Station News

The Connecticut Agricultural Experiment Station
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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 JUNE 2021

DR. CAROLE CHEAH received a grant (June 23) from the Farmington River Coordinating Committee ($10,000) for a 2021-2022 project titled "Augmentative biological control of hemlock woolly adelgid (HWA) as a strategy to mitigate eastern hemlock decline from HWA outbreaks in the upper Farmington River watershed." The FRCC grant supported June *S. tsugae* releases in the People's State Forest and the American Legion State Forest in Barkhamsted.

ADMINISTRATION

DR. JASON C. WHITE, with **DR. NUBIA ZUVERZA-MENA**, met by Zoom with Professor Frank Yang of the University of Nevada-Reno to discuss a joint USDA proposal on microplastics (June 2, 4); participated in the biweekly meeting of the CT Rapid Response Team (RRT) (June 2, 16, 30); participated in the weekly Center for Sustainable Nanotechnology (CSN) All-Hands call (June 2, 9, 16, 23); participated in the National Nanotechnology Initiative (NNI) webinar on "Nanosensors for Food and Agriculture" (June 2); participated in the American Chemical Society (ACS) Zoom webinar titled "Bridging the Gap: Linking Analytical Chemistry to Biological Effects" (June 3); hosted, with **DR. WADE ELMER**, a Zoom call with collaborators at Johns Hopkins University to discuss a collaborative USDA project on nanoscale P delivery (June 3); met with Ms. Elizabeth Holt of the New Haven Preservation Trust and gave a tour of CAES laboratories and programs (June 3); participated in the monthly FDA RRT webinar (June 3); participated in the monthly Laboratory Preparedness Advisory Committee teleconference call with the CT Department of Public Health (June 7); hosted the monthly CSN Nanochemistry-Plant Zoom call (June 8); met by MS Teams with Dr. Anthony Muyombwe of the CT Department of Public Health to discuss collaborative work (June 8); with **DR. NUBIA ZUVERZA-MENA** and **DR. SARA NASON**, participated in a group meeting with collaborators from Yale University and the University of Minnesota to discuss work on a collaborative NIEHS grant (June 9); hosted Ms. Meghan Cahill from the University of Minnesota – Meghan will be joining the Department of Analytical Chemistry as a Research Technician I next month (June 10); hosted Senator Richard Blumenthal for a press conference and discussion on tickborne diseases (June 11); participated in the kick-off meeting of the Cannabis Regulators Association (CANNRA) Public Health and Data Monitoring Special Committee (June 11); participated in the monthly FDA Laboratory Flexible Funding Model Zoom calls for Human and Animal Food and Food Defense (June 14); participated in the monthly Farmland Preservation Advisory Board (FPAB) meeting (June 17); hosted the monthly meeting of the CAES J-1 Visa recipients (June 18); participated in the CANNRA mid-year Zoom meeting (June 21); participated in the bi-monthly Northeastern Regional Association of State Agricultural Experiment Station Directors (NERA) meeting (June 21); participated in the Ph.D. defense of Dr. Jaya Borgatta of the University of Wisconsin Madison (June 22); participated in the 2021 RI, MA, and CT RRT Tabletop Exercise (June 24); participated in the FY21 USDA AFRI Pre-panel Orientation call (June 24); hosted the quarterly CAES Safety Committee meeting (June 25); participated in the bi-monthly FDA 50-State call (June 25); with **DR. KIRBY STAFFORD** and **DR. VICTORIA SMITH**, participated in a Zoom meeting with representatives of the CT Nursery & Landscape Association to discuss the current spotted lanternfly quarantine (June 25); spoke by phone with Professor Jorge Gardea-Torresdey of the University of Texas El Paso to discuss a special issue of *Environmental Science & Technology* that we are guest editing on

the "Environmental Implications of Nanofertilizers" (June 28); participated in the NIEHS Superfund Basic Research Program (SRP) Kick-off call (June 29); and with **DR. KIRBY STAFFORD** and **DR. VICTORIA SMITH**, participated in a Zoom meeting with representatives of the Connecticut Greenhouse Growers Association (CGGA) to discuss the current spotted lanternfly quarantine (June 30).

ANALYTICAL CHEMISTRY

DR. BRIAN EITZER was a participant in the LFFM Human and Animal Food, and Food Defense phone calls (June 14); the Connecticut Rapid Response Team bi-weekly phone calls (June 16, 30); with **DRS. CHRISTINA ROBB**, **WALTER KROL**, and **CHRISTIAN DIMKPA**, met representatives from Randox to discuss their mycotoxin detection system (June 18); and was a participant in the Tabletop Exercise of the Rapid Response Teams of Connecticut, Rhode Island, and Massachusetts (June 24).

DR. CHRISTINA ROBB attended the ChromSoc (U) HPLC Virtual Symposium: A Tribute to John Knox (June 1, 2); attended the Waters webinar "Introducing the next generation of high-resolution mass spectrometry" (June 8); participated in the FDA LFFM Human and Animal Food, and Food Defense monthly meeting (June 14); contributed to the Eastern Analytical Symposium (EAS) Executive Committee meetings (June 7, 14, 21, 28): met with and discussed aflatoxin testing capabilities with Randox Food Diagnostic testing company (June 18); and was received as a member of the UK Chromatography Society (ChromSoc) (June 18).

ENTOMOLOGY

DR. KIRBY C. STAFFORD III was interviewed by James Szkobel-Wolff, Connecticut Public Radio, on tick activity in Connecticut (June 7); interviewed about ticks, mosquitoes, box tree moth, spotted lanternfly, and other subjects by Aaron Kupec, WTIC Radio (June 9); interviewed by Ed Stannard, *New Haven Register*, about babesiosis (June 9); interviewed by Jordan Fenster, Hearst Media, about gypsy moth (June 23); interviewed by Dan Corcoran, NBC Connecticut TV, about gypsy moth (June 25); interviewed by Melissa Sheketoff, WICC Radio, about gypsy moth (June 28); interviewed by Greg Little, WTIC, about gypsy moth (June 29); interviewed by Patrick Skahill, Connecticut Public Radio, about gypsy moth defoliation back in 2017 (June 29); interviewed by Brian Scott-Smith about gypsy moth (June 29); interviewed by Courtney Luciana, WTNH-TV, about gypsy moth (June 29); interviewed by Brigitte Ruthman, *Republican-American*, about gypsy moth (June 29).

