Station News

The Connecticut Agricultural Experiment Station
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Snowy Day at CAES,, Photo by Kitty Prapayotin-Riveros, Department of Analytical Chemistry

The mission of The Connecticut Agricultural Experiment Station is to develop, advance, and disseminate scientific knowledge, improve agricultural productivity and environmental quality, protect plants, and enhance human health and well-being through research for the benefit of Connecticut residents and the nation. Seeking solutions across a variety of disciplines for the benefit of urban, suburban, and rural communities, Station scientists remain committed to "Putting Science to Work for Society", a motto as relevant today as it was at our founding in 1875.

CAES
The Connecticut Agricultural Experiment Station
Putting Science to Work for Society since 1875

This Issue

GRANTS RECEIVED JANUARY 2021

"Understanding and Enhancing PFAS Phytoremediation Mechanisms Using Novel Nanomaterials." V. Vasilis, C. Haynes, **Jason C. White**, **Sara Nason**, and **Nubia Zuverza-Mena**. Awarded from NIEHS in January 2021 for 5 years; $750,000.

The EPA CompTox Dashboard lists over 7,500 per- and poly-fluoroalkyl substances (PFAS), many of which may be toxic at low concentrations and have a high bioaccumulation potential. Perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are on the EPA list of emerging contaminants and levels in drinking water will soon be federally regulated. In addition, new PFAS are being introduced as PFOS and PFOA are phased out. An example is GenX which has received publicity for its release in Cape Fear, NC. While it is important to develop remediation methods for older contaminants, it is also important to determine if the same methods will work for replacement chemicals. All PFAS resist degradation due to the strength of the carbon-fluorine bonds. Few effective PFAS remediation methods are available, and those that do exist are often expensive and impractical. Additional research is needed to develop feasible, cost-effective remediation strategies for PFAS. Previous studies have investigated plant uptake of PFAS both for remediation and uptake into food crops. While it is well known that larger compounds, such as PFOS and PFOA, can accumulate in plant roots, they exhibit limited translocation to above ground tissues. This is true across a variety of studied species. More hydrophilic, smaller PFAS translocate to a much greater extent. Replacement PFAS, such as GenX, have received little study in plants. We propose to examine methods for enhancing plant uptake of PFAS with the goal of making phytoremediation a practical and effective method for removing a wide range of PFAS from contaminated soil. Addition of nanomaterials is an established method for phytoremediation enhancement. For example, fullerene particles enhance plant accumulation of hydrophobic contaminants via contaminant sorption to particles and subsequent particle uptake by the plant. We hypothesize that similar mechanisms are possible with novel carbon dots and ultraporous mesostructured silica nanoparticles. Previous research has shown that both of these materials can be taken up and translocated in plants, and their surface properties can be customized to sorb PFAS. The overarching goal of our research is to synthesize and test novel carbon dot and silica-based nanomaterials that will enhance phytoextraction of PFAS from contaminated sites. Our work will focus on nanomaterial design and determining the capacity of the novel nanomaterials to control PFAS movement in water, soil, and plant systems. Our specific aims are as follows:

Specific Aim 1: Synthesize novel nanomaterials (NNMs) designed to sorb PFAS and translocate through plants. First, ultraporous mesostructured silica nanoparticles will be synthesized with hydrophilic surface modification. These nanoparticles are known to be taken up by plants and can be loaded with perfluorinated molecules; however, they have not been used for PFAS contaminants. Second, luminescent carbon dots will be synthesized via microwave methods with variable amounts of perfluorinated precursors to tune affinity for PFAS. Luminescence will facilitate real-time tracking of the carbon dots in plants. Quantitative 19F-NMR comparison of PFAS sorption by these novel nanoparticle scaffolds will be used to identify the platforms to be examined in Specific Aim 2.

Specific Aim 2: Determine capacity of NNMs to promote PFAS uptake into plants and prevent PFAS leaching from soils. Hemp plants will be grown hydroponically and exposed to a PFAS mixture with and without NNMs added. Changes in PFAS levels in the hydroponic solution and plant tissues will be determined at various times after planting to determine removal efficiency. Plants will be characterized using confocal microscopy, atomic spectroscopy, and high-resolution mass spectrometry to determine NNM and PFAS uptake by various parts of the plant. These experiments will provide key information about the ability of NNMs to enhance plant accumulation of PFAS without interfering effects from soil sorption and variation in field soil composition. Additionally, hydroponic systems are relevant for phytoremediation of surface or groundwater in a pump and treat setup. We will also conduct soil column experiments to test both the leaching potential of the NNMs and the effects of NNMs on the leaching of PFAS. PFAS and NNM levels will be measured in soil and leachate. These experiments will provide information on how PFAS partition between aqueous, soil, and NNM phases, and how effectively NNMs and the PFAS sorbed to them are retained in soil prior to plant uptake. Both the hydroponic and soil column experiments will provide key mechanistic information that will be necessary for successful implementation of NNM-enhanced phytoremediation in field soil systems.

In summary, the proposed project will develop novel nanomaterials for use in phytoremediation of PFAS and provide information on the mechanism and efficacy of the new remediation method. If successful, we will pursue additional funding for larger scale testing in plant-soil systems. While the NNMs will be designed for PFAS remediation, it is likely they will also be useful for remediation of other classes of organic contaminants - a po-

tential topic for future research.

