BRITISH SOCIETY OF SOIL SCIENCE

The British Society of Soil Science

Early Careers' Conference 2023

Wednesday 6 and Thursday 7 December 2023

Assembly Buildings Conference Centre, Belfast, Northern Ireland

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Early Careers' Conference Programme

Day 1 – Wednesday 6 December

10:00am - 11:00am – Registration and Poster Set Up

11:00am – 11:30am – Introduction to the Conference – Saoirse Tracy (SSSI)

11:30am – 12:30pm – Finding Funding As An ECR *[Workshop]* – Dan Evans (Cranfield)

12:30pm - 13:30pm – Lunch | Poster Presentation Session 1 *(Soil Health, Nutrient Management, Water Management)*

13:30pm - 15:30pm – Oral Presentation Session 1: Soil Health

1. Urmi Ghosh – *Application of computational approaches in soil-mineralogy to understand mineral-nutrient relationship*
2. Katie Martin – *Short and long-term effects of slurry applications on earthworm populations*
3. John Nunns – *Effect of wheat roots and bulk density on soil microbial properties and pesticide degradation*
4. Jessica Brook – *Broad scale multiple year temporal changes in the physical structure of agricultural soils across three catchments in Scotland*
5. Cristina Mcbride-Serrano – *Can increased cover crop diversity bind more soil in the field?*
6. Aileen Lynch – *Novel genes associated with insoluble phosphorus can be utilised to assess soil health*
7. Tinashe Mawodza – *Soil management in the construction of the HS2 railway line*

15:30pm - 16:00pm – Break and Refreshments

16:00pm – 17:00pm – Soil Science in Industry *[Workshop]* – Jess Potts (Arcadis) *[Sponsored by Arcadis]*

17:00pm – 17:30pm – Summary of Day 1

19:30pm – 21:30pm – Conference Dinner

Day 2 – Thursday 7 December 2023

8:30am – 9:00am – Welcome and Refreshments

9:00am – 9:30am – Introduction to Day 2 – Paul Hallett (BSSS)

9:30am – 11:30am – Oral Presentation Session 2: Soil Carbon

1. Olivia Azevedo – *The long-term effects of woodland creation on soil structure and the fate of carbon*
2. Mollie Frost – *Calculating the Carbon Sequestration Potential of Cement Bypass Dust as an Agricultural Soil Amendment.*
3. Ana Prada Barrio – *Effects of traffic and tillage management systems on soil organic carbon dynamics*
4. Catriona Willoughby – *Leys, organic amendments and reduced tillage lead to carbon accumulation in farmland soils: a rapid evidence assessment*
5. Sharon Chebet – *Rapid increase in soil organic carbon and structural stability following conversion to semi-natural grassland irrespective of management history*
6. Mary Cvetkovic-Jones – *Savanna soil carbon: interactive impacts of fire and climate on soil respiration*
7. Muhammad Mohsin Abrar – *Long-term manure application enhances organic carbon and nitrogen stocks in Mollisol subsoil*

11:30am – 12:00pm - Break and Refreshments

12:00pm – 13:00pm – BSSS Membership *[Drop in Session]* – Natalie Coles (BSSS)

13:00pm – 14:00pm – Lunch | Poster Presentation Session 2 *(Soil Carbon, Technology and Innovation, and Other)*

14:00pm – 15:30pm – Oral Presentation Session 3: Nutrient Management, and Technology and Innovation

1. Yusra Zireeni – *Effect of slurry acidification on the uptake of S, P and N by plants*
2. Longnan Shi – *Prediction of soil bulk density in agricultural soils using mid-infrared spectroscopy*
3. Jennifer Wardle – *What links soil nutrients to the Hitchhikers Guide to the Galaxy?*
4. William O'Neill – *COM-VITE: A Sustainable Recovered Urban Waste Composite for Soil Conditioning in Silviculture*
5. Hannah Walling – *Improved soil phosphorus management is required to optimise soybean biological nitrogen fixation*
6. Patti Roche – *The influence of soil structure on phosphorus dynamics*

15:30pm – 16:30pm – Closing Remarks and Prize Ceremony

ABSTRACTS

Theme I: Nutrient Management

Theme II: Soil Carbon

Theme III: Soil Health

Theme IV: Technology and Innovation

Theme V: Water Management and Quality

Theme VI: Other themes

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Nutrient Management: Oral Abstracts

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COM-VITE: A Sustainable Recovered Urban Waste Composite for Soil Conditioning in Silviculture

By **William O'Neill[1],** Paul N. Williams[1], Jason Chin[1], Vincent O'Flaherty[2] and John W. McGrath[1]

1. *Queen's University Belfast*
2. *University of Galway*

Silviculture is an important Irish industry, covering ca. 11% of land with Irish government targets of 18% by 2046. The Department of Agriculture, Food and the Marine (DAFM) guidelines define a standard application of chemical granular fertiliser (CGF) in the form of either triple super phosphate (TSP; 46% P2O5; 20% P) or granular rock phosphate (GRP; 25% P2O5; 11% P) for forestry as 27.5 kg P ha-1 of forest, and this, combined with arable agriculture, led to Ireland having the 7th largest consumption of synthetic fertiliser per quantity of agricultural land in the European Union (EU) in 2013. Due to both economic, supply chain and environmental concerns there is a need to replace CGF with more sustainable alternatives. Struvite (magnesium ammonium phosphate; 28% P2O5; 12% P) is a sustainable fertiliser product produced from wastewater recovered phosphorus and nitrogen. Blending struvite with compost derived from municipal composting facilities to achieve more desirable NPK ratios specifically tailored to the individual crop need would have significant benefits in terms of negating the continued importation of synthetic fertiliser. Indeed, both materials have land application advantages, the former provides a concentrated source of P in low pH conditions (and some N) whilst the latter supplies organic material and a moderate NPK supply. Crucially however blending compost with struvite has the potential to moderate struvite dissolution in acidic forest podzols as well as enhancing soil structure and ameliorating run-off due to the slow-release characteristics of the compost. This study seeks to evaluate the suitability and sustainability of blended municipal-solid-waste compost from food (brown) and non-food (green) waste and wastewater-recovered-struvite composite (COM-VITE) for displacing conventional CGF in silviculture applications. The methodologies employed include i) Characterisation of brown and green waste compost in terms of nutrient content and seasonality. ii) Controlled nutrient release experiments (n = 1440) to measure kinetics and nutrient run-off potential with time, soil type and location. Rhizon-bags containing COM-VITE blends, TSP and GRP each containing equivalent quantities of P were deployed across four Irish Sitka spruce forests located in Mayo, Cavan and Fermanagh with ten deployment sites per forestry site. iii) Large scale conifer rhizotron simulations (n = 27) of nutrient mobility, metabolism, transformation within typical forest soil (Mayo and Cavan forests) profiles and root-soil interactions. The rhizotrons (custom built; 300mm dia. and 400mm deep) support Sitka spruce saplings amended with COM-VITE blends and compared to TSP with site and treatment combinations equivalent to field application, conducted in triplicate. Compost characterisation show brown waste compost (N = 2410; P = 647; K = 14595 mg kg-1) contains higher concentrations of NPK than green waste compost (N = 142; P = 2985; K = 11691 mg kg-1), with limited seasonality differences. Rhizotron experiments showed that both COM-VITE blends provided a more sustained/sustainable P flux than TSP, which mobilised and

leached through the soil horizons quickly. These trends were supported as well, from the in situ rhizobag deployments. In conclusion, current findings are encouraging for COM-VITE as a substitute for chemical granular fertilisers used within conventional CGF practice for Sitka spruce cultivation. Further validation is being conducted on longer term behaviours and the impacts on the soil microbiome.

Keywords: Silviculture, forestry, chemical granular fertiliser, struvite, magnesium ammonium phosphate, municipal waste compost, com-vite, rhizotron, nutrient mobility, nutrient leaching.

Funded by: Environmental Protection Agency Ireland

BRITISH SOCIETY
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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

BRITISH SOCIETY OF SOIL SCIENCE

Improved soil phosphorus management is required to optimise soybean biological nitrogen fixation

By **Hannah Walling**

Lancaster University, Munich Technical University, Corteva Agriscience

Global soybean production is currently 339 million tonnes, with further increases of approximately 15% required to meet demand. Soil available phosphorus (P) plays a major role in soybean plant nutrition, with P required to optimise plant response and yield characteristics. Improving soil P management also impacts soybean's nitrogen (N2) fixation capacity; with sufficient P supplies required for nodule formation and function. Through increasing N2 fixation capacity, improved soil P management can have onwards effects on soil health through the return of N through crop residues and intercropping. It is hypothesised that increased plant P acquisition under optimal P management conditions soybean will increase N2 fixation, having onwards effects on yield potential. Nitrogen fixation is hypothesised to increase as a result of increased nodule formation and function resulting from improved P acquisition and allocation. Through analysis of nodule morphology, the proportion of N derived from fixation (%Ndfa) through relative ureide analysis, and onwards yield determining characteristics, we assess soybean biological nitrogen fixation across the whole growth cycle of two varieties of soybean grown under low and high P treatments. Preliminary experiments showed a significant positive response in nodulation and plant biomass under P fertiliser addition. Here, we present findings highlighting the importance of P nutrient efficiency and effective soil P management in improving soybean N2 fixation to optimise production and close yield gaps.

Funded by: Corteva Agriscience, Lancaster University

Presenting time: 7 December 2023, 15:00

What links soil nutrients to the Hitchhikers Guide to the Galaxy?

By **Jennifer Wardle**
University of Aberdeen

Urban agriculture is on the increase, evidenced through the rising demand for allotments and community gardens. Along with mental and physical health benefits, urban agriculture can reduce food miles, maintain urban greenspace, and potentially encourage more conscientious soil management practices than large-scale farming. Since 2019, Aberdeen has experienced a growth in community gardens to promote local food production, community building and environmental sustainability. This was assisted by the Community Empowerment (Scotland) Act 2015 and the resulting Granite City Growing scheme. Pilot research suggested that keen but inexperienced volunteers were growing food and communities with few resources or training opportunities available for the environmental conditions of North-East Scotland, where the growing season is relatively short and cold. Meanwhile, the city is home to many seasoned allotment growers with decades of experience in local conditions.

A study combining quantitative and qualitative research methods was conducted in summer 2022 to investigate Aberdeen's food growing soils. The aim was to help empower local growers to share valuable knowledge and tips on food production and soil management with amateur growers in the region through a bottom-up approach. The main output was a website to disseminate knowledge from the experiences of long-term or alternative growers, as well as experimental approaches from newer growers. Further aims were to increase public engagement in research, provide insight into the priorities and motivations of urban food growers, and stimulate discussion around soil health and its importance in food production and climate change.

An initial survey gathered information on soil management practices, with a sub-section of respondents selected for follow-up interviews. Interviews were accompanied by the collection of soil samples to demonstrate how each participant's management techniques were reflected in the soils they tended. Consultations with experienced technicians and soil scientists in the planning stages led to the selection of the most appropriate extraction and analytical methods to establish the available nutrient content of the soils. Soils were tested for organic matter content, bulk density, pH, nitrates, and available potassium, phosphorus, calcium and magnesium. Individual reports were sent out to all participants to give feedback on their soil properties.

The activity raised more questions than answers, with results seeming akin the answer to the Ultimate Question of Life, the Universe and Everything being 42. What did the numbers mean? Sustainable soil management is crucial to mitigate climate change and enable healthy ecosystem functioning. While several laboratory methods exist to establish available soil nutrients, there are very few possibilities for translation between them. With increasing government and public attention turning towards soil health, tools need to be made available to facilitate comprehension and translatability between analytical methods. Such

Presenting time: 7 December 2023, 14:30

tools could bring societal and environmental benefits by improving the efficiency of small-scale growing activities and reducing excessive nutrient application.

Keywords: urban agriculture, nutrient analysis, allotments, community gardens, small-scale soil management

Funded by: EASTBIO

Presenting time: 7 December 2023, 14:30

Effect of slurry acidification on the uptake of S, P and N by plants

By **Yusra Zireeni**, David Chadwick, David Jones
Bangor University

The addition of sulphuric acid (H2SO4) to slurry lowers its pH and can reduce ammonia (NH3) and methane (CH4) emissions during storage and after field application. Additionally, slurry acidification can enhance P solubilization in animal manures, as well as increase N uptake in the plant by enhanced S availability. However, little is known about the effect of different slurry pH levels on S, N and P uptake in plants. In this study we hypothesized that slurry acidification with H2SO4 would proportionately enhance the growth and uptake of S, N and P by plants.

For that purpose, two pot experiments were designed: (1) used oilseed rape as a crop with a high S demand, and received post-storage untreated slurry, digested slurry, and liquid fraction of digested slurry between two soil layers in the pots; (2) used maize and received fresh whole (non-separated) slurry. The slurries in both experiments were initially acidified to 3 pH levels (6.5, 5.5, and 4.5), in addition to the control non-acidified slurry treatment (pH ~ 7.3). At harvest, the dry matter yield was measured for both crop types. The uptake of slurry-derived S, N and P in maize was estimated by tracing the uptake and fate of added 35S, 15N, and 33P. In the oilseed rape experiment, the content of S in the dry matter yield was analysed.

The results showed a strong correlation between the crop type and S uptake. Thus, for oilseed rape crop that was grown where the untreated slurry was applied, the increase of slurry acidification (lower pH and higher SO4-S content in the slurry) increased S uptake in the plant. However, the data showed that increased S content in the plant does not necessarily increase crop yield. While for oilseed rape grown in pots where the digested slurries were applied, the growth and the uptake of S was not improved by increased of slurry acidification to pH values < 6.5. The dry matter yield of maize was the highest when the slurry was acidified up to pH 6.5, with no benefits of increased acidification seen beyond this point. Increased acidification did not increase the P or S uptake in maize. The analysis of 15N uptake in maize following slurry acidification is ongoing.

