

# The Sequestration

News from the Lal Carbon Center

2023 WINTER EDITION



## INSIDE

Quarterly Viewpoint.....	2
Center Events.....	4
Arrivals & Farewells.....	5
Project Updates.....	8
Near & Far.....	12
In the News.....	13
Annual Publications.....	14
Season's Greetings.....	23
Contact Us.....	23

## Inaugural Carbon Academy

The Lal Carbon Center successfully hosted its inaugural **Carbon Academy Workshop** on November 17, 2023, in the Priva Gathering Space, located in the new Controlled Environment Agriculture Research Complex (CEARC), part of Waterman Agricultural and Natural Resources Laboratory.

The fundamental mission of the Carbon Academy is to provide crucial insights into soil carbon dynamics, addressing multifaceted areas such as carbon farming, on-farm carbon credit

assessments, and soil carbon measurement techniques (including remote sensing and modeling). These topics are explored alongside wider themes encompassing policy frameworks, legal considerations, the intersection of carbon with food security, societal valuation of carbon, payments for ecosystem services, and mechanisms embedded within the carbon market.

These invaluable insights will be tailored to diverse audiences invested in the health (*con't p 3*)

# Quarterly Viewpoint

FROM THE DESK OF PROFESSOR RATTAN LAL

The two week-long conference in Dubai (1-12 December 2023) was attended by 154 Heads of States and Government, as well as 85,000 participants from around the world, representing scientists, the private sector, civil society, international organizations, NGOs, and Indigenous people. Although not specifically stated, COP28 laid the foundation stone of the “beginning of the end” for the fossil era. The final Declaration of COP28 specifically focused on agriculture as an important part of the solution. In Bullet 5 of the Declaration, the mention of “soil health” indicates a statement of historical significance with long-term consequences toward identification and implementation of strategies to harness the potential of land-based carbon sinks. Specific focus on agriculture included the following objectives:

- 1) Scaling up adaptation and resilience activities and responses in order to reduce vulnerability of all farmers,
- 2) Promoting food security and nutrition by increasing efforts to support vulnerable people,
- 3) Supporting workers in agriculture and food systems,
- 4) Strengthening the integrated management of water in agriculture and food systems, and
- 5) Maximizing the climate and environmental benefits by conserving, protecting, and restoring land and natural ecosystems, enhancing soil health, and biodiversity.

However, translating these 5 objectives into action would need an annual allocation of \$100 billion for several decades to empower all land managers and especially small farmers (< 2 ha), most of which are women.

The next two COPs will be held in Azerbaijan (COP29 from 11-22 November 2024) and Brazil (COP30 from 10-21 November 2025).

Sincerely,



Rattan Lal  
Distinguished University Professor of Soil Science, SENR  
Director, CFAES Dr. Rattan Lal Carbon Management and Sequestration Center  
IICA Chair in Soil Science & Goodwill Ambassador for Sustainable Development Issues

# Inaugural Carbon Academy Workshop (con't)

Connecting with soil students at Ohio State University



Dr. Matthew Hamilton presents to undergraduate students interested in soil carbon dynamics.

(con't page 1) of soil from soil students to farmers.

Our inaugural **Carbon Academy** event was an in-person, half-day workshop for undergraduate students interested in soil carbon dynamics. The workshop featured speakers from the Center's **Carbon Farming Alliance for Research and Management (C-FARM)** project, including Dr. Matthew Hamilton, Dr. Rattan Lal, Dr. Klaus Lorenz, and Dr. Tania Burgos-Hernández from the School of Environment and Natural Resources, as well as Dr. Asmita Murumkar from Ohio State University Extension. Each lecturer focused on a specific aspect of soil carbon, from soil physics to policy to modeling.

Dr. Hamilton initiated the workshop with a lecture entitled *Policy dimensions of carbon farming: How institutional factors affect practice adoption*, discussing the myriad of social and political decisions that communities consider regarding soil carbon.

Dr. Rattan Lal's presentation outlined strategies for *Managing Soil Carbon for Addressing Global Warming*, explaining the physics that govern soil carbon processes and how they impact the climate.

Dr. Murumkar, whose work as an Ecosystem Services Field Specialist focuses on outreach to

farmers and agriculturalists, demonstrated digital tools available to model soil carbon in-situ in *Decision tools and models for carbon management*.

This was followed by a practical demonstration of greenhouse gas measurement with Dr. Klaus Lorenz and Lal Carbon Center Lab Manager Kyle Sklenka using a photo acoustic soil analyzer.

Finally, Dr. Lal emphasized the importance of soil carbon in a societal perspective in his lecture *Carbon Farming and the Societal Value of Carbon*, detailing how carbon farming may benefit society agriculturally and economically.

Dr. Tania Burgos-Hernández closed the session by soliciting feedback from the audience, which was made primarily of students from her courses.

We would like to give special thanks to Waterman Director Dewey Mann and Program Assistant Jamie Gothard for allowing us use of Waterman Farms and fantastic event support that made our Carbon Academy Workshop a resounding success.

The Lal Carbon Center plans to host several Carbon Academies annually, specifically tailored to a variety of audiences, from farmers to graduate students to



## IICA: New AGRIMAN AGtivities!

The Inter-American Institute for Cooperation on Agriculture (IICA) is pleased to release two supplemental workbooks for the **AGRIMAN AGventures** comic book series, filled with lots of "ag-tivities" for children 4-7 and 8-12!

You can learn more about this exciting collaboration with IICA here: <https://go.osu.edu/agriman>



Photo Acoustic Soil Analyzer

faculty.

With a focus on the research gathered through the Center's work on C-FARM, the Carbon Academy hopes to empower all who work with soil to apply principles that protect the health of the soil and the carbon cycle of our precious planet.

# 2023 Fall Feast at the Lal Carbon Center

By Hannah Shively

The Lal Carbon Center hosted their faculty, staff, and students for a Fall Feast Potluck to celebrate the season. Though space was limited in a smaller room, Center members brought their favorite Fall dish to share with the group. There was a diverse spread of cuisine that came from the cultures and traditions of our Center members. Some of the savory dishes included lentil soup, vegetable dal, salmon and spinach pinwheels, rice biryani, dal makhani, and pasta salad. For dessert, we had a delicious spread that included a tres leches cake, pumpkin pie, and a traditional German cake called Christstollen. It was a wonderful event that filled our stomachs and our minds!



Paper leaves with thoughts of gratitude written by Center members.



Group photo of the Lal Carbon Center members.  
Photo courtesy Joao Sa.

As we ate, everyone shared the Fall holiday traditions that they do with their families and friends back home. It was lovely to hear about the traditions that our colleagues grew up with. We learned about the Fall celebrations that take place in Brazil, India, Japan, Germany, as well as different states throughout the USA! We also shared what we are most thankful for on colorful leaf cutouts that were spread across the tables.



## Sonam Rustagi Joins Internship in Washington, D.C.

Sonam Rustagi, a first year M.S. student, will be spending part of the spring semester working on Capitol Hill. She was recently accepted into an internship program with the Senate Committee on Agriculture, Nutrition, and Forestry. Sonam is looking forward to working on topics relevant to her research in agriculture policy and soil management. With the 2018 Farm Bill's extension until February 2024, she is excited to see the legislative process up close and learn from committee staff members and policymakers.

## World Soil Day 2023 Celebration

In honor of World Soil Day on 5<sup>th</sup> December 2023, the Lal Carbon Center hosted an online celebration with colleagues from the C-FARM project and within Ohio State. Dr. Rattan Lal briefly discussed the history of World Soil Day and its origins. In 2014, the International Society of Soil Scientists and the UN General Assembly in acknowledged the lifelong contributions to soil made by His Majesty the late King Bhumibol Adulyadej of Thailand by establishing World Soil Day on December 5<sup>th</sup>, to commemorate His Majesty's birthday.

C-FARM PI Dr. Laura Norman of the U.S. Geological Survey presented on the topic of this year's World Soil Day, *Soil and Water: A Source of Life*.



His Majesty King Bhumibol Adulyadej of Thailand in 2010. Appropriately, the name "Bhumibol" means "Protector of Soils."

Source: Wikipedia



# Welcome to the Center!

## Toru Nakajima



Dr. Toru Nakajima is an Associate Professor at the Tokyo University of Agriculture (TUA) in the Department of Agricultural Engineering since 2017. He is currently joining the CFAES Rattan Lal Center for Carbon Management and Sequestration (Lal Carbon Center) as a Visiting Scholar for a one-year term. His research focuses on “carbon sequestration and soil health

through regenerative agriculture,” exploring the relationship between carbon sequestration and the promotion of soil health within the context of regenerative agriculture through the collaborative efforts at the Center.

During the years 2011 to 2014, Dr. Nakajima was a Postdoctoral Researcher at the Lal Carbon Center (formerly C-MASC). Collaborating with the United States Department of Agriculture (USDA), he spearheaded a comprehensive research project titled "Climate Change, Mitigation, and Adaptation in Corn-Based Cropping Systems," working in conjunction with 11 universities and institutes across the Midwest.

The objectives of this research were to 1) increase resiliency of corn production systems to climate variations and extremes, 2) mitigation and adaptation of corn-based cropping systems to climate variations. To accomplish these objectives, the team and Dr. Nakajima conducted extensive research at the Waterman Agricultural and Natural Resources Laboratory, focusing on both drainage and no-tillage sites. The team gathered greenhouse gas (GHG) emission data using a photoacoustic spectrometer (PAS) and gas chromatography on a biweekly basis over three years.

