International Union of Soil Sciences®

International Forum of IUSS Inter-Congress 2024

Abstract

October 21, 2024

Nanjing International Youth Convention Hotel

Nanjing, China

14:00-17:30 Room 730A

Content

Widespread Decline in Recent Tree Growth under Climate Change

Prof. Zhihong Xu, Griffith University, Australia

Abstract

Tree water use efficiency (WUE) has increased globally in the past 150 years, but this has not been translated into global increases in tree growth consistently in space and time. Complex and dynamic forest ecosystems would respond non-linearly to climate change with multiple factors over a long period, and can have tipping points or critical boundaries / thresholds at which a sudden shift to a contrasting dynamic regime might occur. However, prediction of such critical points / thresholds before they are being reached is extremely difficult. Indeed, our comprehensive studies undertaken in the last 18 years (mostly unpublished) have shown for the first time that long-term tree growth of beech and oak in temperate central Europe (Belgium) responded non-linearly to rising atmospheric carbon (C) dioxide (CO_2) and water (H_2O) limitation. This is due to the increasing mean annual temperature and decreasing summer rainfall during 1840s–1990s. It is ***the initial CO_2 fertilisation*** and ***then warming-induced water limitation*** that ***control tree growth under climate change***. This would result in decreased forest CO_2 assimilation and increasing atmospheric CO_2, ***leading to accelerated global warming and increasing water limitation***. It is interesting to note that the atmospheric CO_2 tipping points for a given biome (such as tropical or temperate) would be influenced by both biotic (e.g. tree species and age) and abiotic factors (e.g. water and N availability).We have tested the CO_2 fertilisation - warming-induced water limitation model globally, and our exciting major findings have highlighted that ***there is a widespread decline in tree growth beyond the tipping points of***

atmospheric CO_2 in global forests under climate change.

Profile

Since 2004, **Professor Zhihong Xu** has worked as Professor of Soil-Plant-Climate Systems, School of Environment and Science, Griffith University, Brisbane, Australia. He has published 418 refereed journal and conference papers (including 356 journal papers) and 2 books in biogeochemical cycles of carbon and nitrogen in terrestrial ecosystems (citations: 11865; H-index: 61 by Web of Science). Professor Xu has secured about A$24M of external funding support, with most coming from national competitive grants. Since 2005, he has been the Editor-in-Chief (Soils) of Journal of Soils and Sediments and Chair – Forest Soils Working Group of International Union of Soil Science since 2006.

The role of coumarins in plant iron uptake from soil

Prof. Christian Dubos, IPSIM, France

Abstract

Iron (Fe) is an essential micronutrient for plant growth and development. Despite its importance, Fe uptake in alkaline soils is a challenge for most plants. Pioneering work identified two Fe uptake strategies evolved by plants to take up Fe from soils. Grass species release in the rhizosphere phytosyderophores (PS) and take up Fe in the form of Fe(III)-PS complexes (Strategy II). Non-grass species reduce Fe(III) into Fe(II) that is then taken up into the plant root (Strategy I). Nonetheless, it has emerged that non-grass species such as Arabidopsis also secrete into the rhizosphere catechol coumarins (specialized metabolites) that play a preponderant role in plant Fe nutrition. Here, I will present recent findings we have made in decrypting the molecular role played by coumarins in plant Fe nutrition.

Profile

Christian Dubos studied plant physiology and cell biology at the University Paul Sabatier (Toulouse, France) and did his Master and PhD degrees in Forest tree genetics (INRAE Pierroton, France). Following postdocs studying the transcriptional regulation of gene expression in plants (University of Oxford, UK; University of Toronto, Canada; IJPB institute, France) he was hired by the INRAE as researcher on this topic. Christian Dubos is now an INRAE research director at the IPSIM where he leads the FeROS (Mineral nutrition and oxidative stress) group aiming at decrypting the molecular mechanisms that regulate iron homeostasis in plants.