"A Novel Strategy for Arsenic Phytoremediation." O. Parkash-Dhankher, B. Xing, D. Venkataraman, and **Jason C. White**. Awarded from NIEHS in January 2021 for 5 years; $1,000,000

The overall goal of this project is to utilize hypothesis driven experimentation to elucidate key mechanistic processes governing the phytoextraction of heavy metals and metalloids (co-contaminants) from the soil and hyperaccumulation in aboveground biomass. Detailed investigations will focus not only on biogeochemical processes in the soil that impact contaminant availability to plant roots but also on critical biological limitations and physiological processes that can enable sustained and significant contaminant phytoextraction. We will engineer the pathways for hyperaccumulation of metal(loids) by combining the expression of genes for sulfur assimilation and ion transporters for creating a sink for toxic metal (loids) storage in leaf vacuoles. Engineered nanosulfur will be utilized to modulate the bioavailability and phytoextraction of toxic metals from soil. The choice of plants will be a non-food high biomass industrial oilseed crop *Crambe abyssinica* for dual purpose—phytoremediation and biofuel production. This "bottom-up" focus on mechanisms at and within the abiotic-biotic interface will enable the optimization of plant-based remedial strategies for mix metal contaminants.

Specific Aims:

Generate genetically enhanced *Crambe abyssinica* lines co-expressing bacterial ArsC, γ -ECS, and CaABCC1 and CRISPR-Cas9 edited arsenate reductase CaHAC1.

Develop gene constructs for gene stacking of ArsC, γ-ECS, and CaABCC1 (triple stack) for overexpression in tissue-specific manner.

Identify triple stack homozygous lines of Crambe overexpressing ArsC, γ-ECS, and CaABCC1.

Retransform triple stack lines with CRISPR-Cas9-CaHAC1 gene construct to edit the expressing of endogenous arsenate reductase CaHAC1 for blocking arsenate reduction in roots.

Evaluate the genetically enhanced lines for metal(loids) tolerance and accumulation in above ground tissues in hydroponic and in soil under greenhouse conditions.

Analysis of the triple stack (ArsC+γ-ECS+CaABCC1) + CaHAC1 edited lines for arsenic tolerance, biomass yield, and accumulation in the shoot and root tissues.

Analysis of the triple stack (ArsC+γ-ECS+CaABCC1) + CaHAC1 edited lines for co-contaminants (As, Cd, Hg, Pb and Cr) tolerance, biomass yield, and accumulation in the shoot and root tissues.

Analysis of total biomass and seed yield, oil contents, and metals in seeds and oil for biofuel potential.

Synthesis and application of nanosulfur for modulating the bioavailability and phytoextraction of toxic metal(loids) from soil.

Synthesis and characterization of sulfur nanoparticles (nanosulfur) with and without surface coatings.

Optimization of nanosulfur applications on genetically enhanced Crambe lines for increasing bioavailability and accumulation of metal(loids) in root and shoot tissues and enhanced tolerance.

Study the effect of nanosulfur on sulfur assimilation pathway in Crambe lines exposed to nanosulfur in soil amendment and foliar applications with and without metalloids exposure.

DR. RICHARD COWLES was awarded $22,000 from the Christmas Tree Promotion Board for his project "Rhizosphere Bacterial Inoculants to Protect Fir Roots and Enhance Growth."

ADMINISTRATION

DR. JASON C. WHITE, with the staff of the Department of Analytical Chemistry, "virtually" hosted two assessors from the Association for Laboratory Accreditation (A2LA) for our 2-year assessment of our ISO 17025 accredited programs; the assessors found only one deficiency, which the lab has addressed successfully. The Laboratory Scope of Accreditation, which was expanded to include THC/CBD analysis in hemp and fat/protein in animal feeds,

has been extended to February 2023 (January 4-6); with **DR. CARLOS TAMEZ**, participated in a ZOOM call with collaborators at the Harvard University T.H. Chan School of Public Health and Nanyang Technological University in Singapore to discuss progress on joint experiments (January 8); was interviewed about nanotechnology and agriculture by Ms. Shi En Kim of the University of Chicago (January 11); participated in a ZOOM call with Representative Dorinda Borer, co-chair of the Environment Committee, about presentation of CAES research to the full Environment Committee and Public Health Committee (January 11); participated in monthly FDA LFFM WebEx calls for our new Human & Animal Food and Food Defense cooperative agreement programs (January 11); as co-chair of his committee, attended the PhD Proposal Defense of Mr. Gurpal Singh of the University of Massachusetts Amherst (January 12); participated in NSF Center for Sustainable Nanotechnology (CSN) weekly all hands calls (January 13, 20, 27); with **DR. WADE ELMER** and **MR. MICHAEL CAVADINI**, testified via MS Teams in front of the Commission on Human Rights and Opportunities regarding the review of the CAES Affirmative Action Plan (January 13); participated in a monthly CSN all faculty call (January 14); held a ZOOM call with Professor Philip Demokritou of the Harvard University T.H. Chan School of Public Health regarding collaborative research (January 15); participated by MS Teams in the Plant Science Day 2021 planning committee meeting (January 15); participated in the quarterly CAES Board of Control meeting (January 19); with **DR. GOUDARZ MOLAEI, DR. DOUGLAS BRACKNEY, DR. SARA NASON, DR. PHILIP ARMSTRONG, DR. YONGHAO LI,** and **DR. GALE RIDGE,** gave a presentation of CAES research and service programs by ZOOM to the full Environment Committee and Public Health Committee (January 19); participated in the CT USDA APHIS Cooperative Agricultural Pest Survey (CAPS) Program Winter meeting (January 20); as a member of her Dissertation Committee, participated in the Proposal Defense of Ms. Beza Tuga of the University of Minnesota (January 20); participated in an Experiment Station Associates meeting (January 20); gave a presentation entitled "CAES 2020 Update: Putting Science to Work for Society in a Pandemic" at the annual Connecticut Tree Protective Association (CTPA) meeting (65 attendees) (January 21); participated in the annual CSN External Advisory Board meeting (January 21); participated in a ZOOM call with NIEHS and collaborators at Yale University and the University of Minnesota regarding a recently funded grant proposal (January 22); participated in a ZOOM call with collaborators at the University of Birmingham UK about a textbook we are preparing on nano-enabled agriculture (January 28); participated in a ZOOM call with Ilya A. Medina Velo of Houston Baptist University about USDA reported requirements (January 28); hosted the monthly CAES J-1 Visa Teams meeting (January 29); and participated in a CSN ZOOM call with colleagues at the University of Wisconsin to discuss collaborative research (January 29).