Furthermore, Dr. Nakajima conducted research regarding the assessment of the soil quality index (SQI) across 10 sites in Ohio and Michigan. These assessments were conducted under varying management conditions, including no tillage (NT), conventional tillage (CT), cover crops, and manure application.

In his free time, Dr. Nakajima enjoys spending quality time with his family and surfing in the beautiful oceans in Japan.

## Brennan Spaulding



Brennan Spaulding is joining the Lal Carbon Center as our new Research Technician. He is originally from Cincinnati, Ohio. Growing up, he was a boy scout and a clarinet player, among other things.

In 2019, he moved to Columbus to attend The Ohio State University and graduated in 2023 with a B.S. in Environment and Natural Resources with a specialization in Ecosystem Restoration. Following this, he worked for Preservation Parks of Delaware County where he was able to get some practical experience in ecosystem restoration.

Brennan is very excited to work here at the Lal Carbon Center under the highly experienced Dr. Lal and learn more about the research going into soils.

## Our team is growing!

If you are interested in contributing to the work at the Lal Carbon Center, please visit our Join Us page at [go.osu.edu/join-the-lal-carbon-center](https://go.osu.edu/join-the-lal-carbon-center).

### Current Positions Open:

- Data Analyst

CONT. ON PAGE 6 >>



Vairton Radmann, Associate Professor at the Federal University of Amazonas (UFAM), joins the Lal Carbon Center as a Visiting Fellow completing a Postdoctoral degree. In Brazil, Dr. Radmann carries out research in the Amazon, in the southern region of the state of Amazonas. The focus of the research is to evaluate the attributes of the soil and plants with cover species in the cultivation of açaí (*Euterpe oleracea* Mart.); calibrations of fertilization and liming in Amazonian soils; and evaluate soil and plant indicators in the no-tillage system in the Amazon.

Here in Columbus, Dr. Radmann will complete the project "Carbon dynamics in land use change in the southern region of the state of Amazonas." It evaluates the effects of converting the forest into areas cultivated with açaí (*Euterpe oleracea* Mart.) and Puerária (*Pueraria phaseoloides*), in the total

organic carbon stock, in the recovery rate of total organic carbon fractions and chemical and physical attributes of the soil.

Vairton Radmann completed his doctorate in 2017 in Soil and Water Management and Conservation in Agricultural Areas. Our challenge is to develop sustainable techniques to cultivate deforested land. The standing forest is also profitable, hence the importance of preserving it.

## A Fond Farewell to Muhammad Adnan



I am sincerely grateful and take immense pride in being a part of the CFAES Rattan Lal Center for Carbon Management and Sequestration as a Fulbright Postdoc Research Scholar. The center has provided exceptional facilitation, affording me the invaluable opportunity to collaborate with a dynamic and impressive research team under the guidance of Dr. Lal.

My tenure at the Lal Carbon Center has opened new and advanced insights into knowledge and ideas for me in fields related to carbon sequestration and greenhouse gases emission from arable land and their possible mitigation strategies. Undoubtedly, carbon emission and capture are no longer in balance, and the concentration of CO<sub>2</sub> in the atmosphere is steeply rising thus reaching net-zero C emission is a big undertaking. While agriculture is recognized as a 3rd major anthropogenic source of greenhouse gas emissions (21%), I firmly believe that "Agriculture is not a problem contributing to climate change; rather, it is the

solution to mitigate climate change." However, realizing this potential requires development, exploration, and implementation of ecologically resilient, sustainable, economical and climate smart agricultural strategies.

Therefore, my research focuses on transformation of organic wastes into carbon and nutrient enriched compost and biochar. Their application into soil not only sequester soil carbon but also play vital role in restoring soil health, enhancing water and nutrient use efficiency, remediating heavy metal-polluted soils, and mitigating greenhouse gas (N<sub>2</sub>O) emissions from cultivable land. I am confident that this visit/experience will play a vital role for the devolvement and implementation of climate resilient agricultural practices in Pakistan and may/will turn into a source of research and professional collaboration between University of Swabi and The Ohio State University. Thank you for hosting me.

Md. Nayem Hasan Munna is joining the Lal Carbon Center to pursue a Ph.D. degree at the School of Environment and Natural Resources in the College of Food, Agricultural, and Environmental Sciences, specializing in Soil Science. His research interests revolve around soil fertility, biochar application in soil, and soil organic matter.



He obtained both his M.S. and B.S. degrees in Soil and Environmental Sciences from the University of Barisal, Bangladesh. He is the founder of "Earth Review," an environmental research organization based in Bangladesh. The organization is dedicated to promoting Sustainable Development Goals (SDGs) related to Environmental Conservation,. Its website is [www.earthreview.org](http://www.earthreview.org).

He is the recipient of several awards, including the 2022 Dean's Award from the Faculty of Bio-Sciences based on an extraordinary performance in the M.S. examination and the 2017-18 Dean's Award from the Faculty of Bio-Sciences based on an extraordinary performance in the B.S. (Honors) examination from the University of Barisal, Bangladesh, and the National Science and Technology (NST) Fellowship for the academic year 2021-22 to conduct his M.S. thesis from the Ministry of Science and Technology, Bangladesh.

During his leisure time, he enjoys traveling to explore the diverse cultures and heritages of different destinations worldwide. His portfolio website is [www.nayemhasanmunna.com](http://www.nayemhasanmunna.com).

## Chinmayee Priyadarshini



Chinmayee Priyadarshini is joining the Lal Carbon Center as a Ph.D graduate student in Spring of 2024. She received her B.S. in Agricultural and Allied Sciences in 2019 from Orissa University of Agriculture and Technology, Bhubaneswar, India. Soon after, she pursued her M.S. in Agriculture from Mahatma Phule Krishi Vidyapeeth, Rahuri, India with a specialization in Soil Science and Agricultural Chemistry. Her research focused on long term effects of agroforestry on terrestrial carbon stock in semi arid soil of Maharashtra.

In 2022, she worked as a Senior Research Fellow on the project "National Innovations for Climate Resilient Agriculture" under the Central Research Institute for Dryland Agriculture, in the Keonjhar district of Odisha. She mostly dealt with field implementation of climate resilient farming practices like mulching, natural farming, etc., and monitoring of the project. In 2023, she joined the business consulting firm Erda Illumine Low Carbon Solutions Pvt. Ltd as an Associate: Climate Change. That position dealt with development and execution of community-based NBS projects on-ground, by leveraging climate finance for organizations that are striving to attain their Net Zero and ESG goals.

Currently, she is pursuing her doctoral degree in the School of Environment and Natural Resources with a specialization in Soil Science. Her research interests include carbon sequestration in different types of land settlements, mitigation of global climate change by scientific management of natural resources and wetland carbon management.

She indulges herself in activities like sketching, exploring localities and foods, and dancing in her free time.

# Variable tillage intensity effects on carbon budget and sequestration

*The Lal Carbon Center launches a new project with CNH Industrial*



*One of two fields under study in Franklin County Ohio for this project.*

The Lal Carbon Center is proud to announce a new project with CNH Industrial started in 2023, led by Principal Investigator Rattan Lal and Co-PI Klaus Lorenz. The research project, *Variable Tillage Intensity Effects on Carbon Budget/Sequestration*, focuses

on the impact of varying tillage intensities on soil organic carbon (SOC) stocks and other soil properties, greenhouse gas fluxes, and crop yields. The aim is to bridge knowledge gaps regarding the effect of tillage equipment gang angles (tillage intensity) on these properties. Traditional tillage practices often lead to SOC loss by affecting soil structure and aeration, while no-till methods show potential for reducing the SOC loss. However, implementing no-till universally remains challenging, prompting the need for adjusted tillage intensities tailored to specific conditions.

Specifically, the study investigates the effects of tillage equipment differing in gang angles, strip-till and no-till, across a four-year cropping cycle. It assesses various soil health parameters, crop yield factors, and greenhouse gas fluxes. Tillage treatment experiments have been established at two field sites differing in drainage intensity in Ohio, and these will be studied from 2023 to 2027.

Providing data about variables effecting tillage intensity to producers based on farm field-scale and plot-scale trials will increase the confidence of producers in the efficacy of tillage tools for preparing the desired seedbed quality and obtaining the optimal crop productivity, while reducing impacts on SOC sequestration. The project aims to provide crucial insights for growers to generate guidelines for improved sustainability and productivity in farming practices.

## C-FARM Project Updates

*On-Farm Conservation Agriculture Practices Effects on Soil Health and Agronomic Productivity in the Midwestern USA*

By Yadunath Bajgai

A review of literature on the topic entitled “On-Farm Conservation Agriculture Practices Effects on Soil Health and Agronomic Productivity in the Midwestern USA” has been completed and a summary is as follows. The manuscript has been submitted for publication and it is under review.

To sustain and increase food, feed, fiber and fuel production, care should be taken to protect soils against degradation. Key principles of conservation agriculture (CA), such as minimizing soil disturbance, maximizing soil cover, and diversifying crop species, can protect soils against degradation and enhance ecological resilience and soil health. Hence, a study was conducted using the Web of Science database to review the literature on CA practices and their effects on soil health and agronomic productivity in the Midwestern region of USA. Since on-farm studies are suggested to be more representative than small plots to assess the effects of farming systems on soils, research conducted on a working farm or ranch on a commercial-scale were selected for the review. Thus, small experimental plots within a farmer's field were excluded.