Non-point source loss process and risk assessment of nitrogen and phosphorus in farmland at the watershed scale

Prof. Yongtao Li, South China Agricultural University, China

Profile

Yongtao LI, is Ph.D and professor of soil and environmental science, of College of Resource and Environment, South China Agricultural University. His research interests focuses on biogeochemical process of soil nutrients and contaminants, and bioremediation of degraded and contaminated soils and food safety. He is discipline leader of Agricultural Resources and Environment and Soil Science, and director of Key Laboratory of Arable Land Protection of Ministry of Agriculture of China, Vice president of National Collaborative Innovation Union for Heavy Metal Pollution Prevention in Farmland Environment. and director of Sino-UK international Institute for Environmental Research & Education.

Wise use of organic waste for environmentally positive agriculture

Prof. Morihiro Maeda, Okayama University, Japan

Abstract

Organic waste management is key in the present world that has a population of more than 8 billion. Agricultural sectors provided more cereals, vegetables, and meats in response to the increasing population. In the processes of agricultural production and consumption, a large quantity of organic waste is produced. These organic wastes usually contain much nutrients such as nitrogen and phosphorus, which may be unexpectedly discharged into the environment and deteriorate water quality or emit greenhouse gases (GHGs).

We have studied (1) a catch crop-biological soil disinfestation system, (2) nitrate leaching and GHG emissions from livestock manure compost, (3) the potential use of manure ash as phosphorus fertilizer, and (4) biochar application to the soil for mitigation of GHG emissions and for improving the performance of sediment microbial fuel cells (SMFCs).

The catch crop-soil disinfestation system can absorb residual nutrients from the soil after the main crop and reduce nitrous oxide (N_2O) emissions in biological soil disinfestation in research (1). In research (2), similar nitrate (NO_3-N) leaching occurred both from organic and inorganic N sources after several years, and mature compost can be used for GHG reduction. Application of cattle manure ash worked P fertilizer with low environmental impact in research (3). In research (4), advanced biochar reduced N_2O emissions from soil, but the biochar's function was declined with aging if the biochar was pyrolyzed at a lower temperature of 500°C rather than 800°C. Biochar application to SMFCs was also effective in reducing phosphorus release from the sediment. We need to study more the efficient use of organic

waste to establish environmentally positive agricultural systems in the future.

Keywords

Biochar, nitrate leaching, nitrous oxide, manure ash, sediment microbial fuel cells

Profile

Morihiro Maeda is professor of Soil Management at the Graduate School of Environmental and Life Science, Okayama University, Japan. His main research interests are nitrate leaching, greenhouse gas emissions, biochar amendment, and sediment microbial fuel cells in agricultural soil with different land uses. He has contributed to IUSS as a chair of Commission 4.1 in 2018-2022 and a vice-chair of Commission 3.1 in 2022-present by organizing many international workshops and symposiums on better management of agricultural wastes and land use in developing countries.

Strategies for sustainable use of acid soil in China

Prof. Renfang Shen, Key Laboratory of Soil and Sustainable Agriculture, Institute of Soil Science, Chinese Academy of Sciences, Nanjing; University of Chinese Academy of Sciences, Beijing, China

Abstract

The area of acid soils with pH values lower than 6.5 is about 3.11 million km^2, accounting for 32.4% of the total national land area. Approximately 60.3%, 23.3%, and 16.4% of these acid soils are distributed in the south red and yellow soil region, northeast region, and other regions in China, respectively. Soil acidification has various negative effects, including inhibition of plant growth, reduction of agricultural product quality, and damage to ecological environments. Four strategies are proposed for the sustainable use of acid soils: (1) the improvement strategies for acid soils should be implemented according to soil acidity grades and soil types; (2) the same importance for improving soil acidity and fertility should be accorded to all acid soils; (3) the combined application of organic and chemical fertilizers should be encouraged; and (4) the development of agriculture with local acid soil characteristics should be the new focus. Furthermore, six research directions are suggested to be strengthened: (1) develop new products for the improvement of acid soils; (2) clarify the critical pH for optimal growth of different crops; (3) research efficient N application techniques for reducing soil acidification; (4) emphasize the role of micro-elements in plants in acid soils; (5) breed acid soil-tolerant crop cultivars; and (6) predict soil acidification trend in the following period. Provided the national soil acidification trend, the Chinese government has begun to stop soil acidification in 20 counties of 15 provinces since 2023. At the same time, several national projects related to acid soils are being performed. We believe that soil acidification in China will be effectively controlled, and the quality

and productivity of acid soils will be greatly improved, ultimately contributing to global food security.

