Station News

The Connecticut Agricultural Experiment Station
Volume 13 Issue 8| August 2023

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

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ADMINISTRATION

DR. JASON C. WHITE along with **DR. QUAN ZENG** participated in a Zoom call with collaborators in Italy and Spain regarding a joint USDA grant proposal (July 3); gave remote presentation titled "Nanotechnology-enabled agriculture: A path to global food security?" to a Workshop on Novel Fertilizers and Plant Nutrition at the University of Delaware (July 5); participated in a Zoom call with a journalist to discuss the filming of a podcast at the 113th Annual CAES Plant Science Day (July 5); hosted the monthly CAES J-Visa recipient meeting (July 7); along with **DR. CHRISTIAN DIMKPA** and **DR. SHITAL VAIDYA,** hosted a Zoom call with collaborators at Johns Hopkins University to discuss progress on a joint USDA nanoscale phosphorus project (July 7); participated in a Zoom call with collaborators at the University of Texas El Paso and the University of Rhode Island to discuss a new USDA funded proposal (July 7); participated in a Zoom call with collaborators at the Colorado School of Mines and Johns Hopkins University to discuss a joint grant proposal (July 7); along with **DR. YI WANG** participated in a Zoom call with collaborators at the University of Massachusetts to discuss progress on a joint USDA proposal on nanoscale sulfur (July 7); hosted the monthly NSF Center for Sustainable Nanotechnology (CSN) Nanochemistry-Plant working group Zoom call (July 11); participated in the weekly CSN all-hands Zoom call (July 12); participated in a workshop at Carnegie Mellon University to begin proposal preparation for a NSF Science and Technology Center (July 17-20); gave a presentation by Zoom titled "Nanobiotechnology-based Strategies for Enhanced Crop Stress Resilience" to The International Conference on Sustainable and Applied Nanotechnology for Agriculture and Health (SANTAH) (July 19); along with collaborators from the University of Minnesota met by Zoom with research staff from WinField United - Land O'Lakes Inc. to discuss nanotechnology and agriculture (July 19); met by Zoom with collaborators at the University of Minnesota and Katana AgriScience to discuss nanotechnology and agriculture (July 20); spoke by Zoom with collaborators at Rutgers University to discuss a joint grant proposal (July 21): along with 10 CAES staff travelled to the University of Massachusetts Amherst for the UMass-CAES Nano-enabled Agriculture Symposium and gave a presentation titled "Nanotechnology-enabled Agriculture Research at the CAES" (July 25); gave a Zoom presentation titled "Nanotechnology-enabled agriculture: A path to global food security?" at the 2023 International Symposium on the Advances of Plant Nanobiotechnology; Huazhong Agricultural University, Wuhan, Hubei Province (July 26); participated by Zoom in the PhD proposal defense of a student at the University of Massachusetts Amherst (July 27); participated in the NSF CSN monthly Faculty call (July 27); and participated in a Zoom call with colleagues at the University of Minnesota, Katana AgriScience and OTB Ventures Australia to discuss nanotechnology and agriculture (July 31).

PUBLICATIONS:

1. Sharma, S., Singh, G., **Wang, Y.**, **White, J. C.**, Xing, B., and Parkash Dhankher, O. (2023). Nanoscale sulfur alleviates silver nanoparticle toxicity and improves seed and oil yield in Soybean (*Glycine max*). *Environ. Poll.* DOI: 10.1016/j.envpol.2023.122423

Abstract: Silver nanoparticles (AgNPs) are commonly used in many commercial products due to their antimicrobial properties, and significant exposure in agricultural systems is anticipated. AgNPs accumulation in soil and subsequent uptake by plants can be harmful to plant growth and exposure to animals and humans through the food chain is a major concern. This study evaluated the potential protective role of nanosulfur (NS) and bulk sulfur (BS) at 200 and 400 mg/kg soil application in alleviating silver nanoparticle (AgNPs; 32 and 64 mg/kg) phytotoxicity to soybean [*Glycine max* (L) Merr.].