The highest number of papers covered focused on Ohio, followed by Michigan, and the lowest number covered Kansas and South Dakota. The data collated indicated that a widely practiced cropping system in the Midwestern region of

*(continued page 9)*



### C-FARM Updates (con't)

*On-Farm Conservation Agriculture Practices Effects on Soil Health and Agronomic Productivity in the Midwestern USA*

(continued from page 8) the U.S. is corn-soybean rotation, in some form of spatial or temporal rotations, sometimes also including wheat with pastures/hay grasses.. Soil properties such as bulk density, soil organic carbon content and its fractions, and total N were more commonly studied whilst properties like water infiltration rates, texture, available water capacity, water stable aggregates, pH, EC, soil chemical properties were either sparingly assessed or not assessed in soil under no-till (NT) vs. conventionally tilled (CT) comparison in on-farm conditions. Unlike in NT vs. CT soils, soil texture features as a more commonly assessed property in cover crops vs. without cover crop studies. Knowledge and research gaps were identified to be addressed in order to strengthen the existing database and to enhance the credibility of technical recommendations on CA practices to improve soil health and ecological resilience in commercial farms or ranches.



Dr. Yadunath Bajgai, C-FARM Research Scientist stands in front of winter wheat grown under no-till farming systems after soybean harvest at a farm in Wyandot county, Ohio in December 2023. Besides grain production, the winter wheat strategically acts as cover crop to protect soil over the winter.

Additionally, work in the laboratory to process and analyze soil samples for determination of soil properties has continued apace. Penetration resistance of the C-FARM sites in Pickaway and Wyandot counties has been completed, and soil samples collected from these two counties are being processed for determination of aggregate stability.

### C-FARM will host second annual conference at KSU March 2024



Picture by DeAnn Presley: "The perfect carbon picture doesn't exist—" Image depicts cows grazing in fields in front of factories in Kansas.

The C-FARM Principal Investigators are planning the 2<sup>nd</sup> Annual C-FARM Conference in the last week of March 2024. Kansas State University will host the event, with the guidance of DeAnn Presley, Professor of Environmental Soil Science and Management, and Peter Tomlinson, Associate Professor of Environmental Quality. The C-FARM collaborators plan to meet in Manhattan, Kansas and incorporate field events with farmers that are participating in the research project.

There are also plans to hold the second Carbon Academy workshop there, tailored to the C-FARM farmers, to share research findings and practical applications that have come from the project in the last year.

### Lal Carbon Center Seminars

Would you like to learn about advancements in soil science as they happen? Please join the Lal Carbon Center Fridays at 3:00 pm US Eastern time over Zoom to hear presentations from our Researchers, Postdocs and Graduate Students about recent progress in their research for the Academic Year 2023-2024. Exact schedule and Zoom link located here: [go.osu.edu/23-24-carbon-seminars](https://go.osu.edu/23-24-carbon-seminars)

# Stark Sustainable Soils Initiative

*Sponsored by the Herbert W. Hoover Foundation, the project completes its fourth year*

By Lauren Baldarelli



The **Stark Sustainable Soils Initiative** entered its fourth year with Postdoctoral Researcher Dr. Lauren Baldarelli, who joined the team in March of 2023. In late June, the team started crop measurements throughout the growing season. This involved recording how tall the corn and soybeans were, determining growth stages of the crops (either vegetative or reproductive), and noting any pests or visible signs of plant stress. This continued until the beginning of September. Many thanks to Kaitlyn Cowley from the Herbert W. Hoover Foundation (HWH), Fellow Postdoctoral Researcher Dr. Gunadhish Khanal from the HWH collaboration with Kent State (*see page 11*), and interns Nitesh Kandel of Youngstown State University, all of whom contributed greatly to the success of this part of the project.



Postdoctoral Researcher Gunadhish Khanal (far left) with interns Nathan Shumaker and Jalen Gilbert (left to right) and Postdoctoral Researcher Lauren Baldarelli (far right) collect soil samples. Photo courtesy Lauren Baldarelli.

September was also the start of soil sampling. Dr. Baldarelli and her team sampled all 12 of our participating farms and 2 wooded sites within our Stark County. This resulted in a total of 138 soil core samples and soil bulk density cores from 5 different sites. All soil core samples were air dried and sieved through 2mm mesh. Some of the soil was sent to the Service Testing And Research Laboratory (STAR) laboratory at Ohio State for Mehlich-3 extraction to determine plant available soil nutrients. The rest was used to determine soil organic matter and soil organic carbon and total nitrogen at the Lal Carbon Center Columbus, Ohio. The bulk density cores were oven dried to determine bulk density. They were also wet sieved to account for gravel content in each of our samples.

The team also harvested crop samples from a 1x1m plot at each of the 5 sites within each farm. This year, most farmers were growing soybeans; a couple growing corn; the rest

have long-term forage/hay fields; and one growing oats. The soybean crops were threshed at Snyder Farm (OSU Wooster) to separate the grain from the stock. Corn kernels were separated by hand from the cob for grain analysis. All grain samples were sent to the STAR lab for nutrient analysis. Sampling completed in late October.

Lauren and her team thank Danielle DeYoung of Malone University for her help in the field, the Massillon NRCS office for letting us take over their lab (and office!), and many thanks to Jalen Gilbert and Nathan Shumaker, two interns from Malone University for all their work in both the field and the lab.

Most of November was spent in the lab processing samples. Dr. Lauren moved to Columbus for 5 weeks to complete the following analyses with Dr. Guna: bulk density, soil pH and electrical conductivity, soil organic matter, total carbon and nitrogen, soil respiration and aggregate stability. It was great to work in lab at the Lal Carbon Center, join meetings in person and explore the Columbus area. Many thanks to Lab Manager Kyle Sklenka and Research Technician Brennan Spaulding for all of their help in the lab.

The upcoming winter months will be focused on data analysis and scientific writing.



Thresher used to separate grains from pods or ears. Photo courtesy Gunadhish Khanal.

# A modeling framework for monitoring soil carbon stocks in Latin America and the Caribbean

By Carla Gavilan

The Latin America and the Caribbean (LAC) region is home to a diverse range of countries that are particularly vulnerable to the impact of climate change, mainly due to the unique land use, land tenure systems, and the various ecosystems in the region. Climate change is a macro-critical issue in LAC, and climate mitigation and adaptation are essential.

Monitoring changes in soil organic carbon (SOC) stocks has been recognized as key to facilitating and identifying sustainable land use practices in the context of climate change mitigation, food security, and land degradation. Also, reliable quantification of SOC and accurate modeling of its changes under different management practices is necessary for informed decision-making. One of the most significant obstacles to building viable agricultural monitoring systems in several developing countries is the lack of data to establish a solid basis for linking changes in soil carbon sequestration with changes in agricultural activities. As a result, several LAC countries rely on global default values for reference SOC stocks and emission factors to infer changes in SOC stocks (Tier 1 approach). However, using those values to upscale the calculations to regional-scale projects is associated with low accuracy and high uncertainty.

As part of the *Living Soils of the Americas Initiative* led by IICA (Inter-American Institute for Cooperation on Agriculture) and the CFAES Rattan Lal Center for Carbon Management and Sequestration of Ohio State University, we are developing a modeling framework for monitoring purposes. This framework integrates remote sensing data at different temporal and spatial resolutions, and a process-based model to assess, predict, and monitor SOC changes over time. We aimed to develop a robust, affordable, and scalable protocol that can be implemented in other biomes, even with the minimum data available, to help overcome the limitations that data-scarce regions face. We are testing the framework in a pilot area in the Brazilian Cerrado Biome with promising results. Currently, we are validating these preliminary findings.

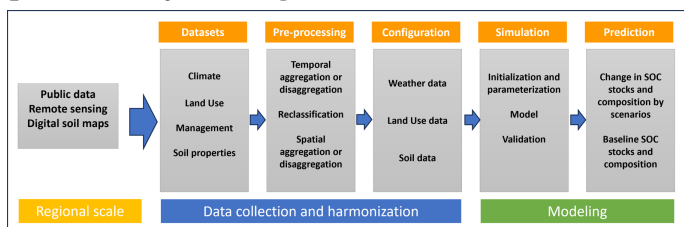


Figure: Framework for soil carbon simulations

# Cover crop impacts on soil carbon inferred by modeling and soil optical properties

By Gunadhish Khanal

Dr. Gunadhish Khanal joined the Kent State and Herbert W. Hoover sponsored project *Cover crop impacts on soil carbon inferred by modeling* and soil optical properties in September of 2023. His research involves ground-truthing the soil carbon modeling research of Dr. Joseph Ortiz (Kent State University), Dr. Rattan Lal (Ohio State University), Dr. Sarah Eichler (Kent State University), and Dr. Remegio Confesor (The Norwegian Institute of Bioeconomy Research - NIBIO).



Gunadhish Khanal loads a car with corn samples. Photo courtesy Lauren Baldarelli.

Collaborative efforts between this project and the **Stark Sustainable Soils Initiative** meant that during September and October, soil samples were collected for soil aggregate analysis. Understanding wet, stable aggregate from the field can be essential to understanding infiltration, soil erosion, runoff, soil aeration, root growth, etc. Tillage and crop management practices greatly affect the formation, and redistribution of soil aggregates in the field, and thereby soil organic matter, which plays a major role in aggregate formation. While soil organic matter helps build aggregates, aggregates protect soil organic matter from rapid turnover. Sieving of the aggregate samples is completed, and it will take until mid-January month to analyze the samples and extract the data.

## Conference of Ministers of Agriculture of the Americas

San Jose, Costa Rica — 3rd – 4<sup>th</sup> October 2023



Photo courtesy Francisco Mello

Dr. Lal traveled to Costa Rica as IICA Ambassador for Sustainable Development Issues to attend the Conference of Ministers of Agriculture of the Americas. Attendees at this conference included several presidents, high-level national officials, senior international agency representatives, and world-renowned academics such as Dr. Lal himself.