Keywords: Acid soil; Acid soil improvement; Soil acidification; Strategies; Sustainable use

Profile

Prof. Renfang Shen, Director General of Institute of Soil Science, Chinese Academy of Sciences, who works as a researcher for nearly 40 years in the fields of soil acidification prevention, productivity improvement, pollution remediation, and plants' adaptation to soil stresses. He is the Honorary President (2020-) and President (2012-2020) of Soil Science Society of China, the Vice President of China Association of Agricultural Science Societies from 2017. He also contributed to the IUSS from 2023 as the Chair of Division 3 to facilitate activities on soil use and management.

Gypsum content and gypsum morphotypes in irrigated soils of the Zhezkazgan Botanical Garden (Semideserts of Kazakhstan Republik)

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[4] Karaganda Buketov University, Kazakhstan Republik

[5] Zhezkazgan Botanical Garden, Kazakhstan Republik

Abstract

The aim of the research was to identify possible changes in the quantity and nature of gypsum morphotypes as a result of 80 years of irrigation in the Zhezkazgan Botanical Garden. Zhezkazgan is located in the semi-desert zone of Central Kazakhstan. The soils of the Zhezkazgan Botanical Garden belong to Gypsysols. For all soils in the key area, the presence of a gypsum horizon in the profile at a depth of 45 to 80 cm with a content of 30-65% is characteristic, which aligns well with literary data (Soils..., 1960). In Russian literature, the deep occurrence of a gypsum horizon is often considered a characteristic feature of grey-brown desert soils (Soils..., 1960; Gerasimova et al., 1992).

The simultaneous presence of carbonates and gypsum in the soil profile, with crystal sizes not discernible by the human eye (less than 0.25 mm), complicates field diagnostics. In literature, a $BaCl_2$ solution is used to refine field diagnostics of gypsum. There are numerous laboratory methods for

determining gypsum, broadly classified into three major groups: chemical, thermal (based on gypsum losing crystallization water), and conductometric methods - which are useful for determining actively water-soluble gypsum, as well as an indirect method based on sulfate ions in aqueous extract. We decided to refine field diagnostics by combining X-ray fluorescence analysis (XRF) with a portable Olympus Delta analyzer and measuring the conductivity of a 1:5 extract (Alvarez et al., 2022). The authors (Alvarez et al., 2022) believe that pure gypsum in a 1:5 aqueous extract may contribute to conductivity values not exceeding 2.2 mS/cm. Determining gypsum based on sulfur content seems to be a promising XRF method (Weindorf et al., 2009). Sulfur - a component of gypsum (chemical formula $CaSO_4 * 2H_2O$) - was determined using portable XRF. Therefore, conductivity values above 2.2 mS/cm would indicate the presence of easily soluble salts (particularly sodium sulfates) in the profile, necessitating corrections for their content. If the conductivity value does not exceed 2.2 mS/cm and sulfur is present according to XRF results, gypsum content can be recalculated using the formula:

$$x(CaSO_4*2H_2O, \%)=(S(\%)*Mr(CaSO_4*2H_2O))/Ar(S),$$

where M is the molar mass of gypsum and Ar is the atomic mass of sulfur.

To verify the obtained soil compounds containing gypsum that is difficult to identify, they were examined under a binocular microscope and an electron microscope. Gypsum in soil exhibits various morphotypes detailed by the authors' team (Alvarez et al., 2022). Some of these formations are characteristic only of original rock materials, while others are specific to secondary, soil-related formations. In a significant portion of gypsum-containing samples, gypsum appeared as lenticular crystals with a wide range of crystal sizes ranging from 10 μm to several centimeters. Microcrystalline gypsum (known as "gazha") with crystal sizes less than 10 μm is identified by its yellowish colours under a binocular microscope.