MS. KATHERINE DUGAS guided an aquatic invertebrate hike and activity with Girl Scouts at Sleeping Giant State Park in Hamden (20 scouts and 4 adults) (June 5).

DR. MEGAN LINSKE was interviewed about climate change impacts on ticks and tick-borne illnesses by Edward Ricciuti for *Entomology Today* (June 22).

DR. GALE E. RIDGE was interviewed about carpenter ants and their impact on manmade structures by Harlan Levy, *Journal Inquirer* (June 21); was interviewed about cicadas and how they are preyed on by the cicada killer wasps and public confusion of this native wasp with the intercepted Asian giant hornet in Washington State by Robert Miller of the *News-Times* (June 22); was interviewed about

hammerhead worms seen in Old Saybrook by Brendon Crowley from the *CT Examiner* (June 22); and was interviewed about the four species of subterranean termites found in the United States by Harlan Levy, *Journal Inquirer* (June 28).

DR. CLAIRE E. RUTLEDGE presented a talk titled "Biological Control of Emerald Ash Borer in Connecticut" to the Yale-Myers Summer Research Series via Zoom (45 adults) (June 24).

DR. VICTORIA L. SMITH participated via Zoom in the quarterly meeting of the Eastern Plant Board (June 4); was interviewed concerning box tree moth and spotted lanternfly by Bob Miller of the *News-Times* (June 8); and participated via Zoom in a meeting of the Yale Biosafety Committee (June 17).

DR. KIMBERLY A. STONER participated in a meeting of the international COLOSS (Prevention of Honey Bee Colony Losses) Bee Nutrition Task Force via Zoom with 37 participants from many countries on four continents (https://coloss.org/projects/nutrition/) (June 9); participated (in person!) in a workshop and tour of the Newhallville Learning Corridor site by Doreen Abubakar of CPEN (Community Place-making and Engagement Network), along with staff from the CT NOFA Ecotype Project in New Haven (0.7 mile from our offices) (35 participants) (June 10); participated as a member of the project team, with Dr. Christina Grozinger and Dr. Victor Gonzalez Betancourt, in a virtual presentation of the project "Amplifying the Buzz" to the Governing Council of the Plant-Insect Ecosystem section of the Entomological Society of America (12 participants) (June 11); and presented (in-person!) a talk titled "Planting for the Bees' Needs" to the Friends of Harkness Memorial State Park at Harkness Memorial State Park in Waterford (12 participants) (June 14).

MS. TRACY ZARRILLO was interviewed about wild bee diversity in Connecticut by Susannah Wood, *Norfolk Now* (June 18).

ENVIRONMENTAL SCIENCES

DR. JOSEPH PIGNATELLO co-authored a virtual talk titled "Optimizing Carbon Amendments that Simultaneously Adsorb and Transform Legacy and Insensitive High Explosives (ER19-1239)" before a grant review panel on progress in an awarded SERDP project (June 9); met virtually with professors from Villanova University, Pacific Northwest National Laboratory, and Oregon Health and Science University on a SERDP grant project (June 28).

DR. PHILIP ARMSTRONG was interviewed about the start of the mosquito surveillance program by News Channel 8 (June 1), NBC CT (June 1), Fox 61 (June 2), WSHU (June 2), and *The Day* (June 3); was interviewed about EEE virus and the statewide monitoring program by the *Valley Inquiry* (June 8); and was interviewed about the first West Nile virus positive mosquitoes identified in Connecticut this year by the *Connecticut Post* (June 29), CT Patch (June 29), WSHU (June 29), NBC CT (June 29), and News Channel 8 (June 29).

MS. ANGELA BRANSFIELD participated in the Federal Select Agent Program's RO webinar series "Drills and Exercises Documentation Requirements" (June 16).

MR. GREGORY BUGBEE gave a talk titled "Hydrilla Invades the Connecticut River"

at the Chester Town Meeting Hall and concurrently via Zoom (approx. 50 attendees) (June 24).

DR. ANDREA GLORIA-SORIA presented a talk titled "The Mosquito and the Worm" at the Center for Genetic Analysis of Biodiversity weekly virtual seminar at Yale University (15 attendees) (June 1); and gave a talk titled "Two Subspecies of the *Aedes aegypti* Mosquito Are Found in Sudan and Originated from Recent Independent Invasion Events" at the Society for the Study of Evolution Annual meeting, Virtual Evolution 2021 (2,668 attendees) (June 21-25).

DR. REBECCA JOHNSON attended the Biology of Vector-borne Diseases training course at the University of Idaho in Moscow, Idaho, on insect vectors, vector-borne diseases, and how plant, animal, and human health are interconnected (June 20-25).

DR. GOUDARZ MOLAEI was interviewed on ticks and tick-borne disease this year in Connecticut by WFSB and NBC Connecticut (June 11); and was interviewed on tick activity this year and changes in the frequency and dynamics of ticks and tick-borne diseases in Connecticut by *Southern Boating Magazine* (June 17).

DR. SARA NASON presented a virtual talk titled "PFAS Analytical Methods" at the Midwest AOAC meeting (approx. 25 attendees) (June 9); met virtually with collaborators from Yale and the University of Minnesota regarding collaborative research (June 9); attended virtual meetings for the Benchmarking and Publications for Non-Targeted Analysis working group (June 9, 24); and met virtually with research collaborators from Princeton University (June 22).

MR. JOHN SHEPARD was interviewed about mosquitoes, eastern equine encephalitis, and West Nile viruses by NBC Connecticut (June 11); was interviewed about mosquito trapping and testing for eastern equine encephalitis, West Nile, and Jamestown Canyon viruses by the *Connecticut Post* (June 15); participated in Arbovirus Situational Awareness conference calls organized by the Northeast Regional Center for Excellence in Vector-Borne Diseases (25-30 attendees) (June 7, 21).