ANALYTICAL CHEMISTRY

The Department of Analytical Chemistry underwent its second ISO 17025 Accreditation renewal assessment by the American Association for Laboratory Accreditation (A2LA). The assessment was done to renew existing scopes (analysis of pesticides, arsenic, and aflatoxin) and to expand into new technical capabilities, including the analysis of THC (tetrahydrocannabinol) and CBD (cannabidiol) in hemp, as well as fat and protein in human food and animal feed. These additions would significantly expand the scope of the laboratory, if approved (January 4-6).

DR. CHRISTINA ROBB attended executive committee meetings for the Eastern Analytical Symposium in her new role as secretary (January 4, 11, 18, 25); submitted an NSF MRI proposal as the co-PI with **DR. SARA NASON** as the PI; met with UConn researchers about the Journal of Liquid Chromatography (January 6); and attended an FDA FERN LFFM Food Defense call (January 11).

DR. BRIAN EITZER attended a ZOOM meeting of the American Bee Research Conference, which included the annual meeting of the NC-1173 Multi-state Hatch project entitled "Sustainable Solutions to Problems Affecting Bee Health" (January 7-8); was a participant

in the FDA FERN Food Defense and Human and Animal Food conference call (January 11); the conference call of the organizing committee of the North American Chemical Residue Workshop (January 14); the conference call of the American Public Health Association Cannabis Community of Practice call (January 14); The American Society for Testing and Materials D37 Subcommittee meeting for Laboratory Analysis Standards for Cannabis (January 27); and the EPA/AAPCO quarterly conference call (January 27).

ENTOMOLOGY

DR. KIRBY C. STAFFORD III, with **DR. KIMBERLY A. STONER**, met with Michael O'Malley, Yale University, to discuss botanical gardens in New Haven (January 8); participated in a National Asian longhorned tick stakeholder call (January 11); was interviewed about winter tick activity and new ticks in Connecticut by Kaitlyn McGrath, NBC CT (January 11); participated in the annual meeting of the Northeast Regional Center for Excellence in Vector-Borne Diseases and presented an update on lone star tick control (168 panelists and attendees) (January 12); participated in a monthly meeting of the Tick IPM Working Group (January 13); was interviewed about federal EAB regulations by Patrick Skahill, Connecticut Public Radio (January 13); participated in a spotted lanternfly conference call (January 14); participated in the NEVBD strategic planning session via ZOOM (54 participants) (January 19); participated in the winter Cooperative Agricultural Pest Survey (CAPS) ZOOM meeting (January 20); attended the virtual winter meeting of the Connecticut Tree Protective Association (January 21); participated in an NEVBD leadership call (January 25); and attended the virtual winter meeting of the Connecticut Nursery and Landscape Association and presented a talk on ticks, tick-borne diseases, and tick control (71 attendees) (January 27, 28).

MS. TIA M. BLEVINS participated in the Connecticut Nursery and Landscape Association Winter Symposium held virtually (approx. 200 participants) (January 27, 28) and participated in a three-day virtual meeting of the Aerial Survey Working Group presented by USDA-USFS Forest Health Protection to continue to improve the reliability and accuracy of the aerial survey program (52 participants) (January 26-28).

MS. JAMIE CANTONI attended the Connecticut Nursery and Landscape Association Virtual Winter Symposium (January 27-28).

MS. KATHERINE DUGAS attended the Connecticut Nursery and Landscape Association Virtual Winter Symposium (January 27-28).

MR. MARK H. CREIGHTON participated in the Apiary Inspectors of America annual conference with regulators from the USA and Canada. Several talks were presented on varroa mite management, the latest news on the Asian giant hornet (*Vespa mandarina*), resistance to amitraz products, and updates from the USDA Beltsville honey bee laboratory (January 12-14); participated and presented at the virtual Connecticut Beekeepers Association annual Beekeepers School. The new beekeepers were introduced to the art of beekeeping, seasonal management goals, disease and pest management, honey bee registration, and neighbor relations (190 participants) (January 9, 16, 23, 30).

DR. GALE E. RIDGE was interviewed about delusional infestation by Sophie McKay, a reporter from London, England (January 19).

DR. VICTORIA L. SMITH participated in a Teams call concerning deregulation of emerald ash borer (January 11); participated in the quarterly meeting, via ZOOM, of the Experiment Station Board of Control, with a presentation on spotted lanternfly (January 19); participated in the winter meeting, via ZOOM, of the CT Cooperative Agricultural Pest Survey (CAPS) committee (January 20); participated in a meeting, via ZOOM, of the Yale Biosafety and Recombinant DNA committee (January 21); participated in a meeting, via ZOOM, of the CT GIS Workgroup (January 25); participated in a Webinar presented by the University of Massachusetts on spotted lanternfly (January 26); participated in a meeting,

via Teams, of the US Forest Service Aerial Survey Working Group (January 26); participated in a meeting, via Teams, of the US Forest Service Aerial Survey Working Group (January 27); participated in a meeting, via ZOOM, of the CT Nursery and Landscape Association (January 28); and participated in a meeting, via Teams, of the US Forest Service Aerial Survey Working Group (January 28).

