appropriate, benchmarks for specific indicators (e.g. earthworms, pH, soil organic matter) are differentiated according to cropping or grassland system. Furthermore, separate threshold values are provided for soil organic matter in cropping systems, according to rainfall region and soil type (light, medium or heavy soils).

Results of in-field assessments and laboratory analyses are presented in the scorecard using a 'traffic light' system. Indicators flagging red require further investigation, and management intervention may be required to address any issues identified. Amber results on the scorecard should be reviewed, possibly with more frequent sampling, whereas a green flag indicates that monitoring should continue on a routine, rotational basis and no immediate action is required.

For routine soil health monitoring, assessments should be made at the same point in a cropping rotation, when the soil has wetted up in the autumn, and at least one month after cultivations or addition of organic materials. Samples should be taken from a circular sampling site, around a geo-located point to enable returning to the same field position in future years. The sampling protocol and benchmark values for the scorecard indicators have been published and are available to download, along with 'how to' videos and a simple-to-use Excel tool to visualise scorecard results from individual fields.

*The soil health scorecard is an output of a partnership that included academic and industry research partners, farmers and levy boards.

Presenting time: 4 December 2023, 15:20 – 16:00

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Keywords: Agriculture, scorecard, monitoring, structure, pH, nutrients, soil organic matter, earthworms

Funded by: AHDB and BBRO

Link to Poster

Presenting time: 4 December 2023, 15:20 – 16:00

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Land Degradation Neutrality Indicator: Enhancing the indicator with Soil Health data

By **Amy Thomas**, Laura Bentley, Chris Feeney, Stephen Lofts, Ciaran Robb, Ed Rowe, Amanda Thomson, Eleanor Warren-Thomas, Bridget Emmett
UK Centre for Ecology & Hydrology Bangor, GB

Land degradation affects around 25% of land globally. Preventing land degradation underpins most of the UN Sustainable Development Goals (SDG), particularly target 15.3. Over 100 countries have set Land Degradation Neutrality (LDN) targets. SDG indicator 15.3.1 provides a simple means of assessment, combining sub-indicators of productivity, soil carbon and land cover to identify area improving and degrading. Each sub-indicator represents multiple Ecosystem Services (ES), alongside biodiversity, therefore trade-offs between these can complicate assessment and create false positives. Due to response rates and data availability for the sub-indicators, LDN is best able to detect land cover change and declining yields. Soil health and soil carbon risk being omitted, along with other aspects of land condition.

Here we explore these issues for the UK, by incorporating land degradation data omitted by the core indicator and highlight key trade-offs. Critically, we demonstrate false positives from the trade-off between increased cropland productivity and soil carbon loss (11% from 1978 to 2007). The carbon loss trend would not be identified without additional survey data from Countryside Survey. These survey data also highlight further soil health degradation issues not reflected by core sub-indicators, including: 44% arable soils exceeding bulk density thresholds; 35% of Countryside Survey squares exceeding contamination thresholds for metals; pH trends with opposing outcomes for habitat and productivity. Additionally, including degradation data for critical load exceedance and erosion produced a switch from net area improving to net area degrading or degraded. With appropriate consideration of trade-offs and inclusion of additional data, the LDN indicator can help to assess and communicate progress on SDG 15.3.

Keywords: Land Degradation; EU Soil Mission; Sustainable Development Goals; Ecosystem Services; Soil Health; Trade offs

Acknowledgements: This work was supported by the Natural Environment Research Council award number NE/R016429/1 as part of the UK-SCAPE programme delivering National Capability. The Countryside Survey of 2007 is funded by a partnership of government funded bodies led by the Natural Environment Research Council (NERC) and the Department for Environment, Food and Rural Affairs (Defra), which includes the Centre for Ecology & Hydrology, Countryside Council for Wales, Forestry Commission, Natural England, the Northern Ireland Environment Agency, the Scottish Government, Scottish Natural Heritage, and the Welsh Assembly Government.

Link to Poster

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Soil Health Response of Cover Crop Termination Methods in Small-Scale Organic Vegetable Production

By **Michaël Brière,** Caroline Halde
Université Laval

The use of cover crops (CC) has increased in the recent years as it provides several benefits to the environment and the agricultural system. The CC are generally incorporated into the soil by tillage. However, in organic small-scale farming systems, CC can be terminated in a variety of ways such as mowing and tarping, or roller-crimping without soil tillage. Few studies have assessed the impact of CC termination methods on soil health in intensive vegetable cropping systems. We hypothesized that physical and biological indicators of soil health would improve, and crop yield would decrease in CC treatments terminated without tillage compared to tilled CC or without the use of CC. Our main objective was to assess the impact of CC terminated with or without tillage on soil health indicators and on vegetable crop yields. A 2-year field trial (2022-2023) was conducted in Saint-Augustin-de-Desmaures, QC, Canada on a clay loam soil. In Y1, the experiment consisted of a spring-seeded CC mixture of oat (Avena sativa L.) and field pea (Pisum sativum L.) followed by a broccoli (Brassica oleracea var. italica) crop. In Y2, a mixture of field pea and faba bean (Vicia faba L.) was followed by a beet (Beta vulgaris var. esculenta) crop. Treatments were arranged in a split-plot design with four blocks. The whole plot factor was CC termination methods (flail-mowed+tilled, flail-mowed+tarped, roller-crimped, and a control without CC) and the sub-plot factor was organic fertilization rates based on nitrogen provincial recommendations (100%, 50% and 0%). In the fall of the first year, soil aggregate stability, available water capacity, soil organic matter and active soil carbon contents were not affected by CC termination methods. Soil respiration rates tended to be greater in the roller-crimped CC treatment (0.070 mg CO2 g-1) than in the control without CC (0.056 mg CO2 g-1; P=0.098). Soil labile nitrogen contents tended to be lower in the roller-crimped CC treatment (186.3 kg N-NH3 ha-1) than in the flail-mowed+tilled CC treatment (229.5 kg N-NH3 ha-1; P=0.092). In the first-year trial, crop yield was reduced in no-till CC termination treatments. In the roller-crimped CC treatment, marketable broccoli head weights were, respectively, 39% and 36% lower than in the flail-mowed+tilled and the control treatments. In the flail-mowed+tarped CC treatment, marketable broccoli head weight was reduced compared to tilled CC. This 2-year trial will show whether no-till CC termination methods can maintain or improve soil health in organic small-scale farming systems in the short-term.

Keywords: cover crops, organic, small-scale farming, soil health, vegetable crops

Link to Poster

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Investigating the impacts on soil health and organic carbon stocks as a consequence of five different long term land uses, in a landscape of similar soil classification, in N. Ireland

By **Ricardo Buffara**
Presented by **John Gilliland**
Wageningen University & Research

The United Kingdom's commitment of reducing economy wide greenhouse gas (GHG) emissions by at least 68% by 2030, compared to 1990 levels, will require coordinated action by multiple sectors of the economy, including Land-Use, Land-Use Change, and Forestry (LULUCF); Agriculture; and Energy (Secretary of State for Business, 2022). Making effective policy recommendations on these fronts requires solid understanding of the underlying processes that affect the degree to which these sectors act as sources, or sinks, of GHG emissions. With such ambitious targets in place, the appeal of nature-based atmospheric carbon removal solutions has gained prominence in recent years. With soil carbon representing an estimated 25% of the total potential of natural climate mitigation solutions, roughly 6Gt of CO2-equivalent sequestered per year, it is regarded as an appealing way to increase carbon sinks and reduce emissions, whilst providing co-benefits via agricultural productivity (Bossio et al., 2020). Atmospheric carbon sequestration in soils, however, is a complex process that is highly context dependent. Understanding the dynamics of SOC and other soil health indicators, in relation to land use and management practices, at increasingly local scales, is needed to make more informed decisions. This study aimed to contribute to the current body of knowledge by (1) assessing if different long-term land uses impacted carbon stocks in different manners; (2) assessing at what depths these impacts took place, 0-15cm, 15-30cm, 30-60cm and 60cm to 100cm; and (3) investigating any possible correlations between soil carbon and a wide range of soil biological health indicators. This chrono sequential observational study was conducted on the mixed farm, Brook Hall, L'Derry, Northern Ireland. The farm is divided into multiple fields which host five distinctly different land uses, permanent grass last ploughed 55 years ago; short rotation willow coppice planted 28 years ago after 30 years of continuous arable rotation; silvo pasture of trees and grass established 120 years ago; 30 year old deciduous woodland planted into improved grassland; and 250 year old deciduous woodland; all managed by the same family for the last 150 years. This mixed land use landscape provided a unique opportunity to compare the long-term effects of these treatments between different fields of similar soil types (cambisols), textures (soils predominantly classified as silt loam) and climactic conditions (cloudy, cool, and wet) and our paper will lay out our findings of this comprehensive investigation.

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Differences in short- and long-term effects of saltwater irrigation on crops and soil microorganisms under a salinity gradient

By **Anais Chanson**
University of Lincoln

Saltwater contamination is a major contributor to agricultural soil degradation. With rising sea levels and increasing dry periods due to climate change, ground water in temperate coastal areas is becoming increasingly brackish, forcing growers to use part-saline ground water to irrigate their crops in summer. In arid areas, saltwater contamination has been reported to decrease crop yields, but the short- and long-term effects of saltwater contamination in temperate areas have not yet been thoroughly investigated, especially its effects on the soil microbial communities. Here we developed a 3-year experiment to study the yearly effects of different levels of saltwater irrigation on crops and soil microorganisms. After the first year, our results show that only the highest level of salinity (6 dS/m) has negative impact on crops and soil microorganisms, while the effects of the medium level of salinity (3 dS/m) on crops and soil microorganisms are not different from the control. However, after 2 years of experiment, our results demonstrate a drastic decrease in crop yield between the control and saltwater irrigation. This experiment will be very useful to growers to help them decide how much and for how long they can safely use part-saline water to irrigate their crops, in order to reduce their costs without decreasing their yield or harming the soil microbial community.