We conclude that suitable slurry pH for slurry storage might render the acidified slurry being less efficient as a source of nutrients for crop growth, that consequently can affect soil health and the environment, depending on the pre-treated slurry type and in general depending on the crop type.

Acknowledgements: Received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grand agreement No.860127

Presenting time: 7 December 2023, 14:00

Nutrient Management: Poster Abstracts

P - 2

Characterization of market available composts in Bangladesh for improving sustainable soil management

By **Md Raju Ahmad**
Queen's University Belfast

Background:
Although compost is used as both a fertiliser source and organic carbon input to agricultural soils, this biomaterial is vulnerable to toxic trace metal (TTM) enrichment presenting an environmental health hazard (Xu et al., 2021). In response to demands for improving waste management and agri-food ecosystems' circularity, a new commercial mass-produced compost product sector has recently emerged in Bangladesh. However, little is known about the sector's capacity and the quality of these products-compost.

Aim and objectives:
To better understand the authorised commercial composting (ACC), including details of industry's location, growth, scale, the life cycle of feedstock, processing technologies, and the economics of compost production. In addition, to analyse the physiochemical properties of compost and evaluate compost's nutrient and TTMs profiles for compliance with national and international standards considering health and safety issues.

Materials and method:
A survey was undertaken among the ACCs (N=31) throughout Bangladesh in February-March/2022. In addition, compost samples (N=135) were collected from the market-available companies (N=45) -(ACCs) and unauthorised commercial compostings (UACCs) in June, September, and December 2022, respectively. Standard methods were used to determined pH, EC, and SOC. Total element nutrients and TTMs were measured by EDXRF. The samples were compared and contrasted against the safety/quality criteria from the Bangladesh standard (BDS) (MoA, 2012) and the UK (PAS-100) British standard (BS) (BSI, 2018).

Results:
The survey data shows that the licensing process of compost production and marketing are time-consuming and complex. As a result, many UACC were willing to begin producing and marketing compost without licensing. Additionally, the variety of the source feedstocks implies a wide range in the final product's characteristics and properties. Compost quality was found to be generally high, but severe Pb contamination, exceeding safety maximum were detected in ACC products. Overall, the quality of the UACC was less than that of the ACC composts, with the former having contamination issues with Cr especially.

Conclusions:
The survey data suggests that the compost production and marketing licensing process is lengthy and complex, leading many UACCs to produce and market compost without

licensing. However, some composts contain high levels of Pb and Cr contamination, which exceed the limits set by the BDS and BS. Therefore, it is important for compost producers to ensure their compost meets the necessary safety standards and should undertake regular checks. Finally, UACCs should consider obtaining the necessary licensing to ensure their composts are safe for use.

Keywords: Compost, Nutrient, Toxic Trace Metals (TTMs), Standard, Bangladesh

Acknowledgements: This work is supported by PhD program of Queen's University Belfast through Bangabandhu Science and Technology Fellowship Trust (Ministry of Science and Technology, Bangladesh) Doctoral Scholarship.

Link to Poster

P - 4

Measuring soil N_2O emissions from different crop nutrient management strategies

By **Elisabeth Appleton,** 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 BBS

Link to Poster

Presenting time: 6 December 2023, 12:30 – 13:30

P - 6

Effect of Mn, S and N soil application on N cycling in winter wheat cropping systems

By **Saoirse Sheehy Ariff,** Paul Murphy
School of Agriculture and Food Science, University College Dublin

Global crop yields are dependent on the continuation of N fertiliser use. Artificial N is one of the most widely used and environmentally harmful fertilisers. To operate within the planetary limits of N pollution and keep food production high for a growing human population, N use efficiency (NUE) must be dramatically increased.

Wheat plants require a range of essential micronutrients, including Zn, Cu and Mn among others to support their growth and development. Soil micronutrient deficiency is a growing issue affecting wheat cropping systems. Since the introduction of conventional agriculture (high-yielding crops, artificial fertilisers and pesticides), many farming systems have developed to rapidly extract soil micronutrients. These farming systems often fail to enrich the soil with micronutrients, resulting in soil micronutrient deficiencies. These deficiencies can have significant impacts on crop productivity and quality. Wheat plants can exhibit various symptoms when these micronutrients are unavailable in sufficient quantities, including stunted growth, yellowing of leaves, and reduced grain yield. Little research has been conducted on the role of micronutrients in NUE and environmental N cycling.

A two-year outdoor lysimeter experiment was conducted to test whether Mn and S application would affect winter wheat (Triticum aestivum; Graham variety) N use efficiency, N pollution and crop yield. The soil used was a leptosol collected from the topsoil horizon in a long-term conventional tillage farm in southeast England. Soil properties that might influence nutrient availability were measured (pH, organic matter, plant available nutrients, soil texture and cation exchange capacity). Treatments of control, S (25 kg/ha) and Mn (20 kg/ha) were applied in aqueous solution to the soil at growth stage (GS) 12 in an incomplete factorial design with five replicates per treatment. The researcher applied N in aqueous solution at two levels: 0 and 300 kg/ha. Each N treatment was applied over GS30, GS31 and GS37, with half the total N applied at GS31. Each lysimeter contained three plants. The straw and grain were separated, dried, and mass measured at full maturity. Leachate was collected weekly, weighed, and frozen. Monthly composite samples were measured for NH4, Total oxidised N and total N. Following the first growing season, N2O and CO2 fluxes were measured using a Photoacoustic Field Gas Monitor (PAS). The researcher took gas measurements after fertilisation and rainfall events and at regular intervals throughout the growing season.

Surprisingly, Mn and S individual application did not significantly affect yield or agronomic NUE despite soil tests indicating that this soil was low in these nutrients. This may show limitations of using conventional soil tests to assess the micronutrient requirements of wheat in a given soil. Applying N increased yields. This poster shows the initial yield results from the experiment's first year.

Presenting time: 6 December 2023, 12:30 – 13:30

P - 6

Key words: 'Nitrogen', 'Wheat', 'Manganese', 'Sulphur', 'N2O', 'Leachate', 'Leptosol'

Funded by: Science Foundation Ireland, Origin Enterprises

Link to Poster

Presenting time: 6 December 2023, 12:30 – 13:30

P - 8

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: 6 December 2023, 12:30 – 13:30

P - 10

Reducing agricultural nutrient loss in Northumbria across the Till and Tweed River catchments: EU LIFE WADER Project

By **Marta Cattin**
Environment Agency, Natural England (CSF)

Designated Protected Areas along the North Northumberland coast are being adversely impacted by eutrophication. Modelling has shown that large amounts of nitrogen (N) and phosphorus (P) are coming from the river Tweed and Till catchments, most likely the result of extensive use of inorganic fertilisers in this sparsely populated area. Funding has been awarded via the EU LIFE WADER (Water and Disturbance Environmental Restoration on the Northumberland coast 2021-2026) project to deliver evidence-based targeted farm advice. An appointed Farm Advisor will inform farmers of the value of soil health through a Visual Evaluation of Soil Structure (VESS) as well as water and soil sampling. As a minimum, soil nutrient analyses will be conducted, with the novelty of integrating this soil advice with phospholipids fatty acids (PLFAs), microbial biomass determined and CO2-C emission from intact soil measured using an infrared chamber. Annual samples will be collected from the same fields/water courses to measure any effect of behavioural change and soil management practices on soil health. The evidence collected will inform policy makers on soil health as well as the local farmers. Additionally, two long-term field experiments (August 2023-August 2026) are being set up with the goal of providing tangible and visual evidence to farmers, influence their decision making on land use and management and reduce nutrients loss from the agricultural sector. The field experiments are involving cover crops and composted farmyard manure (cFYM). During the cover crop field experiment, a cover crop mixture provided by Kings Crops will be compared against bare soil (control), and the effects on water quality, soil biota, structure, nutrient uptake from cover crop, and effects on grain quality of spring barley will be determined. During the cFYM field experiment, cFYM will be applied as soil improver before drilling winter wheat and compared against unamended soil (control). The soil improver and fertiliser potential of cFYM will be assessed, as well as its effects on water quality soil biota, soil structure and grain quality of winter wheat. Both field experiments will utilise a scientific experimental design and monitoring methodology which is designed to allow for sharing of the data and results with the scientific community through publication.

Keywords: nutrient management, EU LIFE, behavioural change, VESS, walkovers, CO2, microbial biomass, PLFAs, cover crops, composted farmyard manure.

Funded by: EU LIFE programme

Link to Poster

Presenting time: 6 December 2023, 12:30 – 13:30

P - 12

Scale-up of novel additive for improved slurry nutrient management

By **Stephen Nolan**[1], Camilla Thorn[2], Vincent O'Flaherty[3]
GlasPort Bio[1], University of Galway[2]

Introduction

GHG and ammonia emissions from the pig sector principally originate from manure management, and more specifically, the handling of slurry (a mix of faeces, urine wash water and bedding material). The extent of emissions, and resulting options for their mitigation vary principally as a result of climatic conditions, pig diet, type of housing and how the slurry is managed. Slurry additives represent a means of reducing gaseous emissions from manure without the need for expensive retro-fitting and in a manner that can tackle emissions of multiple nuisance gasses at once: GHG, ammonia and malodourous and/or noxious gases. Acidification has been considered the gold standard of slurry treatment, but is impractical to implement. Other slurry additives have little, if any, rigorous scientific basis or verification. Hence, GlasPort Bio have developed a novel slurry amendment, and have undertaken to carry out extensive testing and monitoring of efficacy, both as a means to reduce GHG emissions and simultaneously trap valuable resources (nitrogen, sulphur and carbon) in the slurry, giving a higher value organic fertiliser.

Methodology

Following extensive laboratory testing as detailed in Thorn et al (2022), IBC-scale trials were carried out, in conjunction with full-scale application, using dynamic chambers to test for GHG-reduction efficacy. The resulting slurry was then analysed for carbon and nitrogen content, before testing in anaerobic digesters (for increased biogas yield), and pot trials (for increased fertiliser yield – underway).

Results & Discussion

The initial results from the dynamic (left) and closed chambers (right) are presented in Figure 1. As can be seen, methane emissions were significantly reduced in both setups. The resulting slurry is currently being processed in a 100L AD platform and has produced ~50% more biogas than untreated slurry. Ammonia reductions of ~40% were also achieved, resulting in higher N levels in the treated slurry. Pot trials to determine the extent of improved organic fertiliser value are currently underway.

Conclusion

GlasPort Bio have developed a novel slurry additive capable of retaining C and N in organic fertiliser by reducing gaseous emissions, thereby improving organic fertiliser formulation and value. This approach has been verified through rigorous testing and monitoring from lab-scale through to field application. It is anticipated the ongoing pot trials will demonstrate improved slurry nutrient management potential via improved grass yields.

P - 12

Reference: Thorn, C.E., Nolan, S., Lee, C.S., Friel, R., O'Flaherty, V., 2022. Novel slurry additive reduces gaseous emissions during storage thereby improving renewable energy and fertiliser potential. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2022.132004

Funded by: Sustainable Energy Authority Ireland

Presenting time: 6 December 2023, 12:30 – 13:30

P - 14

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: 6 December 2023, 12:30 – 13:30

Soil Carbon: Oral Abstracts

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.

Acknowledgements: Key Laboratory of Arable Land Quality Monitoring and Evaluation, Ministry of Agriculture and Rural Affairs, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, PR ChinaZhongkai University of Agriculture and engineering, Guangzhou, China

Funded by: National Natural Science Foundation of China, Grant/Award Numbers: 42177341, 41620104006

Presenting time: 7 December 2023, 11:00

The long-term effects of woodland creation on soil structure and the fate of carbon

By **Olivia Azevedo**[1], Elena Vanguelova[2], Frank Ashwood[2, 3], Clare Wilson [1], Elisa Fuentes-Montemayor [1], Sietse van der Linde[4], Kirsty J. Park[1]

University of Stirling[1], Forest Research[2], University of Canterbury[3], Netherlands Institute for Vectors[4]

The importance of increasing woodland cover in mitigating climate change is widely recognised, yet quantification of the long-term impact of maturing woodlands on soil structure and carbon stocks remains limited. This study evaluates soil structure and carbon content across a chronosequence of UK woodlands established over 170 years and old-growth woodland (250+ years old) compared to pasture sites.

Our investigation reveals a significant increase in soil organic carbon (SOC) in lowland agricultural landscapes as a result of woodland creation. Woodland creation sites (approximately 20–170 years) contained 5% more stocks of SOC in mineral layers than adjacent pasture, while old growth sites contained 22% more than pasture.

Overall, carbon stocks tended to be greater in woodlands older than 80 years (81–170 years) and old-growth than in younger forests. The fate of carbon also varied based on the age of the woodland. Carbon content in the microaggregates (250–53 μm) of the 31–80 and the 81–170-year groups was almost double that of pasture sites, despite the 81–170-year group having fewer microaggregates. The concentration of carbon in the finer silt and clay fractions (< 53 μm) also increased by 72% in the 81–170 woodland group, indicating long-term carbon sequestration.

This study underscores the potential for woodland creation to promote carbon sequestration. Furthermore, it emphasises the significance of forest age when estimating soil carbon stocks.

Keywords: carbon concentration, carbon sequestration, bulk density, forest soils, MWD, mean weight diameter, soil organic carbon, water stable aggregates, UK.

Presenting time: 7 December 2023, 09:30

Effects of traffic and tillage management systems on soil organic carbon dynamics

By **Ana Prada Barrio**
Harper Adams University

Conventional agricultural practices with excessive tillage and without appropriate soil vehicle management can lead to soil degradation by increasing soil compaction and depleting soil organic matter (SOM). Different soil management practices and the duration of implementation, impact soil organic carbon (SOC) dynamics and long-term persistence. Knowledge gaps still exist on the long-term effects of alternative traffic systems, and their interaction with different tillage systems, on SOC dynamics.