DR. KIMBERLY A. STONER met with Michael O'Malley about plans to establish a botanical garden in New Haven (January 8) and met by ZOOM with co-editors Dr. Simone Tosi of the University of Turin and Dr. Harmen Hendrikson of the Julius Kuehn-Institut in Germany, and with Dr. Anna Shattles of the journal *Frontiers in Sustainable Food Systems*, about launching "Pollen as Food for Bees: Diversity, Nutrition and Contamination" as a Research Topic in the journal. The topic is now open for submissions at: www.frontiersin.org/research-topics/18973/pollen-as-food-for-bees-diversity-nutrition-and-contamination#overview (January 26).

MS. TRACY ZARRILLO attended a virtual meeting of the Native Plant Working Group (January 1) and was interviewed about specialist bees in Connecticut and promoting "wild lawns" for bee forage, particularly for *Andrena violae*, a specialist mining bee that only uses violet pollen to feed its young, by Theresa Barger for Connecticut Magazine (January 27). In January, Ms. Zarrillo was invited by Dr. Kathleen Engelmann of the University of Bridgeport to give a talk about her coastal wild bee study at the Northeast Natural History Conference in April, was invited by Dr. Marta Wells of Yale University to mentor a senior at Yale University, doing a senior honors thesis on wild bee diversity, and was invited by Peter Picone of CT DEEP to collaborate on a project that will track pollinator diversity over time in a newly planted pollinator habitat restoration in Robbins Swamp Wildlife Management Area in Canaan, CT.

ENVIRONMENTAL SCIENCES

DR. JOSEPH PIGNATELLO attended a virtual meeting of the Connecticut Academy of Science and Engineering (January 27).

MR. GREGORY BUGBEE was elected president of the Northeast Aquatic Plant Management Society and gave opening remarks for the virtual 22nd Annual Conference (approx. 200 attendees) (January 14); with **MS. SUMMER STEBBINS**, gave a virtual workshop on "Invasive Aquatic Plants" as part of the 2021 High School Envirothon (approx. 30 attendees) (January 14); conducted a virtual annual Board of Directors meeting of the Northeast Aquatic Plant Management Society (approx. 15 attendees) (January 19); with **MS. SUMMERS STEBBINS**, provided expertise at a virtual meeting organized by the Aquarion Water Company on hydrilla and its recent discovery in their reservoir system (approx. 15 attendees) (January 20); gave a virtual talk entitled "Improving Soil in the Home Garden" to the Orchard Valley Garden Club (approx. 30 attendees) (January 26); and with **MS. SUMMER STEBBINS**, gave a virtual talk entitled "CAES IAPP 2020 Aquatic Plant Survey of Pachaug Pond" to the Pachaug Pond Protective Association (approx. 20 attendees) (January 27).

DR. GOUDARZ MOLAEI presented two talks entitled "Host Interactions of *Aedes albopictus*, an Invasive Vector of Arboviruses, in mid-Atlantic USA" and "Climatic and Environmental Determinants of the Spatial Distribution and Abundance of Disease Vectors, *Ixodes scapularis* and *Amblyomma Americanum*" at the virtual meeting of the Northeast Regional Center for Excellence in Vector-borne Diseases (185 attendees) (January 12); gave a short talk entitled "Tracking Ticks and Tick-borne Diseases in Connecticut" to the joint meeting of the Environment and Public Health Committees of the Connecticut General Assembly (25 attendees) (January 19); and was interviewed about the CAES Tick Testing Laboratory, ticks, and tick-borne diseases by NPR (January 20).

MR. JOHN SHEPARD presented virtually "Arbovirus Activity in Connecticut, 2020" at the 66th Annual Meeting of the Northeastern Mosquito Control Association (123 attendees) (January 6); was interviewed about "Mosquito Trapping and Arbovirus Surveillance in Connecticut" and "Mosquito Colony Maintenance and Use" by Prof. Gillian Eastwood for stu-

dents enrolled in her Medical & Veterinary Entomology Lab (ENT-3264) course at Virginia Tech University (80 students) (recorded on January 7); and participated in the Northeast Regional Center for Excellence in Vector-Borne Diseases 2021 Virtual Strategic Planning Meeting (approx. 50 participants) (January 19).

DR. SARA NASON presented virtually to the Connecticut legislature committees on Public Health and the Environment regarding PFAS and her research on chemical contaminants in sewage sludge during the COVID-19 pandemic (approx. 25 attendees) (January 19); participated in virtual meetings of the Benchmarking and Publications for Non-Targeted Analysis working group (January 7, 13, 21); and met with researchers from Yale and the University of Minnesota regarding a collaborative proposal (January 25).

FORESTRY AND HORTICULTURE

DR. JEFFREY S. WARD participated in New England Society of American Forester (NESAF) 2021 planning committee conference calls (January 5, 8, 19); participated in an Oak Resiliency Landowner Group meeting (January 8); spoke on "The Biodiversity Crisis - Invasive Species and Deer" for the Leetes Island Garden Club (12 attendees) (January 12); met with Massachusetts DCR foresters and Yale Forestry staff to discuss precommercial release of white oak saplings (January 22); discussed the relationship of oak species and soils with Lydia Gibb (Talcott Mountain Science Center & Academy) and a student (January 26); met with a member of the Hamden Land Conservation Trust for a field discussion of forest dynamics at the Rocky Top Preserve (5 attendees) (January 27); and participated in a Forest Ecosystem Monitoring Cooperative regional meeting (January 28).

DR. SUSANNA KERIÖ gave a talk entitled "Drought and Urban Trees" in the Connecticut Tree Protective Association's (CTPA) webinar (200 attendees) (January 21); attended a webinar on archaeobotany (January 26); and contributed to chestnut-related discussion in the Northern Nut Growers Association's Facebook group (January 28).