FORESTRY AND HORTICULTURE

DR. JEFFREY S. WARD was interviewed about climate change and forest resiliency by Jan Ellen Spiegel of the *CT Mirror* (June 1); spoke on "The Roots of Connecticut's forest - and its future" at the North Branford Land Conservation Trust annual meeting (14 attendees) (June 2); visited John Konicki in Oxford to examine a cluster of dying trees (June 3); spoke in North Madison on using slash walls to improve forest regeneration to federal, state, and watershed foresters from throughout southern New England (17 attendees) (June 7); spoke with Will Hochholzer, Alejandro Prieto, and other CT DEEP Forestry staff about improving models to estimate forest regeneration (4 attendees) (June 7); participated in a meeting of the Connecticut Tree Protection Examining Board to revise the oral examination at Lockwood Farm (June 9); spoke on recent forest research activities on the Oak Resiliency Team Zoom call (11 attendees) (June 16); participated in a Forest Ecosystem Monitoring Cooperative State Coordinators Meeting (June 17); was interviewed about defoliators and forest health by Jan Ellen Spiegel of the *CT Mirror* (June 24); gave a talk on "Forest management and forest carbon" to the Connecticut Professional Timber Producers Association at Lockwood Farm (57 attendees) (June 25); was interviewed about impact of gypsy moths by Zak Bennett of the Daily Mail (UK) (June 30).

DR. SUSANNA KERIÖ participated in a Beech Leaf Disease research update Zoom call (June 2); participated in a CT Urban Forestry Council's virtual RFP committee (June 7, 23); served on the Connecticut Tree Protection Examining Board meeting held at Lockwood Farm (June 9); attended a Northern Hardwood virtual conference (June 15); attended a webinar titled "Summer Tree Summit: State of Our Urban Forests" (June 30).

DR. ABIGAIL A. MAYNARD reported on Station activities to a quarterly meeting of the Council on Soil and Water Conservation via Zoom (16 adults) (June 17).

DR. SCOTT C. WILLIAMS participated in a conference call for the Editorial Advisory Board for The Wildlife Society publication, *The Wildlife Professional* (June 3); gave a talk about the link between forest health and public health to the Connecticut Professional Timber Producers Association at Lockwood Farm (57 attendees) (June 25).

MR. JOSEPH P. BARSKY participated in the quarterly meeting of the State Consulting Committee for Agricultural Science and Technology Education and was re-elected Vice-Chair (June 10); and participated in the quarterly meeting of New England Society of American Foresters Executive Committee in East Concord, NH (June 16).

PLANT PATHOLOGY AND ECOLOGY

DR. WADE ELMER, with **DRS. JASON WHITE** and **YI WANG**, participated via Zoom in the CAES-UMASS Nano S update (6 attendees) (June 1); with **DRS. JASON WHITE, CHRISTIAN DIMKPA, WASHINGTON DA SILVA, NUBIA ZUVERZA-MENA**, and **TEJA SHIDORE**, attended via Zoom the CNS Plant Nano Group meeting (26 attendees) (June 8); held a Zoom conference with Drs. Robert McGovern and Meg McGrath concerning their Springer publication (June 14); attended the quarterly meeting of the APS Press Committee (9 attendees) (June 15); attended via MS Teams the CT Management Advisory Council meeting (126 attendees) (June 16); attended via Zoom the monthly APS Foundation Committee meeting (9 attendees) (June 16); attended via Zoom the NIFA plan of work conference webinar (51 attendees) (June 24); with **DR. JASON WHITE, DR. CHRISTIAN DIMKPA,** and **ISHAQ ADISA**, participated in a Zoom conference regarding a NIFA grant project on nano P with Ms. Jaya Borgatta for nano P research at CAES (June 29).

DR. YONGHAO LI presented "Backyard Small Fruits" for the Rockville Public Library Adult Education Program via Zoom (5 adults) (June 2); talked about Disease Management in Christmas Tree Farms at a Twilight Meeting of the Connecticut Christmas Tree Growers Association held in Preston (50 adults) (June 22); staffed the CAES booth at the SiteOne Open House with The Connecticut Agricultural Experiment Station and Other Supplier Partners in East Haven (June 29).

DR. ROBERT E. MARRA participated in a Beech Leaf Disease Working Group Zoom meeting with collaborators from Ohio, West Virginia, Ontario (CA), New York, USDA-ARS, and the US Forest Service. (45 participants) (June 2); presented a talk, via Zoom, titled "Beech Leaf Disease in Connecticut," for a consortium of Fairfield County Land Trusts and Conservation Commissions (215 participants) (June 15); participated, via MS Teams, in the Forest Ecosystem Monitoring Cooperative State Coordinators meeting (25 participants) (June 17).

DR. QUAN ZENG participated in an online editorial board meeting of the journal *Phytopathology* (June 1).

VALLEY LABORATORY

DR. CAROLE CHEAH, in cooperative efforts with Tree-Savers, PA, through donations and purchases, continued with augmentative releases of *Sasajiscymnus tsugae* for biological control of hemlock woolly adelgid (HWA) to address adelgid resurgence in Connecticut hemlock forests in June 2021. These releases were implemented with land preserve and land trust managers, foresters from CT DEEP foresters and the MDC, town conservation commission members, and other volunteers to mitigate hemlock woolly adelgid spread and damage in another 10 hemlock forests in the following towns: Barkhamsted, East Haddam, Eastford, Southington, Hartland, and New Hartford.

DR. RICHARD COWLES discussed "Disease, Mite, and Insect Management" at a Twilight Meeting of the CT Christmas Tree Growers Association held in Preston (40 attendees) (June 22).

DR. JAMES LAMONDIA spoke with representatives of Lancaster Leaf and ITG about tobacco extension and the 100-year anniversary of the Tobacco Station/Valley Laboratory (4 attendees) (May 3); participated in a SCRI Boxwood Blight Grant Project Directors Zoom meeting (12 attendees) (May 19); and participated in the Beech Leaf Disease Update Zoom meeting (24 attendees) (June 2).

DEPARTMENTAL RESEARCH UPDATES JUNE 2021

ADMINISTRATION:

1. Salinas, F., Astete, C. E., Waldvogel, J. H., Navarro, S., **White, J. C.**, **Elmer, W.**, Davis, J. A., Sabliov, C. M. 2021. Effects of engineered lignin-graft-PLGA and zein-based nanoparticles on soybean health. *NanoImpact* 100329.