Funded by: UKRI

Link to Poster

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Can wildflower strips improve drought resistance and resilience in UK apple and pear orchards?

By **Max Davis**
Lancaster University

UK orchards may become more vulnerable to drought in the future, due to climate-change related increases in intensity and frequency of soil drying Therefore, understanding how management practices can influence resistance and resilience to drought is imperative. This study investigated the potential benefits of wildflower strips in increasing drought resistance and resilience in orchard soils. Soil cores from two orchard sites in Kent, U.K., each with plots containing alleyways with conventional- and wildflower-managed plots, were incubated at 21°C and exposed to a single round of drought treatment and rewetting. Carbon dioxide (CO2), representative of microbial respiration, was sampled prior to, and following drought treatment, and then immediately after, and two weeks after rewetting. Control cores were maintained at 75% field capacity (FC) throughout the experiment, whilst mildly droughted and severely droughted cores were reduced to 50% FC and 25% FC under drought treatment, respectively. Overall, respiration was not significantly different between plots within orchard sites, meaning that wildflower strips had no effects on drought resistance or resilience when compared to conventional alleyway management. Findings from this study raise questions around orchard management for improved resistance and resilience to drought, such as wildflower strip composition and establishment, and how management practices can influence soil structure and carbon cycling.

Funded by: BBSRC

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Presenting time: 4 December 2023, 15:20 – 16:00

A soil security assessment: the capacity and condition of nutrient cycling in the Hunter Valley

By **Sandra Joy Pabustan Evangelista**
University of Sydney

Soil functions provide a broad set of vital ecosystem services and play a pivotal role in addressing the eight global existential challenges that we face today– soil, water, energy and food security, climate change abatement, human health, ecosystem & environment and biodiversity protection. The ability of soil to act as a store and regulator of nutrients is considered one of soil's main functions, involving the gains, translocation, transformations, and losses among nutrient pools in soil, thus providing a range of ecosystem services. In many soils, anthropogenic forces have triggered a nutrient imbalance that have severe implications on the ecosystem and environment that exacerbate global issues. Soil security is a conceptual framework that incorporates the biophysical, socioeconomical and political aspects of soil to sustain soil functions and address the global challenges. Soil security to date has lacked a quantitative framework to assess soil functions and associated ecosystem services. This preliminary case study implements a new methodology to quantitatively evaluate the biophysical dimensions (capacity and condition [health]) and investigates the spatial variations in soil nutrient cycling among contemporary land uses and reference states (genosoils and phenosoils) as an indicator of soil security in the Hunter Valley, NSW, Australia. To achieve this, a pragmatic set of indicators are identified, and their respective utility graphs are devised based on existing literature. Potential indicators for capital, connectivity and codification are also proposed for future study. A number of methods are being investigated to aggregate indicators to produce individual dimension scores and to weight the dimensions for aggregation into a biophysical soil security index of a sample point. Results are then mapped across the Hunter valley.

Keywords: soil security, nutrient cycle, soil capacity, soil condition, soil fertility soil health, soil ecosystem services

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Size and Concentration - Dependent Effects of Microplastics on Soil Aggregate Formation and Properties

By **Zheng Fang**, Mark Hodson, Brett Sallach
University of York

Microplastics (MPs) in the soil environment have received particular attention in recent years due to their potential widespread ecological and human health impacts. Given that well-structured soil aggregates can contribute to the abilities of a soil to store carbon, resist erosion and support plant growth, evaluating the impacts of MPs on soil aggregates is important. A major knowledge gap is whether the effects of MPs on aggregates formation and properties depend on MP particle size.

This study investigated the effects of pristine polyethylene powders of different sizes (nominally <35, <125, <500 μm in sizes) and concentrations (0, 0.1, 1, 10%) on aggregate formation, MP incorporation, wettability, water stability, and particle density for two contrasting soils (Woodland soil, WS and Agricultural soil, AS). Control and treated soils were incubated for 75-days at 30 °C and underwent 4-9 wet-dry cycles. Aggregates were produced in all treatments. MP size and concentration impacted on the incorporation of MPs in the aggregates and this varied with aggregate size; the size distribution of aggregates also varied with MP size and concentration treatments. Aggregates produced in soil containing 10 wt% <35 μm MPs had significantly lower MWDs (mean weight diameters) than controls; other treatments showed no significant difference to the controls. The wettability of aggregates (>4 mm) reduced with increasing MP exposure concentrations; the extent of reduction increased as MP exposure sizes decreased. The density of the aggregates (>4 mm) significantly decreased with increasing MP exposure concentration, whereas MP size had no effect. Overall, the influence of pristine MPs on aggregates increased with decreasing size and higher concentrations. More research is required to determine whether ageing of MPs leads to a greater or less impact on aggregate properties.

Keywords: MPs, incorporation, soil structure, wettability, stability, particle density

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Modelling reveals that cropland soil erosion rates in Kenya could be reduced to natural baseline levels through terracing and carefully reduced tillage intensity.

By **Christopher Feeney**
UK Centre for Ecology & Hydrology

As agricultural land area increases to feed an expanding global population, soil erosion will likely accelerate, generating unsustainable losses of soil and nutrients and a significant decline in overall soil health. This is critical for Kenya where cropland expansion and nutrient loading from runoff and erosion is contributing to eutrophication of freshwater ecosystems and desertification. We used the Revised Universal Soil Loss Equation (RUSLE) to predict soil erosion rates under present land cover and potential natural vegetation nationally across Kenya. Simulating natural vegetation conditions allows the degree to which erosion rates are elevated under current land use practices to be determined in relation to a natural baseline. This methodology exploits high resolution (30 metre) digital soil maps and two vegetation cover maps to model topsoil (top 20 cm) erosion rates, lifespans (the mass of topsoil divided by erosion rate), and lateral nutrient fluxes (nutrient concentration times erosion rate) under both scenarios. We estimated the mean soil erosion rate under current land cover at 5.5 t/ha/yr, about 3 times the rate estimated for natural vegetation cover (1.8 t/ha/yr), and equivalent to roughly 320 Mt/yr of topsoil lost nationwide. Under present erosion rates, approximately 8.8 Mt, 315 Kt, and 110 Kt of soil organic carbon, nitrogen and phosphorous are lost from soil every year, respectively. Further, 5.3 % of topsoils (about 3.1 Mha), including within more than 25 % of croplands, have short lifespans (less than 100 years). Additional scenarios were tested that assume combinations of terracing and reduced tillage practices were adopted on all croplands to mitigate erosion. Establishing bench terraces with zoned tillage was found to be the most effective combination and could reduce soil losses by at least 75 % (up to 87.1 t/ha/yr in the worst affected areas). These reductions are comparable to converting croplands to natural vegetation, demonstrating that erosion rates of most agricultural soils can be brought down to natural baseline levels expected for a healthy soil. Extensive long-term monitoring of croplands with terraces and reduced tillage established is required to further verify our modelling results and assess potential co-benefits to soil health such as carbon storage and soil hydraulics.

Keywords: Soil erosion; Topsoil lifespan; Lateral nutrient flux; Potential natural vegetation; Terracing; Tillage; Modelling; Kenya; Croplands; Soil health

Funded by: Natural Environment Research Council (NERC) award number NE/X006247/1 as part of the NC-International programme delivering National Capability

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Presenting time: 4 December 2023, 15:20 – 16:00

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Should soil health scoring functions be based on soil texture? The case of agricultural soils in Quebec, Canada

By **Mélanie Gauthier**
Université Laval

Adoption of soil health indicators to access physical, biological, and chemical properties involves adapting their interpretation for a specific region using scoring functions, i.e., models that synthesize results into scores. In addition, interpreting soil health indicators is challenging since they are impacted by inherent soil properties such as texture. Therefore, the main objective of this study was to develop scoring functions of physical, biological, and chemical soil health indicators that provide quantitative and interpretive scores for agricultural soils of the province of Quebec in Canada. To achieve this goal, we determined the effect of soil texture on 15 soil health indicators using a dataset provided by 1166 soil samples divided between fine, medium and coarse textured soils collected in agricultural areas of Quebec. The scoring functions were developed from the means and standard deviations obtained for each soil health indicator by textural group. Three types of models have been developed: "more-is-better", "less-is-better", and "optimal-is-better". The results showed that 12 indicators were significantly influenced by soil texture and required to separate scoring functions, except for wet aggregate stability, penetration resistance of the surface hardness and pH. Overall, the results of this study led to the development of new scoring functions based on soil texture to interpret soil health indicators objectively and accurately for the benefit of Quebec farmers and agricultural stakeholders. The findings of this study demonstrated the need to adapt scoring functions to better account for the impact of regional factors on agricultural soils for the interpretation of soil health indicators.

Acknowledgements: This research was carried out with the financial support from the Prime-Vert program——3.1 Support for experimental development, technological adaptation, knowledge translation and transfer from the Minister of Agriculture, Fisheries, and Food of Quebec, and from the Mitacs Acceleration program.