The conference was held with the purpose of proposing and considering solutions to the most urgent challenges facing the sector, at a time when food security is at the top of the global agenda. Dr. Lal's lecture, entitled **Carbon Farming: A New Crop for Addressing Climate Change** played a big role in the discussions had at the conference.

Dr. Lal traveled to Morocco to attend a scientific event titled "The Voice of Africa" put on by The Mohamed VI Polytechnic University (UM6P). The event was held to address some of the economic issues that the continent is facing and generate worthwhile solutions and ideas.

The President of UM6P, Hicham El Habti, stated, "We aim to create a space where Africa's voices could be heard loudly and clearly, and where our continent's

challenges and opportunities could be fully explored in harmony with those of world class researchers, experts, and entrepreneurs."

Dr. Lal's presentation at this event, **Conceptual Basis of MASHA Project**, which stands for Managing Soil Health in Africa, outlined the goals of this ambitious collaboration. It has the goal of restoring the agricultural success of the African continent.

## The Voice of Africa UM6P Side Event: Food Security

Ben Guerir, Morocco  
— 7<sup>th</sup> October 2023



## Agri-Investment Forum and Expo

Georgetown, Guyana —  
19<sup>th</sup> – 20<sup>th</sup> October 2023



Dr. Lal gifting the book to Guyana President Irfaan Ali. Photo courtesy Francisco Mello.

The Agri-Investment Forum and Expo was hosted by the Government of Guyana, Ministry of Agriculture of Guyana, and the CARICOM Secretariat on the 19<sup>th</sup>- 20<sup>th</sup> of October. The aim of this event was to promote informed dialogue among key stakeholders within the agriculture value chain. The event included attendees such as policy makers, development partners, foreign and local private investors, farmers, distributors, and academic researchers such as Dr. Lal.

The focus of the discussions was related to Caribbean

investment opportunities in agriculture and food production, as well as agricultural financing, trade opportunities, and infrastructural development needs. Dr. Lal's presentation, **Making Agriculture a Part of the Solution to Climate Change and Other Environmental Issues of the 21st Century**, was to promote discussion regarding agriculture being part of the solution to climate change and other issues that need addressing within Guyana and the Caribbean region of the world.

## Harvard Conference on Consciousness

Boston, Massachusetts, USA —  
26<sup>th</sup> – 27<sup>th</sup> October 2023



Harvard Medical School, with Balachundar Subramaniam, MD, held the **Consciousness – Science, Spirituality and Social Impact** conference dedicated to exploring consciousness from the lens of various scientific disciplines and examining the challenges and opportunities that these models present in arriving at a deeper understanding of consciousness, according to the description on their website. Part of this event was devoted to the profound interdependence of environmental

consciousness, overall individual health, and the health of our soil in regard to how these shape our collective well-being.

Dr. Lal's presentation, **The Importance of Soil Management to Mitigate Climate Change**, which addressed the importance of soil management and how it can mitigate climate change, played a huge role in the discussion of how the health of our soil and our environmental consciousness shapes our collective well-being.

The Mohammed VI Polytechnic University (UM6P) put on a special soil health event hosted by the Chair of Soil Sciences in collaboration with the Institute for Advanced Studies. This event included talks from world-renowned soil experts, such as Dr. Lal himself. The talks revolved around the multifaceted role of

soil health in addressing societal challenges.

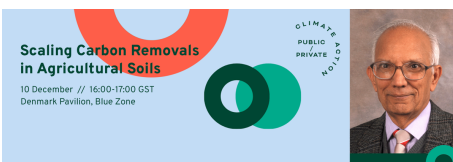
Dr. Lal's lecture **Managing Soil Health in Africa: Food, Climate, and SDG Security** addressed food and climate security as well as how to achieve the 17 Sustainable Development Goals proposed by the United Nations.

## Chair in Soil Sciences, Mohammed VI Polytechnic University

Ben Guerir, Morocco —  
23<sup>rd</sup> November 2023

## 28th Conference of the Parties (COP28)

Dubai, United Arab Emirates  
— 10<sup>th</sup> December 2023



Dr. Lal traveled to Dubai in December in order to attend the 28th Conference of the Parties (COP28), which is the formal meeting of the UNFCCC parties to work together on solutions to tackle climate change. Dr. Lal joined the Denmark Pavilion and the Danish Ministry of Climate to set an ambitious climate goal: to

reduce greenhouse gas emissions by 70% by 2030.

Dr. Lal's presentation, **Scaling Carbon Removal in Agriculture**, contributed to the discussion of sharing solutions in order to achieve this goal as well as to improve the threat of climate change around the world.

## The Lal Carbon Center in the News

The November issue of Columbus Monthly magazine featured an article by Randy Edwards about the life and research of Dr. Rattan Lal.

Please explore this article online at  
Columbus Monthly here:  
[go.osu.edu/columbus-monthly](https://go.osu.edu/columbus-monthly)



Photo of Columbus Monthly magazine courtesy of Cynthia Lindsay

# Annual Publications

## Books Written

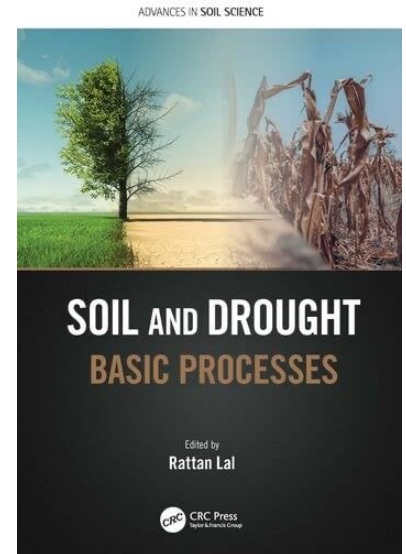
1. Lorenz, K. and Lal, R., 2023. Organic Agriculture and Climate Change. Springer Nature ISBN:978-3-031- 172144, 232pp.  
<https://doi.org/10.1007/978-3-031-17215-1>

## Books Edited

2. Jayaraman, S., R.C. Dalal and R. Lal (eds) 2023. Sustainable Soil Management: Beyond Food Production. Cambridge Scholars Publishing, ISBN 13: 978-1-5275-0204-8, pp 350.
3. Lal, R. (Ed) 2023. Soil and Drought: Basic Processes. ISBN: 9781032286747

## Refereed Journal Articles

4. Alam, M. M., Hossain, A. M., Hakim, A., Islam, M. R., Soufan, W., El Sabagh, M., Adnan. (2023). Application of Vermicompost to Boro Rice (Brrri Dhan 28) can save Phosphate Fertilizer with Sustaining Productivity and Soil Fertility. *Pak. J. Bot*, 56(1), 293-304.
5. Ali, J., Jan, I., Ullah, H., Fahad, S., Saud, S., Adnan, M., ... & S. Elshikh, M. (2023). Biochemical response of okra (*Abelmoschus esculentus* L.) to Selenium (Se) under drought stress. *Sustainability*, 15(7), 5694.
6. Briedis, C., J. Sa, R. Lal, A. Ferreira, J. Franchini, et al. 2023. Preservation of labile organic compounds is the pathway for carbon storage in a 23-year continuous no-till system on a Ferralsol in southern Brazil. *Geoderma Regional* 33. doi: 10.1016/j.geodrs.2023.e00643.
7. Cui, L., J. Ma, G. Quan, J. Yan, J.A. Ippolito, and H. Wang. 2023. Biochar alters the degradation and transport of kasugamycin in soil and spinach. *MDPI Agriculture*. 13, 2172.  
<https://doi.org/10.3390/agriculture13112172>.
8. Das, S., A. Das, R. Idapuganti, J. Layek, D. Thakuria, et al. 2023. Liming and micronutrient application improves soil properties and productivity of the groundnut-rapeseed cropping system in an acidic Inceptisol of India's eastern Himalayas. *Land Degradation & Development* 34(12): 3681-3699. doi: 10.1002/ldr.4713.
9. Huang, Y., B. Tao, R. Lal, K. Lorenz, P. Jacinthe, et al. 2023. A global synthesis of biochar's sustainability in climate-smart agriculture- Evidence from field and laboratory experiments. *Renewable & Sustainable Energy Reviews* 172. doi: 10.1016/j.rser.2022.113042.
10. Idapuganti, R. G., Das, A., Sungoh, H., Layek, J., Mandal, S., Verma, B. C., Lal, R., Rangappa, K., Babu, S., & Hazarika, S. (2023). Can biochar conserve soil moisture and improve soil properties for sustainable intensification of acid soils in the Eastern Indian Himalayas? *Land Degradation & Development*, 1–17. <https://doi.org/10.1002/ldr.4981>
11. Iqbal, A., Ligeng, J., Mo, Z., Adnan, M., Lal, R., Zaman, M., ... & Tang, X. (2024). Substitution of vermicompost mitigates Cd toxicity, improves rice yields and restores bacterial community in a Cd-contaminated soil in Southern China. *Journal of Hazardous Materials*, 465, 133118.
12. Jamal, Y., Adnan, M., Ahmad, M., Mussarat, M., Saleem, M. H., Saeed, B., ... & Golokhvast, K. S. (2023). Partial substitution of exogenously applied phosphatic fertilizers by phosphate solubilizing bacteria in maize under calcareous soil. *PeerJ*, 11, e15038.
13. Kissel, D.E., J.W. Gaskin, M.L. Cabrera, B.R. Bock, and R. Lal. 2023. Agriculture as part of the solution to climate change: Incentivizing the adoption of no-till and cover crops. *Journal of Soil and Water Conservation* 78(5): 103A-104A. doi: 10.2489/jswc.2023.0620A. .