Abstract: The majority of published research on the effect of engineered nanoparticles on terrestrial plant species is focused on inorganic nanoparticles, with the effects of organic polymeric nanoparticles (NP) on plants remaining largely unexplored. It is critical to understand the impact of polymeric NPs on plants if these particles are to be used as agrochemical delivery systems. This study investigates the effect of biodegradable polymeric lignin-based nanoparticles (LNPs) and zein nanoparticles (ZNP) on soybean plant health. The LNPs were synthesized by emulsion evaporation from lignin-graft-poly(lactic-co-glycolic) acid, and ZNPs were synthesized by nanoprecipitation. Dynamic light scattering confirmed that LNPs measured 114 ± 3.4 nm in diameter, with a narrow size distribution and a zeta potential of -53.8 ± 6.9. ZNPs measured 142 ± 3.9 nm and had a zeta potential of +64.5 ± 4.7 mV. Soybeans were grown hydroponically and treated with 0.02, 0.2, and 2 mg/ml of LNPs or ZNPs at 28 days after germination. Plants were harvested after 1, 3, and 7 days of particle exposure and analyzed for root and stem length, chlorophyll concentration, dry biomass of roots and stem, as well as total C, N,P, K, Ca, Mg, S, Fe Na, Al B, Cu, Mn, Mo, and Zn. Root and stem length, chlorophyll, and dry biomass did not differ significantly between treatments and controls for LNPs-treated plants at all concentrations, and at low doses of ZNPs. At 2 mg/ml ZNPs, chlorophyll levels increased by 12%, root biomass increased by 31%, and stem length was reduced by 16% in comparison to the control. Nutrient uptake was largely unaffected by 0.02 and 0.2 mg/ml ZNPs. However, at 2 mg/ml, Na increased (by 9% in stem and leaves and 78% in roots) and an increase in Fe uptake was observed in

the roots for both ZNPs (by 117%) and LNPs (50%). Additionally, an increase in Cu uptake (67%) and a reduction of Al and Mg (43% and 40% relative to control) was observed in the ZNPs treated soybean roots at high concentration of particles. To our knowledge this is the first study to show the effect of zein and lignin based polymeric NPs designed for agrochemical delivery on soybean plant health.

2. Li, Q., Ma, C., **White, J. C.**, and Xing, B. 2021. Effects of phosphorus ensembled nanomaterials on nutrient uptake and distribution in *Glycine max* L. *Agronomy* 11:1086.

Abstract: Nanoscale hydroxyapatite was synthesized to investigate its potential as a phosphorus (P) ensembled nanofertilizer using soybean (*Glycine max* L.) as a model plant. Varied precipitation intensities (0%, 30%, 60%, and 100%) were simulated by adding selected volumes of the fertilizer via foliar and root application routes. Total amounts of added P were the same across all the treatments. The importance of a wash-off effect was investigated on foliar treated seedlings by evaluating different watering heights (20, 120, and 240 cm above the seedlings). The conventional analogue phosphate (pi) was used as a comparison with the synthesized nHA. Fresh weight, pigment content, macro- and micronutrient content were measured in soybean tissues across all the treatments after 4 weeks of greenhouse cultivation. The synthesized nHA showed superior effects on plant nutrient content upon high precipitation intensities. For example, at 100% precipitation intensity, there was 44.0% more P and 77.1% more Ca in shoots, and 250.5% more P and 140.1% more Ca in pods, as compared to the control, respectively. No impact on soybean biomass was evident upon the application of nHA or pi. Further investigation into customizing nHA to enhance its affinity with crop leaves and to extend retention time on the leaf surface is warranted given that the present study did not show significant positive impacts of nHA on soybean growth under the effects of precipitation. Taken together, our findings increase understanding of the potential application of nHA as a nano-enabled fertilizer in sustainable agriculture.

3. Ma, C., Li, Q., Jia, W., Shang, H., Zhao, J., Hao, Y., Li, C., Tomko, M., **Elmer, W.**, **White, J. C.**, and Xing, B. 2021. Role of nanoscale hydroxyapatite in disease suppression of Fusarium-infected tomato. *Environ. Sci. Technol.* https://doi.org/10.1021/acs.est.1c00901.

Abstract: The study investigated the mechanisms by which large- and small-sized nanoscale hydroxyapatite (nHA) suppressed Fusarium-induced wilt disease in tomato. Both nHA sizes at 9.3 mg/L (low) and 46.5 mg/L (high dose) P were foliar-sprayed on Fusarium-infected tomato leaf surfaces three times. Diseased shoot mass was increased by 40% upon exposure to the low dose of large-sized nHA compared to disease controls. Exposure to both nHA sizes significantly elevated phenylalanine ammonialyase activity and total phenolic content in Fusarium-infected shoots by 30-80% and 40-68%, respectively. Shoot salicylic acid content was also increased by 10-45%, suggesting the potential relationship between antioxidant and phytohormone pathways in nHA-promoted defense against fungal infection. Exposure to the high dose of both nHA sizes increased the root P content by 27-46%. A constrained analysis of principal coordinates suggests that high dose of both nHA sizes significantly altered the fatty acid profile in diseased tomato. Particularly, the diseased root C18:3 content was increased by 28-31% in the large-sized nHA treatments, indicating that nHA remodeled the cell membrane as part of defense against Fusarium infection. Taken together, our findings demonstrate the important role of nHA in promoting disease suppression for the sustainable use of nHA in nano-enabled agriculture.

4. Noori, A., Bharath, L. P., and **White, J. C**. 2021. Type-specific impacts of Ag on the protein profile of tomato (*Lycopersicon esculentum*). *Int. J. Phytorem*. In press.

Abstract: Silver nanoparticles (AgNPs) are particularly among the widely used nanomaterials in medicine, industry, and agriculture. The small size and large surface area of AgNPs and other nanomaterials result in their high reactivity in biological systems. To better understand the effects of AgNPs on plants at the molecular level, tomato (*Lycopersicon esculentum*) seedlings were exposed to 30 mg/L silver in the form of nanoparticle (AgNPs), ionic ($AgNO_3$), or bulk (Ag0) in 50% Hoagland media for seven days. The effects of silver on the expression of plant membrane transporters H+-ATPase, vacuolar type H+-ATPase (V-ATPase), and enzymes isocitrate dehydrogenase (IDH), and catalase in roots was assessed using RT-qPCR and immunofluorescence-confocal microscopy. We observed significantly higher expression of catalase in plants exposed to AgNPs (Fold of expression 1.1) and $AgNO_3$ (Fold of expression 1.2) than the control group. The immunofluorescence imaging of the proteins confirmed the gene expression data; the Mean Fluorescence Intensity (MFI) of catalase was detected as 180 ± 33 *103 MFI, 404 ± 59 *103 MFI, and 1114 ± 135 *103 MFI in plants exposed to AgNPs, Ag0, and $AgNO_3$ respectively. Exposure to $AgNO_3$ resulted in the upregulation (Fold of expression 1.2) of H+-ATPase and downregulation (Fold of expression 0.7) of V-ATPase. We also observed a significant reduction in the expression of the redox-sensitive tricarboxylic cycle (TCA) enzyme mitochondrial IDH in plants exposed to AgNPs (120 ± 23 *103 MFI), $AgNO_3$ (101± 13 *103 MFI), or Ag0 (43± 7 *103 MFI) compared to the control (196 ± 19 *103 MFI). This study shows that exposure to silver affects the expression of genes and protein involved in membrane transportation and oxidative response. The ionic form of silver had the most significant effect on the expression of genes and proteins compared to other forms of silver. The results from this study improve our understanding about the molecular effects of different forms of silver on important crop species.