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Effect of Potato peel waste biochar produced through different production techniques on soil properties and crop growth

By **Monica Isukapalli**
The University of York

In arid regions like the United Arab Emirates, where 80 % of the land is deserts, sandy soils represent a high proportion of the agricultural land but also presents significant agricultural challenges. The coarse texture of sandy soil contributes to low organic carbon content, poor water retention capacity, and nutrient leaching. Biochar is a carbon-rich organic material that has recently been used in arid soils to improve the soil's physical and chemical properties. In 2019, the total consumption of potatoes reached around 163kt in the United Arab Emirates (UAE) with a population of 9.771 million people. Each year, potato peel goes to waste as a by-product of potato consumption. Technological developments have provided various thermochemical processes for converting food waste into value-based products such as biochar. This poster focuses on the first experimental exploration of producing biochar from potato peel waste using a microwave reactor. Microwave reactors, due to higher heating rate compared to conventional methods, offer a more energy-efficient means of pyrolysing material to produce biochar. The potato peel waste for this study was provided by Mc Cain's and Tony's food and was pyrolysed at 3kW using a large-scale microwave reactor for 20 minutes. Two types of biochar were produced: partly charred biochar (PCB) and pure biochar (PB). When comparing the characteristics of the biochars, PB has higher C (56.22 %), pH (8.24) and higher concentration of cations (K, Mg, Ca and P) present on the exchange sites compared to PCB (46.56 %C and 4.87 pH). Wheat was grown in Lufa2.1 soil (88.2% sand, 8.4% silt and 3.5% clay) modified by adding <2mm of $CaCO_3$ (from crushed chalk rock) to the soil to give a total of 46 wt % $CaCO_3$, similar to that of UAE soils. The experiment comprised a control (C) and two treatments, soil loadings of either 5 wt % partly charred biochar (PCB) or pure biochar (PB). 50 ml of de-ionised water along with 50 ml of Hoagland solution was added every other day, and leachates were collected and analysed for nutrients, dissolved organic carbon and pH. After 12 weeks, soil nitrate, ammonium, cationic exchange capacity and soil pH were measured. PB amendments significantly increased leaf growth (20 % more than PCB and 7 % more than CB), total plant biomass (3.5 % more than CB and no difference was found in PCB), and water retention (11 % more than PCB and 10 % more than CB). Nitrate, phosphate, calcium, magnesium and manganese concentrations in the leachate decreased in the order CB > PCB > PB but leachate potassium was greater in PB (40.2 mg/L) than in PCB (26.6 mg /L) or CB (20.1 mg/L). The PB-amended soil had significantly higher concentrations of nitrate (6.1 mg/kg), ammonium (3.8 mg/kg) and cationic exchange capacity (268.89 cmol/kg) compared to both PCB (2.27 mg/kg, 1.56 mg/kg and 171.63 cmol/kg) and CB (1.16 mg/kg, 1.16 mg/kg and 155.74 cmol/kg). The characteristics of biochar play a crucial role in influencing Sandy soil's physical and chemical properties and consequently plant growth.

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Short-term Influence of Rice Husk Biochar Coupled with Organic Fertilizer for Sustainable Agriculture

By **Yun-Gu Kang**, Jae-Han Lee, Jun-Yeong Lee, Jun-Ho Kim, Taek-Keun Oh*
Department of Bio-Environmental Chemistry, College of Agriculture and Life Science, Chungnam National University, Daejeon 34134, South Korea

Organic fertilizer and biochar are considered eco-friendly materials as they are derived from natural resources, such as rice husk and soybean residues. In particular, biochar has gained significant attention as a soil amendment to mitigate climate change and achieve carbon neutrality. However, there is limited study exploring the combined effects of biochar and organic fertilizer in conjunction with inorganic fertilizer usage. This study assessed the short-term effects of organic fertilizer coupled with different concentrations of rice husk biochar in Chinese cabbage fields situated in two regions of South Korea. The combination rates of organic fertilizer and rice husk biochar were set at 9:1 (v/v, OF90BC10) and 7:3 (v/v, OF70BC30), and untreated (control) and only-organic fertilizer (OF100) treatments were included for comparison to access the influence of organic fertilizer and rice husk biochar. The results of the field experiments demonstrated that OF70BC30 produced the highest yield, with 2.21 kg/plant in Daejeon and 2.73 kg/plant in Yesan, respectively. Additionally, OF70BC30 improved the head height, leaf length, and chlorophyll content of Chinese cabbage. However, no statistically significant difference was observed among the OF100, OF90BC10, and OF70BC30 treatments. Furthermore, the application of OF70BC30 and OF90BC10 positively impacted the soil nutrient contents, particularly nitrogen and phosphorus, which are available for uptake by Chinese cabbage. Overall, the combination of organic fertilizer and rice husk biochar at ratio of 7:3 proves to be an effective strategy to improve Chinese cabbage yield and enhance soil fertility for sustainable agriculture.

Keywords: Biochar, Biomass recycling, Carbon neutral, Chinese cabbage, Organic fertilizer, Soil fertility, Sustainable agriculture

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How does intensive organic farming promote soil health in Québec, Canada?

By **Stéphanie Lavergne,** Caroline Halde, Derek H. Lynch
Laval University / Dalhousie University

The ability of organic cropping systems to sustain soil organic matter and soil health may vary with management intensity. Little research has examined, the impact of varying tillage intensity, organic fertilization type, cover crop use, and crop species on soil health within organic intensive field crop production systems under Canadian conditions. Soil health can differ across the same cropping system because of variations in pedoclimatic conditions and management practices. A field survey was conducted in the fall of 2019 and 2020 on 11 certified organic farms following an intensive three-year rotation without perennial crops in Québec, Canada. On each farm, soil health indicators (soil organic carbon [SOC], total nitrogen [TN], particulate organic carbon [POC] and nitrogen [PON], permanganate oxidizable carbon [POXC], autoclaved-citrate-extractable [ACE] protein, available water capacity [AWC], water-stable aggregates [WSA], pH, residual ammonium [NH4], residual nitrates [NO3] and mineralizable carbon [MinC]) were measured in a corn field, a soybean field, and a cereal field. A field margin was also included at each farm in 2020 as a reference site. As expected, soil health measured in the reference sites differed from managed fields with the highest SOC, POXC, ACE protein, AWC, WSA, and MinC. Most of the soil health indicators did not vary among crops, except for POC, PON, and WSA which were the lowest in the soybean fields likely due to frequent tillage and low crop residue associated with this crop. Correlation analysis between soil health indicators was conducted to better understand the relationships between soil health indicators. Positive correlations were observed between SOC, biological soil health indicators, and physical soil health indicators. Principal component analysis was conducted to describe the major patterns of variation in the data set. The first principal component (PC1) explained 27% of the variation and was dominated by soil health indicators related to soil carbon and nitrogen (SOC, TN, POC, PON, NH4, and MinC). The second principal component (PC2) explained 15% of the variation and was dominated by soil texture (clay and sand), POXC, and ACE protein. Univariate analyses were conducted to assess the effect of management practices on soil health indicators. Increasing the total number of crop species (cash crops and cover crops) in the three-year rotation was associated with high POC, PON, and WSA, whereas increasing the organic fertilization application rate (nitrogen applied over the three-year rotation) was associated with high MinC. Selected soil health indicators, such as POXC and ACE protein, were not sensitive to management practices in the context of this study. These results will help organic growers in choosing the best management practices to improve soil health in Québec, Canada. The information provided on the provision of ecosystem services (e.g., soil health) by organic farming systems is of value to the Canadian organic sector broadly in positioning the sector as proactive on the issues of soil health, which is being increasingly strongly promoted as priorities for agriculture at the provincial and federal level in Canada.

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Keywords: Soil management, crop diversity, organic amendment, cover crops, tillage, mechanical weeding.

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Critical evaluation of the new PARIO™ Plus method for soil particle-size analysis on a range of contrasting textural classes

By **Luis Lopez-Sangila,** Anna Fenelona, Linda Moloney-Finna, David Walla, Karl Richardsa, Karen Dalya

Environment, Soils and Land Use Department, Teagasc, Johnstown Castle Research Centre, Wexford, Y35 TC97, Ireland

Soil particle-size analysis (PSA), also known as soil texture, is one of the most important parameters to classify soils and characterize its physico-chemical properties, capabilities and vulnerabilities. The standard PSA methods (ISO 11277:2020), mainly the 'hydrometer' and 'pipette' methods, have been developed over a century and use a combination of sample prep techniques (soil organic matter oxidation, particle dispersion) and wet-sieving, together with the principle of particle-size sedimentation (Stoke's law), to calculate the percentage of sand, silt and clay in soils. From the two, the 'Pipette method' is accepted as the gold standard for providing accurate results, also when compared to alternative PSA methods (e.g., laser diffraction). However, both standard PSA methods are inflexible and time-consuming for lab operators (e.g., only the particle sedimentation process may take 6-8 hours for a normal 'pipette' procedure, even more for the 'hydrometer') and still prone to measurement errors during human intervention.

Here, we present results comparing the standard 'Pipette' with a new soil PSA method commercialized by METER™, known as PARIO Plus. This method is based on the same sedimentation principle (Stokes' law) and adopts the same assumptions and sample preparation than the standard methods (as per ISO/IEC 17050:2010). Instead of recording the particle weight of pipette aliquots, the PARIO Plus device continuously measures pressure and temperature changes (at 10s intervals) within the soil suspension column, enabling a continuous particle-size distribution curve spanning from 63 to 2 μm, via a specific algorithm (Durner et al. 2017. Water Resources Research). The manufacturer claims this new method allows for faster (2.5h) and almost unattended, automated silt and clay determinations, allegedly reducing measurement time by 70% and the overall methodological error to lower rates than the standard PSA methods cited.