DR. SCOTT C. WILLIAMS participated in the 2021 Virtual Annual Meeting of the Northeast Regional Center for Excellence in Vector-Borne Diseases (January 12); gave a ZOOM presentation to the Wildlife Biology class at Lyman Memorial High School on career development (17 students, 1 teacher) (January 13); participated in a ZOOM call regarding the status of the Department of Defense-funded tick management project (January 26); and presented a remote, invited lecture to the Worcester (MA) Garden Club about the relationship between blacklegged ticks and Japanese barberry (42 attendees) (January 28).

MR. JOSEPH P. BARSKY participated in NESAF 2021 planning committee conference calls (January 5, 19); participated in an NESAF executive committee conference call (January 13); and attended the CTPA Annual Winter Meeting (January 21).

PLANT PATHOLOGY AND ECOLOGY

DR. WADE ELMER, with **DR. JASON WHITE** and **MR. MICHAEL CAVADINI**, testified before the Commission on Human Rights and Opportunities on the CAES Affirmative Action Plan (43 attendees) (January 13); attended the Board of Control meeting held at the Connecticut Farm Bureau in Wethersfield (12 attendees) (January 19); attended (via ZOOM) a meeting/virtual tour with the CT state Environment Committee and Public Health Committee (January 19); attended a CT Management Advisory Council Meeting (January 20); attended the American Phytopathological Society Foundation meeting via ZOOM (9 attendees) (January 20); attended the Connecticut Nursery and Landscape Association Virtual Winter Symposium (January 27-28); and attended the monthly NIFA Reporting System Webinar (POW) (January 27).

DR. YONGHAO LI gave a presentation about the Plant Disease Information Office to the full Environment and Public Health Committees of the Connecticut General Assembly via ZOOM (22 attendees) (January 19); attended a National Plant Diagnostic Network Nation-

al Webinar (January 12, 13); attended the Connecticut Tree Protective Association Annual Meeting via ZOOM (January 19); attended the Virtual Ornamental Disease Diagnostic Session (January 20, 21, 26); and attended the Connecticut Nursery and Landscape Association Winter Symposium via ZOOM (January 27).

DR. ROBERT E. MARRA participated in a Connecticut CAPS meeting (via ZOOM) where he presented an update on Beech Leaf Disease (January 20); and participated in a plot network meeting of the Forest Ecosystem Monitoring Cooperative (January 28).

DR. QUAN ZENG, with Dr. David Rosenberger, Mr. Glen Koehler, and Dr. Dan Cooley, shared their perspectives on "Stupid Questions of Fire Blight" to a group of extension agents, educators, and professors at the Northeastern Tree Fruit IPM Working Group via ZOOM (25 attendees) (January 12); and had a ZOOM conference call with Drs. Dan Cooley and Paul O'Connor from the University of Massachusetts (January 21).

VALLEY LABORATORY

DR. RICHARD COWLES presented virtually "Soil Acidification for Improved Health of Christmas Tree Transplants" for the North Carolina Christmas Tree Workshop (40 attendees) (January 29).

DR. JAMES LAMONDIA participated in a Connecticut Agricultural Information Council ZOOM meeting to plan Ag Day at the Capitol (January 12).

DEPARTMENTAL RESEARCH UPDATES JANUARY 2021

Aulakh, Jatinder S., P. S. Chahal, V. Kumar, A. J. Price, and K. Guillard. 2021. Multiple herbicide-resistant Palmer amaranth (*Amaranthus palmeri*) in Connecticut: Confirmation and response to POST herbicides. Weed Technology, https://doi.org/10.1017/wet.2021.6.

Abstract- Palmer amaranth is the latest pigweed species documented in Connecticut in 2019. In a single dose experiment, the Connecticut Palmer amaranth biotype survived the field-use rates of glyphosate (840 g ae ha^{-1}) and imazaquin (137 g ai ha^{-1}) herbicides applied separately. Additional experiments were conducted to (1) determine the level of resistance to glyphosate and acetolactate synthase (ALS) inhibitors in the Connecticut -resistant (CT-Res) biotype using whole-plant dose-response bioassays, and (2) evaluate the response of the CT-Res biotype to POST herbicides commonly used in CT cropping systems. Based on the effective dose required for 90% control (ED_{90}), the CT-Res biotype was 10-fold resistant to glyphosate when compared with the Kansas-susceptible (KS-Sus) biotype. Furthermore, the CT-Res biotype was highly resistant to ALS-inhibitor herbicides with only 18% control with 2,196 g ai ha^{-1} of imazaquin. It was also cross resistant to other ALS-inhibitor herbicides including: chlorimuron-ethyl (13.1 g ai ha^{-1}), halosulfuron-methyl (70 g ai ha^{-1}), and sulfometuron-methyl (392 g ai ha^{-1}). The CT-Res Palmer amaranth was controlled 75 to 100% at 21 d after treatment (DAT) with POST applications of 2,4-D (386 g ae ha^{-1}), carfentrazone-ethyl (34 g ai ha^{-1}), clopyralid (280 g ae ha^{-1}), dicamba (280 g ae ha^{-1}), glufosinate (595 g ai ha^{-1}), lactofen (220 g ai ha^{-1}), oxyfluorfen (1,121g ai ha^{-1}), and mesotrione (105 g ai ha^{-1}) herbicides. Atrazine (2,240 g ai ha^{-1}) controlled the CT-Res biotype only 52%, suggesting the biotype is resistant to this herbicide as well. This research reports the first case of Palmer amaranth from Connecticut with multiple resistance to glyphosate and ALS-inhibitors. Growers should proactively use all available weed control tactics, including the use of effective PRE and alternative POST herbicides (tested in this study) for effective control of the CT-Res biotype.

Cerbu, C., M. Kah, **Jason C. White**, C. E. Astete, and C. Sabliov. 2021. Fate of biodegradable engineered nanoparticles used in veterinary medicine as delivery systems from a One Health perspective. *Molecules* (in press).