Irrigation in the key area is carried out by furrow irrigation and hose watering with good quality water having SAR=3.5 and slightly above 1 g/L mineralization of calcium-sodium chloride-sulfate composition. Kurlow's formula for water is provided below.

$$M\,1{,}16\ \frac{Na\,42\ Ca\,42\ Mg\,15}{SO_4\,53\ Cl\,46};$$

The results obtained by us fit within the range of annual variations in mineralization and composition of water obtained by other researchers. The source of irrigation is the waters of the Kara-Kengir River below the Kengir reservoir and the industrial zone of the city of Zhezkazgan. Long-term monitoring of the Kara-Kengir River shows variability in total mineralization ranging from 200-300 mg/L during the flood period to 2-3 g/L during the autumn-winter thaw. The composition of water varies from hydrocarbonate-calcium to chloride-sulfate-calcium and even chloride-sulfate-calcium-sodium.

During irrigation, gypsum can recrystallize and undergo gradual decomposition along cleavage planes (Poch et al., 2018), exhibiting a specific texture resembling a "fractured battlement" under an electron microscope. However, we observed the "fractured battlement" texture in a localized area of soil sample that has never been irrigated, possibly preserved from earlier times.

Regarding the quantity of gypsum, it was estimated that irrigation with Kara-Kengir waters on this site over 80 years could accumulate no more than 10% gypsum. The remaining variability is associated with the heterogeneity of gypsum-bearing parent rocks. We used the Radioactive Fluorescence Analysis (RFA) method to determine the gypsum content. The gypsum content was determined based on sulfur content with control of electrical conductivity and calcium activity. The main assumption is that sulfur is present in the soil in the form of sulfates. As shown in Figure 1, the correlation between sulfur content and electrical conductivity is not very reliable, as it is complicated by the presence of easily soluble salts and incomplete dissolution of gypsum.

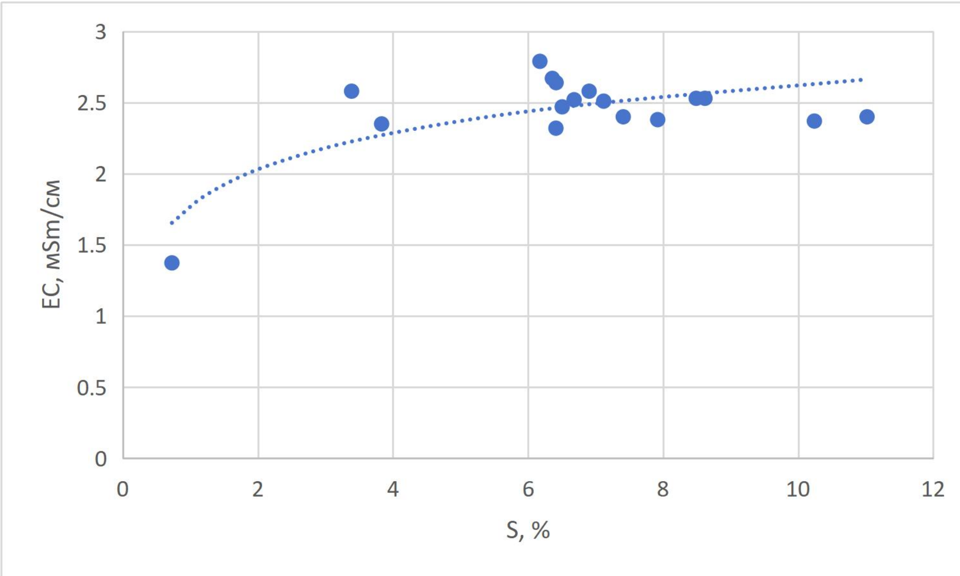

Figure 1. The relationship between XRF sulfur content and electrical conductivity (water extract 1:5) in soils with morphological gypsum formations.

However, sulfur content can be used to assess the profile distribution of gypsum content in the soil (example - Figure 2, well Zh27-2). The conversion of sulfur S (%) into gypsum was performed using the formula: gypsum (%) = (S (%) * 172)/32.