We tested these claims by directly comparing the sand, silt and clay percentage results and procedures from the standard 'pipette' and PARIO Plus methods, on a range of mineral soils from Ireland and Spain with contrasting texture and soil organic matter (SOM%) contents. Linear regressions indicate a very strong, 1:1 correlation between PARIO Plus vs. 'Pipette' sand ($R^2 = 1.00$), silt ($R^2 = 0.99$) and clay ($R^2 = 0.99$) percentage, for 36 out of 37 samples, with one extreme alluvial soil (>60% clay; 0.3% sand) being a consistent outlayer after several repetitions. Occasional repetitions using several PARIO Plus devices indicated good reproducibility, although the devices require manufacturer recalibration every two years to ensure measure robustness. The PARIO Plus method requires significantly more sample (25 to 50g) to carry out the analysis, a figure which may double in order to calculate the weight loss from SOM oxidation (a required input for the PARIO Plus calculations). We evaluate the

suitability of the proposed SOC-to-SOM% conversion factor (1.72) used for estimating this weight loss and suggest an alternative conversion factor - based on empirical data - for more accurate measurements when SOC% or SOM% values are known.

Keywords: soil, particle-size analysis, texture, METER, PARIO, pipette, method, evaluation

Acknowledgements: This work was carried out entirely by public funding from the Department of Agriculture (Republic of Ireland), and none of the authors have any conflict of interests with METER™ whatsoever

Figure 1

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By **Aileen Lynch**
Queens University Belfast

Introduction and Background

This project is set within the soil nutrient and health scheme. The primary focus is how the microbial communities cycle biochemical nutrients, including phosphorous, carbon, and nitrogen. Investigating improved practices for nutrient acquisition in soils, thus increasing fiscal growth for Northern Ireland (NI) agricultural economies. Methane, the second most abundant GHG, is short-lived at 9.1 ± 0.9 years, as it reacts with ·OH radicals, but accounts for a quarter of the radiative forcing due to shortwave absorption (Olid et al., 2022, Staniaszek et al., 2022). Furthermore, the 14.7 ppb methane increase in 2020 was the largest in forty years, increasing twice as fast as CO2 (Jackson et al., 2021).

Commercial fertilisers or nitrogen-fixing microorganisms provide bioavailable nitrogen. Conijn et al. (2018) suggest that the global use of nitrogen is 60% in excess, resulting in nitrogen loss in the environment, freshwater systems, and the atmosphere. Nitrogen pollution can result in eutrophication, soil acidification, reduced biodiversity in terrestrial and aquatic ecosystems, and, through NOx depletion of the ozone, increasing global warming (Schulte-Uebbing et al., 2022). Zhu et al. (2021) meta-analysis of 60 different ecosystems demonstrated that nitrogen, particularly atmospheric nitrogen deposition, affects up to 14% of the carbon flux. Liu et al. (2022) used net ecosystem production to show that a 30% decrease in NOx reduced soil N deposition and, therefore, reduced net primary production.

Available phosphorus depends on solubility, erosional processes, biological availability, and anthropogenic methods (2022(Jusino-Maldonado et al., 2022)). Over 30% of soluble phosphorous is used on agricultural lands, which is thought to exceed 27 TgP yr−1 by 2050 (Zou et al., 2022). Consumption of soluble phosphorus exceeds reserves in many countries, resulting in a global phosphorous shortage and affecting global food distribution. The fertilisers used globally contain soluble phosphorous, resulting in a run-off of the nutrients to surface water. The higher concentrations of nutrients in the freshwater systems result in an acceleration of eutrophication, resulting in hypoxic ($O_2 < 2$ mg/L) and anoxic conditions ($O_2 = 0$ mg/L) (Seidel et al., 2021). Therefore, methods to introduce nitrogen, carbon and phosphorous into agricultural soils must be evaluated to increase their retention and reduce NOx, CH4, and CO2 release into the atmosphere.

Methods

Soil samples were collected from agricultural farms throughout Northern Ireland as well as sixty experimental plots in AFBI's Glen wherry site. Shotgun metagenomic sequencing was completed, and microbial taxonomy and abundance were quantified. Samples were also tested for over 47 elements including phosphorous, nitrogen, and carbon. Metadata was

collected regarding farm usage for the working farms, and fertilisation regimes were monitored within the Glen Wherry site.

The metagenome was analysed for known genes involved in solubilising insoluble phosphorous, capturing carbon, and nitrogen cycling. These genes and the microbial communities were then statistically analysed compared to the biochemical data and metadata provided. Aiming to gain better insight towards improving soil health, increasing productivity, capturing carbon, and setting a baseline for future soil monitoring.

Results/Discussion/Conclusion to be completed by the time the poster is complete.

P - 32

Modified Spent Coffee Grounds (SCG) and Biochar remediation of heavy metal contaminated urban soils in Glasgow

By **Prudence W Mhlophe**
University Of Glasgow

Heavy metals have long been a major source of soil pollution for both urban and agricultural soils. Different remediation methods have been implemented, some of which have proved successful, and others haven't. Earlier cleanup methods' efficacy was prioritised, while today's innovative methods are assessed for sustainability, cost, and multifunctionality. Due to the low cost of the biomass and its purpose as part of waste reuse, the use of spent coffee grounds for soil restoration is a great example of a sustainable remediation strategy. It has been demonstrated that using raw coffee grounds and biochar to amend and improve soil is successful. The purpose of this study is to investigate how used coffee grounds can help soils immobilise heavy metals. Used coffee grounds will be utilised in two ways: half will be converted into Biochar (by pyrolysis at 550°C), while the other half will be used raw. Both will undergo additional hydrogen peroxide modification after being pyrolyzed to produce biochar. Raw SCG, modified SCG, pristine Biochar, and modified Biochar will be the four main treatments. Each of them will be divided into application rates of 5% and 10%, with each treatment being repeated five times. 500g of contaminated soil will be combined with these treatments in a plastic column. The treatments will spend six weeks in a temperature-controlled space, receiving regular irrigations of distilled or deionized water, with the leachate being collected and tested. The top of the column will be covered, gas fluxes will be measured. After six weeks of growth, bok choy plants will be examined for the presence of heavy metals to determine the impact of the treatments on the bioavailability of heavy metals. Heavy metal concentrations in the soil/SCG/Biochar combinations will also be analysed.

P/S There should be some preliminary analysis results from FTIR, SEM and XRD analysis of the raw SCG, Biochar and both modified treatments by the time the conference comes. The poster will be updated with these.

Funded by: James McCune Smith Scholarships and GALLANT, Glasgow

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Presenting time: 4 December 2023, 15:20 – 16:00

P - 34

Linking soil biodiversity and geochemistry in Ireland (TellSoilBio)

By **Aisling Moffat**, Olaf Schmidt
University College Dublin

The EPA's State of the Environment Report 2020 makes it clear that Ireland faces persistent problems in relation to biodiversity loss and human-induced degradation of natural ecosystems. However, most knowledge on terrestrial biodiversity in Ireland and globally is based on research on above-ground taxa including higher plants, vertebrates and some aesthetic insects including butterflies and bees. Consequently, efforts to protect nature are also focused on these selected taxa. Below-ground biodiversity, by contrast, is a neglected, invisible, understudied and often cryptic portion of the overall biodiversity, and it rarely receives the attention it deserves. This urgently needs to change, given the essential roles of healthy, biologically active soils for providing food, supporting environmental and human health, and achieving climate neutrality.

TellSoilBio is a project conducted in collaboration with the Environmental Protection Agency of Ireland. This novel study will be the first of its kind in the Republic of Ireland to analyse soil biodiversity and geochemistry in parallel. The aim of the project is to establish the importance of soil geochemical properties as determinants of the distribution and diversity of soil microbial and faunal taxa, and determine if indicator species/elements can be deciphered. A sub-sample of 200 sites, previously sampled within the Tellus project, will be chosen based off their soil geochemical gradients. A regional survey of the north-east/west of the Republic of Ireland will be conducted, where soil microfauna (nematodes), mesofauna (enchytraeid worms), micro-arthropods (mites and springtails), along with 16S rRNA and ITS alpha and beta diversity will be analysed. Animal enumeration, identification and body-mass estimation will be done using a novel high-throughput approach based on image analysis of mixed communities. High-resolution images of each sample will be generated by a flatbed scanner and analysed by a computer-vision pipeline based on deep learning algorithms currently under development and peer-review. Abundances of bacterial, fungal and archaeal taxa in soil samples will be assessed using the RT-qPCR technique. Through identifying "hot" and "cool" spots in soil biodiversity in relation to soil geochemical patterns, the TellSoilBio project will assist us to understand natural patterns in soil biodiversity, as well as agricultural productivity and land use suitability relying on soil biological activity. Results generated will therefore aid in informing the development of a sustainable soil protection strategy in Ireland.

Keywords: Soil Biodiversity, Mesofauna, Macrofauna, Microbial diversity, Soil Chemistry, Spatial Analysis

Funded by: EPA

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Presenting time: 4 December 2023, 15:20 – 16:00

P - 36

Effects of a megafire on the arbuscular mycorrhizal fungal community and parameters in the Brazilian Cerrado ecosystem

By **Jadson B. Moura[1,2]**, Rodrigo F. Souza[1,3], Wagner G. Vieira-Júnior[1,4], Leidiane S. Lucas[5,6], Jose M. Santos[1,2], Sandro Dutra e Silva[2,3] and César Marín[7]

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Aim of study: To evaluate the effects of a mega-fire on the arbuscular mycorrhizal fungi (AMF) community and parameters in soils under Cerrado vegetation.