Abstract- Veterinary medicine is calling for novel solutions to address the challenges of today such as antibiotic resistance and need for increased animal production. In re-

sponse to this call, a multitude of delivery systems were developed in the form of engineered nanoparticles (ENPs), a subclass of which are polymeric, biodegradable ENPs (pbENPs). These particles were developed to deliver antibiotics, vaccines, and hormones, and in general were proven beneficial in many regards, especially when comparing efficacy of the delivered drugs to that of the free drugs. Unfortunately, the fate of pbENPs developed for veterinary applications is not known. pbENPs undergo biotransformation as they are transferred from one ecosystem to another and these transformations while far from being understood, affect their impact on health and environment. This review addresses nanoparticle fate and the impact of nanoparticles transformations on animals, environment, and people from a One Health perspective.

Yang, Jingjing, **Joseph J. Pignatello**, Kun Yang, Wenhao Wu, Guining Lu, Lijuan Zhang, Chen Yang, and Zhi Dang. Adsorption of organic compounds by biomass chars: Direct role of aromatic condensation (ring cluster size) revealed by experimental and theoretical studies, *Environmental Science & Technology*, 2021, 55(3):1594-1603. **DOI:** 10.1021/acs.est.0c04852. Article was featured by an illustration on the issue cover.

Abstract- Biomass chars are a major component of the soil black carbon pool and a potential tool in environmental remediation, where their role as sorbents is of primary interest. Surface area, porosity, functional group composition, and percent aromatic carbon are regarded as important properties controlling char sorption of organic compounds. Here, we show for the first time that the degree of aromatic condensation directly affects sorption affinity (not sorption capacity). The Dubinin-Ashtakov characteristic sorption energy (E_{DA}, kJ/mole) of 22 compounds on a thermoseries of bamboo chars correlates strongly with the DP/MAS-^{13}C-NMR-determined bridgehead aromatic carbon fraction (x_b), which relates with mean ring cluster size. Density functional theory-computed binding energies (E_{bd}) for five compounds on a representative series of polyaromatic hydrocarbons also correlate positively with x_b, leveling off for rings larger than ~C_{55}. The E_{bd}, in turn, correlates strongly with E_{DA}. The increase in E_{bd} with cluster size applies also to both monolayer and bilayer sorption between parallel polybenzenoid sheets representing slit micropores. The increase with size is due to increasing cluster polarizability, which strengthens dispersion forces. The findings underscore a previously overlooked explicit role of aromatic condensation in sorption energy and illustrate the potential utility of E_{DA}-E_{bd} comparison for unknown sorption prediction.

Molaei, Goudarz, **Eliza A.H. Little, Noelle Khalil**, B. N. Ayres, W. L. Nicholson, and C. D. Paddock. Established population of the Gulf Coast tick, *Amblyomma maculatum* (Acari: Ixodidae), infected with *Rickettsia parkeri* in Connecticut. *Journal of Medical Entomology*, tjaa299, https://doi.org/10.1093/jme/tjaa299, January 18.

Abstract- We identified an established population of the Gulf Coast tick (*Amblyomma maculatum* Koch) infected with *Rickettsia parkeri* in Connecticut, representing the northernmost range limit of this medically relevant tick species. Our finding highlights the importance of tick surveillance and public health challenges posed by geographic expansion of tick vectors and their pathogens.

Rawat, S., K. Cota-Ruiz, H. Dou, V. Pullagurala, **Nubia Zuverza-Mena**, **Jason C. White**, G. Niu, N. Sharma, J. Hernandez-Viezcas, J. Peralta-Videa, and J. Gardea-Torresdey. 2020. Soil weathered CuO nanoparticles compromise foliar health and pigment production in spinach (*Spinacia oleracea*). *Environ. Sci. Technol.* (in press).

Abstract- In this study, spinach plants exposed to fresh/unweathered (UW) or weathered (W) copper compounds in soil were analyzed for growth and nutritional composition. Plants were exposed for five weeks to freshly prepared or soil-aged (35 days) nanoparticulate CuO (nCuO), bulk scale CuO (bCuO), or $CuSO_4$ at 0 (control), 400, 400, and 40 mg/kg of soil, respectively. Foliar health, gas exchange, pigment content, catalase and ascorbate peroxidase enzymes, gene expression, and element bioaccumulation were evaluated. Foliar biomass was higher in UW control (84%) and in UW ionic treatment (87%), compared to the corresponding W treatments ($p \leq 0.1$). Shoot Cu bioaccumulation for both UW and W (nano and bulk) CuO were significantly higher than control but showed no effect of weathering. No significant differences were observed in the root Cu bioaccumulation across the different treatments. At 40 days post transplantation, the intercellular CO_2 concentration was reduced by 28% for W nCuO treatment compared to the W control ($p \leq 0.1$). Root catalase activity was increased by 110% in UW bCuO treatment as compared to the W counterpart; the value for the W ionic treatment was increased by 2167% compared to the UW counterpart ($p \leq 0.05$). At day 10 of the exposure period, Chl a for UW control was 72% greater than the W control ($p \leq$

0.05). At 20 days post transplantation, W nCuO-exposed plants had ¤ 56% lower carotenoid content compared to both W control and the UW counterpart ($p \leq 0.05$). Additionally, by 30 days the Chl a value for the W control was 91% greater than the UW control ($p \leq 0.05$). The findings show that the weathering process significantly increased detrimental effects of CuO exposure on leaf pigment production over the full life cycle of spinach. However, the gene expression analysis in the leaves showed that W nCuO treatments yielded comparable levels of CuSOD and FeSOD as compared to the other Cu treatments.