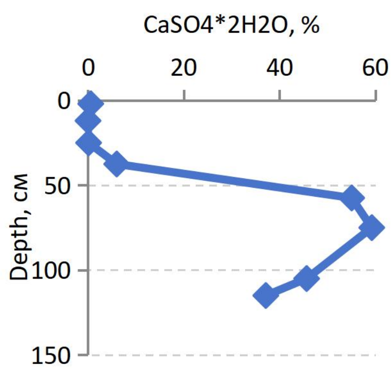

Figure 2. Profile distribution of gypsum content in irrigated soil.

Presumably, as a result of the interaction of irrigation water with the underlying gypsum containing rock during furrow irrigation, dissolution of gypsum occurred, transitioning it into a microcrystalline form. The coarse crystalline form was preserved at a depth of 90 (see Figure 3) and deeper. Overall, gypsum in the botanical garden is noted at a depth of 40-90 cm predominantly in a coarse crystalline form.

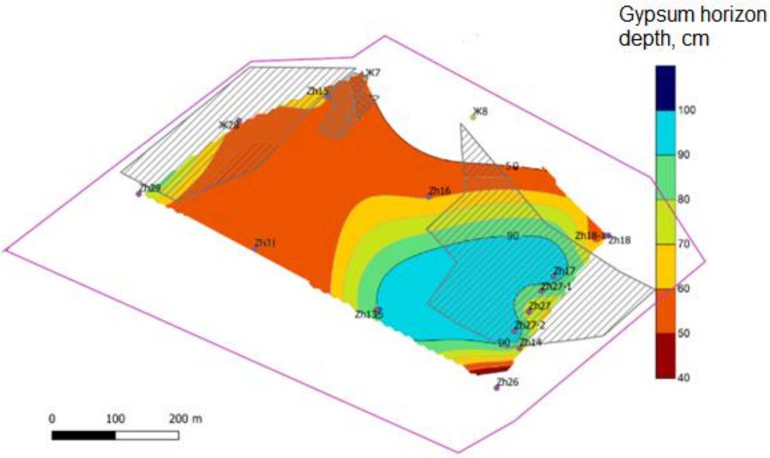

Figure 3. Map of the depth of occurrence of coarse crystalline gypsum (with crystal sizes larger than 0.25 mm). Hatching indicates irrigated areas.

A more detailed study of gypsum forms in irrigated soil under an electron microscope will be performed later; for now, we present the profile appearance of irrigated soil under a binocular microscope (magnification 10X and 20X).

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Profile

Golovanov Dmitrii, Doctor of Geography, Professor of the Faculty of Geography of PPI-MSU University in Shenzhen (China), Associate Professor of the Department of Landscape Geochemistry and Soil Geography of Geographical Faculty of Lomonosov Moscow State University. Golovanov graduated from Geographical Faculty of Lomonosov Moscow State University (1984) under the lead of prof. Maria Glazovskaya, for 35 years participated in the Joint Russian-Mongolian Integrated Biological Expedition (head Prof. Peter Gunin). The topic of the PhD thesis: Oasis soil formation in the extremely arid deserts of Mongolia (2006). He also participated in the works of the Dokuchaev Soil Science Institute (Moscow) in Kazakhstan and Central Asia (Uzbekistan).

Soil health managements for agriculture green development

Prof. Fusuo Zhang, China Agricultural University, Nanjing, China

Associate Prof. Guangzhou Wang, China Agricultural University, Nanjing, China

Abstract

Agriculture Green Development (AGD) represents the future of modern agriculture, with soil health serving as its foundation. This presentation will provide a comprehensive overview of the concept, current research progress, and emerging trends in soil health both domestically and internationally. By reviewing key management strategies for cultivating healthy soils, this talk introduces innovative ideas and approaches to advance soil health, while also addressing the challenges and opportunities in soil health engineering.