# Annual Publications (con't)

---

## Refereed Journal Articles (con't)

---

14. Kolganova, A., Lal, R., and Ferkins, J. 2023. Biochar's electrochemical properties impact on methanogenesis: Ruminal vs Soil Processes. *J. Agric. Chemistry and Env.* 12(1): 28-43, Feb 2, 2023. doi: 10.4236/jacen.2023.121003
15. Lal, R. 2022. Nature-based solutions of soil management and agriculture. *Journal of Soil and Water Conservation* 77(2): 23A-29A. doi: 10.2489/jswc.2022.0204A.
16. Lal, R. 2022. Sustaining soil for advancing peace: World is one family. *Journal of Soil and Water Conservation* 77(3): 43A-47A. doi: 10.2489/jswc.2022.0411A.
17. Lal, R. 2022. The flood-drought syndrome and ecological degradation of the Indo-Gangetic Plains of South Asia. *Journal of Soil and Water Conservation* 77(6): 85A-90A. doi: <https://doi.org/10.2489/jswc.2022.1006A>.
18. Lal, R. 2023. Agriculture in the North Western Sahara Aquifer System: A miracle in the making? *Journal of Soil and Water Conservation* 78(3): 57A-62A. doi: 10.2489/jswc.2023.0106A.
19. Lal, R. 2023. Carbon farming by recarbonization of agroecosystems. *Pedosphere* 33(5): 676-679. doi: 10.1016/j.pedsph.2023.07.024.
20. Lal, R. 2023. Farming systems to return land for nature: It's all about soil health and re-carbonization of the terrestrial biosphere. *Farming System* 1(1): 100002. doi: 10.1016/j.farsys.2023.100002.
21. Lal, R. 2023. Restoring South Asia's degraded soils and ecosystems for peace and prosperity. *Journal of Soil and Water Conservation* 78(5): 97A-102A. doi: 10.2489/jswc.2023.0327A.
22. Lal, R., and N. Kumar. 2023. The Space of Pseudofunctions with Application to Disjointness Preserving Mappings. *Mediterranean Journal of Mathematics* 20(1). doi: 10.1007/s00009-022-02203-2
23. Layek, J., and R. Lal. 2023. Long-Term Effects of Single Application of Biochar on Physical and Hydrological Properties of Crosby Silt Loam Soil in Central Ohio, USA. *Journal of Soil Science and Plant Nutrition* 23: 5013-5025. doi: <https://doi.org/10.1007/s42729-023-01533-8>
24. Layek, Jayanta. A Das, V.K. Mishra, R. Lal, R. Krishnappa, et al. 2023. Improved agronomic practices and high yielding rice varieties maintain soil health and enhance yield and energy use efficiency under shifting cultivation landscapes of eastern Himalayas. *Land Degradation & Development* 34(15): 4751-4767. doi: <https://doi.org/10.1002/ldr.4807>
25. Li, L., K. Mao, J.A. Ippolito, W. Xing, Y. Wang, and T. Li. 2023. Phosphate, lime and bentonite affect heavy metals and phosphorus availability in acidic and calcareous soils. *Commun. Soil Sci. Plant Anal.* <https://doi.org/10.1080/00103624.2023.2211094>.
26. Li, L., Y. Liu, J.A. Ippolito, W. Xing, Q. Zuo, and F. Wang. 2023. Fermentation affects heavy metal bioaccessibility in Chinese mantou. *Environ. Sci. Pollut. Res.* <https://doi.org/10.1007/s11356-023-26727-6>.
27. Li, L. Y. Cao, J.A. Ippolito, W. Xing, K. Qiu, H. Li, D. Zhao, Y. Wang, and Y. Wang. 2023. Cadmium and lead bioavailability to poultry fed with contaminated soil-spiked feed. *Sci. Tot. Environ.* 879:163036. <http://dx.doi.org/10.1016/j.scitotenv.2023.163036>
28. Lin, B., R. Li, K. Liu, O. Oladele, Z. Xu, et al. 2023. Management-induced changes in soil organic carbon and related crop yield dynamics in China's cropland. *Global Change Biology* 29(13): 3575-3590. doi: 10.1111/gcb.16703.
29. Liptzin, D., E.L. Rieke, S.B. Cappellazzi, ... J.A. Ippolito, ... C.L.S. Morgan, and C. Wayne Honeycutt. 2023. An evaluation of nitrogen indicators for soil health in long-term agricultural experiments. *Soil Sci. Soc. Am. J.* 2023; 1-17. DOI: 10.1002/saj2.20558.
30. Liu, P, L. Li, J.A. Ippolito, W. Xing, Y. Wang, Y. Wang, Y. Cheng, and K. Qiu. 2023. Heavy metal distribution in wheat plant components following foliar Cd application. *Chemosphere.* <https://doi.org/10.1016/j.chemosphere.2023.138177>.
31. Maas, E., and R. Lal. 2023. A case study of the RothC soil carbon model with potential evapotranspiration and remote sensing model inputs. *Remote Sensing Applications-Society and Environment* 29. doi: 10.1016/j.rsase.2022.100876.

# Annual Publications (con't)

---

## Refereed Journal Articles (con't)

---

32. Mandal D, Patra S, Sharma NK, Alam NM, Jana C, Lal R. Impacts of Soil Erosion on Soil Quality and Agricultural Sustainability in the North-Western Himalayan Region of India. *Sustainability*. 2023; 15(6): 5430-5444. <https://doi.org/10.3390/su15065430>
33. Moonilall, N.I., K.A. Sklenka, M.A. Nocco, and R. Lal. 2023. Rehabilitative capacity of amendments to restore maize productivity following artificial topsoil erosion/ deposition. *Field Crops Research* 304. doi: 10.1016/j.fcr.2023.109178.
34. Nandal, A., S. Yadav, A. Rao, R. Meena, and R. Lal. 2023. Advance methodological approaches for carbon stock estimation in forest ecosystems. *Environmental Monitoring and Assessment* 195(2), article 315. doi: 10.1007/s10661-022-10898-9.
35. Naorem, A., S. Jayaraman, N. Sinha, M. Mohanty, R. Chaudhary, et al. 2023. Eight-year impacts of conservation agriculture on soil quality, carbon storage, and carbon emission footprint. *Soil & Tillage Research* 232. doi: 10.1016/j.still.2023.105748.
36. Norman, L. M., Lal, R., Wohl, E., Fairfax, E., Gellis, A. C., & Pollock, M. M. (2022). Natural infrastructure in dryland streams (NIDS) can establish regenerative wetland sinks that reverse desertification and strengthen climate resilience. *Science of The Total Environment*, 849. <https://doi.org/10.1016/j.scitotenv.2022.157738>
37. Padilla, J.T., D.W. Watts, J.M. Novak, V. Cerven, J.A. Ippolito, A.A. Szogi, and M.G. Johnson. 2023. Magnesium activation affects the properties and phosphate sorption capacity of poultry litter biochar. *Biochar*. 5:64. <https://doi.org/10.1007/s42773-023-00263-5>.
38. Pradhan, G., R. Meena, S. Kumar, and R. Lal. 2023. Utilizing industrial wastes as compost in wheat-rice production to improve the above and below-ground ecosystem services. *AGRICULTURE ECOSYSTEMS & ENVIRONMENT* 358. doi: 10.1016/j.agee.2023.108704.
39. Reddy, S., C. Srinivasarao, P. Rao, R. Lal, S. Rakesh, et al. 2023. Greenhouse gases emissions and agronomic productivity as influenced by varying levels of N fertilizer and tank silt in degraded semiarid Alfisol of Southern India. *LAND DEGRADATION & DEVELOPMENT* 34(4): 943–955. doi: 10.1002/ldr.4507.
40. Reicosky, D., D. Brandt, R. Reeder, R.Lal, and D.R. Montgomery. 2023. Plowing: Dust storms, Conservation Agriculture, and need for a “Soil Health Act.” *Journal of Soil and Water Conservation* 78(5): 105A-108A. doi: 10.2489/jswc.2023.0619A.
41. Serafim, M., I. Mendes, J. Wu, F. Ono, L. Zancanaro, et al. 2023. Soil physicochemical and biological properties in soybean areas under no-till Systems in the Brazilian Cerrado. *Science of the Total Environment* 862. doi: 10.1016/j.scitotenv.2022.160674.
42. Shahab, M., Roberto, S.R., Adnan, M. (2023). Phenolic Compounds as a Quality Determinant of Grapes: A Critical Review. *J Plant Growth Regulation* 42, 5325–5331 (2023).
43. Shahzadi, E., Nawaz, M., Iqbal, N., Ali, B., Adnan, M., Saleem, M. H., ... & Marc, R. A. (2023). Silicic and Ascorbic Acid Induced Modulations in Photosynthetic, Mineral Uptake, and Yield Attributes of Mung Bean (*Vigna Radiata* L. Wilczek) under Ozone Stress. *ACS omega*, 8(15), 13971-13981.
44. Shrestha, R., P. Jacinthe, R. Lal, K. Lorenz, M. Singh, et al. 2023. Biochar as a negative emission technology: A synthesis of field research on greenhouse gas emissions. *Journal of Environmental Quality* 52(4): 769-798. doi: 10.1002/jeq2.20475.
45. Stokes, S.C., P. Trivedi, K. Otto, J.A. Ippolito, and T. Borch. 2023. Determining soil health parameters controlling crop productivity in a citrus greening disease affected orange grove. *Soil Environ. Health*. 1:1000016.
46. Swamy, S., H. Darro, A. Mishra, R. Lal, A. Kumar, et al. 2023. Carbon stock dynamics in a disturbed tropical forest ecosystem of Central India: Strategies for achieving carbon neutrality. *ECOLOGICAL INDICATORS* 154. doi: 10.1016/j.ecolind.2023.110775.