Williams, Scott C., **K. C. Stafford III**, **Megan A. Linske**, **Doug E. Brackney**, A. M. LaBonte, **Heidi R. Stuber**, and **Duncan W. Cozens**. 2021. Effective control of the motile stages of *Amblyomma americanum* and reduced *Ehrlichia* spp. prevalence in adults via permethrin treatment of white-tailed deer in coastal Connecticut, USA. *Ticks and Tick-borne Diseases* 12:101675. https://doi.org/10.1016/j.ttbdis.2021.101675.

Abstract- The lone star tick, *Amblyomma americanum*, is a common human-biting species whose range has been largely restricted to the southeastern United States, until recent detections of established populations on Long Island, New York, and throughout coastal southern New England. We evaluated the effectiveness of topical treatment of 10% permethrin delivered via 4-poster devices to white-tailed deer, *Odocoileus virginianus*, in the management of a newly discovered *A. americanum* population in Norwalk, Connecticut. Using a high-density deployment of one 4-poster device/12.7 ha, we were successful in significantly reducing densities of host-seeking adults (93% reduction), nymphs (92%), and larvae (96%) from 2018 to 2020. We also documented a significant reduction (87%) in parasitizing adults and nymphs on white-tailed deer from 2018 to 2019. The prevalence of *Ehrlichia chaffeensis* and *Ehrlichia ewingii* combined in host-seeking adults declined significantly from 47% at the time the *A. americanum* population was discovered in 2017 to 7% in 2020. However, the prevalence in nymphs remained static (~9%) throughout the study period. These data demonstrate that, when properly deployed in a density dependent manner in terms of deer abundance, 4-poster devices can effectively manage parasitizing and host-seeking *A. americanum* populations and reduce the prevalence of two ehrlichial species of public health importance.

JOURNAL ARTICLES APPROVED JANUARY 2021

Adeel, M., N. Shakoor, M. Shafiq, A. Pavlicek, F. Part, C. Zafiu, A. Raza, P. Zhang, G. Jilani, **Jason C. White**, E.-K. Ehmoser, I. Lynch, and Y. Rui. A critical review of the potential toxic effects of manufactured nano-objects on earthworms. *Environmental Science: Nano*

da Silva, Washington, and **Madeleine Dumas**. Grapevine red blotch disease. *CAES Fact Sheet*

Elmer, Wade H., **Nubia Zuverza-Mena**, **Lindsay R. Triplett**, E. L. Roberts, R. A. Silady, and **Jason C. White**. Foliar application of copper oxide nanoparticles suppresses Fusarium wilt of chrysanthemum. *Environmental Science & Technology*

Li, C., **Zhengyang Wang**, S. Bakshi, **Joseph J. Pignatello**, and S. J. Parikh. Evaluation of select biochars and clays as supports for phytase to increase the fertilizer potential of animal wastes. *Science of the Total Environment*

Ma, C., Y. Hao, J. Zhao, **Nubia Zuverza-Mena**, A. G. Meselhy, O. Parkash Dhankher, Y. Rui, **Jason C. White**, and B. Xing. Physiological and molecular responses of rice (*Oryza sativa* L.) to graphitic carbon nitride (g-C_3N_4) and heavy metal co-exposure. *Nanomaterials*

Marmiroli, M., L. Pagano, R. Rossi, R. De La Torre-Roche, G. O. Lepore, R. Ruotolo, G. Gariani, V. Bonanni, S. Pollstri, A. Puri, A. Gianoncelli, G. Aquilanti, F. d'Acapito, **Jason C. White**, and N. Marmiroli. Copper oxide nanomaterial fate in plant tissue: Nanoscale impacts on reproductive tissues. *Environmental Science & Technology*

McMillan, Joseph R., C. A. Harden, J. C. Burtis, **Mallery I. Breban**, **John J. Shepard**, **Tanya A. Petruff**, **Michael J. Misencik**, **Angela B. Bransfield**, J. D. Poggi, L. C. Harrington, **Theodore G. Andreadis**, and **Philip M. Armstrong**. The community-wide efficacy of larval control in catch basins for West Nile virus risk reduction in Connecticut, United States. *Pest Management Science*

Patel, Ravikumar, P. Kandel, E. Traverso, K. Hockett, and **Lindsay Triplett**. A Pseudomonas plant pathogen uses distinct modes of stationary phase persistence to survive bacteriocin and streptomycin treatments. *mBio*

Shang, H., C. Ma, C. Li, J. Zhao, **Wade Elmer**, **Jason C. White**, and B. Xing. CuO nanoparticle-embedded hydrogels to enhance nutrient supply and growth of lettuce infected with *Fusarium oxysporum* f. sp. *lactucae*. *Environmental Science & Technology*

Sigmon, L. R., **Ishaq Adisa**, B. Liu, **Wade H. Elmer**, Jason C. White, **Christian O. Dimkpa**, and D. H. Fairbrother. Biodegradable polymer nanocomposites provide effective delivery and reduced runoff of phosphorus during plant growth. *Environmental Science & Technology*

Stravoravdis, S., **Robert E. Marra**, N. R. LeBlanc, J. A. Crouch, and J. P. Hulvey. RNA-Seq of boxwood blight pathogens uncovers evidence for 1 putative xenobiotic determinants of antifungal sensitivity. *Applied and Environmental Microbiology*

Wan, Y., Y. Z. Si, **De-Wei Li**, L. Huang, and L. H. Zhu. First report of *Diaporthe cercidis* causing leaf blotch of *Acer pictum* subsp. *mono* in China. *Plant Disease*

Yang, Y., P. Duan, K. Schmidt-Rohr, and **Joseph J. Pignatello**. Physico-chemical changes in biomass chars by thermal oxidation or ambient weathering and their impacts on sorption of a hydrophobic and a cationic compound. *Environmental Science & Technology*

Zhao, L., M. Huang, A. Wang, G. Ren, S. Chen, X. Tan, Y. Huang, R. Ji, D. Zhou, Y.-G. Zhu, A. Keller, J. L. Gardea-Torresdey, and **Jason C. White**. Semiconductor-based reprogramming of metabolic pathways in photosynthetic microorganisms. *Science*

ARTICLES OF INTEREST JANUARY 2021

The commissioned artwork for the Jenkins-Waggoner Laboratory is finally coming into being!