2. Hofman, T., Ghoshal, S., Tufenkji, N., Franklin Adamowski, J., Bayen, S., Chen, Q., Demokritou, P., Flury, M., Hüffer, T., Ivleva, N. P., Rong, J., Leask, R. L., Meric, M., Mitrano, D., Sander, M., Pahl, S., Rillig, M., Walker, T., **White, J. C.**, and Wilkinson, K. (2023). Pathways to sustainable use of plastics in plant agriculture. *Nature Commun. Earth Environ*. DOI: 10.1038/s43247-023-00982-4

Abstract: Plastics have become an integral component of modern agriculture food production, but their widespread use has led to the accumulation of large quantities in soils, and the urgency for a more sustainable use of plastics cannot be underestimated. Rational use and reduction, collection, reuse, and innovative recycling are key measures to curb plastic pollution from agriculture. Plastics that cannot be collected after use must be biodegradable in an environmentally benign manner. Harmful plastic additives must be replaced with alternatives to reduce toxicity burdens and included in the ongoing negotiations surrounding the UN Plastics Treaty. While plastics offer many benefits in plant agriculture and full substitution is not currently possible without increasing the overall environmental footprint and jeopardizing food security, alternatives with smaller environmental impacts should be used and promoted within a clear socio-economic framework. Better monitoring and reporting, technical innovation, education and training, and incentives could help reduce agricultural plastic pollution.

3. Jia, W., Ma, C., **White, J. C.**, Qi, Y., Wang, J., Cao, H., Zhu, Q., Sun, H., Wang, C., and Xing, B. (2023). Magnetic biochar mediates BDE-153 accumulation and metabolism in rice (*Oryza sativa* L.) by modulating iron plaque and the fatty acid profile. *ACS ES&T Engineering*. DOI: 10.1021/acsestengg.3c00268

Abstract: The present study investigated the role of different doses of magnetic biochar (MBC, 0.65 to 6.7 g/L) in altering 2, 2', 4, 4', 5, 5'- hexabrominated diphenyl ether (BDE-153) accumulation and metabolism in rice under hydroponic conditions for 10 days by modulating iron plaque (IP) formation and the fatty acids (FAs) profile as compared to biochar (BC). Both metabolomic and proteomic techniques were employed to further understanding of the molecular response in BDE-153-treated rice as affected by MBC co-exposure. Amendment with MBC enhanced IP formation by 3.0- and 2.5-fold as compared to BDE-153 and BC treatments, respectively. Treatment with MBC inhibited the FAs con-

tent by up to 39.9% compared to BDE-153 alone, and a significant negative correlation between IP and total fatty acid content (R2=0.7851**) was found. Although there is no obvious dose dependency of MBC on BDE-153 accumulation in rice, the accumulation of BDE -153 in rice was inhibited by 31.4-81.9% upon exposure to different doses of MBC. The reductive debromination of BDE-153 on the root surface and inner roots was greatest at 1.3 g/L MBC. The transfer of BDE-153 from the root surface to inner root under MBC co-exposure was affected by both root fatty acids and IP. MBC inhibited the expression of acyl carrier protein (ACP) associated with FAs synthesis, increased the expression of superoxide dismutase [Cu-Zn] and the content of FA 18:1+3O related to FAs metabolism, and consequently suppressed the FAs biosynthesis. In addition, IP formation under MBC treatments weakened the correlation between BDE-153 translocation and FAs content. Taken together, these findings demonstrate the molecular mechanisms of BDE-153 metabolism under MBC co-exposure and highlight the potential of this novel strategy for in-situ remediation of BDE-153 contaminated environments.