A long-term field-scale experimental site was established at Harper Adams University (United Kingdom) aimed to investigate the effects of three traffic management systems imposed on a sandy loam soil: standard inflation pressure tyres (STP), low tyre inflation pressure (LTP) and controlled traffic farming (CTF) on soils managed with three tillage systems: deep (25 cm), shallow (10 cm) and zero tillage on (i) total soil organic carbon (SOC) stocks (0-30 cm) and (ii) SOM fractions (total particulate organic matter-C [POM-C] and mineral-associated organic matter-C [MAOM-C] (0-30 cm).

The results indicated some evidence that by combining CTF with Zero tillage, SOC stocks could be increased. In particular, CTF with Zero tillage stored 14 Mg/ha more than STP and LTP treatments. SOM fractions were affected differently by traffic and tillage across the soil profile: while POM-C concentrations were significantly higher in CTF Zero tillage at 0-10 cm and at 20-30 cm, MAOM-C was not significantly affected by the treatments apart from 20-30 cm where CTF Zero tillage was borderline non-significantly higher.

Keywords: soil organic carbon (SOC), soil carbon sequestration, SOM fractions.

Funded by: Douglas Bomford Trust, The Morley Agricultural foundation and in-kind support of Väderstad and Michelin.

Presenting time: 7 December 2023, 10:00

Rapid increase in soil organic carbon and structural stability following conversion to semi-natural grassland irrespective of management history

By **Sharon Chebet**
Agroscope and ETH Zurich

Intensive tillage presents a threat to soil organic carbon (SOC) and soil structural stability. Conversely, the conversion to semi-natural grassland has the potential to reverse mild soil degradation.This study was to evaluate the potential of the short-term conversion to semi-natural grassland. The findings explicitly highlight the potential benefits of converting arable land to semi-natural grassland, even in the short term. The study takes into account four different straw rates (SR: 0, 4, 8, 12 Mg ha-1 yr-1) and two cover crop treatments (CC: without and with a ryegrass cover crop), and examines the impact of these factors on SOC and structural stability after 1-2 years following the conversion. Previous studies have had limitations, such as the absence of long-term data and contrasting initial conditions. That is why my study, with its four straw rates alleviates the limitation and most importantly, there was regular sampling from 1981 to 2019 when the land was under arable farming. Hypothetically, the conversion to a semi-natural grassland would affect SOC and structural stability differently depending on the management history of the soil.

I conducted an analysis of soil samples from 2019 (cropping) and 2021(semi natural grassland). The conversion led to a significant increase in SOC and improved soil structural stability, which are key indicators of soil health. This suggests that even small changes in land use practices can have positive effects. I found that straw incorporation had a significant effect on SOC and clay dispersion (CD) in 2021, but not on wet stable aggregates (WSA), while the ryegrass cover crop did not have a significant effect on any of the measured parameters. Despite differences in initial soil condition, there was a rapid increase in SOC and soil structural stability due to an increase in root density and aboveground biomass, which facilitated the enmeshment of microaggregates to macroaggregates in addition to the released binding agents during decomposition. All these occurred irrespective of the prehistory. Surprisingly, I found that straw incorporation had a significant effect on clay dispersibility in the 1-2mm aggregate size distribution, but not in the 8-16mm size distribution, and that the cover crop did not have a significant effect in either size distribution. I expected the 1-2mm size distribution to have lower dispersibility than the 8-16mm due to the binding of microbial products, but this was not the case. The interaction between year and SOC was significant for clay dispersibility, but not for WSA. This suggests that SOC affects clay dispersibility differently depending on the year, with a coefficient of determination (R2) of 0.64 in 2019 and 0.60 in 2021. There was no interaction between year and SOC observed for WSA. In conclusion, previous soil management practices augmented the current soil status by increasing the amount of SOC following conversion while keeping the old carbon pool intact but there was rapid changes irrespective of the prehistory. The benefits of grasslands suggest that they are suitable for promoting

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good soil quality and mitigating climate change, and thus, making them suitable management practice in carbon farming.

Presenting time: 07 December 2023, 10:30

Savanna soil carbon: interactive impacts of fire and climate on soil respiration

By **Mary Cvetkovic-Jones**[1], Mary Hodgson, Nicolas Ostle, Catherine Parr
Lancaster University[1], UK Centre for Ecology & Hydrology, University of Liverpool, University of Witeatersrand, University of Pretoria, Kruger National Park Scientific Services

The influence of savannas on the global carbon (C) cycle is becoming increasingly clear. There is growing concern that climate change has the potential to alter biological processes regulating soil carbon cycling in savannas. Interactions between climate, fire regimes and herbivory are expected to affect soil microbial breakdown and respiration of organic matter. The timing and intensity of savanna fires are known to drive changes in plant community composition that alter the quantity and quality of C inputs to the soil and resultant CO2 release to the atmosphere. Specifically, there is considerable uncertainty regarding the impacts of fire and climate on the biological and biogeochemical resilience of these soils. We studied granitic soils sampled along a managed seasonal fire gradient, from long-term Experimental Burn Plots, in Kruger National Park, South Africa. Measures of soil microbial biomass and community composition, pH and C:N ratios were made to determine variability across the seasonal fire gradient. We also examined how differences in microbial composition and abiotic properties affect short-term soil C-cycling in a C-substrate addition experiment at different moisture levels. We found that higher intensity fire regimes increased C-substrate induced respiration rates and influenced soil biological properties. The different responses to C substrates under different seasonal fire regimes suggests that changes in soil microbial communities can contribute to rapid C cycle responses and the resilience of systems to moisture variance.

Keywords: Savannas, Soil Respiration, Fire, Herbivory, Climate Change, Long-term Experiments, Glucose Assay, Soil Carbon, Soil Biogeochemistry, Soil Resilience

Funded by: Envision DTP

Presenting time: 07 December 2023, 10:45

Calculating the Carbon Sequestration Potential of Cement Bypass Dust as an Agricultural Soil Amendment

By **Mollie Frost**
Lancaster University and University of South Australia

With the ever-increasing rates of anthropogenic carbon dioxide (CO2) emissions, climate change threatens humanity's existence on Earth. The result, global warming, poses challenges such as encroaching sea levels, desertification and droughts which lead to strains on agriculture and ecosystems.

To overcome this, there are new initiatives to both reduce further CO2 emissions, use new carbon sources, and to return anthropogenic CO2 back into the terrestrial and marine storage. This research focuses on the use of cement bypass dust (CBPD), a waste product from the production of cement, as a soil amendment to return and store carbon in the terrestrial environment.

Of the terrestrial carbon storage sinks, soil is the key as it is a naturally carbon-rich from biotic activities involving plants, and macro- and micro-organisms. It also can store sequestered carbon resulting from the weathering processes of rocks and minerals. Previous studies have focused on using calcium and silicate-based crushed rocks, rich in Ca and Mg, which react with water once entering the soil system to produce base cations, and bicarbonate and carbonate anions. These are transported eventually to be stored long-term in the ocean environment as insoluble carbonate precipitates.

High Ca content and alkalinity of CBPD make this waste material suitable for sequestering carbon in soil through processes similar to enhanced mineral weathering. Due to high pH and potassium content, CBPD is also suitable as a liming material and fertiliser that can promote crop growth, furthering carbon sequestration through increased rates of photosynthesis and biomass entering the upper soil horizons. Due to the ever-increasing demand for agricultural fertilisers, applying non- conventional materials, such as CBPD, with high economic and carbon costs for extraction and processing, to soils for crop production would promote a circular economy.

The research approach taken is a mixture of pot experiment, a soil column experiment and field trial. Measurements will be taken from bulk soil, rhizospheric soil, soil leachates and plant tissues to determine the net carbon sequestration potential of CBPD. This research will result in lowering net CO2 emissions which are associated with agricultural fertilisers and cement production and increasing carbon storage in the terrestrial environment.

Funded by: ERDF

Presenting time: 07 December 2023, 09:45

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

Presenting time: 7 December 2023, 10:15

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

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Soil Carbon: Poster Abstracts

P - 1

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.

Acknowledgements: Key Laboratory of Arable Land Quality Monitoring and Evaluation, Ministry of Agriculture and Rural Affairs, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, PR ChinaZhongkai University of Agriculture and engineering, Guangzhou, China

Funded by: National Natural Science Foundation of China, Grant/Award Numbers: 42177341, 41620104006

Link to Poster

Presenting time: 7 December 2023, 13:00 – 14:00

P - 3

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

Presenting time: 7 December 2023, 13:00 – 14:00

P - 5

Trees for carbon? Applying spatial autocorrelation of SOC to inform long-term monitoring of net-ecosystem carbon stocks within upland based native woodland creation projects

By **Francesca Darvill**[1], John Crawford, Dominick Spracklen, Pippa Chapman
University of Leeds[1]*, Woodland Trust*

Driven by 2050 global net-zero and 2030 biodiversity targets, woodland creation is a critical nature-based solution that lies at the heart of the UK Government's 5-year Environmental Improvement Plan. Increased woodland cover in degraded upland landscapes is expected to improve delivery of vital ecosystem services (ES) for climate adaption, including increased soil organic carbon (SOC) sequestration via increased biomass inputs and root exudation. Despite future reliance on changing upland land management for ES benefits, soil carbon response to native woodland creation (NWC) in England's uplands are relatively under researched. Assessing the effects of NWC is challenging, mainly due to the longevity of study required to detect even small changes of SOC. As a result, most recent evidence is a product of randomised complete block design (RCBD) within chrono-sequence experimental plots between 20 to 50 years after tree planting. An arising theme from these experiments is low disturbance tree planting could result in declines in net ecosystem carbon stock due to significant loss of SOC that outweighs biomass accumulation over decadal timescales. However, the lack of pre-planting SOC data means it is difficult to determine the net carbon trajectories of tree planting schemes, particularly within heterogeneous soil-scapes.

SOC is a spatially correlated soil attribute, and spatial analysis simulations have demonstrated a greater statistical power for determining change in shorter time frames, particularly in topographically varied landscapes like those typical of the English uplands. Here we demonstrate how a distance-weighted sampling strategy will be applied to map spatial variability of upland soil properties at Snaizeholme, a large NWC site in the Yorkshire Dales. SOC data has been collected at the site using a nested model in which six vertical and six horizontal independent transects reside within each of the three valley aspects (East, South and West). This provides 3 independent field sites with 6 independent repetitions with 2 factors within the elevations of 400m to 420m of the hillslope, where the densest tree planting will occur. From each transect seven distance-weighted cores have been collected (0 m, 0.05 m, 0.25 m, 1.05 m, 3.05 m, 11.05 m and 27.05 m) (n=252). The cores sample soil from 0-15 cm depth, representing topsoil SOC. The spatial autocorrelation of SOC can then be modelled by plotting semi-variance in a variogram. In addition, further analyses of bulk density, pH, soil moisture and soil texture data will be collected from the core samples to provide detail of co-variance between soil properties within field sites. This high-resolution data will allow us to describe the spatial variability of SOC and the effectiveness of plot-scale averaging in these systems. Results from this work will also go on to inform statistically powerful monitoring strategies to detect change SOC stock and gaseous carbon flux pathways to compile evidence of net-ecosystem carbon changes within timeframes required to meet the UK's tree-planting and net-zero ambitions.

Presenting time: 7 December 2023, 13:00 – 14:00

Key words: Soil Organic Carbon, Upland, Spatial analysis, Climate change, Sequestration, Topography, native woodland creation

Funded by: Sowerby Foundation, Woodland Trust

Presenting time: 7 December 2023, 13:00 – 14:00

P - 7

Agroforestry for ammonia abatement and reducing greenhouse gases

By **Kaisa Ilmari**
Forest Research

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

Link to Poster

Presenting time: 7 December 2023, 13:00 – 14:00

P - 9

Rebound of Soil Aggregation, Carbon Stocks, and Biodiversity Under Regenerative Agriculture Approaches

By **Sam Keenor,** Brian Reid
Presented by **Louisa Moor**
University of East Anglia

Aim:

To determine the influence of a regeneratively managed perennial crop system on soil aggregation, carbon stability and soil biodiversity.

Method:

Soil was collected from regeneratively managed blackcurrant fields, established for 1-, 2-, 4- and 8-years. Soil samples were used to determine soil aggregate stability, pH, SOM/SOC content (loss on ignition), and aggregate fraction carbon stability (CHNO). Soil mesofauna analyses (pitfall traps) were conducted to assess soil biodiversity.

Results:

Soil aggregate stability and stable aggregate fractionation was observed to increase with time. Total SOM/SOC were observed to increase with duration of regenerative approaches. Soil pH not significantly altered over the 8-year period. Soil carbon recalcitrance (defined by H:C vs. O:C plots was observed to increase. Soil mesofauna biodiversity assessment (Shannon diversity/equitability, species richness and unique species) were observed to increase with increased time and SOM.

Conclusions:

Data acquired sustains regenerative agricultural methods as a means to rebuild soil carbon stocks and improve soil aggregate development. As such regenerative agriculture principals may hold promise for ecosystem rejuvenation and enhancement and as a potential means of soil carbon sequestration.

It is hypothesised that this observed soil carbon uplift will support biodiversity gains for mesofauna and furthermore microbial populations. These being supported by greater provision of carbon resources to sustain soil food webs. However, synergies and antagonisms between more resource and its chemical (reactance) and physical (greater aggregate stability) protection are expected to have additional shaping influences on the ultimate outcomes observed.