5. Cao, X., Wang, C., Luo, X., Yu, L., **White, J. C.**, **Elmer, W.**, Parkash Dhankher, O., Wang, Z., and Xing, B. 2021. Elemental sulfur nanoparticles enhance disease resistance in tomato. *ACS Nano*. doi.org/10.1021/acsnano.1c02917.

Abstract: In agricultural systems, loss of crop yield to pathogen damage seriously threatens efforts to achieve global food security. In the present work, "organic" elemental sulfur nanoparticles (SNPs) were investigated for management of the fungal pathogen *Fusarium oxysporum* f. sp. *lycopersici* on tomato. Foliar application and seed treatment with SNPs (0.3-1 mg/plant, 30 and 100 nm) suppressed pathogen infection in tomatoes, in a concentration- and size-dependent fashion. Foliar application with 1 mg/plant of 30 nm SNPs (30-SNPs) exhibited the best performance for disease suppression, significantly decreasing disease incidence by 47.6% and increasing tomato growth by X%. Importantly, the disease control efficacy with SNPs was 1.43-fold greater than the commercially available fungicide hymexazol. Mechanistically, SNPs activated the salicylic acid-dependent systemic acquired resistance pathway in tomato shoots and roots, with subsequent upregulating of the expression of pathogenesis-related and antioxidase-related genes, enhanced activity of disease-related enzyme, and the increased synthesis of phytotoxin and antioxidants. In addition, SNPs could also be distributed in the tomato stem, and directly inactivate in vivo pathogens. Confocal and transmission electron microscopy imaging shows that the oxidative stress in tomato shoots and roots, the root plasma membrane damage, and the growth of the pathogen in stem were all significantly decreased by SNPs application. The findings highlight the significant potential of SNPs as an eco-friendly and sustainable crop protection strategy.

6. Elmer, W., **Zuverza-Mena, N.**, **Triplett, L.**, Silady, R., Roberts, E., and **White, J. C.** 2021. Foliar application of copper oxide nanoparticles suppress Fusarium wilt development on chrysanthemum. *Environ. Sci. Technol*. In press.

Abstract: Micronutrients applied as nanoparticles of metal oxides have shown efficacy in vegetable and other crops for improving yield and reducing Fusarium diseases, but their role in ornamental crop management has not been investigated. In 2017, 2018 and 2020 nanoparticles of CuO, Mn2O3, or ZnO were foliarly applied at 500 µg/mL (0.6 mg/plant) to chrysanthemums transplants and planted in potting soil infested with *Fusarium oxysporum* f. sp. *chrysanthemi* or noninfested potting soil. An untreated control and a commercial fungicide, Fludioxonil, were also included. Chrysanthemums treated with nanoscale CuO had a 55, 30, and 32% reduction in disease severity ratings compared to untreated plants in 2017, 2018 and 2020, respectively. Specifically, the averaged dry biomass for the 3 yrs. was reduced 22% by disease, but treatment with nanoscale CuO led to a 23% increase when compared to controls. Similar trends with plant height were observed. Horticultural quality was improved 28% with nano CuO and was equal to the fungicide. Nanoscale Mn2O3 and the fungicide did not consistently reduced disease ratings or increase dry biomass each year. Nanoscale ZnO was ineffective. Nanoscale CuO-treated plants had 24 to 48% more Cu/g tissue than controls ($P < 0.001$). These findings agree with past reports on food crops where single applications of nanoscale CuO improved plant health, growth, and yield, and could offer significant impacts for managing plant diseases on ornamentals.

7. Shang, H., Ma, C., Li, C., Zhao, J., **Elmer, W.**, **White, J. C.**, and Xing, B. 2021. CuO nanoparticle-embedded hydrogels to enhance nutrient supply and growth of lettuce infected with *Fusarium oxysporum* f. sp. *lactucae*. *Environ. Sci. Technol*. In press.

Abstract: The use of nanotechnology to suppress crop diseases has attracted increasing attention in agriculture. The present work investigated the antifungal efficacy of CuO nanoparticle (NPs)-embedded hydrogels, which were synthesized by loading CuO NPs in hydrogels formed from crosslinked interaction between chitosan and acrylic acid, against Fusarium wilt of lettuce (*Lactuca sativa*) caused by *Fusarium oxysporum* f. sp. *lactucae*. In comparison with CuO NPs, 7-day Cu dissolution from CuO NPs-embedded hydrogels was 34.2-94.8% slower regardless of media type, including water, soil extract, or potato dextrose broth. In a greenhouse study involving exposure to CuO NPs-embedded hydrogels, CuO NPs, or Kocide 3000 with equivalent amounts of Cu (31 mg/kg), the fresh shoot biomass was significantly increased by 40, 26.1 and 22.4%, respectively, as compared to the infected control. Furthermore, 28.1 and 17.1% increases in root biomass were evident in the CuO NPs-embedded hydrogel and Kocide 3000 treatments, respectively, relative to the infected control. The addition of hydrogels alone had no impact on the infected seedlings. Notably, CuO NPs-embedded hydrogels enhanced uptake of P, Mn, Zn, and Mg and increased the levels of organic acids, including malic acid, butenedioic acid, gluconic acid, and galactaric acid as compared to the diseased control. Increased salicylic acid (SA) and decreased jasmonic acid (JA) and abscisic acid (ABA) levels with the addition of different forms of Cu may have enhanced disease resistance. Taken together, our findings provide useful information for improving the delivery efficacy of agrichemicals via nano-enabled strategies and advance understanding of plant defense mechanisms triggered by Cu-based NPs.

8. Adeel, M., Shakoor, N., Ahmad, M. A., **White, J. C.**, Jilani, G., and Rui, Y. 2021. Bioavailability and toxicity of nanoscale/bulk rare earth oxides in soil: Physiological and ultrastructural alterations in *Eisenia fetida*. *Environ. Sci.: Nano* 8:1654.