4. Gomez-Maldonado, D., Phillips, S. G., **Vaidya, S.**, Bartley, P. C., **White, J. C.**, Fairbrother, D. H., and Peresin, M. S. (2023). Modifying soluble NPK release with hydrophobized nanocellulose-based hydrogels for sustainable enhanced efficiency fertilizers. *Environ. Sci.*: *Nano.* DOI: 10.1039/D3EN00306J

Abstract: Enhancing the delivery efficiency of NPK fertilizers benefits both crops and the environment through moderating the supplied dosage of nutrients in the soil, avoiding side reactions, maximizing absorption by the plant, and minimizing leaching and runoff. Bio-based materials such as cellulose are ideal scaffolds for nutrient delivery due to their inherent biocompatibility, biodegradability, and significant water uptake. In this work, nanocellulose-based hydrogels were regenerated from mixed softwood in acidic media and loaded with NPK by immersion in varied concentrations of an NPK-rich fertilizer solution. High loading of NPK was achieved within the hydrogel, but immersion in the matrix provided only slight slowing of nutrient release compared to rapid solubility of conventional formulations. Densification, crosslinking, and coating of the hydrogels with beeswax were ineffective strategies to further slow NPK release. Following these results, both gas and solution-phase esterification reactions of the cellulosic matrix with hexanoyl chloride were performed after NPK loading to introduce a hydrophobic surface layer. While solution-phase modification led to phosphorus leaching and was overall ineffective in altering nutrient release, the gas-phase modification slowed the release of P and K by more than an order of magnitude. Moreover, it was found that varying both the properties of the hydrophobic surface layer and the nutrient loading provide a means to tune release rates. Overall, this work demonstrates the potential of nanocellulose-based hydrogels to be used as an environmentally safe and sustainable vehicle for the controlled release of nutrients in agricultural applications.

5. Shang, H., Ma, C., Lia, C., Cai, Z., Shen, Y., Han, L., Tran, J., **Elmer, W.**, **White, J. C.**, and Xing, B. (2023). Aloe vera extract gel-derived selenium nanoparticles enhance disease resistance in lettuce by modulating the metabolite profile and bacterial endophytes composition. *ACS Nano*, *17*(14), 13672–13684. DOI: 10.1021/acsnano.3c02790

Abstract: The use of nanotechnology to suppress crop diseases has attracted significant attention in agriculture. The present study investigated the antifungal mechanism by which aloe vera extract gel-biosynthesized (AVGE) selenium nanoparticles (Se NPs) suppressed Fusarium-induced wilt disease in lettuce (*Lactuca sativa*). AVGE Se NPs were synthesized by utilizing sodium selenite as a Se source and AVGE as a biocompatible capping and reducing agent. Over 21d, 2.75% of total AVGE Se NPs was dissolved into Se ions, which was more than 8-fold greater than bare Se NPs (0.34%). Upon exposure to soil applied AVGE Se NPs at 50 mg/kg, fresh shoot biomass was significantly increased by 61.6 and 27.8% over the infected control and bare Se NPs, respectively. As compared to the infected control, the shoot levels of citrate, isocitrate, succinate, malate, and 2-oxo-glutarate were significantly upregulated by 0.5-3-fold as affected by both Se NPs. In addition, AVGE Se NPs significantly increased the shoot level of khelmarin D, a type of coumarins, by 4.40- and 0.71-fold over infected controls and bare Se NPs respectively. Additionally, AVGE Se NPs showed greater up-regulation of jasmonic acid and down-regulation of abscisic acid content relative to bare Se NPs in diseased shoots. Moreover, the diversity of bacterial endophytes was significantly increased by AVGE Se NPs, with the value of Shannon index 40.2 and 9.16% greater over the infected control and bare Se NPs. Collectively, these findings highlight the significant potential of AVGE Se NPs as an effective and biocompatible strategy for nano-enabled sustainable crop protection.