Key Words: Soil carbon sequestration, soil aggregate stability, soil biodiversity, regenerative agriculture

Funded by: NERC and ARIES DTP (NE/S007334/1), The Wendling Beck Exemplar Project, and Norwich Research Park Grand Challenges Fund

Presenting time: 7 December 2023, 13:00 – 14:00

P - 11

Anaerobic fermentation of food waste to connect fork to farm and store carbon in soils

By **Samantha Kehoe**
University of Reading

Reduction of emissions in food waste management, valorisation of food waste streams and organic carbon management for sequestration and soil health are becoming increasingly relevant as we approach climatic tipping points. Lactic acid fermentation of food waste has the potential to address and connect these issues at a large scale, creating a circular economy through improved application of a simple biotechnology. Lactic acid fermentation can initiate break down of a wide range of organic materials through application of a Lactobacilli inoculated bran or spray in anaerobic conditions, producing a stable organic soil amendment in a short period of time. This process, commonly known as 'Bokashi', is currently used to manage food waste at residential scale but further research is needed on carbon storage possibilities and socio-economic barriers to larger scale use.

The wider hypothesis of the 4-year project is that lactic acid fermentation of food waste has the potential to produce an organic amendment with lower CO2 emissions or energy use than the most common current food waste management alternatives. This is underpinned by the hypotheses that gaseous emissions in Bokashi fermentation are significantly lower than that of aerobic composting, and that the amendments produced are high quality. To interrogate these hypotheses and overcome barriers to scaling up, the theoretical basis needs to be confirmed, including the fate of carbon post-fermentation once added to soil.

The first trial in this project addresses a gap in the literature by quantifying gaseous emissions and basic chemical characteristics of food fermentation with different microbial addition rates. Using a vegetable mix and a commercially available Bokashi microbial bran ("Effective Microbes") in lab-scale fermenters, four-week fermentations with five different amounts of microbial bran application will be compared.

Headspace gas analysis for CO2, CH4 and N2O will show emissions during fermentation, pH of fermentation products will indicate fermentation 'success', and carbon and NPK analysis of liquid and solid products will show how key nutrients are distributed for optimal soil application. Comparing these key parameters will provide useful data on optimal microbial addition rates, gaseous emissions under anaerobic conditions and nutrient differences in solid and liquid products. Collectively this will begin to address questions of cost efficiency, potential emissions savings, application methods and values of fermentative products. A further study will investigate the fate of carbon once added to soils.

The results of this experiment will be presented alongside an overview of the wider project plans and goals.

Presenting time: 7 December 2023, 13:00 – 14:00

Key Words: Food waste, Bokashi, soil health, soil amendments, carbon, waste valorisation, fermentation

Funded by: BBSRC FoodBioSystemsDTP with CASE support from Agriton Ltd.

Presenting time: 7 December 2023, 13:00 – 14:00

P - 13

Improving soil organic carbon through crop rotations: a Western Australian Case Study using a digital twin approach to analyse ground survey and remote sensing data

By **Christopher Lakey**
Downforce Technologies Limited

Over the past sixty years, agricultural production has focused on delivering maximum harvest yields and increased crop productivity, through intense tillage and widespread application of nitrogen-based fertilisers. The result has been a widespread loss of soil health coupled with significant greenhouse gas emissions from topsoils that are putting the agricultural and food sectors at risk. To counteract these trends, there is increasing interest in sustainable land management and carbon farming practices that can restore soil health, regenerate cropland and pasture but also reduce costs by shifting production away from nitrogen intensive input strategies to low input carbon cropping systems.

In this study, we applied a multi-temporal digital twin, using data fusion of in situ and remote sensing measurements, to investigate the impacts of crop rotation on soil health. We examined the impact of incorporating Australian sweet lupin (Lupinus angustifolius) into crop rotations to produce a valuable nutritional crop as well as improve soil health. A dekadal soil organic carbon (SOC) analysis at a 10m resolution was conducted over a property in Western Australia with ~4000ha of cropping split across50 separate fields.

Based on a five-year crop rotation history, with 7 crops and 17 different crop rotation types, we generated a series of soil health analytics. Our results showed that there was a general increase in SOC in four of the crop transitions into lupins, and that for two of the transitions into canola (rapeseed) the increase was greater than for lupins. These results highlight the immense potential of high-resolution SOC data at the local level for farmers to develop and test carbon neutral/positive cropping practices and strategies, and at a national scale for policy makers to develop policies and monitoring programmes to restore soil health and deliver carbon neutrality.

Link to Poster

Presenting time: 7 December 2023, 13:00 – 14:00

P - 15

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]
University of Birmingham1, Lancaster University2, University of Exeter3

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.

Funded by: NERC grant no NE/T000449/1

Presenting time: 7 December 2023, 13:00 – 14:00

P - 17

The influence of trees on soil organic carbon levels in the Waite Arboretum

By **Jay Ryan**, Ashlea Doolette, Ronald Smernik
University of Adelaide

Soil plays a critical role in the global carbon cycle as it can act as both a source and sink of atmospheric CO2 and has a larger and more stable carbon (C) storage potential than biomass. To maximise soil C storage, factors that maximise transfer of C from the atmosphere via plants to soil must be better understood. This study focusses on the role of trees in that process within the Waite Arboretum. The average organic C concentration in the 0-10 cm soil layer for a set a 51 soil cores collected across the arboretum from open spaces in a 50 m x 100 m grid pattern was 3.19%, which is considerably higher than the range of 1-2.5% previously reported for adjacent Waite Campus topsoils under various forms of agricultural management. Follow-up sampling targeted at areas under and close to tree canopies suggests this grid average is a substantial underestimate, with higher average values at half canopy (7.47%) canopy edge (5.10%) and even double canopy distance (3.84%) for twelve selected trees of different species all being significantly higher. Importantly, the elevation in under-canopy C concentration varied substantially between the trees. This study highlights the challenge posed in assessing soil C in systems with scattered trees, since soil C concentration varied substantially on the 1-10 m scale. This study also demonstrates the value of using mid- infrared prediction in tandem with tradition chemical analyses for assessing soil C in such systems.

Funded by: AW Howard Trust and The University of Adelaide

Presenting time: 7 December 2023, 13:00 – 14:00

Soil Health: Oral Abstracts

Broad scale multiple year temporal changes in the physical structure of agricultural soils across three catchments in Scotland

By **Jessica Brook**
University of Aberdeen

A healthy soil structure is vital for successful productivity from agricultural land and for the maintenance of important ecosystem services. The structure and porosity of soil impacts its water retention and drainage properties, with deterioration of soil structure leading to susceptibility to compaction, erosion and nutrient loss. As a result, soil structure degradation is a serious threat to both agriculture and the environment in Scotland. Through a resampling strategy using the Visual Evaluation of Soil Structure (VESS), together with the collection of quantitative soil physical data, we investigated temporal changes in the physical structure of soil. This builds on a study undertaken in winter 2015/16 which considered the effect of soil structure and field drainage on water quality and flood risk on agricultural soils across Scotland. The 2015/16 survey of 120 fields across 4 river catchments in Scotland found widespread soil physical degradation over the winter months, with severe soil structural degradation recorded in 18% of topsoils and 9% of subsoils. A subset of 42 of these fields was revisited in January 2016 following the most severe rainfall event ever recorded in Scotland, which led to a 30% increase in severely degraded topsoils. While this study demonstrated the short-term negative impacts caused by weather, the longer-term impacts are not known. I therefore conducted a resampling in winter 2022/23 of the subset of 42 fields from three river catchments: the River Ugie, the South Esk, and the East Pow. The previous sampling strategy was repeated, using GPS to identify the original locations sampled in each selected field, with three samples from in-field locations, three from heavy traffic areas with visible damage to the soil surface, and three from the field margins. In addition to VESS I also measured penetration resistance and collected an undisturbed soil core from a 2-7cm depth. These cores were then used for the measurement of soil bulk density and macroporosity. Analysis of the results of this investigation is underway, however preliminary analysis found most soils to be VESS scores 2 and 3 in in-field locations, and an average of 4 in areas categorised as 'degraded', indicating changes in management may be required to improve the overall soil physical health. Research such as this is important for both an increased understanding for farmers on how to actively manage their soils to reduce environmental impacts, and for the development of future governmental policies on land management.

Keywords: soil health, soil structure, soil management, agriculture, visual analysis, VESS

Funded by: SUPER DTP

Presenting time: 6 December 2023, 14:15

Application of computational approaches in soil-mineralogy to understand mineral-nutrient relationship

By **Urmi Ghosh**[1], Stephen Hillier

The James Hutton Institute[1]*, Swedish University of Agricultural Sciences (SLU)*

The mineralogy of soils exerts a strong influence on chemical processes leading to nutrient availability and has long been known to influence the properties and functions of soils such as fertility. Also, recent interest has arisen in amending soil with crushed silicate rocks, driven by a desire to achieve more climate-smart farming and claims that it leads to benefits such as better plant growth, increases in the rate of carbon sequestration, and overall may be considered better practice than chemical fertilizer application. A better quantitative understanding of mineralogy may help in devising more appropriate nutrient management strategies for agricultural soils. X-ray powder diffraction (XRPD) is a powerful technique for quantitative mineralogical analysis. We have used XRPD data of soils from a 20 km grid of the National Soil Inventory of Scotland 2007–2009 [1] and used the automated full pattern summation (AFPS) algorithm in the 'powdR' package [2] for R [3] using quartz as an internal standard and a reference library of 160 pure phase diffraction patterns (silicates, oxides, glass, organics, etc.) to quantify the mineral proportions in the NSIS soil samples. Using high-performance parallel computing (UK's Crop Diversity Bioinformatics HPC), >700 soil XRD patterns can be analyzed in a few hours. The quality of the fits obtained between the measured and the fitted XRPD patterns indicates that a good level of precision has been obtained. We have used Mineral Network Analysis (MNA) to visualize the mineral co-occurrence and spatial relationships and to infer new information about existing relationships in the data. Different Machine Learning (ML) regression algorithms can predict the nutrient capacity and other physical properties of the soils from soil mineralogy. An earlier study [4] has shown that the Cubist model can efficiently predict the aqua regia extractable base cation concentrations using soil mineralogy, pH, and organic matter. A preliminary model of Water Stable Aggregates (WSA) prediction using Random Forest Regression using a smaller mineral and carbon dataset also shows promising results (R2train = 0.90, R2test = 0.57). In this study, we try to understand which minerals control the availability of essential micronutrients for plant growth using the ML approach.

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Presenting time: 6 December 2023, 13:30

Novel genes associated with insoluble phosphorus can be utilised to assess soil health

By **Aileen Lynch**
Queens University Belfast

This project will reduce reliance on soluble phosphorus, which results in run-off and eutrophication of freshwater ways. Excessive P fertilisation also results in soil compaction, phosphate rock depletion, and reduction in crop production, suggesting alternatives to current phosphorus fertilisation practices need to be examined. Also, methane, the second most abundant greenhouse gas, is short-lived at 9.1 ± 0.9 years, as it reacts with ·OH radicals, but accounts for a quarter of the radiative forcing, global warming, due to shortwave absorption. Therefore, using microorganisms that utilise methane as a carbon source can reduce the methane released into the atmosphere.

My research group has shown that methanotrophs can utilise insoluble phosphorus and single-carbon compounds such as methane for their carbon and energy sources. Methanol dehydrogenases, cell wall proteins of methanotrophs, are Ca2+ dependent (MxaF) and Ln3+ dependent (xoxF). We aim to show that the novel genes coding for these proteins, mxaF and xoxF, associated with insoluble phosphorus acquisition, can determine the relative health of agricultural soils, reduce current fertilisation practices, and will aid in carbon sequestration.

Soil samples will be obtained from most agricultural land in Northern Ireland and experimental farm plots. The soil sampling and monitoring will occur over four years. A full metagenomic analysis will be completed to survey for pathogens, microbial abundance, methanotrophs, and novel genes maxF and xoxF. All samples will also have their macronutrients (P, K, Ca, S, and Si) and trace elements (Fe, Cu, and Ln) quantified using XRF-MS. The Ce content of the soil samples will be completed using a combination of a (4-(2-pyridyl azo)resorcinol) indicator and ICP-MS. Each farm will complete a land-use questionnaire, including fertilisation practices, ploughing, and liming. All metadata, chemical data, and metagenomic data will then be analysed using in silico bioinformatics to determine correlative relationships between these data and mxaF and xoxF genes.

The above field studies will be paired with lab-based experimentation with methanotrophs isolated from virgin soils in the Alps and Northern Ireland soils, which have been shown to use insoluble phosphorus as a P source. These Methanotrophs will be used to determine causative effects from correlations found in field studies. Radishes will be grown experimentally to monitor the microbial abundance and diversity changes, the biomass of the radishes, mxaF and xoxF genes, and physiochemical fluctuations based on treatment with soluble and insoluble phosphorus over nine months using the tools mentioned above. The results and analysis for the different project elements will be collated and ready for the presentation. We are currently at the data collection stage of the project.

Funded by: DAERA and AFBI

Presenting time: 6 December 2023, 14:45

Short- and long-term effects of slurry applications on earthworm populations

By **Katie Martin**, Olaf Schmidt, Saoirse Tracy, Fiona Brennan

University College Dublin and Teagasc

Land spreading of animal slurries is an important practice for recycling essential nutrients in agricultural systems. However, there are widespread reports of earthworm mortality at the soil surface shortly after slurry application, leading to farmers questioning whether this is deleterious to soil biology. Whilst post-slurry application earthworm mortality is widely seen, there is currently little research surrounding this phenomenon. Despite this short-term effect on earthworm populations on farms, research has reported long-term increases in total earthworm populations, with earthworms using slurry as a food source.

In this research we aim to measure the impacts of slurry applications on earthworms in the short- and long-term. Using grassland and arable field experiments, we aim to assess how slurry management and slurry types affect earthworm communities.