Abstract: The accumulation of rare earth oxides (REOs) in soils is linked with application of nanoscale phosphatic fertilizers, but their effects on earthworm species are poorly understood. We investigated the impacts of nanoscale and bulk-REOs of lanthanum and ytterbium (La_2O_3, Yb_2O_3) at low (25, 50 mg kg^{-1}), intermediate (100, 200 mg kg^{-1}) and high (500, 1000 mg kg^{-1}) concentrations on soil properties and earthworm health. The bioaccumulation of nanoscale and bulk Yb_2O_3 was 12-28% greater than La_2O_3 and occurred in a dose-dependent manner. At 100 mg kg^{-1}, nanoscale and bulk La_2O_3 and Yb_2O_3 induced earthworm mortality by 33-35% and 13-15%, and reduced reproduction by 10-32% and 10-12%, respectively. Ultrastructural observations reveal that nanoscale and bulk REO at the higher doses induced abnormalities in internal organelles, including mitochondria, Golgi apparatus and chloragosomes. Nanoscale REO significantly reduced earthworm digestive and cast enzymes by 20-80% at medium and higher concentrations as compared to bulk materials. Earthworms reduced REO toxicity in the soil by minimizing exposure to microbial biomass carbon and soil enzymes. The data show that REOs beyond 50-100 mg kg^{-1} adversely impacts soil microbiota; these findings provide important understanding of the fate and effects of REO in agricultural systems.

ANALYTICAL CHEMISTRY

1. Drummond, F. A., Lund, J., and **Eitzer, B.** 2021. Honey bee health in Maine wild blueberry production. *Insects* *12*(6):523. https://doi.org/10.3390/insects12060523

Abstract: The paper describes a two-year study conducted in Maine wild blueberry fields (*Vaccinium angustifolium* Aiton) on the health of migratory honey bee colonies in 2014 and 2015. In each year, three or five colonies were monitored at each of nine wild blueberry field locations during bloom (mid-May until mid-June). Colony health was measured by assessing colony strength during wild blueberry bloom. Potential factors that might affect colony health were queen failure or supersedure; pesticide residues on trapped pollen, wax comb, and bee bread; and parasites and pathogens. We found that Varroa mite and pesticide residues on trapped pollen were significant predictors of colony health measured as the rate of change in the amount of sealed brood during bloom. These two factors explained 71% of the variance in colony health over the two years. Pesticide exposure was different in each year as were pathogen prevalence and incidence. We detected high prevalence and abundance of two recently discovered pathogens and one recently discovered parasite, the trypanosome *Lotmaria passim* Schwartz, the Sinai virus, and the phorid fly, *Apocephalus borealis* Brues.

2. **Wang, Y.**, Chen, S., Deng, C., Shi, X., Cota-Ruiz, K., **White, J. C.**, Zhao, L., and Gardea-Torresdey, J. L. (2021). Metabolomic analysis reveals dose-dependent alteration of maize (*Zea mays* L.) metabolites and mineral nutrient profiles upon exposure to zerovalent iron nanoparticles. *NanoImpact* 23, 100336. https://doi.org/10.1016/j.impact.2021.100336

Abstract: Maize plants were cultivated in field soils mixed with zerovalent iron nanoparticles (nZVI) at 0, 50, and 500 mg/kg soil for four weeks. Upon exposure to 500 mg/kg nZVI, ICP-MS results showed that Fe accumulated by roots and translo-

cated to leaves was increased by 36% relative to untreated controls. At 50 mg/kg, root elongation was enhanced by 150–200%; at 500 mg/kg, pigments, lipid peroxidation, and polyphenolic levels in leaves were increased by 12, 87 and 23%, respectively, whereas the accumulation of Al, Ca, and P were decreased by 62.2%, 19.7%, and 13.3%, respectively. A gas chromatography–mass spectrometry (GC–MS) based metabolomics analysis of maize roots revealed that antioxidants and stress signaling-associated metabolites were downregulated at 50 mg/kg but were upregulated at 500 mg/kg. At 50 mg/kg, the content of glutamate was increased by 11-fold, whereas glutamine was decreased by 99% with respect to controls. Interestingly, eight metabolic pathways were disturbed at 50 mg/kg, but none at 500 mg/kg. This metabolic reprogramming at the lower dose represented potential risks to the health of exposed plants, which could be particularly important although no phenotypic impacts were noted. Overall, metabolites analysis provides a deeper understanding at the molecular level of plant response to nZVI and is a powerful tool for full characterization of risk posed to crop species as part of food safety assessment. The findings from the study will improve our understanding of the potential risks posed from nZVI on crop species, which is critical for sustainable application in the future.

ENVIRONMENTAL SCIENCES

1. Burtis J. C., J. D. Poggi, T. B. Duval, E. Bidlack, **J. J. Shepard**, P. Matton, R. Rossetti, and L. C. Harrington. Evaluation of a methoprene aerial application for the control of *Culiseta melanura* (Diptera: Culicidae) in wetland larval habitats. *Journal of Medical Entomology* 2021tjab108, https://doi.org/10.1093/jme/tjab108

Abstract: Eastern equine encephalitis virus (EEEV) is an arbovirus endemic to the eastern United States. Human cases are rare but can be serious. The primary enzootic vector is *Culiseta melanura* (Coquillett) (Diptera: Culicidae), an ornithophagic mosquito. We conducted an aerial application of a granular methoprene formulation in Hockomock Swamp (Massachusetts), which represents a focus of EEEV transmission. Water collected from inside and outside *Cs. melanura* crypts was evaluated in bioassays of early fourth instar *Cs. melanura* larvae using treated and untreated water. Adult eclosion rates were 36% significantly lower in treated compared with untreated water ($P < 0.05$). Eclosion rates for water collected from inside crypts were significantly higher (62%) than rates from outside crypts (30%) ($P < 0.05$), indicating higher efficacy outside crypts. We tested whether reduced methoprene efficacy inside the crypts was due to reduced chemical penetration into this habitat. Chemical water analyses confirmed that methoprene concentrations were lower inside the crypts (0.1 ± 0.05 ppb) compared to water from outside crypts (1.79 ± 0.41 ppb). The susceptibility of *Cs. melanura* to methoprene was also determined to allow for comparison against concentrations observed in water collected from the field (LC-95: 1.95 ± 0.5 ppb). Overall, methoprene-treated water prevented mosquito development for up to 4 wk, but with a reduction in efficacy between 4- and 6-wk post-application. Our results suggest that aerial methoprene applications can effectively treat open water in wetlands but may not provide efficacious control of *Cs. melanura* due to an inability to penetrate larval habitats.