Study area: Chapada dos Veadeiros National Park, Goiás, Brazil. This site suffered the biggest fire in its history on October 10, 2017, with an affected area of 66,000 ha.

Materials and methods: We analyzed AMF spore density, roots' mycorrhizal colonization rate, easily extractable glomalin (EEG), as well as the AMF genera present. These parameters were evaluated in burned and unburned areas of five common phytophysiognomies of the region.

Main results: Fire presence immediately affected the mycorrhizal community parameters in Cerrado soils, which tended to increase afterwards. The presence of AMF genera did not differ between burned and unburned areas, with Acaulospora, Claroideglomus, Diversispora, Glomus, Funneliformis, Sclerocystis, and Gigaspora being present. The recovery of AMF community conditions in the Cerrado after fire events could also be observed in the mycorrhizal parameters evaluated, as the values of spore density, roots' mycorrhizal colonization rate, and EEG were similar in the burned and unburned areas.

Research highlights: AMF diversity, and especially their community parameters, show great recovery after fire events, since they are crucial in processes like nutrient cycling and soil aggregation.

Acknowledgments: This work has the support of the Fundação de Apoio à Pesquisa do Distrito Federal – FAPDF.

Presenting time: 4 December 2023, 15:20 – 16:00

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Degradation of different fabric types and their impact on soil health

By **Miranda Prendergast-Miller**, A. Rogers, Kelly Sheridan
Northumbria University

100 billion new garments are made every year yet we know little about the environmental impact during 'wear-and-use' and at the 'end-of-life' of clothing and textiles. There is also growing concern about: the shedding of microfibres from clothing and textiles; how microfibres enter our air, water and soils; and their potential impact on environmental and human health. While there has been a growing body of evidence on microplastics in aquatic environments, there is a lack of data on soils and soil health. Although synthetic microfibres are the usually dominant type of microplastics found across a range of environmental samples, recent research has highlighted the considerable presence of natural fibres too, which have been largely overlooked. Due to concerns about microfibre pollution and textile waste in landfills, we need a better understanding of the fate of different fabrics and fibres in our soils. We set up an incubation study burying 5 cm2 fragments of different fabrics in soil, comprising 100% cotton, cotton-polyester blends and 100% polyester. We selected fabrics with contrasting plain dyes (light vs dark colours) to test whether dye quality affected degradation rates. Over the course of the short-term incubation, fabric and soil samples were retrieved and analysed for various properties to help us track changes in fabric samples and soils. Here we present preliminary results from the experiment to begin to understand how fabrics and fibres degrade in soil and their impact on soil properties and soil health.

Keywords: soil health; textile degradation; microfibres.

P - 40

Wicked Wick of the West: Why Neighbourhood Matters at the Root-Soil Interface

By **Annette Raffan**
University of Aberdeen

At the root-soil interface, many grass species like timothy form a 'rhizosheath'. Rhizosheaths are composed of soil particles which stick to the roots due to root hairs and soil-binding root exudates. The rhizosheath is currently understood to be an advantage under low phosphorus and low water availability. But rhizosheath functionality and structure is not fully understood, especially in regards to its impact on soil properties in the context of a plant community. Therefore we question whether the rhizosheath is a competitive adaptation to quickly wick water to where it is needed most in a plant's root system. For a drought-stricken plant, this phenomenon would be advantageous, lest a more competitive 'wicked wick of the west' steals water first.

We developed a dry root, 'wick test' to compare timothy (*Phleum pratense* L. cv. Comer) rhizosheath behaviour when grown as a monoculture, and when grown in the presence of a 'more wicked wick of the west'; chicory (*Cichorium intybus* cv. Puna II). We altered soil phosphorus, to manipulate competition and rhizosheath formation.

Initial soil wicking (sorptivity) rates for roots were 1000x higher than previously reported for soil. There was a stronger impact of chicory on timothy rhizosheath properties than phosphorus. Under high phosphorus conditions and if chicory was present, timothy roots had a smaller rhizosheath yet water sorptivity increased by around 50% per unit area.

In summary, this highlights timothy grass has an ability to manipulate its root-soil interface to improve water movement in a competitive environment. By creating a faster-wicking rhizosheath for its size, timothy can mitigate the presence of chicory as a 'wicked wick of the west'. It emphasises the importance of understanding community-level interactions on soil structure development and soil health.

Keywords: root-soil interface, rhizosheath, sorptivity, plant-soil interactions, chicory, timothy, phosphorus, community interactions, soil structure

Funded by: NER UKRI

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Biostimulants: moving towards a mechanistic understanding of their impact on soil health

By **Dannielle Roche**
Cranfield University

Biostimulants are gaining interest for their promise to improve crop productivity by positively impacting crop nutrient use efficiency, tolerance to abiotic stresses, and ultimately yield and quality without causing adverse environmental side effects, as can be the case with conventional fertiliser use in agriculture. Biostimulants have been commonly split into two categories; non-microbial products such as humic substances, seaweed extracts and protein hydrolysates, and microbial products including beneficial fungi and bacteria. Biostimulants are thought to provide these benefits predominantly through plant-related mechanisms such as by mimicking plant hormones that improve nutrient uptake from the soil. However, there is a lack of deep mechanistic understanding of how biostimulants provide said benefits, especially their potential impact on soil properties as a crucial mechanism for improving crop productivity.

This research focuses on the impact of non-microbial biostimulants on native soil microbiology. The hypothesis is that the biostimulants stimulate the soil microbiology and associated chemical and physical soil properties. Improvement of these soil properties are associated with benefits to crop productivity (quantity and quality).

The first phase of this study investigated the effects on soil health of three main categories of non-microbial biostimulants (seaweed extract, protein hydrolysates and humic substances) in different application combinations (single, pairs and triplets). The soil properties measured in this soil-based incubation experiment (i.e. no crop) included soil biological (microbial biomass, respiration and fungi/bacteria ratio), chemical (available and total nitrogen, pH) and physical (aggregate stability and water retention) parameters. The results of this experimental phase did not support the stated hypothesis. The biostimulants, whether applied as single treatments or in combinations, did not stimulate the native soil microbiology significantly. This corresponded to insignificant changes in the chemical and physical soil parameters. Despite the lack of significant relationships in this experiment, the results can contribute to a better mechanistic understanding of non-microbial biostimulants, namely whether the presence of plant roots is critical for biostimulant performance.

The next phase of experiments will investigate the same biostimulant treatments applied to a crop (spinach). This is to test the hypothesis that biostimulants stimulate the plant-promoted soil microbiology (i.e. microbial activity in the rhizosphere) leading to improved soil nitrogen availability and uptake in the crop. Nitrogen supply in the chosen crop (spinach) is associated with improved leaf quality (in terms of chlorophyll content, vitamin C and leaf strength) and yield (fresh and dry marketable biomass).

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Keywords: Biostimulants, soil microbiology, crop productivity, seaweed extract, humic substances, protein hydrolysates

Funded by: Sainsbury's

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Presenting time: 4 December 2023, 15:20 – 16:00

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Soil quality and soil-based ecosystem services in solar parks across the Netherlands

By **Luuk Scholten**
Wageningen University & Research

Solar parks are a rapidly expanding novel land use primarily to produce renewable energy. However, the aim is to make them multifunctional, and limit negative impacts on soils or even improve soil quality . Solar parks change the microclimate and cause shading below the panels, influencing plant growth and carbon and water inputs to the soil. This research aimed to test the effect of solar parks on soil organic matter (SOM) dynamics and vegetation productivity in 17 solar parks with contrasting designs across the Netherlands. Soil and vegetation biomass samples were taken between (gap) and below the panels. Vegetation biomass was significantly lower below the panels (2.4 to >10 times lower depending on park design), while SOM, total carbon content and hot water extractable carbon did not differ. Fungal and bacterial PLFAs and the F:B ratio were higher in the gap compared to below panels. These results indicate potentially large effects over time on soil quality and stress the need for guidelines for ecologically sound solar park designs to prevent soil damage.