To quantify the initial effects of slurry applications on earthworm mortality, we performed earthworm counts at the surface of a grassland plot experiment. This experimental site in Co. Wexford, Ireland is investigating slurry application methods which can reduce ammonia emissions including Low Emission Slurry Spreading (LESS) techniques and slurry acidification. The treatments include: a chemically fertilised control, and slurry treatments with and without acidification applied using different techniques: splash plate, trailing hose, trailing shoe and injection. The number of surfaced and dead earthworms were counted 1 and 2 hours after slurry application. There are very few studies quantifying earthworm mortality post slurry application so this research will build our understanding of this phenomenon. Additionally, slurry management techniques which reduce ammonia emissions are gaining popularity so an understanding of their impacts on earthworm populations is of great interest.

Secondly, the long-term impacts of slurry application and slurry type on earthworm populations is measured on a grassland site in Co. Wexford and an arable site in Co. Wicklow, Ireland. The earthworm populations are being sampled across spring and autumn seasons on experimental plots that have been treated with no fertiliser, chemical fertiliser, cattle slurry or pig slurry over 4 years. This sampling will allow a better understanding of how applications of slurry impact earthworm community size and species composition over longer periods of time.

Altogether, this research will give insight into both the short- and long-term impacts of slurry applications on earthworm communities. This includes the impacts of slurry type, application method and acidification treatments on earthworm mortality and earthworm populations. These results will provide information on potential slurry management strategies that may benefit earthworm populations on farms and will be used to inform farmers of soil biological effects of this important management practice.

Presenting time: 6 December 2023, 13:45

Funded by: Department of Agriculture, Food and the Marine, Ireland

Presenting time: 6 December 2023, 13:45

Can increased cover crop diversity bind more soil in the field?

By **Cristina McBride-Serrano**[1], Tim George, John Quinton
Lancaster University[1]*, James Hutton Institute*

Agricultural intensification has simplified landscapes thereby reducing biodiversity, depleting natural resources, and threatening ecosystem services. Resilience to abiotic stress is therefore decreasing, creating uncertainty about effects of climate change on agricultural production and environmental degradation. While much research has focused on the direct benefits of increased plant diversity for crop productivity, quantifying the effects on soil water availability and soil-associated agroecosystem services regulated by root systems has been relatively ignored. How cover crops bind soil (rhizosheath development) has attracted little attention even though they can decrease soil erodibility.

A field trial investigated the impact of cover crop diversity on rhizosheath development and soil erodibility by conducting overland flow simulations. Species (Secale cereale, Brassica juncea, Vicia faba) were chosen for their suitability to UK environmental conditions. Results established that rhizosheath formation was not affected by crop diversity and was greater in treatments containing Secale cereale. Overland flow simulations showed species diversity did not have an impact on soil erodibility, and soil hydraulic properties had a greater influence.

By providing evidence for increased plant diversity effects on agroecosystem function, this work will inform land managers about cropping practices to conserve soil function and aid in delivering environmental policy targets.

Keywords: cover crops, soil erosion, rhizosheath, plant diversity, root diversity, soil management, agroecosystem services, runoff, water management

Funded by: James Hutton Institute and Perry Foundation

Presenting time: 6 December 2023, 14:30

Effect of wheat roots and bulk density on soil microbial properties and pesticide degradation

By **John Nunns**[1], Wilfred Otten, Mark Pawlett
Cranfield University[1]*, University of Reading, Syngenta*

Roots exert a significant amount of influence on the soils they inhabit. However, their influence is often not considered in pesticide degradation trials, calling into question how representative the laboratory testing environment is. This is especially relevant for pesticides where application will not occur without root presence in the soil. Roots have the potential increase microbial population mass. A shift in the composition of the microbial hierarchy is also possible, due to both the pro- and anti-biotic nature of root exudates. These different factors have the potential to impact pesticide degradation through changing the prevalence on bacteria and fungi. Further understanding of the influence of roots on biological, physical, and chemical properties and processes is needed for the development of future innovative chemicals and crop protection products. We quantified the effect of soil structure and roots on pesticide degradation and the microbial population in replicated, large, 1.2 m2, lysimeters packed under different conditions over a period of 3 months. The lysimeters were filled with a sandy loam soil at two bulk densities (1.13 and 1.34 g/cm3), and either left bare or planted with spring wheat. These lysimeters were then sprayed with two different pesticides to monitor degradation rates. Samples were taken 1, 7, 14, 30, 60, and 90 days after spraying to quantify the breakdown of these pesticides, alongside the biological response as detailed below. Indicators of changes to the general microbial mass and activity have been observed through respiration monitoring and the extraction of total biomass carbon. Phospholipid fatty acid was quantified to identify changes to soil microbiological composition. Specific data monitoring of microbes relevant to pesticide degradation will be obtained through DNA extraction and analysis.

Keywords: Roots, rhizosphere, structure, bulk density, pesticide, degradation, bioremediation, microbiology, community composition

Funded by: Syngenta

Presenting time: 6 December 2023, 14:00

Soil Health: Poster Abstracts

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Understanding the chemo-dynamics of coastal wetland soils for improving agricultural sustainability in Southern Bangladesh

By **Sayeda Sabrina Ali**, Paul Williams,
Queen's University Belfast

Understanding soil chemical dynamics is critical to improve sustainable agriculture in coastal wetlands of Barishal, an important rice producing zone in southern Bangladesh. In the present study, an extensive soil survey campaign comprising of 72 locations (all rice fields) within Barishal, based on agro-ecological zones (AEZ, namely Ganges tidal floodplain and Young Meghna estuarine floodplain) and soil salinity levels over two consecutive seasons (wet and dry), was conducted. Energy dispersive X-ray fluorescence spectrometry (EDXRF) was used to determine the total concentration of the soil samples along with the measurement of soil organic matter, and physical-chemical properties. Soil samples were also subject to Olsen-P extractions and colorimetric analysis. Coastal fringes in GTF are significantly ($p<0.0001$) higher in salinity than the inlands. On the contrary, salinity was more homogenous in Young Meghna estuarine floodplain (YMEF). Dry season salinity is found to be significantly different ($p<0.001$) than in wet season. Soil organic matter content is comparatively very low in the region (0.2-0.8%) and it decreases with increasing soil salinity level in Ganges tidal floodplain (GTF). However, total concentration of elements varies between AEZs. Furthermore, to have insights on the solute chemistry, a sub-set of these soils ($n=52$) have been incubated anaerobically to regenerate the soil pore water dynamics of a paddy rice system. After six weeks of incubation, Diffusive gradient in thin film (DGT) samplers, with Chelex/titanium oxide mixed binding layers, were deployed and companion porewaters were collected. Analysis of the DGT was by ICP-QQQ-MS, and porewaters a combination of ICPMS and OES systems, along with DOC, pH, Eh and EC. The experimental system generated had a wide-ranging salinity gradient (1-20 dS/m) in the porewaters. Despite, large/significant differences in the bulk chemistries of the soil, the porewater solute trends, were less variable across AEZ and season, with the exception of Fe. Here, pronounced differences were observed with Fe in GTF being higher. There was a significant/positive correlation of Na and essential macro and micronutrients in GTF and YMEF porewaters. Further, there was a strong negative relationship with salinity/Na concentration and elemental partitioning, in the GTF soils (across dry and wet seasons). This was not replicated in YMEF sites/samples. Key findings are that for the calcareous soils of Barisal, salinity is modulating the plant essential elemental kinetics irrespective of season, but to different extents across AEZs. This has implications for management strategies and highlights the need for AEZ specific policies and recommendations across Barisal division.

Keywords: Salinity, Barishal, wetland, season, essential nutrients, DGT, dissolve organic carbon.
Funded by: Bangabandhu Science and Technology Fellowship Trust

Link to Poster

Presenting time: 6 December 2023, 12:30 – 13:30

P - 18

Using Sustainable Soil Amendments for Accelerated Bioremediation of 4-6 ring PAHs in Hydrocarbon Contaminated Wetlands

By **Okelani Aworabhi**
Cranfield University

Wetlands are located on coastal routes for oil and gas exploration, production, and transportation, this makes wetlands vulnerable to pollution by oil spills. Some of the endemic microorganisms in wetlands can utilise hydrocarbons as an energy source but the process is often slow as the natural state of wetland environments is generally unfavourable for biodegradation of hydrocarbons. Wetlands are often microaerobic, oxygen deficient, and negatively affected by tidal waves that lead to nutrient wash out.

This study aims to introduce bioavailable nutrients in form of nitrates and improve oxygen concentrations in saturated wetland environments with the intent to improve the capacity of the endemic microorganisms to produce enzymes for accelerated metabolism of 4-6 ring PAHs.

Sediments were spiked with crude oil in a potted experiment which was run for 90 days and analysed on day 0, 7, 45 and 90. The experiment design consisted of a control, a treatment with an addition of poultry droppings, a second treatment were straw was added and a third treatment with a combination of poultry droppings and straw. 5 replicates were taken to ensure accuracy in data analysis.

Findings from experimental analysis showed that addition of straw and poultry droppings can lead to increased oxygenation and accelerated biodegradation of HMW hydrocarbons in saturated wetland environments. This was evident as a positive redox potential was measured in both treatments containing straw with respective values of 455mV in straw and 166.46mV in poultry droppings and straw which is indicative of an oxidizing environment.

Statistical analysis of the total PAHs showed a significant effect between the days ($p= 0.000$). The treatment with straw and poultry droppings had the overall highest percentage degradation (84.3%) of total PAHs across all treatments and control from day 0 to day 90. PAH degradation in poultry droppings was 55.3%, 43.6% in straw and 35.5 % in the control. Repeated measure ANOVA of the 4-6 ring PAHs showed a significant effect between the treatments ($p=0.0001$) and the days ($p=0.0102$). Straw and poultry droppings led to 84.2% degradation of 4-6 ring PAHs between day 0 and day 90, 28.6% in straw and 57.1% for poultry droppings and 27.5% in the control. The complimentary physical qualities of straw and nutrient potential of poultry droppings led to more efficient bioremediation than in the treatments where amendments were used separately. Hence, for more efficient bioremediation, a combination of complimentary soil amendments should be used.

Key words - Remediation, wetlands, hydrocarbons, microorganisms, microaerobic, anaerobic, degradation, oilspills, sediments, pollution

Funded by: Petroleum Technology Development Fund

Presenting time: 6 December 2023, 12:30 – 13:30

P - 20

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

By **Amy Thomas**, Amy Thomas, Laura Bentley, Chris Feeney, Stephen Lofts, Ciaran Robb, Ed Rowe, Amanda Thomson, Eleanor Warren-Thomas, Bridget Emmett
Presented by **Laura Bentley**
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

Presenting time: 6 December 2023, 12:30 – 13:30

P - 22

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

Presenting time: 6 December 2023, 12:30 – 13:30

P - 24

Impacts of saltwater and freshwater flooding on plant-soil feedbacks of radish (Raphanus sativus).

By **Rebecca Campbell**
Edge Hill University

Global climate change is accelerating, leading to coastal flooding and encroachment of seawater into agricultural lands. The resultant crop failure will lead to economic loss and serious risks to food supplies. Within the UK, the northwest of England produces 15% of the food in Britain and contributes over £726 million to the economy. A considerable proportion of this land is only marginally above sea level and hence under significant flooding risk. While the immediate impact of flooding on production is well understood the impact on subsequent generations is less clear. In particular the legacy of previous generations of plants on plant-soil-feedback is recognised but little explored. The aim of this study is to assess the long-term impact of both salt and freshwater flooding on soil health, via plant-soil feedbacks.

In the first (conditioning) generation, radish plants (Raphanus raphanistrum subsp. sativus: Brassicaceae), a common crop in NW England, were grown individually in mesocosms and flooded with saltwater and freshwater. This conditioned soil was then used in the second generation, in a full factorial design measuring plant biomass with attendant calculation of plant-soil feedbacks. The microbial community and nutrient levels of the soil was also characterised. The results will determine the legacy of flooding on plant growth and performance.

P - 26

A nationwide assessment of microplastic abundance in agricultural soils: the influence of plastic crop covers within the UK

By **Samuel Cusworth**
Lancaster University

Agricultural soils are substantial receptors of plastic pollution, with agriplastics potentially making an important contribution to the overall microplastic load to agricultural soils. The intensive use and mismanagement of plastic crop covers, particularly plastic mulch films, nets and fleeces, represents a pollution pathway. In this study, we have analysed the microplastic concentrations in agricultural soils in 324 samples from 108 sites across the UK, where carrots or potatoes were grown, using a combined digestion and density separation method. Microplastics were stained with Nile Red and quantified using fluorescence microscopy. Microplastic concentrations ranged from 1320 – 8190 particles kg^{-1}, with a mean of 3680 ± 129.1 particles kg^{-1}. Where no plastic crop covers were used for potato and carrot production, a mean of 2667 ± 84.1 particles kg^{-1} were detected. At sites where plastic crop covers were used in the past 10 years, a mean of 4689 ± 147.1 particles kg^{-1} were recorded.

Keywords: Plasticulture, microplastics, plastic pollution, agricultural systems, legacy plastics

This project was funded by BBSRC (EAA7536XS04) and Waitrose Agronomy Group as part of the Waitrose Collaborative Training Partnership. Waitrose and Partners contributed to the funding and development of this project.