6. Li, M., Zhang, P., Guo, Z., Cao, W., Gao, L., Li, U., Tian, C. F., Shen, Y., Ren, F., Rui, Y., **White, J. C.**, and Lynch, I. (2023). Molybdenum nanofertilizer boosts biological nitrogen fixation and yield of soybean through delaying nodule senescence and nutrition enhancement. *ACS Nano*, *17*(15), 14761–14774. DOI: 10.1021/acsnano.3c02783

Abstract: Soybean (*Glycine max*) is a crop of global significance and has low reliance on N fertilizers due to its biological nitrogen fixation (BNF) capacity, which harvests ambient N2 as a critical ecosystem service. BNF can be severely compromised by abiotic stresses. Enhancing BNF is increasingly important not only to alleviate global food insecurity but also to reduce the environmental impact of agriculture by decreasing chemical fertilizer inputs. However, this has proven challenging using current genetic modification or bacterial nodulation methods. Here, we demonstrate that a single application of a low dose (10 mg/kg) of molybdenum disulfide nanoparticles (MoS_2 NPs) can enhance soybean BNF and grain yield by 30%, compared with conventional molybdate fertilizer. Unlike molybdate, MoS_2 NPs can more sustainably release Mo, which then is effectively incorporated as a cofactor for the synthesis of nitrogenase and molybdenum-based enzymes that subsequently enhance BNF. Sulfur is also released sustainably and incorporated into biomolecule synthesis, particularly in thiol-containing antioxidants. The superior antioxidant enzyme activity of MoS_2 NPs, together with the thiol compounds, protect the nodules from reactive oxygen species (ROS) damage, delay nodule aging, and maintain the BNF function for a longer term. The multifunctional nature of MoS_2 NPs makes them a highly effective strategy to enhance plant tolerance to abiotic stresses. Given that the physicochemical properties of nanomaterials can be readily modulated, material performance (e.g., ROS capturing capacity) can be further enhanced by several synthesis strategies. This study thus demonstrates

that nanotechnology can be an efficient and sustainable approach to enhancing BNF and crop yield under abiotic stress and combating global food insecurity.

7. Kah, M., Sabliov, C., **Wang, Y.**, and **White, J. C.** (2023). Nanotechnology as a foundational tool to combat global food insecurity. *One Earth*, *6*(7), 772-775. DOI: 10.1016/j.oneear.2023.06.011

Abstract: With a global population racing toward 10 billion people in the next 25 years, the challenge to global food production, storage, and distribution will be immense. There are a range of technologies and strategies that could, at least in theory, be successfully applied to improve food security in a sustainable way. Nanotechnology is one such strategy that is being increasingly recognized as having great potential. Here, we present examples of how nanotechnology can be applied from farm to fork and help to improve availability, access, and utilization of food. We also discuss major challenges associated with efficient production and deployment at industrial scale, regulatory and safety concerns, and consumer acceptance. Recognizing that issues of food security are highly contextual, we recommend increasing discipline convergence and multisectorial collaborations from a one-health perspective to guide the development and commercialization of impactful nano-enabled solutions that will combat global food insecurity.

8. Tuga, B., O'Keefe, T., **Deng, C**., Ligocki, A., **White, J. C.**, and Haynes, C. (2023). Designing nanoparticles for sustainable agricultural applications. *Trend Chem*. DOI: 10.1016/j.trechm.2023.07.004

Abstract: Progress towards achieving global food security continues to be hindered by several economic, geo-political and environmental variables which has led the United Nations to place emphasis on achieving Zero Hunger by 2030. Thus, it is important to invest in novel, eco-friendly, cost-effective solutions that will increase agricultural productivity. For this reason, nanoscale materials are increasingly being developed for use in agriculture with attention on controlling various properties such as size, shape, surface modifications and transformations for improved impact in plants. With continued interdisciplinary and collaborative efforts among nanoparticle experts and plant scientists, the research area will evolve to identify the best nanoparticle properties for foliar application to plants.

ANALYTICAL CHEMISTRY

DR. CHRISTIAN DIMKPA gave a virtual presentation titled Nanotechnology in agro-environmental research: insights into implications and applications on at the Bio-Geo Colloquium of the University of Jena, Germany (July 4). The presentation was attended by faculty, students and staff of the Institute of Geosciences, Institute of Microbiology and Institute of Biodiversity.