Keywords: Solar parks, soil carbon, soil quality, soil health, vegetation, shading

Funded by: Netherlands Enterprise Agency (RVO)

Link to Poster

Presenting time: 4 December 2023, 15:20 – 16:00

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Legacy of soil warming and cover crops on the response of soil microbial function to repeated wet/dry cycles

By **Tom Sizmur**
University of Reading

The response of soils to extreme weather events will become increasingly important in the future as more frequent and severe floods and droughts are expected to subject soils to wet/dry cycles as a result of climate change. These extreme events will be experienced in the UK against a backdrop of overall warmer winters. However, farmers in the UK and elsewhere are adopting cover cropping as a sustainable management practice to increase soil organic matter, benefit soil health, and to increase the resilience of soils to help mitigate the impacts of climate change. We examined the legacy of winter warming and cover crops on the response of soil microbial function to repeated wet/dry cycles. We introduced open top chambers to warm the soil surface of a field plot experiment in which cover crops (single species monocultures and 4-species polycultures) were grown over the summer after harvest and before planting of autumn sown cash crops in a cereal rotation. Soil samples were collected from warmed and ambient areas of the experimental plots in spring, before harvesting the cereal crop We quantified respiration (a measure of soil microbial function) with high-frequency CO2 flux measurements after 0, 1, 2, 4, or 8 wet/dry cycles imposed in the laboratory and the addition of barley grass powder substrate at a rate of 10 mg g-1 soil. Repeated dry-wet cycles increased the cumulative respiration rate observed, suggesting that repeated perturbations selected for a community that processed the barley shoot powder more quickly. This adaptation may have been due to a greater quantity of osmolytes produced by microorganisms exposed to repeated drought events. These osmolytes may have been rapidly metabolised upon re-wetting and primed the decomposition of the barley shoot powder. When we calculated the cumulative respiration after 8 wet/dry cycles, relative to cumulative respiration after 0 wet/dry cycles, our data revealed that the legacy of winter warming significantly reduced, but cover crops significantly increased, the ability of the soil microbial community to adapt to the repeated wet/dry cycles. This adaptation of the soil microbial community was positively correlated with the concentration of water extractable organic carbon in the soils prior to imposing the wet/dry cycles or adding the substrate. The availability of labile carbon may have mediated the ability for microorganisms to synthesise osmolytes in response to drought. We conclude that cover crops may enhance the ability of the soil microbial community to adapt to drought events and mitigate the impact of winter warming, possibly due to the provision of labile organic carbon for the synthesis of osmolytes.

Keywords: Soil respiration; Cover Crops; Climate Change; Warming; Drought; Stress; Perturbation; Adaptation; Resistance; Osmolytes

Funded by: BBSRC

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Comparative Analysis of As Concentration in Soil near Abandoned Mines: Impact of Hydride Generation and Wavelength by ICP-AES

By **Yu-jin Song**
Korea Environment Corporation

This study investigates a comparative quantitative study of soil arsenic concentrations near abandoned mines, with a specific focus on the influence of hydride generation and wavelength choice. Furthermore, it presents criteria for interpreting analysis results.

Under Korean Standard Test Method, three primary methods for analyzing arsenic are as follows: (1) hydride generation-atomic absorption spectrophotometry (HG-AAS), (2) inductively coupled plasma-atomic emission spectrometry (ICP-AES), and (3) hydride generation-inductively coupled plasma-atomic emission (HG-ICP-AES).

While AAS is widely used with a rich historical background, ICP-AES is preferred for its relatively superior sensitivity and the ability to simultaneously analyze multiple elements.

Hydride generation reduces matrix effects, enhancing sensitivity and lowering detection limits, making it favorable for low-concentration range analyses. However, it is often considered unfavorable due to the additional effort and time required.

This study compared results obtained from identical extracted solutions analyzed using (2) and (3) methods at two different wavelengths, 193.696nm and 188.979nm, with (3) as the reference. Notably, in concentrations below 25mg/kg, low correlation (R2) values of 0.26 and 0.86 were observed. In the range of 25mg/kg to 100mg/kg, correlations of 0.80 and 0.77 were identified, and for concentrations exceeding 100mg/kg, a high correlation of 0.99 was noted. Furthermore, despite detection in (3), the 193nm wavelength using (2) produced an undetectable result in 90% of cases. Overall, the interference encountered at 193nm wavelength in the absence of hydride generation suggests that using (2) is recommended when values below 25mg/kg, Zone 1 worrison levels in Korea, are obtained, and results should be validated using (3).

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Microplastics generated from biodegradable (polylactic acid) mulch mitigate the bioaccumulation of cadmium in earthworms more than those generated from conventional (polyethylene) mulching material

By **Xiao Xiao**
University of York

Biodegradable polylactic acid (PLA) has been developed to replace non-biodegradable conventional polyethylene (PE) in a range of applications including as an agricultural mulch material as a response to growing concerns about plastic pollution. Under some management practices mulches are ploughed into the soil at the end of their use which can lead to the production of plastic fragments including microplastics. Microplastic mulch residues can also form following degradation of the mulches due to exposure to UV radiation and the weather. Mulches are commonly used in China, where cadmium (Cd) contamination of agricultural soils is also an ongoing challenge due to the use of Cd-bearing phosphate fertilisers. It is already know that MPs can interact with metals. In this study we asked the question whether a shift from conventional to biodegradable plastics is likely to impact on MP-Cd interactions and more specifically what impacts this might have on soil organisms. We investigated Cd concentrations in earthworms and soil pore water after exposing the earthworm Lumbricus terrestris to Cd and two types of MPs both individual (Cd or MP) and in combination (Cd and MP). We used nominal Cd concentrations of 0, 1, 5, 10, 15, 30, 50, 100 mg / kg, and MP concentrations (PE and PLA) of 0, 0.1, 0.3 and 3 % w / w. 1 adult earthworms were exposed in 300 g of soil for 28 days in each treatment. At the end of the experiment we measured the Cd concentration in the earthworms and soil pore water. Cd concentrations in earthworms ranged from 3.124 - 31.36 mg / kg and pore water concentrations from 0.0008549 - 0.4156 mg / L. The Cd concentrations all increased with increasing nominal concentrations of Cd in the soil and decreased with increasing concentrations of MPs. PLA treatments had significantly lower measured Cd concentrations in both earthworms and pore water compared with PE treatments ($P < 0.001$, two way ANOVA). We also carried out adsorption experiments and found that PLA MPs adsorbed more Cd compared with PE MPs though differences were not statistically significant ($P = 0.805$, Mann-Whitney rank sum test). These results suggest, that when Cd and MP interact in the soil, PLA MPs adsorb more Cd, removing it from solution and reducing its bioavailability and uptake by earthworms. Thus a shift in mulch composition from PE to PLA and the formation of MPs from this material may reduce the immediate risk of Cd toxicity in Cd-bearing soils. However, as the PLA biodegrades it may then release the sorbed Cd resulting in increased exposure risks at a later date.

Funded by: Chinese Scholarship Council and University of York

Link to Poster

Figure 1

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Agri-environment application of functionalised mesoporous silica

By **Jiawei Yang**
Queen's University Belfast - Institute for Global Food Security (IGFS)

Cadmium (Cd) is a priority agricultural concern because it presents a major food safety issue, and threat to human health. Functionalised mesoporous silica (FMS) can be defined by the physical/structural characteristics of the inert hosting material and/or the chemistries of the functionalization. Both factors control the behaviour of the material and its suitability for different tasks and conditions, which give it the ability to selectively adsorb/immobilize specific target elements. Because of FMS's properties, we hypothesise it could be a future soil amendment method. In this study, it was demonstrated that FMS treatment efficiently remediates high Cd-contaminated soil (5 and 10 mg/kg) (Cd risk screening level in soil: 0.3 mg/kg) in pot trials with two rice (Oryza sativa L.) cultivars and cabbage (Brassica). The variation of Cd in cabbage, rice grain and different rice tissues was studied, and the Cd fraction in soil was analysed.

The FMS amendment decreased Cd concentration in wholegrain rice by 68-80%, and had no impact on yield, when compared to the control/non-FMS amended soil. The Cd concentration in wholegrain rice decreased to 0.07 and 0.18 mg/kg in both rice cultivars (Chuanyou 670 and Yiyou 1787), lower than the Chinese safety standard limit (0.2 mg/kg, d.wt.). Likewise, the Cd concentration in cabbage decreased from 0.24 mg/kg to 0.08 mg/kg (a decrease of 67%). The test soils were also enriched in arsenic. The grain concentration of the Chuanyou 670 rice grown in FMS treated soil was 45% lower than that of the control treatment. Interestingly though the FMS amendment had no effect on the arsenic content of rice Yiyou 1787 and cabbage ($P > 0.05$). Furthermore, there was no disruption to the profiles of essential trace elements there was a significant increase of in planta accumulation of Si with FMS additions.

Cd is mainly uptake by rice roots is via the manganese transporter OsNRAMP5, and OsHMA2 is involved in the translocation of Cd from root to shoot, but root iron plaque has been observed to have a blocking effect on Cd entry into rice. The DCB method was used to extract Cd from root plaque and shows FMS amendments decreased Cd content in root plaque by 42-79 % compared to the control. Furthermore, extractions using the BCR sequential scheme, showed that a considerable fraction of the Cd was Si-bound in the FMS treatment, and was not liberated even after heating for 1 hrs at 175°C with strong mineral acids (7.5 ml 6 M HCl and 2.5 ml 14 M HNO3 were added to 1 g soil residue). This confirms the stability of the FMS for Cd. These finding suggests that FMS is an effective remediation strategy to reduce Cd bioavailability in highly polluted agriculture soil, that it is functional for both anaerobic and anerobic cropping regimes, and that it provides plant nutrition in the form of Si, but is not detrimental for the uptake of other, needed, trace elements.