2. Cui, Zhouqi, **Blaire Steven**, and **Quan Zeng**. Complete genome sequences of *Curtobacterium*, *Pantoea*, *Erwinia*, and two *Pseudomonas* sp. strains, isolated from apple flower stigmas from Connecticut, USA. *Microbiology Resource*

Announcements 10.19 (2021): e00154-21. https://journals.asm.org/doi/10.1128/MRA.00154-21

Abstract: The genome sequences of 5 bacterial strains isolated from apple flower stigmas are reported. The strains represent species of *Curtobacterium*, *Pantoea*, and *Erwinia* and two species of *Pseudomonas*. These data will provide information for future taxonomic studies and information for investigating the metabolic and functional characteristics of apple flower-colonizing bacteria.

3. **Doug E. Brackney, Jacquelyn C. LaReau**, and Ryan C Smith. 2021. Frequency matters: How successive feeding episodes by blood-feeding insect vectors influences disease transmission. *PLoS Pathogens* 17:6 e1009590

Abstract: Recent studies have begun to highlight the integral yet previously unexplored mechanisms by which vector blood feeding contributes to the transmission of vector-borne diseases. While at present, evidence has only been provided for mosquitoes and sandflies, the influence of multiple blood meals on both viral and parasitic pathogens suggests that arthropod feeding behaviors may influence a wide range of vector–pathogen interactions. Moreover, evidence suggests that parasite or virus infection can manipulate vector blood-feeding behaviors, further highlighting the influence of additional blood meals on the transmission of veterinary and medically important diseases.

4. **Goudarz Molaei**, **Eliza A. H. Little**, **Scott C. Williams**, and **Kirby C. Stafford III**. First record of established populations of the invasive pathogen vector and ectoparasite *Haemaphysalis longicornis* (Acari: Ixodidae) in Connecticut, United States. *Journal of Medical Entomology*, tjab117, https://doi.org/10.1093/jme/tjab117, Published: 29 June 2021.

Abstract: A number of invasive tick species capable of transmitting pathogens have been accidentally introduced into the U.S. in recent years. The invasion and further range expansion of these exotic ticks have been greatly facilitated by frequent global travel and trade as well as increases in legal and illegal importation of animals. We describe the discovery of the first established populations of *Haemaphysalis longicornis* Neumann and the first fully engorged human parasitizing specimen documented through passive tick surveillance in Fairfield County, Connecticut, U.S. We also report several individual specimens of this invasive arthropod and vector of multiple pathogens of medical and veterinary importance collected through active tick surveillance from three counties (Fairfield, New Haven, and New London). Considering the potential for invasive ticks to transmit numerous native and emerging pathogens, the implementation of comprehensive surveillance programs will aid in prompt interception of these ticks and reduce the risk of infection in humans and wildlife.

PLANT PATHOLOGY AND ECOLOGY

1. **Steven, B.**, **LaReau, J. C.**, **Taerum, S.** J., **Zuverza-Mena, N.**, and **Cowles, R. S.** 2021. What's under the Christmas tree? A soil sulfur amendment lowers soil pH and alters fir tree rhizosphere bacterial and eukaryotic communities, their interactions, and functional traits. *Microbiology Spectrum*. https://doi.org/10.1128/spectrum.00166-21

In this study, we describe the legacy effects of a soil sulfur amendment experiment performed 6 years prior and the resulting alterations to the rhizosphere communities of fir trees on a Christmas tree plantation. The pH of bulk soil was 1.4 pH

units lower than that of untreated soils and was associated with reduced Ca, Mg, and organic matter contents. Similarly, root chemistry differed due to the treatment, with roots in sulfur-amended soils showing significantly higher Al, Mn, and Zn contents and reduced levels of B and Ca. 16S rRNA and 18S rRNA gene sequencing was pursued to characterize the bacterial/archaeal and eukaryotic communities in the rhizosphere soils. The treatment induced dramatic and significant changes in the microbial populations, with thousands of 16S rRNA gene sequence variants and hundreds of 18S rRNAgene variants being significantly different in relative abundances between the treatments. Additionally, co-occurrence networks showed that bacterial and eukaryotic interactions, network topology, and hub taxa were significantly different when constructed from the control and treated soil 16S and 18S rRNA gene amplicon libraries. Metagenome sequencing identified several genes related to transport proteins that differentiated the functional potentials of the communities between treatments, pointing to physiological adaptations in the microbial communities for living at altered pH. These data show that a legacy of soil acidification increased the heterogeneity of the soil communities as well as decreasing taxon connections, pointing to a state of ecosystem instability that has potentially persisted for 6 years.

JOURNAL ARTICLES APPROVED JUNE 2021

Aytac, Z., J. Xu, S. Kumar, **Brian D. Eitzer**, T. Xu, N. Vaze, K. W. Ng, **Jason C. White**, M. Chan-Park, Y. Luo, and P. Demokritou. Enzyme- and relative humidity (RH)-responsive nature derived antimicrobial electrospun biodegradable polymer fibers for food packaging. *Applied Materials and Interfaces*.

Bugbee, Gregory J., and **Summer E. Stebbins**. Staffordville Reservoir, Diagnostic feasibility study 2019. *CAES Bulletin* (Web Only).

Burtis, J. C., J. D. Poggi, T. B. Duval, E. Bidlack, **John J. Shepard**, P. Matton, R. Rossetti, and L. C. Harrington. Evaluation of a methoprene aerial application for the control of *Culiseta melanura* (Diptera: Culicidae) in cryptic wetland habitats. *Journal of Medical Entomology*.

Duan, J. J., R. G. Van Driesche, J. Schmude, R. Crandall, **Claire Rutledge**, N. Quinn, B. H. Slager, J. R. Gould, and J. Elkinton. Significant suppression of emerald ash borer by introduced larval parasitoids: Potential for North American ash recovery. *Ecological Applications*.

LaMondia, James A., and L. M. Dandurand. Effects of planting density on litchi tomato (*Solanum sisymbriifolium*) trap crop efficacy against the tobacco cyst nematode *Globodera tabacum*. *Journal of Nematology* (abstract).