DR. BRIAN EITZER (Emeritus) attended the 59th annual North American Chemical Residue Workshop in Fort Lauderdale, Florida (July 23-27). **DR. EITZER** is a member of the board of directors for the conference and acts as a judge of the posters.

DR. YI WANG, **DR. CHAOYI DENG**, **DR. PAUL AIKPOKPODION, DR. SHITAL VAIDYA, DR. JINGYI ZHOU, DR. CHRISTIAN DIMKPA** and **DR. JASON WHITE** participated in a collaborative symposium on Nano-enabled Agriculture Symposium at UMass Amherst (July 25).

DR. YI WANG visited UConn invited by Dr. Mingyu Qiao and Dr. Yangchao Luo for future collaboration (July 26).

PUBLICATIONS

1. Modifying soluble NPK release with hydrophobized nanocellulose-based hydrogels for sustainable enhanced efficiency fertilizers. (2023). Gomez-Maldonado, D., Phillips, S. G., **Vaidya, S.**, Bartley, P. C. III, **White, J. C.**, Fairbrother, D. H., and Peresin, M. S. *Environ. Sci.: Nano*, DOI: 10.1039/D3EN00306J

Abstract: Enhancing the delivery efficiency of NPK fertilizers benefits both crops and the environment through moderating the supplied dosage of nutrients in the soil, avoiding side reactions, maximizing absorption by the plant, and minimizing leaching and runoff. Bio-based materials such as cellulose are ideal scaffolds for nutrient delivery due to their inherent biocompatibility, biodegradability, and significant water uptake. In this work, nanocellulose-based hydrogels were regenerated from mixed softwood in acidic media and loaded with NPK by immersion in varied concentrations of an NPK-rich fertilizer solution.

ENTOMOLOGY

GRANTS AWARDED:

1. DR. MEGAN LINSKE (PI) and **DR. SCOTT WILLIAMS** were awarded a two-year contract from the Centers for Disease Control and Prevention to evaluate "Efficacy of fall application of synthetic and natural acaricides to suppress host-seeking *Ixodes scapularis* ticks." $230,818.

DEPARTMENTAL RESEARCH UPDATES:

DR. GOUDARZ MOLAEI presented an invited talk on challenges of ticks and tick-borne diseases in Connecticut (July 6) was interviewed by Cape Cod Times/ USA Today (July 12); WTIC Radio, NPR, WTNH, WFSB Channel 3, and Fox 61 (July 31).

TIA M. BLEVINS attended the Connecticut Nursery & Landscape Association (CNLA) Summer Field Day with presentations highlighting pests of concern for Connecticut's green industry including beech leaf disease, spotted lanternfly, and box tree moth (July 26).

ANGELA BRANSFIELD participated via Zoom in Yale University's Biosafety Committee meeting (July 20).

DR. KELSEY FISHER met with colleagues from University of Maryland (July 6); Iowa State University (July 6 and 21); presented a webinar titled "Monarch butterfly ecology, behavior, and vulnerabilities in North Central United States Agricultural Landscapes" in collaboration with Dr. Steven Bradbury (Iowa State University) and Dr. Niranjana Krishnan (University of Maryland) for the Corteva Agrosciences Ecological Modeling Seminar Series (July 12); Corteva Agrosciences (July 14); non-profit organizations (July 14); presented a table display on monarch butterfly ecology and conservation needs at the All Things Pollinator outreach event serving the Newhallville community with the Community Placemaking Engagement Network in New Haven, CT (July 15); Missouri University of Science and Technology (July 19); presented about general entomology and monarch butterfly ecology and conservation for the CT DEEP Teacher Summer Camp at Lockwood Farm with **KATHERINE DUGAS** (July 19); attended the monthly Managed Pollinator Protection Plans working group virtual meeting (July 20); and University of Georgia (July 21); attended a webinar through Monarch Joint Venture to learn about combining solar energy strategies with monarch butterfly and pollinator conservation (July 25).