Key strategies for promoting healthy soils include removing limiting factors, increasing soil organic carbon content and nutrient use efficiency, harnessing biological potential, and fostering synergistic interactions between above-ground and below-ground ecosystems. The goal of soil health engineering is to enhance both agricultural productivity and the ecosystem services provided by soils. This is achieved by optimizing internal regulatory processes within the soil while reducing reliance on external inputs. The cultivation of healthy soils requires a holistic, systems-based approach, integrating the entire agricultural value chain—ranging from external inputs and crop production to product processing and waste recycling. Additionally, achieving this vision depends on cross-disciplinary innovation, collaboration between government, farmers, researchers, and extension institutions, as well as robust policy support and incentive systems. Together, these efforts are essential for realizing soil health as the cornerstone of AGD, ensuring a

sustainable and productive future for agriculture.

Profile

Prof. Fusuo Zhang is a plant nutritionist working at China Agricultural University and Dean of National Academy of Agriculture Green Development, and an academician of the Chinese Academy of Engineering. He has been dedicated to the field of plant nutrition and has published more than 700 papers in internationally renowned journals such as Science, Nature, and PNAS, and authored more than 90 books. He received many national awards such as the State Natural Science Award and the State Science and Technology Progress Award. He was also awarded honorary doctorates from Wageningen University and Lancaster University.

Guangzhou Wang is an Associate Professor work at the Department of Plant Nutrition in China Agricultural University. His interests mainly focus on the plant-microbe feedback and soil health improvement. He has published 31 peer reviewed papers in domestic and international high profile journals such as Nature Communications, Ecology Letters and Global Change Biology. He is currently the committee members of both Soil Health Working Group of Soil Science Society of China and the Rhizosphere Nutrition Professional Committee of the Chinese Society of Plant Nutrition and Fertilizer Science. He also served as the guest editor for the journal of Frontiers of Agricultural Science and Engineering.

Soil management in Northern areas - from reducing erosion to improving soil health

Dr. Lillian Øygarden, NIBIO, Norway

Abstract

Agricultural production systems and their influence on water quality has been especially in focus since the eighties. First, the environmental focus was on contributions from point sources like leakage from ensilage and from storage of manure and spreading of manure during winter period. New laws and regulations were implemented to reduce runoff from these point sources. Then, the diffuse pollution from agricultural areas became more focused as an important source for nutrient transport to water bodies.

In 1988 there was an algae blooming in the North Sea and the surrounding countries signed the OSPAR agreement to reduce nutrients like nitrogen and phosphorus to the sea.

For agriculture-in Norway- this lead to increased effort for soil inventory and soil classification and especially for classifying erosion risk of agricultural areas. National Agricultural monitoring programmes in different agricultural catchments (JOVA monitoring programme www.jova.no) were started. Soil research documented reduced tillage, and soil management (timing, type and intensity) that could reduce erosion and also losses of phosphorus. Subsidies were established for farmers to reduce erosion (from 1990) - paid after the four erosion risk classes. Subsidies included measures like leaving surface in stubble during autumn and winter period, only autumn harrowing, direct drilling. Later subsidies included retention ponds and buffer zones and grassed waterways. All these measures were focused on soil management- soil physics- to reduce the erosion and transport of particles from the agricultural

areas.

The latest year there has been a change in focus – to productivity for food production, possibilities to increase soil carbon content and soil health. Subsidies now include use of catch crops to protect soil surface, reduce erosion and losses of both nitrogen and phosphorus. Indicators for soil health is being developed and also implemented in the national monitoring programmes. It has also been implemented a new National Programme for Soil Health. This presentation gives an overview of the development for measures to reduce erosion to the National programme for soil health.

Profile

Lillian Øygarden is Head of research at Division Environment and Natural Resources in NIBIO (Norwegian Institute of Bioeconomy Research). She has more than thirty years of experience from work with agriculture and environmental impact. She has a PhD in soil physics – focusing on soil erosion in small agricultural catchments during winter and snowmelt periods. She has worked with measures in agriculture to reduce runoff and nutrient losses. The latest years she has worked with effects of climate change on agriculture and strategies for adaptation measures. This includes especially effects of extreme weather conditions and adaptation of soil and water conservation.