# Annual Publications (con't)

---

## Refereed Journal Articles (con't)

---

47. Thorndyke, M.P.†, O. Guimaraes, M. Medrado, H.Y. Loh, B.V. Tangredi, A. Reyes, R.K. Barrington, K. Schmidt, N.M. Tillquist, L. Li, J.A. Ippolito, J.T. Zervoudakis, J.J. Wagner, and T.E. Engle. 2023. The effects of long-term molybdenum exposure in drinking water on molybdenum metabolism and production performance of beef cattle consuming a high forage diet. *Biol. Trace Elem. Res.* <https://doi.org/10.1007/s12011-022-03532-9>.
48. Trimarco, T., J.A. Ippolito, J. Brummer, and C. Buchanan. 2023. Tracking soil health changes in a management-intensive grazing agroecosystem. *Soil Systems*. 7:94. <https://doi.org/10.3390/soilsystems7040094>.
49. Wang F., Harindintwali J.-D., Wei K., et al., (2023). Climate change: Strategies for mitigation and adaptation. *The Innovation Geoscience* 1(1): 61-95, 100015. doi: <https://doi.org/10.59717/j.xinn-geo.2023.100015>.
50. Xia, L., L. Cao, Y. Yang, C. Ti, Y. Liu, et al. 2023. Integrated biochar solutions can achieve carbon-neutral staple crop production. *Nature Food* 4(3): 236–246. doi: 10.1038/s43016-023-00694-0
51. Xing, W., L. Fang, J.A. Ippolito, F. Cai, Y. Wang, Y. Wang, Y. Yang, and L. Li. 2023. Effect of soluble phosphate and bentonite amendments on lead and cadmium bioavailability and bioaccessibility in a contaminated soil. *Sci. Tot. Environ.* 900:166370. <https://doi.org/10.1016/j.scitotenv.2023.166370>.
52. Xu, Z., M. Sun, X. Xu, X. Cao, J.A. Ippolito, S.K. Mohanty, B-J. Ni, S. Xu, and D.C.W. Tsang. 2023. Electron donation of Fe-Mn biochar for chromium(VI) immobilization: Key roles of embedded zero-valent iron clusters within iron-manganese oxide. *J. Hazard. Mater.* 456:131632. <https://doi.org/10.1016/j.jhazmat.2023.131632>.

## Chapters in Multi-Authored Books

---

53. Jayaraman, S., R.C. Dalal, and R. Lal 2023. Conclusions: Perspective on Sustainable Soil Management. Chapter 12. In: J.Somasundran et al. (eds) “Sustainable Soil Management: Beyond Food Production,” Cambridge Scholars Publishing, New Castle Upon Tyne, U.K., pp 322-335. ISBN: 1-5275-0204-X
54. DeClerck, F.A.J., Koziell, I., Benton, T., Garibaldi, L. A., Kremen, C., Maron, M., Rumbaitis Del Rio, C., Sidhu, A., Wirths, J., Dickens, C., Estrada Carmona, N., Fremier, A. K., Jones, S. K., Khoury, C. K., Lal, R., (2023). A Whole Earth Approach to Nature-Positive Food: Biodiversity and Agriculture. In: von Braun, J., Afsana, K., Fresco, L.O., Hassan, M.H.A. (eds) *Science and Innovations for Food Systems Transformation*. Springer, Cham. [https://doi.org/10.1007/978-3-031-15703-5\\_25](https://doi.org/10.1007/978-3-031-15703-5_25)
55. Lal, R. (Ed.). (2023). *Soil and Drought: Basic Processes* (1st ed.). CRC Press. Chapter 1: Drought Hazard to Dryland Farming in Arid Region, pp 1-10. <https://doi.org/10.1201/b22954>

## Keynote Presentations

---

56. Afkairin, A., M. Dixon, C. Buchanan, J.A. Ippolito, D. Manter, J.G. Davis, and J. Vivanco. 2023. Uncovering the impact of the rhizosphere microbiome of pulse crops on soil phosphorus availability. ASA-CSSA-SSSA Conference. St. Louis, MO. October 29-November 2.
57. Christensen, L., J. Ippolito, A. Card, R. Bruegger, and J. Ritten. 2023. Webinar: Climate Smart Agriculture. Colorado State University Extension. Virtual. Jan. 25. INVITED.

# Keynote Presentations (con't)

---

58. Chorpenning, C., M. Borton, B. McGivern, L. Grant, T. Trimarco, V. Seitz, A. Nuñez, L. Eash, P. Olayemi, S. Fonte, T. Bauder, E. Wardle, J., J. Ippolito, M. Schipanski, R. Keshavarz Afshar, and K. Wrighton. 2023. The Colorado agricultural soil microbiome database (CASM): hundreds of metagenome-assembled genomes from agricultural soils across Colorado as a reference to surveying soil health. ASA-CSSA-SSSA Conference. St. Louis, MO. October 29-November 2.
59. Dacres, A.P., N.T. Basta, and J.A. Ippolito. 2023. Bioavailability-based remediation of lead (Pb)-contaminated sites through the application of biochar amendments. ASA-CSSA-SSSA Conference. St. Louis, MO. October 29-November 2.
60. Desjardins, M., A. Bary, J. Ippolito, S. Cappellazzi, D. Liptzin, and D. Griffin-Lahue. 2023. Effects of long-term biosolids applications in two dryland agroecosystems on physical, biological and chemical soil health properties. Western Nutrient Management Conference. Reno, NV. March 9-10.
61. Ducey, T.F., J.A. Ippolito, K. Trippe, K.A. Spokas, D.C. Watts, and M.G. Johnson. 2023. From spoils to soils: Lessons learned using biochar to reclaim mining-impacted heavy-metal laden lands for public use. 1st Joint International Conference of ICOBTE and ICHMET. Wuppertal, Germany. Sept. 6-10.
62. Grant, L., B. McGivern, T. Trimarco, C. Chorpenning, I. Lelewi, A. Oliverio, C. Welch, T. Bauder, E. Wardle, M. Borton, J. Ippolito, K. Wrighton. 2023. Uncovering the hidden potential of soil health via multi-omics approaches. Front Range Microbiome Symposium. Colorado State University, Fort Collins, CO. April 27-28.
63. Hoffman, O., N. Carr, C. Buchanan, T. Trimarco, and J. Ippolito. 2023. Comparing soil health in southern Minnesota: Agricultural vs. ecological. Colorado State University Graduate Student Showcase. Fort Collins, CO. November 15.
64. Hopkins, A.P., R. Jensen, R. Kerry, B.G. Hopkins, E.A. Woolley, N.C. Hansen, J. Ippolito. 2023. Spatial variability of leaf area index from drone imaging of two irrigated wheat fields. European Geosciences Union Conference. Vienna, Austria. April 23-28.
65. Hopkins, A., and J.A. Ippolito. 2023. Soilhive: A global platform to inform targeted investment and research on soil health. ASA-CSSA-SSSA Conference. St. Louis, MO. October 29-November 2.
66. Hopkins, A., and J.A. Ippolito. 2023. Multivariate ecoregion analysis of nutrient runoff from agricultural land uses in North America. ASA-CSSA-SSSA Conference. St. Louis, MO. October 29-November 2.
67. Ippolito, J. 2023. Local to global approaches for solving environmental soil issues. Environmental Sciences Graduate Program, Ohio State University. Jan. 27. INVITED.
68. Ippolito, J. 2023. Interviewed for Associated Press article: Colorado ponders storing carbon in defunct oil and gas wells. Available at: <https://apnews.com/article/science-politics-colorado-state-government-business-55e5f50bd1cb26584c2bd45088dcc6a4> February 17.
69. Ippolito, J. 2023. Interviewed by 850 KOA Denver regarding Colorado utilizing biochar for placement into defunct oil and gas wells. February 22.
70. Ippolito, J. 2023. Biosolids application to agricultural land in Colorado: A five-decade review. Michigan Water Environment Association Conference. Battle Creek, MI. March 29-30. INVITED.
71. Ippolito, J., L. Li, and T. Banet. 2023. Can soil and plant health, and ecosystem services, be improved via reclamation efforts in heavy metal-contaminated alluvial mine tailings deposits? European Geosciences Union Conference. Vienna, Austria. April 23-28.
72. Ippolito, J. A. 2023. A four-decade review of biosolids land application in Colorado. W4170 multi-state work annual meeting. Chicago, IL. June 27-28.
73. Ippolito, J., L. Li., and T. Banet. Can soil/plant health be improved via reclamation efforts in heavy metal-contaminated alluvial mine tailings sediment deposits? 1st Joint International Conference of ICOBTE and ICHMET. Wuppertal, Germany. Sept. 6-10.
74. Ippolito, J. 2023. Biochar use for heavy metal contaminated mine land remediation. Biochar and Mine Reclamation: Cleaning Brownfields and Contaminated Water. Webinar hosted by The International Biochar Initiative. Sept. 21. INVITED.
75. Ippolito, J. 2023. ENR 2000 Data Analysis Panel Discussion. Sept. 28. INVITED by Kristi Lekies.
76. Ippolito, J. 2023. Career paths and research in the field of soil science. ENR8990.04 Soil Science Seminar, SENR, The Ohio State University. October 10.