DR. ANDREA GLORIA-SORIA participated in the annual meeting of the "Comprehensive characterization of ancestral populations of the vector *Aedes aegypti* on Indian Ocean islands" International Working Group, Yale University, New Haven, CT (June 6-9).

DR. MEGAN LINSKE participated in a call with members of Genesis Labs, Inc. to discuss the 2023 field season and the application of their rodent-targeted products in laboratory trials (July 25).

DR. GALE RIDGE was interviewed by the Lakeville Journal about this year's spongy moth activity (July 5).

JOHN SHEPARD was interviewed about invasive mosquito species and the range expansion of mosquitoes in North America by PCT Magazine (July 20 and 26).

DR. VICTORIA SMITH was interviewed by Hearst CT Media, concerning spotted lanternfly (July 5); was interviewed by the Lakeville Journal, concerning spongy moth (July 6); participated (via Zoom) in a webinar, sponsored by USDA-APHIS-Plant Protection and Quarantine, concerning post-entry quarantine regulations (July 12); was interviewed by News 12 Connecticut, concerning spotted lanternfly (July 13); participated via Teams in a webinar concerning the Plant Pathogen Diagnostic Certification Program (July 18); participated in the mid-year meeting of the Cooperative Agricultural Pest Survey, held in the Jones Auditorium (July 18); participated via Teams in the quarterly call of the Eastern Plant Board (July 25); participated in the CT Nursery and Landscape Summer Meeting, with a presentation titled "BOLO: Spotted Lanternfly and Box Tree Moth," held at Monrovia Nursery in Granby (July 26); participated via Teams in the business meeting of the Eastern Plant Board, held in Little Rock, Arkansas (July 31).

DR. KIRBY C. STAFFORD III (Emeritus) was interviewed on ticks and the Lyme disease vaccine by Bloomberg News (July 19) and interviewed by reporter Eric Boodman about the new Lyme Shield System with a Lyme disease vaccine rodent targeted bait (July 26).

TRACY ZARRILLO organized and co-chaired an online meeting of leading New England bee experts to discuss a collaborative project which will synthesize what is known about New England bees (July 20).

PUBLICATIONS:

1. Price, K. J., **Khalil, N.**, Witmier, B. J., Coder, B. L., Boyer, C. N., Foster, E., Eisen, R. J., and **Molaei, G.*** (2023). Evidence of Protozoan and Bacterial Infection and Co-Infection and Partial Blood Feeding in the Invasive Tick *Haemaphysalis longicornis* in Pennsylvania. *Journal of Parasitology*, *109*(4), 265–273. DOI: 10.1645/22-122

Abstract: The Asian longhorned tick, *Haemaphysalis longicornis*, an invasive tick species in the United States, has been found actively host-seeking while infected with several human pathogens. Recent work has recovered large numbers of partially engorged, host-seeking *H. longicornis*, which together with infection findings raises the question of whether such ticks can reattach to a host and transmit pathogens while taking additional bloodmeals. Here we conducted molecular blood meal analysis in tandem with pathogen screening of partially engorged, host-seeking *H. longicornis* to identify feeding sources and more inclusively characterize acarological risk. Active, statewide surveillance in Pennsylvania from 2020 to 2021 resulted in the recovery of 22/1,425 (1.5%) partially engorged, host-seeking nymphal and 5/163 (3.1%) female *H. longicornis*. Pathogen testing of engorged nymphs detected 2 specimens positive for *Borrelia burgdorferi* sensu lato, 2 for *Babesia microti*, and 1 co-infected with *Bo. burgdorferi* s.l. and *Ba. microti*. No female specimens tested positive for pathogens. Conventional PCR blood meal analysis of *H. longicornis* nymphs detected avian and mammalian hosts in 3 and 18 specimens, respectively.