Presenting time: 6 December 2023, 12:30 – 13:30

P - 28

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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Estimation of soil erosion and sediment yield using RUSLE model, SATEEC System, Remote Sensing, and GIS Techniques-A Case Study of Navroud Watershed, Iran

By **Mahboobeh Fallah**
Coventry University

Soil erosion poses a significant environmental threat to soil quality, natural resources, and sustainable farming. Understanding the dynamic factors influencing soil erosion is essential for making informed decisions in managing watersheds and conserving soil. The current study aimed to analyze the spatial and temporal patterns of annual soil loss (SL) and sediment yield (SY) in the Navroud watershed between 2000 and 2018. This analysis relied on remotely-sensed data, GIS integrated RUSLE Model, and the GIS-based SATEEEC model. To achieve this, various model parameters, such as rainfall erosivity (R), crop management (C), soil erodibility (K), and topographic factors (LS), were prepared. Additionally, to enhance model accuracy, modifications were made to the R factor by incorporating the snowmelt-runoff erosivity factor (SR). Long-term records of suspended sediment loads were used to validate the model results at the watershed outlet. The RUSLE model revealed that average annual SL rates in the Navroud basin varied from 0 to over 100 tons per hectare per year. When using the R factor and the total rainfall-runoff erosivity (TR) factor, the average SL rates were 5.39 and 14.95 tons per hectare per year, respectively. Conversely, for the SATEEC model, SL ranged from 0 to 144 and 0 to 461 tons per hectare per year, with slightly higher average rates of 6.2 and 16.76 tons per hectare per year using the R factor and TR factor, respectively. Overall, the performance of both the RUSLE and SATEEC models was relatively low (R2 = 0.39-0.44, NSE = -0.05, 0.15) when solely relying on the R factor for simulating SL. However, significantly improved estimations of SL and SY were observed when the TR factor replaced the R factor (R2 = 0.77-0.75, NSE = 0.33-0.36). In summary, the RUSLE model showed slightly better results than the SATEEC model in the Navroud watershed. Furthermore, incorporating the SR factor to estimate the R factor significantly enhanced the accuracy of the models. To conclude, these findings underscore the importance of considering the SR factor in erosion models, particularly in mountainous regions. These results also offer valuable insights for implementing effective conservation practices to mitigate soil erosion risks in the Navroud watershed.

Funded by: Coventry University and Tarbiat Modares University

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Presenting time: 6 December 2023, 12:30 – 13:30

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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: 6 December 2023, 12:30 – 13:30

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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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By **Munisath Khandoker**
Rothamsted Research

Aggregate stability describes the ability of soil aggregates to remain stable against external forces such as rapid wetting and raindrop impact. Stable aggregates can improve soil structure, water holding capacity and protect organic matter. Aggregate stability is therefore an essential physical indicator of soil health. Current methods to measure aggregate stability often involve disrupting soil aggregates in distilled water. These tests are time-consuming, require specialised equipment and are usually done in laboratories.

The Soil Aggregate Stability (SLAKES) smartphone application, developed by the University of Sydney, Australia, quantifies aggregate stability by measuring how quickly soil aggregates disintegrate once submerged in water. The SLAKES application requires three soil aggregates between 2-15 mm in diameter to be placed in a petri dish. Water is added, and the SLAKES app provides a measurement of aggregate stability within 10 minutes.

To determine the sensitivity of the SLAKES app, we compared its aggregate stability measurements with that of the established "Le Bissonnais" method. Soil samples of different textures were taken from fields under fallow, permanent grass, and continuous arable cropping management at two experimental sites on different soil types. The SLAKES app's results were similar to those achieved with the standard "Le Bissonnais" method. The SLAKES app could differentiate between different managements on clayey soil but was less sensitive when tested with sandy soil. Despite this, the SLAKES app is a legitimate method to measure aggregate stability. The app offers a simple, fast, and cheap alternative to standard laboratory methods, allowing land managers and non-scientists to actively test the quality of their soils.

Funded by: Rothamsted Research, The Lawes Trust

P - 40

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

By **Angeliki Kourmouli**
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 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 significant role in human lives as the loss of soil functions can have not only disastrous consequences (eg. loss of soil's water infiltration function can cause an 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. 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 primary 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.

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

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

P - 42

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

By **Stéphanie Lavergne**
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.

Funded by: Organic Science Cluster 3 (2018-2022)

Link to Posters

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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

Link to Poster

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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

Presenting time: 6 December 2023, 12:30 – 13:30

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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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The effect of earthworm casts on the germination of different agricultural plant species

By **Amy Rowe**

A study is currently being undertaken to further investigate and understand the effect of earthworm casts on the germination of different agricultural plant species. The plant species chosen for this experiment were White Clover (Trifolium perens), Perennial Ryegrass (Lollium perenne), Large flowered Hemp-nettle (Galeopsis speciosa), Spreading Hedge Parsley (Torilis arvensis), Corn Poppy (Papvaer rhoeas), Corn Marigold (Glenbionis segetum), Mustard (Sinapsis alba) and White Campion (Silene dioica). This incorporates a mixture of common plants found to grow easily, and rare plant species that have been found more difficult to propagate in agricultural settings. Investigating the germination rates and the effect of earthworm casts on the species mentioned aims to further increase biodiversity in agricultural settings while also increasing our research and knowledge of plant species with ever decreasing population. Previous literature suggests that earthworm casts can have a positive impact on germination rates. However, currently there is no further research focusing on the earthworm cast and soil ratio or on the overall impact to species that are rare and difficult to germinate. The benefits of earthworms, and their casts, in specific relation to soil health are widely discussed and reported; although, there is currently less research focusing on earthworm and plant interactions.

The seeds were tested using a variety of seed viability methods to assess the germination rates and overall ease of germination between the different species. The methods include the use of germination cabinets, top of paper method, agar plates, horticultural sand and compost. The variety of methods allowed for further evaluation of the species that were more difficult to germinate.

Earthworms are known as granivores and have been found through previous research to have varying preferences when it comes to seed ingestion. Although, little research has been published to observe the reactions between an earthworm's gastrointestinal microbiome and the seeds ingested. The overall aim of this study is to investigate the effects earthworm egestion has on seeds and whether it has the potential to increase the seeds viability and have an impact on seed dormancy times. The study is performed through the use of choice and no-choice seed ingestion trials of a range of arable plant species that have been found to have varying rates of germination (these include White Clover (T. perens), Mustard (S. alba), Large flowered Hemp-nettle (G. speciosa), White Campion (S. dioica), and Spreading Hedge Parsley (T. arvensis)). After the seeds have been recovered from the earthworm casts they will then be tested through viability testing and compared with the results of seeds that had not been ingested. Earthworms have the ability to promote crop growth through enhancing microbial activity, cast production and mobilising plant available nutrients. Thus, they have the potential to increase above-ground biodiversity as well as beneficially changing the habitat below-ground.

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How does silvoarable agroforestry with fruit and nut trees affect soil health in the UK?

By **Rosy Scholes**
University of Reading

Silvoarable agroforestry is the practice of integrating trees with arable crops, typically in the form of alley-cropping. These systems offer numerous benefits and have garnered the interest of both farmers and policymakers; however, empirical evidence of their impact on soil health is sparse.

We compare soil health across five silvoarable farms with fruit-nut trees to arable controls. These systems incorporate fruit and nut trees in 3-4 m tree strips alongside a typical arable crop rotation with 15-24 m alleys. We collected data at various points within these systems, including the tree row, the edge of the crop alley, 5 m into the crop alley, and the middle of the crop alley (7.5-12 m). The same sampling protocol was followed in paired control fields.

The array of soil health measures includes earthworm abundance, diversity, species richness, and biomass; microbial biomass (including fungi:bacteria ratios); soil respiration; rate of decomposition (Tea Bag Index); aggregate stability; water infiltration rate; bulk density; soil organic matter; soil carbon (organic and inorganic); macro- and micro-nutrients; ion exchange in soil (using PRS® probes); and pH levels.

This presentation will share results from the first year of data collection, from a broader PhD study on soil health and resilience in silvoarable systems.

Keywords: agroforestry; silvoarable; alley-cropping; soil health.

Funded by: BBSRC; FoodBioSystems DTP

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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

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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

Presenting time: 6 December 2023, 12:30 – 13:30

Technology and Innovation: Oral Abstracts

Prediction of soil bulk density in agricultural soils using mid-infrared spectroscopy

By **Longnan Shi**, Sharon O'Rourke, Felipe Bachion de Santana
University College Dublin, Environment Soils and Land Use Department, Teagasc, Ireland

Soil bulk density (BD) is a key physical parameter in soil quality control and in the calculation from soil organic carbon (SOC) mass (g/kg) content to area stock (kg/ha). However, BD laboratory analysis is time-consuming, labour intensive and expensive, especially for a national-scale soil assessment. Hence, how to fill the omissions of BD values for all or some records in soil databases is widely discussed. This study employed different chemometric and machine learning algorithms to estimate BD in Irish soil from 671 horizon-based samples from MIR spectral libraries by partial least square regression (PLSR), random forest, Cubist and support vector machine (SVM). The best performance was observed for the SVM model with a higher ratio of performance to interquartile distance (RPIQ = 3.61) and R2 (0.81) values and lower root mean square error of prediction (RMSEP = 0.132). Moreover, BD highly correlated wavenumber bands were determined by principal components analysis (PCA) and variable importance analysis. Soil organic matter (SOM) was identified as the primary factor in the spectral soil BD model. The generalisation error of predicting unknown samples using a spectral soil bulk density (BD) model was calculated by employing leave-one-out cross-validation (LOO-CV) on SVM. Estimation of BD by the spectral BD model was compared with published traditional pedo-transfer functions (PTFs), results were then compared for the overall models, different horizon types and specific depth categories. The spectral soil BD model is significantly better than traditional PTFs overall, with RMSEP equalling 0.132 g/cm3 and 0.196 g/cm3 respectively. The spectral soil BD model showed a similar accuracy on the A horizon, but considerable performance improvements were found on the other types of horizon. As for different depth categories, there is no significant accuracy difference between shallow (A-Samples: 5-20 cm) and deep (S-Samples: 35-50 cm) topsoil for the spectral soil BD model, which differs from traditional PTFs. The findings suggest that spectral modelling techniques, such as SVM, can provide high accuracy and homogenous performance across different depth layers, making them suitable for national soil surveys and large-scale carbon stock assessments. The best SVM model was then used to estimate BD values for a large archive of samples from the northern half of Ireland (Terra Soil project) and soil BD maps were generated at two different fixed-depth layers respectively. Besides that, all predicted soil BD values will be used for calculating soil carbon stock and assessing carbon deficit and sequestration potential in subsequent stages of the research.

Funded by: Teagasc

Presenting time: 7 December 2023, 14:15

Technology and Innovation: Poster Abstracts

Innovation in tree pit design: the role and impact of engineered solutions in street tree growth and establishment

By **Dean Bell**
University of the West of England

Internationally, cities are setting politically driven planting targets in recognition of the health, wellbeing and environmental benefits delivered by street trees. However, establishing trees in hard landscapes presents significant technical challenges and traditional techniques are often unsuitable in meeting progressively adverse growing conditions. Moreover, high-density urban forms can confer significant competition for space. Securing sustainable soil volumes for tree pits is a substantial and ongoing challenge. This is particularly true in modern conditions where cities are built around the demands of the engineered environment and whereby the grey infrastructure prevails to supress street tree success. Urban streetscapes represent a notable departure from natural conditions, inflicting a litany of physical stresses that threaten tree survival and contribute to the high street tree mortality rates experienced internationally.

A major challenge in growing and establishing street trees is the need to resolve the conflicting engineering and biological demands of soil. Soils must be able to support the load bearing requirements of pavements whilst simultaneously possess the capacity to support tree root growth. Therefore, to be successful in integrating trees and pavements, pavement surfaces must have structural systems in place for support. This commonly necessitates tree pits to serve a dual purpose: to provide both a biological growth medium and a load bearing capacity conforming to engineering specifications. Further, if trees are to grow and establishment alongside pavements, tree pits must also provide an advantageous soil volume to accommodate vigorous root growth. In recent decades, innovation and technological advances have produced integrated design solutions that marry the competing demands of pavement support and soil access for root growth in a common soil volume. These “engineered tree pit solutions” achieve the balance through either a physical structure or a load bearing soil in the root zone that seeks to replicate forest-floor soil conditions.

The techniques can be divided into “soil design” or the “structural isolation of function”. Soil design comprises structural growing media which are load bearing substrates achieved through a skeleton of sand or aggregate. Structural isolation of function comprises a physical structure in the tree root zone that protects the root system and acts as a vault to support a large volume of uncompacted soil. Here we present a literature-informed typology of the engineered solutions currently available that marry competing needs in hard landscapes through multifunctional tree pit infrastructure. This presentation also draws on fieldwork data related to tree growth and establishment, and an international survey focussed on practitioner experiences of the impact of engineered tree pit solutions on urban tree growth and survival in hard landscapes.

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Prediction of streamflow using machine learning models and Normalized Difference Snow Index: a case study of two watersheds with different climatic zones in Iran

By **Mahboobeh Fallah**
Coventry University

Streamflow simulation is of vital importance for watershed planning and sustainable water resources management. This study aimed to investigate the ability of three machine learning (ML) methods including Support Vector Regression (SVR), Artificial Neural Network with Backpropagation (ANN-BP), and Gradient Boosting Regression (GBR) for simulating streamflow on a daily scale in two different watersheds namely Latian and Pasikhan with different climatic zones, land cover, and hydrological characteristics in Iran. For model development, four major predictors including precipitation (P), maximum temperature (Tmax), minimum temperature (Tmin), and the Normalized Difference Snow Index (NDSI) from MODIS Satellite were considered during the years 2000-2018, and the efficiency of the models in simulating streamflow was assessed with the presence and absence of NDSI. Statistical indicators such as Root mean square error (RMSE), coefficient of correlation (R), and Nash-Sutcliffe efficiency (NSE) were used to assess the models' performance. Findings indicated that the accuracy of all applied models was enhanced in simulating streamflow using the NDSI index compared to the condition in which no snow cover dataset was used. The highest level of accuracy was observed in the GBR using NDSI (NSE=0.72, R= 85, and RMSE = 3.43 m3 /s) in both watersheds except the validation stage in the Pasikhan watershed where NDSI and ANN-BP technique were employed. In most cases, the minimum accuracy in the streamflow simulation was revealed using the SVR model for the validation and calibration steps. Although SVR demonstrated the lowest level of accuracy in simulating streamflow for both validation and calibration stages in most cases, the ANN-BP model led to the minimum performance in the prediction of streamflow in the validation stage with the absence of snow cover in the Pasikhan watershed. All models' efficiency for simulating streamflow was significantly enhanced for the Latian watershed as a snowmelt-dominated region compared to the Pasikhan watershed, particularly using snow cover products. The reason for the better efficiency of models in the Latian basin could be due to the fact that this area is located at higher altitudes having higher LS-factor values and lower vegetation coverage compared to the Pasikhan basin. All these factors cause the streamflow to reach the Latian watershed outlet with higher velocity and less retardation compared to the Pasikhan watershed despite having higher rainfall and consequently discharge rate in the latter one. Furthermore, another possible reason for the better performance of models in Latian watershed using snow cover products would be because of being a snowmelt-dominated region, which in turn leads to the improvement in the simulation of streamflow when using snow cover data as a predictor. In general, the efficiency of all models for predicting the streamflow was improved, where this improvement was notably higher in the Latian watershed than Pasikhan watershed in both calibration and validation stages particularly

using snow cover products. Therefore, according to the comparison of the models, the accuracy ranking is GBR> ANN-BP > SVR for both watersheds at the daily scale.