# Keynote Presentations (con't)

---

77. Ippolito, J.A. 2023. Soil health perspectives across varied landscapes. International Workshop on Environmental Science and Technology. Henan University of Technology, Zhengzhou, Henan Province, China. October 20. Virtual. INVITED.
78. Ippolito, J.A. 2023. Distribution of PFAS in agricultural systems and current remediation strategies panel. 2023 Center for PFAS Research Annual Symposium. East Lansing, Michigan. Oct. 22-24. INVITED.
79. Ippolito, J.A. 2023. Regenerative Agriculture and Soil Health: The Inspirational Story of Jay Norton. ASA-CSSA-SSSA Conference. St. Louis, MO. October 29-November 2.
80. Ippolito, J. Conventional vs minimum till corn under furrow-irrigation: Soil health challenges in Colorado. Plain City, OH. December 6. INVITED.
81. Lal, R. 2023. Managing soil health for environmental and climate security in the Latin American and Caribbean Region. Congresso Futuro, Public Relations Team, Morande 441, Santiago, Chile, 4th January.
82. Lal, R. 2023. Regenerative agriculture on global scale for people and the planet. Future Harvest Conference Keynote, The Chesapeake Alliance for Sustainable Agriculture, College Park, Maryland, USA. 12-14 January.
83. Lal, R. 2023. Saving our Vanishing Soils: Global perspective. The City Gardens Club, Annual Environmental Forum, 19th January.
84. Lal, R. 2023. Managing soil health for food and climate security. Global Forum for Food and Agriculture (GFFA), World Food Program (WFP), Berlin, 20th January.
85. Lal, R. 2023. Soil, Climate, Water Issues: Addressing the global and Indian scenarios. Walmi, Dharwad Conference, Department of Water Resources, Kunatka, India, 23 January.
86. Lal, R. 2023. Managing ecological footprint of food systems. Carbon Footprints, Journal Editorial office, Beijing, China, 2nd February.
87. Lal, R. 2023. Ecological footprint of food and agriculture systems. Educational office of Carbon Footprint journal, 2nd February.
88. Lal, R. 2023. Pulses for sustainable agriculture in era of climate change. Plenary Lecture, ICU Pulses 2023 Conference. ICAR, New Delhi, 11th February.
89. Lal, R. 2023. Soil and ecological degradation in Indo-Gangetic Plains. 1st Int. Conf. About Cop-27 Climate Change and Food Security. Pir Mehr Ali Shah Arid Agricultural University, Rawalpindi, Pakistan, 15 February.
90. Lal, R. 2023. Translating science of soil carbon into action through cooperation with private sector. SSSA/SSSC Symposium, 22nd February.
91. Lal, R. 2023. Climate farming for climate and food security. National Center for Appropriate Technology. Butte, Montana, 28th February.
92. Lal, R. 2023. Soil health and how to work with the soil to unlock its true potential. Agri-Insider Business Group, Ireland, 28th February.
93. Lal, R. 2023. Managing soil health for adaptation to and mitigation of climate change. California climate change webinar, 2nd March.
94. Lal, R. 2023. Isotopes in soil sciences research. Stable Isotope Biogeochemistry Class (EARTHSC 5622), Mendenhall Lab, 7th March.
95. Lal, R. 2023. Importance of sustainable soils for the future of humanity. Moldova Academy of Sciences, NATIOONS, 13 March.
96. Lal, R. 2023. Processes, factors and causes of soil and ecological degradation in Pakistan, International conference on soil pollution and remediation, Forman Christian College University, Lahore, Pakistan, 16 March.
97. Lal, R. 2023. Living soils of America. Intl. Soil and Plant Analysis Conference, Concepcion, Chile, 22nd March.
98. Lal, R. 2023. Carbon Farming and Payments for Ecosystem Services. Intl. Soil and Plant Analysis Conference, Concepcion Chile, 23rd March.

# Keynote Presentations (con't)

---

99. Lal, R. 2023. Climate change and soil science. Webinar by Methodist Theological School, Delaware, Ohio, 19th April.
100. Lal, R. 2023. Managing soil as nature-based solution to achieving climate and food security: Role of CA4SH. Friends of Soil Health Dialogue, CA4SH session. 19th April.
101. Lal, R. 2023. Integrated management of degraded soils to ensure food and climate security. International Conference at the National University of Uzbekistan, 19-22 April.
102. Lal, R. 2023. Protecting and restoring soil health by sequestering carbon for returning land to nature. Professor World Peace Academy Event, 21st April.
103. Lal, R. 2023. The Living Soils of America (LiSAM) program: Potential and opportunities, LiSAM Board Meeting, San Jose, Costa Rica. 27th April.
104. Lal, R. 2023. Climate Change and its impact on African agriculture. AAA Science Day, Meknes, Morocco. 3rd May.
105. Lal, R. 2023. Bringing Soil Health Revolution Forward and Operationalizing. CA4SH Side Event at AimForClimate, Washington D.C. 10th May.
106. Lal, R. 2023. Managing soil health for food and climate security. Extinction or Regeneration Conference, London, U.K. 11-12 May.
107. Lal, R. 2023. Concluding remarks for AgCarbon Conference. UMGP, Ben Guerir, Morocco. 24-25 May.
108. Lal, R. 2023. Carbon farming for advancing Sustainable Development Goals. Plenary Lecture, AgCarbon Conference, 24-25 May, Ben Guerir, Morocco.
109. Lal, R. 2023. Managing soil health with Vetiver (*Vetiveria Zizinioides*) for food and climate security. 7th Int. Vetiver Conference, Chiang Mai, Thailand, 29-31st May.
110. Lal, R. 2023. Processes of soil carbon sequestration. 7th Int. Vetiver Conference, Chiang Mai, Thailand, 29-31st May.
111. Lal, R. 2023. Tribute to Her Royal Highness Maha Chakri Sirindhorn: The Determined Developer, 7th Int. Vetiver Conference, Chiang Mai, Thailand, 29-31st May.
112. Lal, R. 2023. Agriculture Revolution in Brazil: Accomplishments and Challenges. Syngenta OneAgro 2023, 13-14 June, 2023, Campinas, Brazil.
113. Lal, R. 2023. Managing agriculture for climate and food security. OneAgro 2023 Conferences, Syngenta, Campinas, Brazil, 13-14 June.
114. Lal, R. 2023. Principals of carbon farming. OneAgro 2023, Campinas, Brazil, 13-14 June.
115. Lal, R. 2023. SDG2 & Soil. Advancing Success Towards SDG2 (Zero Hunger) Through Science and Technology, National Academy of Sciences Building, Washington, D.C., 14 July.
116. Lal, R. 2023. Carbon Sequestration – Enabling Brazilian Agriculture to Foster Global Sustainability. SOEA Conference: Official Week of Engineering and Agriculture with CONFEA/CREA, Porto Alegre, Brazil, 10th August.
117. Lal, R. 2023. Carbon Sequestration: How Brazilian Agriculture Can Contribute to Global Sustainability. CONFEA Conference, Porto Alegre, 8-11 August.
118. Lal, R. 2023. Soil, Spirituality, Science, and Religion. Professor World Peace Academy Event, 23rd August.
119. Lal, R. 2023. Soil, Climate, Water, Food Security Issues in India. Visit of Minister of Agriculture and the Delegation. Washington, D.C., 2nd September.
120. Lal, R. 2023. Food-Energy-Water-Soil Nexus: FEWS. The ICEF Forum 2023, Japan. 5th September.
121. Lal, R. 2023. Towards National Soil Nutrient Roadmaps in Tanzania. Africa Food Systems Forum, Tanzania, 6th September.
122. Lal, R. 2023. Restoring Soil Carbon in Drylands for Advancing Sustainable Development Goals of the U.N. Agenda 2030. Regional Action for Climate Change (RACC), STS, Japan, Pre-COP Webinar, 11th September.
123. Lal, R. 2023. Carbon Farming: A New Crop for Addressing Climate Change. IICA Ambassador for Sustainable Development Issues, San Jose, Costa Rica, 3rd – 4th October.
124. Lal, R. 2023. Soil Health via Carbon Sequestration: Challenges and Opportunities in Brazilian Agriculture. Bayer C Science Talks, Univ. Of Sao Paulo, Piracicaba, Brazil, 4th October.