Mammalian blood was detected in all *H. longicornis* female specimens. Only 2 *H. longicornis* nymphs produced viable sequencing results and were determined to have fed on black-crowned night heron, *Nycticorax nycticorax*. These data are the first to molecularly confirm *H. longicornis* partial blood meals from vertebrate hosts and *Ba. microti* infection and co-infection with *Bo. burgdorferi* s.l. in host-seeking specimens in the United States, and the data help characterize important determinants indirectly affecting vectorial capacity. Repeated blood meals within a life stage by pathogen-infected ticks suggest that an understanding of the vector potential of invasive *H. longicornis* populations may be incomplete without data on their natural host-seeking behaviors and blood-feeding patterns in nature.

2. Fisher, K. E. (2023). Understanding Monarch Movement. *Connecticut Gardener*, *29*(3), 12-13.

Abstract: Monarch butterflies (*Danaus plexippus*) are a charismatic species known for their characteristic orange and black coloration and annual migration from Mexico to Canada. Unfortunately, the monarch butterfly is an example of a common species that is becoming less common because of human impact. The monarch butterfly population decline is linked to many factors but is most significantly associated with the loss of habitat including milkweed and nectar resources because of land conversion, agriculture intensification, and urbanization. Here, Iowa was used as a case study for monarch butterfly conservation. With a final goal in place to establish 460,504 hectares of habitat in Iowa over 20 years, the Iowa Monarch Conservation Consortium came together to figure out where monarch habitat should be planted first so that it makes the biggest impact. Based on collaborative empirical studies, if new habitat could be established within 50 m of existing habitat it will create a functionally for monarch butterflies; however, because the monarch is a highly mobile insect, it doesn't have to be perfect. Establishing milkweed and nectar resources is the most important thing to do for monarch butterfly conservation.

ENVIRONMENTAL SCIENCE AND FORESTRY

DR. SCOTT WILLIAMS participated in a Zoom call with scientists from MaineHealth and Columbia University on next steps forward with a human survey component on a collaborative research project (July 6); participated in a Zoom call with Dr. Caroline Zeiss of Yale University School of Medicine about surveilling various Connecticut wildlife species for Covid-19 exposure (July 7); participated in a collaborative Zoom call with members of the Banfield Biologic NIH SBIR-funded tick repellent fabric team (July 11); interviewed by Maryn McKenna from Wired Magazine about CAES research regarding the efficacy of the systemic pesticide treatment of wild white-tailed deer for tick management (Ticks and the Diseases They Carry Are Spreading. Can This Drug Stamp Them Out? | WIRED) (July 12); interviewed by Cindi Jacobson about CAES involvement with the Connecticut Wildlife Action Plan (July 17).

JOSEPH P. BARSKY attended the Connecticut Tree Protective Association Summer Meeting in Farmington (July 20).

GREGORY BUGBEE gave a talk titled "Bashan Lake Update - 2023" at the annual meeting of the Bashan Lake Association at the East Haddam Grange (50 attendees) (July 21); gave a talk titled "*Hydrilla* Invades the Northeast" at the Aquatic Plant Management Society Conference in Indianapolis, Indiana (60 attendees) (July 27).

DR. JEREMIAH FOLEY, IV visited the University of Florida's Center for Aquatic and Invasive Plants in Gainesville, FL to learn about their research program and experimental infrastructure (July 10); hosted and advised five mechanical and computer engineering students from Northeastern University working to identify early season detection of *Hydrilla* using spectral imagery (July 21); attended and co-presented "Novel *Hydrilla* Invades the Northeast" at the 63rd Annual Meeting of the National Aquatic Plant Management Society, Indianapolis, IN (July 24-27).

DR. SUSANNA KERIÖ attended the Connecticut Tree Protective Association Summer meeting (July 20); attended the Connecticut Urban Forest Council meeting (July 27); met with Bryan Wacker from the Meter Group, Inc. to discuss data collection options for urban tree research (July 27).