Key Words: Functionalised mesoporous silica, In-situ remediation, Cadmium, Rice, Cabbage

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Presenting time: 4 December 2023, 15:20 – 16:00

Technology and Innovation: Oral Abstracts

Testing soil profiles to support calcareous grassland habitat creation

By **Silvia Arpano**, Christopher McCloskey
Cranfield University

Calcareous grasslands are important biodiversity sites and among Europe's most species-rich plant communities. These habitats are, however, threatened; many of the UK's calcareous grasslands were lost to changing land use during the 20th century and pressure remains on the surviving (often fragmented) sites. Due to their ecological value and threatened nature there is significant interest in restoring and creating new areas of calcareous grassland, and a growing number of projects are working to restore or re-create these internationally important chalk grassland ecosystems. A major calcareous grassland creation project in the Colne Valley, west of London is planned as part of the Central 1 section of the HS2 (High Speed 2) Phase One rail development, being delivered by the Align joint venture. The aim is to create a large area (90 hectares) of calcareous grassland as part of a larger (127 hectare) mosaic habitat creation including calcareous grassland, wood pasture and wetlands on land that is currently used for construction but was previously low-grade arable land. The 'Colne Valley Western Slopes' will, when complete, be the largest single area of habitat creation along the HS2 route and will significantly contribute to the project's commitment to deliver 'No Net Loss' in biodiversity. Re-use of HS2 construction by-products in the creation of soil profiles that can support calcareous grassland has the potential to combine sustainable re-use of construction materials with the development of novel ways to create or restore calcareous grassland habitats and contribute to net biodiversity gain. These materials include 2.6 M m3 of excavated chalk from 16 km of tunnel construction, crushed limestone and concrete from decommissioned compounds/haul roads, and subsoils (stripped during site clearance). However, optimising the use of such by-products in habitat creation is under-explored, and investigation is needed into how they might be best re-purposed to create the specialised soil environment needed to support chalk grassland habitats. The physical, chemical and biological properties of soils, including soil structure, infiltration capacity and nutrient supply are essential for supporting the diverse plant communities found in calcareous grasslands. We are therefore testing constructed soil profiles using different configurations of site-derived materials / construction by-products. Numerous soil and plant metrics are used to assess the materials' ability to support calcareous grassland creation through a combination of controlled environment studies and field trials. Here we present final results from the main large-scale, controlled-environment trial at Cranfield University, in which we are testing four soil profile configurations and the effect of the upper soil layer depth in large (1 m3) soil mesocosms. The development of calcareous grassland on these profiles is being closely monitored over a six-month period, including above- and below-ground imaging to monitor sward and root development, alongside close monitoring of soil hydrology, soil microbial dynamics, nutrient cycling, and vegetation establishment and diversity. The research will provide a uniquely high-resolution examination of how calcareous grassland can develop on

Presenting time: 5 December 2023, 16:15

constructed soils and allow us to develop novel methods for circular re-use of infrastructure construction by-products in creating biodiverse habitats of high conservation value. –

Keywords: Soil restoration, habitat creation, calcareous grasslands, soil depth, site-won materials

Presenting time: 5 December 2023, 16:15

FTIR spectroscopy combined with chemometrics to map lime requirement from unknown samples covering large-scale heterogeneous areas

By **Felipe de Santana**[1], Karen Daly, Rebecca Hall
Teagasc[1], Geological Survey Ireland

Lime requirement (LR) analysis has been based on using the SMP buffer method since 1965 in Ireland. The pH (SMP) values are used to calculate LR based on the pH target for each case, i.e. for grassland the target pH (SMP) is 6.7. To increase 0.1 units in the pH is recommended lime the soil with 1.5 tons/hectare, i.e. soil with pH 6.5 will require 3.0 tons/hectare of liming. The SMP buffer is composed of potassium chromate and p-nitrophenol, both classified as hazardous for humans and the environment. Furthermore, potassium chromate is categorised as carcinogenic and mutagenic, being classified as a "Substance of Very High Concern" by the European Chemicals Agency. Based on this reason, efforts have been made by the research community to mitigate its use.

Among the alternative techniques, MIR spectroscopy is one of the most promising alternative techniques to replace the LR and other soil analyses. The method is considered fast, non-destructive, and requires minimal or no sample treatments. However, for soil spectroscopy to replace wet chemical methods, there is a need to achieve high prediction accuracy of unknown samples to map predicted values across large spatial scales confidently. To achieve this, a systematic approach was developed using MIR spectroscopy to predict the lime requirement (LR) of 5,652 mineral and organo-mineral (MOM) soils collected from grassland soils in the northern regions of the Republic of Ireland. From these MOM soil samples, 766 samples were randomly selected and sent to classical analysis to be used as calibration samples (n = 515 – build the SVR spectra models) and internal validation (n = 251 - estimate the model accuracy), resulting in LR errors of ± 0, 1.5 and 3.0 t/ha for 58.96%, 37.85% and 2.40% of the internal validation set, respectively.

A systematic approach for MIR spectroscopy combined with chemometrics was augmented by including spectral control charts to identify unrepresentative spectra in predicting unknown samples. This step increased the confidence in the predicted results by identifying samples with spectral signatures outside the range contained in the calibration set. Spectral models should not predict samples classified as unrepresentative by the spectral control chart and must be analysed using the reference method.

From the 4,886 unknown samples, the spectral control chart classified 4,487 (91.83%) and 399 (8.17%) unknown samples as representative and unrepresentative. The results show the enormous potential of MIR spectroscopy in mitigating the use of SMP buffer. The proposed methodology can also predict soil attributes using large spectral libraries, providing confidence for building regional and national scale soil maps.

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Presenting time: 5 December 2023, 17:00

X-ray fluorescence core scanning for high resolution geochemical characterisation of soils.

By **Shayan Kabiri**, Sharon O'Rourke, Jonathan Turner
University College Dublin

X-ray fluorescence (XRF) core scanning is a widely used technique for elemental analysis in the assessment of sediment cores in geology, mining, environmental science, and paleoclimatology. In this study, a method for the calibration of this semi-quantitative method for geochemical characterisation in soil cores was developed. The conversion of XRF counts to soil geochemical composition can be challenging due to the complex nature of soil matrices, nonlinear relationships between reference data and counts, collinearity, noise, and extrapolation outside measured range. Here a machine learning-based approach for calibrating XRF counts to soil geochemical composition is proposed. The calibrated geochemical composition was used to predict the soil organic carbon concentration by proxy with high resolution.

The XRF counts and reference ICP measurements were acquired for elemental compositions on nine cores from Irish agricultural soil and have been calibrated using logratio calibration equation (LRCE), elastic network regression and random forest, and assessed using cross-validation. Three additional validations methods were also used. First a noise with signal to noise ratio of 5 was imposed on test sets in cross-validation to test models for robustness against noise. Second each core was left out as test sets to test models for generalizability. Third, each depth interval of cores was left out as test sets to check models for depth autocorrelation.

Results showed random forest, cubist, and elastic network regression on average outperformed LRCE by 74%, 39% and 7% in cross-validation scores with random forest having an average R^2 of 0.75. For example, phosphorus and sulphur, elements of interest in soil science, were calibrated with validation R^2 of 0.9 and 0.82 using random forest. For noise study, random forest, cubist, and elastic network regression outperformed LRCE by 633%, 488% and 488% in cross-validation scores with random forest having an average R^2 of 0.66. For core-out validation random forest, cubist, and elastic net show, 119%, 76% and 114% improvement in performance compared to LRCE with random forest having average R2 of 0.45 and for depth-out validation 277%, 211%, and 266% improvement compared to LRCE with random forest having an average R^2 of 0.34. The soil organic carbon model had a cross-validation R^2 of 0.97, with phosphorus, strontium, and sulphur as the three most important predictors.

In conclusion, our study demonstrates the potential of machine learning-based approaches for calibrating XRF counts to soil geochemical composition. Random forest shows meaningful advantage over other methods especially in robustness against noise, and even though there is a degree of autocorrelation in depth axis, random forest seems to be much more successful in overcoming this and has more generalizability. Moreover, evidence was

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found on the possibility of predicting soil organic carbon based on elemental concentrations, but a more diverse dataset of soil organic carbon profiles is needed to further test this.

Keywords: xrf core scanning; soil geochemistry; machine learning; soil nutrients; calibration; soil analysis; chemometrics; soil organic carbon.

Funded by: Irish Research Council

Presenting time: 5 December 2023, 16:45

Remote sensing of cover crop legacies on soil health and main crop N-uptake dynamics

By **Dr. Nikolaos C Vavlas**, Prof. Gerlinde B. De Deyn, Prof. Lammert Kooistra
Wageningen University & Research

Sustainable management of arable cropping systems requires insight into the temporal dynamics and spatial variation of crop performance to minimize nutrient losses and enable soil health-based precision agriculture. In arable systems, growing cover crops is a tool to promote soil health as they enable nutrient retention in autumn/winter and provide nutrients in spring/summer to the main crop upon cover crop mineralization by the soil biota. However, different cover crop monocultures and mixtures affect the soil biology and nutrient dynamics differentially due to the variation in quantity and quality of the plant material returned to the soil.

To understand the legacy effects of cover crops on the main crop we need high resolution data of the crop responses to soil health conditions throughout the growing season. Remote sensing can provide such high-resolution data yet requires solid parameterization before it can be operationalized. Here we studied the temporal dynamics of soil nitrogen (N) availability and N uptake in barley in response to the soil legacy of different cover crops. We used high-resolution multispectral images of the main crop acquired from a Unmanned Aerial Vehicle (UAV), and in situ collected plant and soil parameters in a long-term field experiment with eight different cover crop treatments. The cover crop legacies significantly affected N uptake, biomass, and canopy chlorophyll content (CCC) in barley, with highest values in barley grown after vetch-radish or oat-radish and lowest in barley on fallow or oat legacy plots. The temporal dynamics of N-uptake throughout the barley growing season revealed that cover crop legacy effects became apparent/distinct by the end of stem elongation. This work demonstrates the potential of remote sensing to monitor and understand temporal and spatial variation of crop canopy traits in response to cover crop induced soil health legacies. This approach can contribute to more efficient N use by enabling fine-tuning of the quantity, timing, and location of fertilization.

Keywords: Cover crops, UAV, soil health, crop N uptake, N cycling, remote sensing.