Artists Marion Belanger and Martha Willette Lewis won a competition put forward by **the State of Connecticut's Council on the Arts,** headed by Tamara Dimitri. The open-call for proposals asked for artists to use the collection of the **Osborne Library** at **CAES** to make a special, permanent work of art for the **Jenkins-Waggoner Laboratory** lobby. Their immersive installation, titled ***Plants & Insects*** will include wallcoverings, framed prints, specimens, and a digital slideshow to show off the beauty of the often-fragile **CAES** collections.

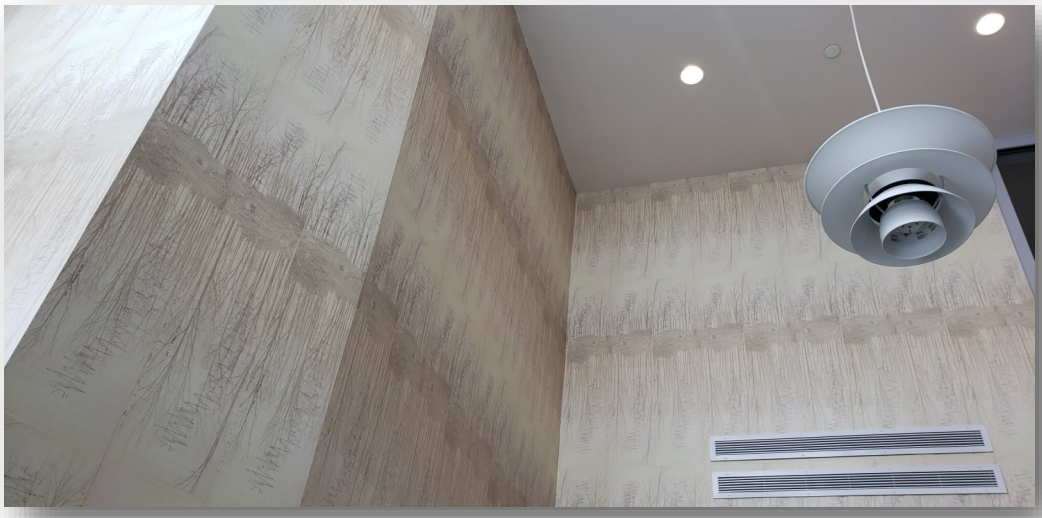
Marion and Martha got to work last February, actively researching in the archive and finding works and images to include. COVID and closings have presented a real challenge, but the two have truly enjoyed their time in the **Osborne Library** stacks and are now into the production and installation phase of the project. Last week bespoke wallcoverings, designed by Lewis went up in the Lobby and the Atrium. These custom papers use intake books, weather graphs, and images from the many historic books in the collection as their basis. Meanwhile Marion's beautiful photographic prints were drawn from the many negatives and prints that documented past research. She cleaned, scanned, and enlarged the images. They are currently being framed. The custom museum quality frames are being specially manufactured by a firm in rural Massachusetts - again COVID is delaying and slowing this process, but it is happening. Installation is scheduled for February.

As they await the frames, Lewis & Belanger are beginning the assembly of the digital slide show, and the arduous task of selecting what will be included. There is a wealth of beautiful, interesting historic material and culling is one of the important tasks here - to put together something rich, compelling, and full that shows off some of the highlights of the library in a way that allows the public to engage with the collection without damaging it.

About the artists:

Marion Belanger photographs the cultural landscape where geology and the built environment intersect, particularly where shifting identities of place and boundaries are in flux. She is the author of *Rift/Fault* (Radius Books, 2016) and *Everglades: Outside and Within* (Center for American Places at Columbia College Chicago, 2009). The artist was awarded a John Simon Guggenheim Fellowship and she was an honoree for the 2016 Shpilman International Prize for Excellence in Photography from the Israeli Museum of Art. Her work is held in numerous collections including the National Gallery for Art, the New Orleans Museum of Art, the Library of Congress, and the Yale University Beinecke Rare Book & Manuscript Library. Belanger earned an M.F.A. from the Yale University School of Art where she was the recipient of both the John Ferguson Weir Award and the Schickle-Collingwood Prize, and a B.F.A. from the College of Art & Design at Alfred University.

Martha Willette Lewis is a professional artist whose practice centers on books, the history of science and of human knowledge through drawing, prints, and site-specific installation. She was selected to participate in the 2015 **The National Academies Keck Futures Initiative Conference**: ***Art and Science, Engineering, and Medicine/Collaborations: Ideation, Translation and Realization***, has presented her artwork to the **Laboratory of Atomic and Solid-State Physics** at **Cornell University**, and was the first ever artist in residence at the **Yale Quantum Institute**, where she has a permanent artwork installed in the lobby. Her temporary installation – ***I'll be your Qubit*** - was a sold-out event at **the International Festival of Arts and Ideas**. This immersive art project was a collaboration with Professor Michel Devoret, **YQI** Researcher Stefan Krastanov, and **YQI** Manager Dr. Florian Carle. She currently is working on a book with members of **YQI** on the hand-built nature of Quantum Computing that features her artworks and drawings. This fall, she begins a three-year artist residency at the school of architecture at the **University of Hong Kong**'s **School of Architecture**, where she will be focusing on a site-specific installation. Martha got her BFA from **The Cooper Union for The Advancement of Science and Art** in New York, and an MFA from the **School of Art** at **Yale University**.

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