Keywords: Artificial Neural Networks, Gradient Boosting Regression, NDSI, Streamflow Prediction

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Exploring the potential of X-ray Computer Tomography for potato cyst nematode management

By **Eric Pereira**, S. Tracy
University College Dublin, School of Agriculture and Food Science

The detection of potato cyst nematodes (PCN) in the soil is crucial for the effective management and control of this pest. Traditional methods to detect PCN involve soil sampling and laboratory analysis, which can be time-consuming, laborious, and expensive. X-ray computed tomography (CT) has emerged as a promising non-destructive technique for soil analysis. X-ray CT is a high-resolution imaging technique that produces detailed three-dimensional images of objects and surfaces. In the context of PCN detection, X-ray CT can be a valuable tool to scan soil samples and produce detailed images of PCN within the soil. This technique is fast and precise, making it an ideal tool for screening large numbers of soil samples in a short amount of time. Therefore, in this study, we aimed to evaluate the efficacy of X-ray CT technology to identify cyst nematodes in different types of soil.

Different types of soils, such as sand, loamy, and a mix of sand and loamy soil (1:1: v/v) containing PCN, were subjected to X-ray CT analysis. The results revealed that X-ray technology is highly effective in identifying cyst nematodes in all types of soil, regardless of their texture and composition. Furthermore, using this technique, it was possible to determine that PCN caused a negative effect on roots, resulting in less dense root architecture. These findings suggest that X-ray CT can be a cost-effective and fast technique, making it a valuable tool for large-scale nematode detection and monitoring programmes. Moreover, it can provide essential insights into the belowground dynamics of plant-PCN interactions through their effects on root architecture.

Keywords: cyst nematodes, soil, X-ray CT

Acknowledgement: Leverhulme Trust grant RPG-2019-162

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Presenting time: 7 December 2023, 13:00 – 14:00

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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 (e.g., diffuse reflectance spectroscopy; DRS), we need to improve the accuracy of soil spectroscopic 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, I will discuss the known reduceable sources of uncertainty and suggestions to reducing them in this presentation. Reducing the uncertainty sources is important for building a global spectra library that can be used for spatio-temporal local, regional, and global soil monitoring and assessment.

In fact, the uncertainties are the sources of mistake, that may or may not directly affect statistical or mathematical accuracy of calibration models which are error sources. However, the uncertainty sources can come from two origins including known knowns, known unknowns and unknown unknowns. The uncertainties can be classified as so-called Aleatory (stochastic) or intrinsic uncertainty, which is irreducible, and reducible uncertainty called Epistemic uncertainty. The following are seven known (reducible) sources of uncertainty that will be discussed with some suggestions to reducing them.

1) standard protocols for scanning and data acquisition: there are various internal standards already in use in different labs around the world. The simple 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 evaluation and pros and cons of each will be discussed.

Th effects of mineral class, particle size distribution, and moisture are already known to make interventions in soil attributes inference. It forms a group of known mistakes and not stochastic errors. In summary, suggestions include sensors improvement, mathematical treatment of spectra and multiple times scanning procedures.

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The rationale behind building a global spectral library and why it is important to contribute towards it from a local scale effort will be explained. 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.

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

Link to Poster

Presenting time: 7 December 2023, 13:00 – 14:00

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Measuring soil properties with an in-field spectroscopy device

By **Jessica Underwood**
Reading University

Introduction:

Current soil sampling methods are expensive, time consuming and destructive. Due to these constraints, the standard practice is to combine several samples from across the field into one sample for laboratory analysis. This raises lots of challenges for monitoring of soil properties such as soil carbon, as fields are very heterogeneous, and changes in sample location may be the cause of changes in values measured, as much as a change in management. In-field spectroscopy scanners can be used in the field to quickly sample many points, but there are uncertainties as to how accurate they are, and how to use them. This paper will present results from two field trials which aimed to establish how a low-cost handheld spectroscopy device can be used in the field.

Methodology:

The first experiment compared methods of scanning, and the accuracy of the results compared to laboratory tests. The second experiment looked at variability across a field. Accuracy of scanner: A total 77 samples were analysed. The samples were taken from fields from 7 farms across the south of England. Scans were taken in the field, the top layer of soil and debris was removed, and the scanner placed directly on the soil. The topsoil (3 cm depth) from this location was collected and scanned in the lab. Loss on ignition (LOI), Total C and N and pH measurements were run to compare to the results from the scanner. Variability across field: Using the same collection and laboratory test as above (with the removal of LOI), 12 transects of 4 samples were collected, over a 600 x 200 m field area. Within this grid 3 additional clusters were collected to investigate variability around a sampling spot.

Results:

A correlation matrix was made for each of the measurements from experiment 1 to establish how accurate the scans were. The results for all three soil properties show significant positive correlations. This indicates that the device will be able to be used to predict soil properties with some degree of accuracy. The dataset from experiment 2 was randomly sampled, from one sample up to 48. The means of these samples were plotted for each soil property to establish how many samples are needed to be close to the mean of the field. The means of the random sampled datapoints settle around the average between 10-15 samples. Which suggests this would be a good number to take over a field to capture the fields variability. A heatmap showing the variability across the field has been produced.

Next Steps:

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Work out if soil type effects the accuracy of the device. Look at soil depth compared to surface scan. Take the average of multiple random samples to allow determination of sample number.

Key words: Soil, Carbon, Properties, In-field, Spectroscopy

Presenting time: 7 December 2023, 13:00 – 14:00

Water Management and Quality: Poster Abstracts

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Flooding vs. alternate wetting and drying rice cultivation practices: looking back to identify a way forward for global warming potential

By **Megha Kaviraj,** Yafei Guo, Gianni Micucci, Sami Ullah
University of Birmingham

Rice uses 34-43% of the global irrigation water and is responsible for the usage of 24-30% of the world's total freshwater (Surendran et al., 2021). More than 75% of rice produced in India is cultivated using the traditional continuous flooding (CF) irrigation method, which is a labour-intensive, time, and energy-consuming process. Alternate Wetting and Drying (AWD) is a popular water-saving approach used in various parts including China, Bangladesh, India, and Vietnam in recent years. AWD is a method of periodic irrigation until the soil becomes drier followed by full irrigation in the form of flooding. However, this continuous flooding (CF) and AWD conditions alter soil biogeochemical fluxes, resulting in greenhouse gas emissions (GHGs) in rice systems. The objective of our investigation was to comprehensively evaluate nitrogen fate by N15 isotope signature study in correlation with soil, plant health and global warming potential under CF and AWD conditions. The soil mesocosm experiment was conducted at the University of Birmingham with imported Indian paddy soil and Jasmine rice (var KDML 105). Initial soil data viz., pH, EC, TC, TN, P, NO3-, NH4+, and soil gravimetric moisture was recorded. Plant physiological parameters including plant height, tiller count, stem sheath, plant biomass, root biomass, chlorophyll content, and stomatal conductance were measured. Weekly GHG fluxes for methane, nitrous oxide and carbon dioxide under two treatment conditions were monitored and analyzed. Our results depicted that plant biomass (52.57%), root biomass (28.57%), height (24.77%), effective tiller number (45.15%), stem sheath diameter (53.38%) and stomatal conductance (66.49%) were significantly ($p<0.05$) higher in CF compared to AWD treatment. A similar trend was observed in rice leaf chlorophyll (Chl a, b and total chl) contents. Interestingly, the chlorophyll a and b ratio was observed higher (1.63) in AWD compared to CF (1.03) conditions. This was likely during the process of chlorophyll degradation, Chl b may be converted into Chl a, thus resulting in the increase of ratio to cope with the stress by maintaining the leaf photosynthetic efficacy. The result of soil NO3- content was 27.94, 40.25 mg kg-1 and NH4+ was 1.29, 0.89 mg kg-1 in CF and AWD, respectively. Soil enzyme data revealed that β-glucosidase (BG), β-N-acetyl-glucosaminidase (NAG), and acid phosphatase (AP) were higher in AWD, whereas leucine aminopeptidase (LAP) activity was significantly higher in CF. Higher LAP activity might be a response to limited nutrient availability, as LAP helps to release amino acids that can serve as a source of nitrogen for microorganisms. GHG emissions rate viz., CH4-C, CO2-C, and N2O-N emissions were significantly higher in CF by 60.49, 3.22 and 72.05%, respectively. Moreover, the global warming potential was projected higher under CF, 10.92 mg kg-1 compared to AWD, 2.19 mg CO2 kg-1. This study indicated that the AWD's multifaceted approach to mitigating global warming in rice soil may encompass policy, technology, science, and adoption. Future initiatives should keep emphasizing the optimization of this practice for its significant contribution to both climate change mitigation and sustainable agriculture.

Presenting time: 6 December 2023, 12:30 – 13:30

Keywords: Rice cultivation, global warming potential, soil enzymes, plant physiology, chlorophyll content, water management.

Acknowledgement: The authors are very thankful for the projects that supported this research namely UKRI-NERC, Large Area Distributed Real-Time Soil (DiRTS) Monitoring project (NE/T012323/1) and BBSRC project (BB/R021716/1).

Contaminants in saprolite: an overlooked hotspot of environmental concern?

By **Gemma Shaw**
Cranfield University and British Geological Survey

Saprolite is a transitional zone of highly weathered rock between soil and unweathered bedrock. Pedogenic processes transform saprolite into soil.

Contaminants may enter saprolite from agricultural spreading on soils, waste burial, contaminated surface water, or other pathways and sources. It is important to understand how they behave in the weathered profile so that their transport and fate can be accurately predicted. This could inform risk assessments, remediation strategies, and approaches to the management of emerging contaminants in the environment.

This research is particularly timely in the context of persistent, emerging contaminants, such as per-and polyfluoroalkyl substances (PFAS).

The role of saprolite in the transport, storage and potential re-release of contaminants has implications for the health and quality of future soils, crops, and water. For example, storage and concentration of persistent contamination may in future migrate upwards, or the soil may be eroded such that the contamination becomes accessible by crop roots. In the context of groundwater, thick and ubiquitous saprolite is often considered to be a protective layer for the groundwater below, for example acting to filter out colloidal contamination before it reaches the major aquifer. For persistent contamination, this could therefore raise concerns of possible contaminant build-up in saprolite, remobilisation from saprolite, or potential rhizosphere interactions.

However, there does not appear to be clear consensus about contaminant transport and fate in saprolite, and more studies are required, particularly for persistent, emerging contaminants. Currently, many of the available papers are based on a single site. Furthermore, the boundaries of the saprolite zone are not precisely defined. There are currently gaps in knowledge about the roles saprolite plays in contaminant fate and transport. This project aims to identify and address some of those gaps.

The project aims to review the current evidence on the presence and behaviour of contaminants in saprolite and use this to inform digital mapping of saprolite and contamination risks, fieldwork sampling of saprolite contamination, mesocosm experiments and modelling. This will enable the identification and quantification of both natural processes and risks.

This poster presents the findings from the first project phase - a systematic literature review. The literature review addresses the question: What is the state-of-the-art of knowledge on the presence and behaviour of contaminants in saprolite? It reviews the research on contamination in saprolite and identifies research gaps to be addressed. It also presents preliminary findings from laboratory column experiments.

Keywords: saprolite, pollution, contaminants, weathered profile, emerging contaminants, PFAS, biosolids

Funded by: NERC (CENTA DTP), Cranfield University, British Geological Survey

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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

Link to poster

Presenting time: 6 December 2023, 12:30 – 13:30

Other Themes: Oral Abstracts

Soil management in the construction of the HS2 railway line

By **Tinashe Mawodza**, Lungile Lembede
Balfour Beatty VINCI (HS2 joint venture)

Despite being generally beneficial to the community at large, massive infrastructure projects often have significant impacts on soil quality and health which result in reduced productivity after their completion. Of major note is the reduction of soil quality as brought about by compaction, erosion, as well as soil contamination which are prevalent on most construction sites. Proper management of soil both during and after infrastructure projects is crucial to restore and maintain soil health, fertility, and functionality for use after construction. In our current project, the construction of High-speed 2 (HS2) Railway line, we have applied several different techniques for the management and restoration of soil such as deep tillage and soil segregation to improve soil structure and nutrient availability thus helping to maintain our soils Agricultural Land Classification (ALC) post construction. We highlight the importance of implementing and optimising soil handling techniques that reduce the damage to fragile ecosystems that are prevalent throughout the span of the railway line construction path. We also analyse the overall effectiveness of our management of soil both during and after this project as it is essential to mitigate the negative impacts of infrastructure development on soil and the surrounding environment. The implementation of sustainable soil management practices as we highlight can ensure that soil remains productive and healthy, promoting long-term sustainability and resilience thus it is essential for this to be considered during this project.