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Technology and Innovation: Poster Abstracts

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Investigation on novel slurry treatments to mitigate ammonia emissions from Northern Ireland's livestock sector

By **Azadeh Dabiri**
Queen's university of Belfast, Agri-Food and Biosciences Institute

Ammonia (NH3) emissions from Northern Ireland are higher per capita than those from the rest of the UK, which has caused significant environmental and public health problems. Agricultural NH3 emissions are the primary cause of air pollution in the region, according to the Department of Agriculture, Environment and Rural Affairs (DAERA) in Northern Ireland. The vast livestock sector in the area and the generation of significant quantities of animal manures are two reasons for the high levels of NH3 emissions there. According to DAERA, the overall amount of livestock slurry produced in Northern Ireland in 2020 was around 5.5 million tonnes, with cattle slurry being the majority of the volume at roughly 3 million tonnes. Slurry is typically utilised as an agricultural fertiliser since it includes nitrogen and phosphate. Yet, improper management might contribute to water and air pollution. Cattle slurry has the potential to emit NH3 into the atmosphere, as organic matter in the slurry breaks down, NH3, a consequence of the breakdown of urea in urine and faeces, is released as a gas. When pollutants like sulphur dioxide and nitrogen oxides are released into the environment, they can combine with NH3 to generate particulate matter, which can exacerbate respiratory troubles and other health concerns. Furthermore, NH3 can contribute to the formation of acid rain, which can cause soil acidification and other environmental issues. Reduced NH3 volatilization from slurry storage is crucial for increasing the slurry fertiliser efficiency and reducing negative environmental repercussions. Managing slurry is therefore an essential step in lowering emissions, particularly NH3 emissions. Livestock manure includes organic material and nutrients that can be recycled to improve the soil's fertility for plant growth. In order to significantly reduce NH3 losses, notably from animal slurry management as the primary NH3 source, it is crucial to look beyond currently available technologies and determine novel techniques of abatement. Therefore, it is crucial to develop new, eco-friendly, and economically viable technologies to further reduce NH3 emissions and promote sustainable growth in the agri-food sector throughout Northern Ireland. Throughout this study, sustainable methods for reducing NH3 emissions from cattle slurry storage in Northern Ireland will be studied. In addition, the influence of various feeding strategies for ruminants (e.g., the use of seaweed) in conjunction with cattle slurry treatments will be investigated.

Keywords: ammonia, air pollution, soil pollution, acidification, slurry, Northern Ireland.

Funded by: DAERA

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Sources of uncertainty in proximal soil sensing and suggestions for reducing them

By **Amin Sharififar**
The James Hutton Institute

To increase the reliability of proximal soil sensing, we need to improve the accuracy of soil estimations of characteristics and decrease the associated uncertainty of estimations. This can help with more desired spatio-temporal soil monitoring and management. Based on a comprehensive literature review and operational experience, the known reduceable sources of uncertainty and suggestions to reducing them are briefly mentioned in this presentation. The uncertainty sources can come from three origins including known knowns, known unknowns and unknown unknowns. The uncertainties can be classified as so-called Aleatory (intrinsic stochastic uncertainty), which is irreducible, and reducible uncertainty called Epistemic uncertainty.

The followings are seven known (reducible) sources of uncertainty in soil spectroscopy: 1) standard protocols for scanning and data acquisition: there are various internal standards already in use in different labs around the world. The solution for this issue is to use a commonly agreed-upon standard protocol. In addition, data pre-treatment techniques can reduce the variability among spectra obtained from different sources. 2) The problem of large number of features (wavelengths) with small number of soil samples for local/farm scale evaluations which results in low and non-generalisable accuracy. It can be reduced by dimensionality reduction. 3) Heterogeneity of soil samples and challenges in mathematical calibration of their spectra. This can be reduced by calibration techniques such as sub-setting and the use of deep learning. 4) Calibration model transferability and generalisation, which can be improved by pre-treatment of spectra and standardisation. 5) Transmission from lab scanning to on-the-go field scanning. In this regard, improved sensors, scanning techniques and spectra correction can be beneficial. 6) Transferability of spectra from the laboratory to laboratories (across labs transferability). Harmonised protocols and transfer functions are recommended for this issue. 7) Wavelength range and different technologies; their cost-benefit and pros and cons of each can be a factor in using a suitable device.

The effects of mineral class, particle size distribution, and moisture are known to make interventions in soil properties inference. These form a group of known mistakes and not stochastic errors. In summary, suggestions include sensors improvement, mathematical treatment of spectra and multiple-time scanning procedures. Building a global spectral library and its dynamic calibration should be considered for more accurate local scale temporal soil monitoring. Coping with the above-mentioned challenges in soil proximal sensing can optimise and operationalise its use for more routine farm-scale soil monitoring and assessment at desired spatial and temporal resolutions.

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Keywords: Vis-NIR spectroscopy, spectra library transferability, soil monitoring, calibration model transfer, standard soil sensing

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Water Management and Quality: Poster Abstracts

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Influences of climate, land use and policy variables on stream water quality following the fertiliser closed period

By **Maelle Fresne**, Phil Jordan, Rachel Cassidy
AFBI, Ulster University

Calendar-based closed periods for the application of fertiliser to farmland are enforced by regulation to prevent water pollution during the wettest parts of the year. Depending on climate, soil conditions and land use in the weeks following the end of the closed period, fertiliser applications can impact stream water quality. However, it remains unclear which variables have the greatest influence.

The objective of this study was to determine the influence of climate, land use and policy variables on changes in stream water quality observed after the closed period in agricultural catchments in Northern Ireland.

This analysis was based on 11 to 13 years datasets of fortnightly stream water samples taken in the 26 Upper Bann and Colebrooke sub-catchments, and analysed for total phosphorus, soluble reactive phosphorus, and total oxidised nitrogen. We combined a range of climate (e.g., rainfall depth and intensity, air temperature, soil moisture deficit, 7-day antecedent climatic conditions) and policy (e.g., regulatory distance from waterways of fertiliser application) variables into Partial Least Square Regression models to determine the portion of variations in phosphorus and nitrogen concentrations explained by each of these variables.

Preliminary results showed that the accounted variables explained more variations in stream water chemistry in the Upper Bann than in the Colebrooke catchment: 30.7% vs 28.0% for total phosphorus, 59.1% vs 26.7% for soluble reactive phosphorus, and 43.9% vs 7.6% for total oxidised nitrogen, respectively. However, the error in prediction was higher for the Upper Bann models than for the Colebrooke models. In the Upper Bann catchment, the accounted variables that explained most of the variations in total phosphorus concentrations were air temperature (explained 7 % of the variations), rainfall (amount and intensity - 6,4 %), and distance of application of chemical fertiliser (5.6 %). Rainfall explained 17 % of the variations in soluble reactive phosphorus concentrations, while soil moisture deficit explained 7.1 % of the variability. Variations in total oxidised nitrogen were firstly explained by distance of application of organic manure (10.2 %), rainfall (9.8 %) and 7-day antecedent rainfall (8.7 %). In the Colebrooke catchment, variations in total phosphorus were primarily explained by 7-day antecedent rainfall (6.3 %), sub-catchment identity (4.8%), and soil moisture deficit (3.5%). Rainfall explained 7.2 % of the variations in soluble reactive phosphorus concentrations, while soil moisture deficit explained 3.9 % of the variability. Variations in total oxidised nitrogen were firstly explained by rainfall (2.2 %).

Although the explained variations were low, the data and analysis so far suggest weather pressures as most prominent influences on nutrient state in the study rivers over the long term. Further development of this work will include the addition of land use variables (e.g.,

portion of grass and crops, cattle slurry, and fertiliser use) in the models to refine understanding of the main variables influencing stream water quality in these catchments. This will help to better manage agricultural fields and policies to mitigate nutrients losses to water bodies in the context of a changing climate.

Keywords: Phosphorus, Nitrogen, Catchments, Partial Least Square Regression.

Funded by: DAERA

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Microbially Mediated Manganese Mobilisation

By **Arthur Taylor**
University of Edinburgh

The research presented provides evidence that water-logging of soils contributes to the microbial reduction and mobilisation of manganese and demonstrates the use of birnessite Indicator of Reduction In Soils devices as a low cost but effective method of monitoring and mapping these processes.

Manganese rich soils from Scotland uplands have, in recent decades, been seen to release manganese into surface waters in quantities that pose a problem for drinking water quality. Certain drinking water reservoirs have been showing peak manganese concentrations that exceed safe limits and manganese removal from drinking water is costly.

The mechanisms and processes linking changes in climate and land use to the mobilisation of manganese from soils are little understood but the effect of drying, rewetting and water-logging cycles with the associated redox conditions and microbial processes are known to be central. How these processes are mediated by context like vegetation type, land management practices and climatic conditions is essential for monitoring and mitigation.

The soil column experiment conducted found evidence that water-logging significantly increases the leaching of manganese in soils, that microbial oxidation in drained soils can prevent manganese mobilisation and that the interaction between microbial processes and water-logging on manganese solubility is significant, meaning that water regime and microbial processes as interdependent drivers of the mobilisation of manganese.

Birnessite Indicator of Reduction In Soils devices were also analysed in the column experiments and it was shown that they can be effectively used to monitor microbially mediated mobilisation of manganese from the stable solid phase to mobile soluble phases. It is recommended that such devices could be used across a catchment to probe, at fine spatial and temporal scale, the relationship between these processes with land use and climatic conditions.

Keywords: Microbial Manganese Mobilisation Water-logging Water Quality

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