LaMondia, James A., **Brian D. Eitzer**, and R. R. Black. Management of fungicide residues in Connecticut shade-grown tobacco. *Tobacco Science*.

Li, Yonghao, and **Robert E. Marra.** Beech Leaf Disease – Updates 2021. *CAES Fact Sheet*.

Nason, Sara L., E. Lin, **Brian Eitzer**, J. Koelmel, and J. Peccia. Changes in sewage sludge chemical signatures during a COVID-19 community lockdown part 1: Traffic, drugs, mental health, and disinfectants. *Environmental Toxicology and Chemistry*.

Nason, Sara L., E. Lin, K. J. G. Pollitt, and J. Peccia. Changes in sewage sludge chemical signatures during a COVID-19 community lockdown part 2: Non-targeted analysis of sludge and evaluation with COVID-19 metrics. *Environmental Toxicology and Chemistry*.

Quinn, N. F., J. S. Gould, **Claire E. Rutledge**, A. Fassler, J. S. Elkinton, and J. J. Duan. Spread and phenology of *Spathius galinae* Belokobylskij & Strazanac (Hymenoptera: Braconidae) and *Tetrastichus planipennisi* Yang (Hymenoptera: Eulophidae), recently introduced for biocontrol of *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae). *Biological Control*.

Steven, Blaire, Josephine Hyde, and **Jacquelyn C. LaReau**. The axenic and gnotobiotic mosquito: emerging models for microbiome host interactions. *Frontiers in Microbiology*.

Stravoravdis, S., **Robert E. Marra**, N. R. LeBlanc, J. A. Crouch, and J. P. Hulvey. Evidence for the role of CYP51A and xenobiotic detoxification gene overexpression in differential sensitivity to azole fungicides in boxwood blight pathogens. *International Journal of Molecular Sciences*.

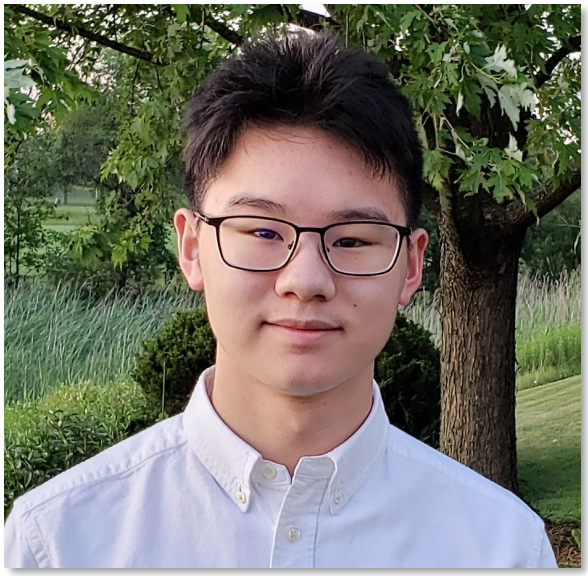
Van Driesche, Roy G. Jonathan M. Schmude, Nicole F. Quinn, Toby R. Petrice, **Claire E. Rutledge**, Therese M. Poland, Leah S. Bauer, and Joe Elkinton. 2021. Niche partitioning and coexistence of parasitoids of the same feeding guild introduced for biological control of an invasive forest pest. *Biological Control*. In press.

Zulli, A., A. Pan, S. M. Bart, F. W. Crawford, E. H. Kaplan, M. Carter, A. Ko, **Duncan Cozens**, M. Sanchez, **Doug E. Brackney**, and J. Peccia. Predicting daily COVID-19 case rates from SARS-CoV-2 RNA concentrations across a diversity of wastewater catchments. *Environmental Science & Technology*.

NEW STAFF, STUDENTS, AND VOLUNTEERS JUNE 2021

MR. SIMON DUGGAN joined the Station in June as an undergraduate research intern in the Department of Analytical Chemistry. He is currently pursuing an Associate Degree in Biology and plans to study botany in the future. Simon aims to better understand human negative impacts on the environment, with the hopes that they could be mitigated in the future. As a member of the Center for Sustainable Nanotechnology's Summer Undergraduate Research Experience (SURE) Program, Simon will focus his work on a nano-agriculture project. For this research, Simon will examine the ability of copper oxide nanoparticles to promote fungal disease tolerance in tomatoes and the effects of lithium cobalt oxide on soybean plant tissues with mentor Dr. Carlos Tamez.

DR. SHITAL R. VAIDYA joined the Station as a Research Affiliate in June 2021; she previously worked as a scientific collaborator during May 2021. She obtained a Ph.D. degree in Nanotechnology from the University of Trieste, Italy, in 2015. Her Ph.D. research focused on understanding the magnetic properties of metallic and metal oxide thin films using Auger Photoelectron Coincidence Spectroscopy. She also has extensive experience of teaching Physics at different levels for more than four years. With a Physics major, Dr. Vaidya completed her Master of Science program from the Department of Physics, University of Pune, India, in 2008, and the Bachelor of Science studies from A.W. College, Otur, University of Pune, India, in 2006. As a junior research fellow at the University of Pune, Dr. Vaidya chemically synthesized copper and zinc oxide nanoparticles and analyzed their optical, magnetic, and structural properties. Her research showed room-temperature ferromagnetism in copper nanoparticles. At CAES, Dr. Vaidya is working with Dr. Nubia Zuverza-Mena in the Department of Analytical Chemistry (DAC) and helping a graduate student in DAC to characterize the green-synthesized nanoparticles by UV-Visible, dynamic light scattering (DLS), scanning electron microscope (SEM), and transmission electron microscope (TEM). She's processing nanoparticle-treated plant tissues to localize and analyze the nanomaterial within roots and leaves at the cellular level. Her next steps in these studies are optimizing the cutting of the resin-embedded samples using a microtome and studying the nanoparticle transport process in plants using TEM. Dr. Vaidya can be reached via her email, shitalravaidya@gmail.com.



MR. ALEXANDER ZHONG is a summer intern working virtually with Dr. Sara Nason through the Doris Duke Conservation Scholars Program at Yale School of the Environment. He is a junior undergraduate student at Emory University studying data science and biology. He will be assisting with analyzing PFAS in dried blood spots.

MR. ETHAN PAINE recently accepted a position as Technician at the Valley Laboratory. He graduated cum laude with a Bachelor of Science in Ecology and Evolutionary Biology from the University of Connecticut in December 2015. Ethan had previously worked at the Valley Lab as a Seasonal Research Assistant.

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