# Keynote Presentations (con't)

---

125. Lal, R. 2023. Agriculture in the LAC Region: Challenges and Opportunities. IICA Ministerial Meeting, 3-5th October, IICA, San Jose, Costa Rica.
126. Lal, R. 2023. Conceptual Basis of MASHA Project. The Voice of Africa UM6P Side events: Food Security, Ben Guerir, Morocco, 7th October.
127. Lal, R. 2023. The Role of Healthy Soil for the People and the Planet. CA4SH Dialogue Presentation at the 2023 WFP Event, Des Moines, Iowa, 17th October.
128. Lal, R. 2023. World Food Day: Pride and Celebrations. IARI, 2023 WFD Celebrations, New Delhi, India, 17th October.
129. Lal, R. 2023. Making Agriculture a Part of the Solution to Climate Change and Other Environmental Issues of the 21st Century. Agri-Investment Forum and Expo, Georgetown, Guyana, 19th – 20th October.
130. Lal, R. 2023. Repairing and Protecting World's Finite and Fragile Soils. Conference by the Cooperative Sector, Rome, Italy, 25th October.
131. Lal, R. 2023. The Role of Healthy Soil for the People and the Planet. CA4SH Side Event, WFP, Des Moines, IA, 24-26th October.
132. Lal, R. 2023. The Importance of Soil Management to Mitigate Climate Change. Harvard Conference on Consciousness, Conscious Approach to Environment and Leadership, Harvard University, 27-28th October.
133. Lal, R. 2023. Stakeholder Dialogue on Enhancing Fertilizer Use Efficiency for Sustainable Soil Health. Workshop by TAAS, New Delhi, India, 28-29th October.
134. Lal, R. 2023. Regenerative Agriculture. RUFORUM AGM, Cameroon, West Africa, 1st November.
135. Lal, R. 2023. Restoring and Sustaining Soil Health in Africa. From the Ground Up: Innovations in Sustainable Fertilizer and Soil Health Management in African Agriculture, Special Session, 2023 Tri-Society Meeting, St. Louis, Missouri, 1st November.
136. Lal, R. 2023. From the Ground Up: Innovations in Sustainable Fertilizer and Soil Health Management in African Agriculture. Tri-Society Meeting: Open Science Inspires, St. Louis, Missouri, October 29th – November 1st.
137. Lal, R. 2023. Soil and Land Management for Food and Nutrition Security and Harnessing Net Carbon Sink Capacity. World Agri-food Innovation (WAFI) Conference CAU, Beijing, China, 1st-6th November.
138. Lal, R. 2023. Making Pastoral Agriculture a Part of the Solution to Addressing Anthropogenic Global Warming. The International Symposium on Pastoral Agriculture Sustainable Development, Lanzhou, China, 14th – 17th November.
139. Lal, R. 2023. Role of CA4SH in Addressing Global Issues. The CA4SH Quarterly Planning Meeting, 14th November.
140. Lal, R. 2023. Global Challenges and How to Address Them. The CA4SH Quarterly Planning Meeting, 14th November.
141. Lal, R. 2023. Welcome to the Carbon Academy Workshop. Carbon Academy Workshop, Waterman Agricultural and Natural Resources Laboratory, Columbus, OH, 17th November.
142. Lal, R. 2023. Managing Soil Carbon for Addressing Global Warming. Carbon Academy Workshop, Waterman Agricultural and Natural Resources Laboratory, Columbus, OH, 17th November.
143. Lal, R. 2023. Carbon Farming and the Societal Value of Carbon. Carbon Academy Workshop, Waterman Agricultural and Natural Resources Laboratory, Columbus, OH, 17th November.
144. Lal, R. 2023. Carbon Management in Agricultural Produce. ICAR Res. Complex for Coastal Agriculture. Goa, Morocco, 23rd November.
145. Lal, R. 2023. Managing Soil Health in Africa: Food, Climate, and SDG Security. Chair in Soil Sciences, UM6P, Ben Guerir, Morocco, 23rd November.
146. Lal, R. 2023. The Importance of Soil for Food and Agriculture. CAF Event at COP28, Dubai, 3rd December.
147. Lal, R. 2023. Advances towards making agriculture a part of the solution to global warming and other environmental issues. 2023 WSD, Brazil Gateway, OSU, 5th December.

# Keynote Presentations (con't)

---

148. Lal, R. Lal, R. 2023. Ecosystem services in food-energy-water-soil (FEWS) nexus. 2023 WSD, IARI, New Delhi, 5th December.
149. Lal, R. 2023. IICA's LiSA Initiative: Carbon Farming and Sustainable Development Goals of the United Nations Agenda 2030, COP28, Dubai, 8th December.
150. Lal, R. 2023. Scaling Carbon Removal in Agriculture. Denmark Pavilion, Danish Ministry of Climate, Energy and Utilities, COP28, Dubai, 10th December.
151. Lal, R. 2023. Managing Soil Carbon for Addressing Global Issues. Danish Pavilion, COP28, Dubai, 10th December.
152. Lal, R. 2023. Global Environmental and Food Security: The Role of Latin America and The Caribbean. IICA, COP28, Dubai, 10th December.
153. Lal, R. 2023. Brazil as a Provider of Global Food Security, Technology Innovation, and an Example of Sustainable Development. COP28, CNI/CNA Pavillion, 10th December.
154. Lal, R. 2023. Brazil Plan ABC and Its Role in Global Food and Climate Security. COP28, Ministry of Agriculture, Brazil, 11th December.
155. Lal, R. 2023. Managing Soil Health for Climate and Environmental Security. International Academic on Cultivated Land Conservation and Productivity Improvement, Inner Mongolia Academy of Agricultural and Animal Husbandry Sciences, Hohhot, Inner Mongolia, China, 14th December.
156. Li, L., W. Xing, P. Liu, Y. Liu, J.A. Ippolito, Y. Zhang, Y. Wang, Y. Wang, and Y. Yang. 2023. Cadmium accumulation in wheat grains and reduction of its health risk. Proceedings of the 24th Conference of the Branch of Soil Environment, Soil Science Society of China. Wuhan, China. May 10-12, 2023.
157. Li, L., J. Ippolito, W. Xing, Y. Wang, Y. Yahg, and X. Huang. 2023. Heavy metals in a long-term Pb smelting affected area: Fate and risk of legacy Pb and Cd. 1st Joint International Conference of ICOBTE and ICHMET. Wuppertal, Germany. Sept. 6-10. INVITED KEYNOTE.
158. Lindsey, L., and J. Ippolito. 2023. Battle for the Belt: Episode 23 – Common soil fertility problems in Ohio. Available at: <https://www.youtube.com/watch?v=CI5c3MeX4WE>. The Ohio State University. Posted August 12.
159. Miner, G.L., C.E. Stewart, J.A. Delgado, J.A. Ippolito, S. Haley, R.E. Mason, M.J. Guttieri, E.A. Ainsworth, S.E. Beebout, and J. McGrath. 2023. Global change impacts on crop mineral nutritional quality: A framework towards advancing mechanistic understanding. ASA-CSSA-SSSA Conference. St. Louis, MO. October 29-November 2.
160. Schumak, C.E., T.R. Green, J.A. Ippolito, A.A. Andales, H. Kipka, N. Lighthart, C. Baffaut, C.C. Truman, A.M. Ritter, K. Mankin. 2023. Modeling surface water atrazine concentrations of Goodwater Creek Experimental Watershed, MO using the fully distributed agricultural ecosystem services (AgES) watershed model. ASA-CSSA-SSSA Conference. St. Louis, MO. October 29-November 2.
161. Tariq, H., E. Bechtold, C. Broeckling, C. Buchanan, J. Ippolito, M. Wiltse, M. Wilkins, and T. Borch. Impact of oilfield-produced water irrigation on soil and crop health. Goldschmidt Conference. Lyon, France. July 9-14.
162. Tariq, H., E. Bechtold, C. Broeckling, C. Buchanan, J.A. Ippolito, M. Wiltze, M.J. Wilkins, and T. Borch. 2023. Impact of oilfield-produced water irrigation on soil and crop health. AGU. San Francisco, CA. December 11-15.
163. Tariq, H., E. Bechtold, C. Broeckling, C. Buchanan, J. Ippolito, M. Wiltse, M. Wilkins, and T. Borch. Impact of oilfield-produced water irrigation on soil and crop health. Goldschmidt Conference. Lyon, France. July 9-14.
164. Trimarco, T., E. Wardle, E. Deleon, A. Brown, C. Buchanan, and J.A. Ippolito. 2023. Exploring the soil health-water quality-ecosystems services nexus of long-term conservation tillage plots under furrow irrigation. ASA-CSSA-SSSA Conference. St. Louis, MO. October 29-November 2.
165. Vince, B., B. Richards, C. Beacom, F. Yoder and J. Ippolito. 2023. Ohio No-Till Conference Panel Member. Ohio No-Till Conference - Partnering with the All-Ohio SWCS. Plain City, OH. December 6.
166. Umeobi, E.C., T.F., Ducey, M.G. Johnson, and J.A. Ippolito. Soil health alterations in natural and remediated heavy metal contaminated soils. 1st Joint International Conference of ICOBTE and ICHMET. Wuppertal, Germany. Sept. 6-10.

# Keynote Presentations (con't)

---

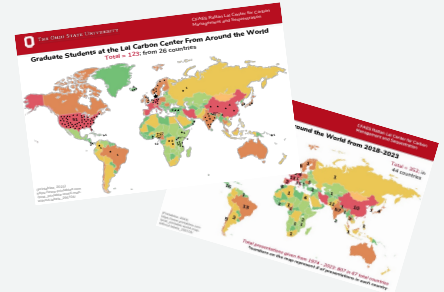
167. Umeobi, E.C., T.F., Ducey, M.G. Johnson, and J.A. Ippolito. 2023. Soil health alterations in natural and remediated heavy metal contaminated soils. ASA-CSSA-SSSA Conference. St. Louis, MO. October 29-November 2.

## Lal Carbon Center Maps

Hannah Shively has designed some lovely maps illustrating the global impact of the Center.

Explore the maps here:

<https://go.osu.edu/lal-carbon-center-maps>



**Happy  
New Year  
from the  
Lal Carbon  
Center!**

View our animated 2023 card here:

<https://carbon.osu.edu/2023-seasons-greetings>

Here are just some of the ways that our current Center members wish their loved ones a **Happy New Year!**

**Spanish:** Feliz Año Nuevo

**Portuguese:** Feliz Ano Novo

**German:** Frohes Neues Jahr

The Lal Carbon Center (Rattan Lal Center for Carbon Management and Sequestration) is part of the College of Food, Agricultural, and Environmental Sciences (CFAES)

---



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES

CFAES Rattan Lal Center for Carbon Management and Sequestration  
2021 Coffey Rd  
210 Kottman Hall  
Columbus, OH 43210