Funded by: HS2

Presenting time: 6 December 2023, 15:00

Other Themes: Poster Abstracts

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Using high-frequency monitoring methods to quantify nitrous oxide fluxes in a temperate grassland following fertilisation with contrasting ammonium to nitrate ratios

By **Angela Agyemang Duah**
Teagasc/University College Dublin

Nitrogen (N) fertilizer is considered the best single predictor of nitrous oxide (N2O) emissions from agricultural soils, which are responsible for ~50% of the global N2O emissions, a potent greenhouse gas that depletes stratospheric ozone. The emission from N fertilizer application is dependent on the type of fertiliser used (i.e. fertilizers with different ammonia-to-nitrate ratios), and these emissions can be episodic making it difficult to capture long-lived and often sporadic N2O peak events. Missing these pulse events could underestimate the annual emissions of N2O.

Despite ongoing research into emission rates and underlying processes, there is still uncertainty in quantifying and predicting agricultural N2O emissions owing in large part to their high temporal variability among land uses and treatment. Estimating soil N2O emissions using static chambers is challenging due to the high spatial variability and episodic nature of these fluxes. However, an advanced method of continuously tracking how N addition influences N2O fluxes could lead to a better understanding of the factors influencing variability in N2O emissions. The aims of this research are to a) examine the effects of different commonly used synthetic N fertilizer formulations with contrasting nitrate to ammonium ratios on N2O emissions b) assess the disparities and uncertainties in quantifying N2O emissions from synthetic N fertilizers at different temporal scales from temperate grasslands using manual and automated chambers.

Nitrogen fertilizers with varying ammonia to nitrate ratio (calcium nitrate, ammonium sulphate, NPK 18-6-12 and NPK 27-2.5-5) was applied at 40 kg N ha-1 to experimental plots at Teagasc, Johnstown Castle in five split application from March to August 2023. We tested the combination of static chambers with automated chambers. Manual sampling was conducted using chambers made up of a 0.4 m ×0.4 m stainless steel collar and lids that is 0.1m high. Gas samples were collected four days in the first two weeks of fertilizer application, twice a week for the following two weeks and then reduced to once a week until the next N application.

Nitrous oxide fluxes were analysed continuously at high frequency using two N2O Trace Gas Analysers from LI-COR Biosciences (LI 7820) connected to two multiplexers (LI- 8250) and 16 automated chambers (8100-104). Soil temperature and soil water content were monitored at a depth of 5cm using sensors (Stevens HydraProbe) directly connected to the chambers. The chamber measurement period was 3 minutes (with minimum detectable flux (MDF) of 0.004 nmol m-2 s-1) during which the chambers were closed and pre and post-purge periods will be 180s. The flow rate to/from chambers to the LI-7820 is ~2 to 3 lpm.

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Each chamber was closed during individual chamber measurement periods and was fully opened when not sampling.

Both manual and automated chambers were placed over soil collars that were inserted at a depth of 5cm a week prior to chamber flux measurements to minimize disturbances.

The experiment is ongoing and the final results will be presented in the main conference in December.

Keywords: nitrous oxide, manual sampling; nitrogen fertilizers; automated sampling; grassland

Funded by: Department of Agriculture, Food and Marine

Link to Poster

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Spatial Mapping of Cation Exchange Capacity across Different Soil Types Using Soil Spectroscopy and Digital Soil Mapping Techniques

By **Mohammed MohammedZein**

Doctoral School of Environmental Science, Hungarian University of Agriculture and Life Sciences, Land and Water Research Center, Agricultural Research Corporation, Sudan

The soil is crucial in providing vital ecosystem services to humanity, including climate regulation and soil fertility. Soil fertility, acidity and structural resilience are significantly affected by the cation exchange capacity (CEC), making it one of the most vital soil properties. The data from CEC is frequently useful for fertilizer recommendations; however, obtaining information on CEC at the field level and its measure in the laboratory is time-consuming and expensive. To enhance the value of limited CEC data, the combination between soil spectroscopy and digital soil mapping can be beneficial where large amounts can be acquired expeditiously. The integration of the mid-infrared spectral library and environmental covariates can permit analysis, prediction and spatial mapping of different soil properties, such as cation exchange capacity in rapid, timely, cheap, non-destructive and accurate ways. This study examined the predictive capacity of the mid-infrared (MIR) spectral library and environmental covariates for spatial mapping of CEC from 0 – 30 cm depths.

This study utilized the data from the national mid-infrared (MIR) spectral library based on legacy soil samples in the frame of the Hungarian Soil Conservation Information and Monitoring System (SIMS) Survey, 1992. The predicted CEC dataset was extracted from MIR spectral library and checked then CEC was predicted again for the whole dataset using Partial Least Regression Model (PLSR). CEC model performance was assessed by: Coefficient Determination (R2), Root Mean Square Error (RMSE) and Ratio Performance to Deviation (RPD). Spline fitting algorithm was used to generate standardized depths from 0 - 30 cm for CEC data. A set of 21 environmental covariates was downloaded from different websites, preprocessed, verified for consistency with the SCORPNA model and used for this study including Digital Elevation Models (DEM) and its attributes, seven bands of landsat5, Normalized Difference Vegetation Index (NDVI) map, land cover map and climate data layers at a spatial resolution of 30 m. CEC and environmental covariates were intersected in one dataset and randomly split into training and testing datasets. Accordingly, a random forest model was built for spatial mapping CEC based on the training dataset, while R2, RMSE and Mean Square Error (MSE) were used to evaluate the model's goodness using the testing dataset.

The PLSR calibration model result of CEC was predicated with moderate accuracy (R2≥ 0.61, RMSE ≥ 7.49 and RPD ≥ 1.60) from MIR spectral library, whereas the random forest model showed good results and CEC was highly estimated spatially (R2 ≥ 0.40 and RMSR ≥ 8.3). The final digital soil CEC map with 30 m resolution using a random forest model could be used as a baseline for planning purposes of plant nutrient optimization strategies. This

study concluded that the use of the MIR spectral library can provide valuable data regarding the spatial distribution and mapping of CEC.

Keywords: SIMS, Mid-infrared spectral library, partial least square regression, coefficient determination, root mean square error, DSM, random forest, environmental covariates, NDVI

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Impact of Urine N Content and environmental conditions on Ammonia (NH3) emissions following urine deposition

By **Ernest Osei-Asante**
Teagasc/University College Dublin

Introduction

Livestock production in temperate regions directly feeds about one billion people, but it is also a major contributor to gaseous emissions (ammonia (NH3) and nitrous oxide (N2O)) and nitrate (NO3-) leaching. Urine deposition from grazing livestock represents a major source of nitrogen (N) loss in temperate grasslands. Among the major factors affecting ammonia (NH3) emissions from urine in cattle-grazed grasslands is the concentration of N in the urine. Cattle urine N concentration varies largely depending on the animal feed source and ranges from 2 – 20 g N L-1. Such a large variation in urine N concentration is expected to cause a differential impact on NH3 emissions. However, studies investigating the effect of different urine N concentrations on NH3 emissions are lacking. This empirical data is needed to map out mitigating strategies to reduce NH3 emissions. This study aims to explore how varying N concentrations in cattle urine and environmental conditions will affect NH3 emissions by quantifying NH3 emissions from different urine N concentrations in spring, summer and autumn seasons.

Methods

The study site is located in Teagasc Research Centre, Johnstown Castle, Co. Wexford, Ireland (52°180N, 6°300W) on a luvic gleysol with a loam texture. The study site was originally established as monoculture grassland consisting of perennial ryegrass (Lolium perenne L.). The existing grass was cut to 5 cm and plots of dimension 1.5 m x 1.5 m (2.25 m2) were established. A 0.45 m2 area was created within each plot for urine simulation.

Urine samples of concentration 7.1 g N L-1 were collected from Holstein-Friesian dairy cows fed with perennial ryegrass (PRG) with 150 kg/ha chemical N, PRG with 225 kg/ha N, PRG with white clover (WC) and 150 kg/ha chemical N, or PRG with WC. The following treatment was formulated by diluting the initial urine with DI water or by spiking with urea - I)2.5 g N L-1 II) 5.0 g N L-1 III) 7.5 g N L-1, IV) 10.0 g N L-1. Two additional treatments, Distilled (DI) water only and No urine or water were also included.

In April 2023 (i.e., spring season) 2 L of the above treatments were applied as urine patches in the 0.45 m2 area. Ammonia emissions are being quantified twice daily for 14 days following application using a photoacoustic gas analyser. Urine application and NH3 quantification will be repeated in the subsequent summer and autumn seasons.

Results and Discussion

This experiment is ongoing, early results indicate that N concentrations impact NH3 emissions following urine deposition. The final results will be presented at the conference.

Presenting time: 7 December 2023, 13:00 – 14:00

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Keywords: Urine deposition/patches, Ammonia (NH3) emissions, Nitrogen (N) concentrations, Livestock production

Funded by: Walsh Scholarship

Link to Poster

Presenting time: 7 December 2023, 13:00 – 14:00

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N and P nutrient leaching from long-term slurry application on permanent grassland on clay loam soil

By **Zizhou Qi**
University College Dublin

Over one-third of rivers and a quarter of lakes in Ireland are failing to meet their environmental quality standards for nutrients. This is impacting Ireland's goal to improve water quality and achieve its EU Water Framework Directive targets. Nitrogen (N) and phosphorus (P) leached from different forms of fertilizer application may contribute to groundwater and surface water contamination causing numerous environmental issues in the agroecosystem and health problems in human beings. There is a lack of knowledge on the magnitude of the effects of the nutrient management strategies and their long-term implementation on N and P nutrient leaching from the soil to the groundwater and surface waters in Ireland. The accurate optimization of the nutrient management strategies requires monitoring of soil water concentrations under the range of management strategies and quantification of the N and P leaching from the soil profile.

The objective is to study the N and P leaching in organic and inorganic forms from a long-term application of cattle and pig slurry and mineral NPK fertilizer over the drainage seasons 2021/22 in Hillsborough (54°28′ 0″ N, 6°6′ 0″ W), Northern Ireland, UK. The long-term experiment in Hillsborough was set up in 1970 to measure the effects of frequent applications of organic and inorganic nutrients on plant productivity and soil biogeochemistry. It was set up in a split-plot design with nutrient management as a main factor and grass-species biodiversity (rye-grass vs multi-species sward treatment) as a subplot factor replicated three times. The multispecies sward was reseeded (05/08) after ploughing (31/07) in spring 1969. Leaching was measured in six nutrient management (control, synthetic fertilizer, pig and cattle slurry with high and low rates) and both biodiversity treatments. Soil solution from an 80 cm dept was extracted using suction cups every ten days over a 5-month drainage period. N and P leaching were quantified from nutrient concentrations of various species multiplied by an effective rainfall obtained through Schulte's Soil Moisture Deficit hybrid model. The total N, total oxidized N, ammonium, total P, and dissolved reactive P have been analyzed, the N and P losses have been quantified for the above species. Nutrient concentrations and losses were analyzed as repeated measures with a linear mixed effects model in R.

Most of the concentrations of various nutrient species were affected by an interactive effect between nutrient management and biodiversity level. The influence of permanent grassland renovation and reseeding is also evident. However, the concentrations are low, below the water quality thresholds defined by water quality legislation and national background levels in groundwater or surface waters despite the high rates of continuous nutrient applications for over 50 years. This is likely associated with the high natural attenuation capacity of the soil driven by clay-loam texture. The data will be further used in the optimization of the nutrient management strategies using an ecosystem process-based model DayCent. We

believe that the results of this study will have direct implications for agri-environmental policies in the Rep. of Ireland and in the UK.

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Dirty Matters – the Soil Game

By **Christina van Midden**, Nicolas Beriot, Emma Burak
Cranfield University

Soil is an integral aspect of several vital functions, services and socio-economic activities, such as biomass production and clean water supply. Consequently, many of the UN Sustainable Development Goals (SDGs) such as SDG 2: food security, SDG 6: clean water, and SDG 13: climate change can be delivered by good soil management. Despite its necessity, there is a general lack of awareness regarding the importance surrounding soil as a resource. With our project, we wanted to make soil literacy and awareness accessible to a wide audience. Our aim was to create a fun and educational boardgame that demonstrates the ability of soils to deliver on these SDGs whilst showcasing the interlinking complexity of the soil ecosystem. The resulting game is called Dirty Matters: The Soil Game. It focuses on how soil management practises affect soil, which in turn affect the SDGs. Dirty matters is a fully cooperative game where the players embody soil organisms (including the mole, earthworm, and mycorrhizal fungi) and move around the soil implementing soil management techniques (such as cover crops, no tillage regimes, and adding manure) to counteract events that negatively impact the soil (such as soil compaction, acid rain, and erosion). This is all done with the overarching aim of keeping the soil healthy enough to meet the yield requirements of a growing population whilst trying to avoid polluting water and excessive carbon loss. The process of making this boardgame initially involved brainstorming sessions to form a game design and then rigorous research to make sure our concepts were backed by up-to-date science. Once a playable game design was achieved, we started play testing with other soil scientists and a variety of other communities to make sure both the mechanics and science worked, tweaking the game after each session to incorporate feedback. The final stages included making it look appealing by engaging with a graphic designer. As of today, Dirty Matters is free to download and printer friendly educational tool to advance the understanding of soil and how we should take care of it and everything in it.

Funded by: British Society of Soil Science

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Soil Benchmark

Soil Benchmark was set up by BSSS members, Tom Scrope and Ben Butler; and provides data driven tools to farmers' existing information to uncover practical insights that improve the health of their soils.

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Presenting time: 7 December 2023, 13:00 – 14:00