DR. SARA NASON attended the virtual meeting of the CT PFAS testing Laboratory Capacity and Capability discussion group (July 11); attended virtual meetings for the Best Practices for Non-Targeted Analysis working group (July 19).

SUMMER STEBBINS with **RILEY DOHERTY** and **Madison Manke**, gave an aquatic plant workshop to 7-9 year olds for the Ledyard Parks and Recreation Department (85 attendees) (July 26); with **Madison Manke**, gave a talk titled "Invasive Aquatic Plants in Connecticut" to the Aquarion Water Company (25 attendees) (July 31).

DR. BLAIRE STEVEN participated in the Gordon Research Conference on Applied and Environmental Microbiology at Mount Holyoke College, South Hadley, MA and presented a talk titled "The Free Assembly of the Microbiome in the Axenic Mosquito" (130 attendees) (July 16-21).

DR. ELISABETH WARD was interviewed for the Yale School of the Environment Annual Report (July 6); met with Colleen-Murphy Dunning, Dr. Shimon Anisfeld, and Dr. Mark Ashton (Yale School of the Environment), Dr. Danica Doroski (State Urban Forestry Coordinator, CT DEEP), and Dawn Henning (Assistant Engineer, City of New Haven) to plan panel and workshop on urban forestry and green infrastructure in New Haven (July 6 and 27); along with **DR. JEFFREY S. WARD**, met with Chris Martin, Andrea Urbano, and William Hochholzer (Forestry Division, CT DEEP) and Peter Beringer (Landowner Assistance Program Coordinator, USDA Forest Service) to discuss grant on the effects of forest management on carbon storage and sequestration; met with Cameron McIntire (Plant Pathologist, USDA Forest Service) to discuss the effects of Beech Leaf Disease on forest carbon storage and sequestration and tree regeneration (July 6); participated in the Forest Ecosystem Monitoring Cooperative conference planning meeting (July 19); participated in the Connecticut Tree Protection Association summer meeting (July 20); met with Jess Wikle (Forest Manager, University of Vermont) and Dr. Mark Ashton (Dean of The Forest School, Yale School of the Environment) to discuss the effects of irregular shelterwood harvests on surface soil organic matter (July 27); met with Nathan Siegert (Forest Entomologist, USDA Forest Service) to discuss forest ecosystem responses to Emerald Ash Borer invasion (July 31); participated in the Beech Leaf Disease working group meeting (July 31).

DR. LEIGH WHITTINGHILL met with representatives from Meter Group, Inc. to discuss current and future research and green roof monitoring (July 27).

PUBLICATIONS:

1. Whittinghill, L. J., Ballard, M., Chaudhary, A., Kandel, S., Mullins, C., and Poudel, P. (2023). Runoff water quality from different urban agricultural systems using common nutrient management practices. *HortScience*, *58*, 855-870. DOI: 10.21273/HORTSCI17215-23

Abstract: Urban agriculture is regaining popularity as a method of food cultivation to meet the food needs of communities that reside in densely populated areas. Although this method of farming has many benefits, little research has evaluated the potential impacts of practice on the environment, such as water quality resulting from nutrient runoff. To address this gap, this study analyzed runoff water collected from raised beds and small plastic pool container plots with four different types of nutrient management treatments (conventional fertilizer, organic fertilizer, low-compost + organic fertilizer, and high compost). Water samples were collected from each of the raised bed and container plots once per month, weather permitting, and analyzed for pH, conductivity, color, turbidity, nitrate-nitrogen, ammonia-nitrogen, total phosphorus, and potassium. Although there were some significant differences between the raised beds and container plots, they did not translate to meaningful differences in water quality for most variables measured, except for nitrate-nitrogen. The conventional fertilizer treatment demonstrated greater or more variable nutrient leaching than the other nutrient management treatments. This result suggests an opportunity for improved nutrient management by urban farmers to reduce nutrient leaching. Sampling time was found to have a significant impact on runoff water quality, which

could be attributed to varying precipitation rates between samplings and timing of sampling in relation to compost and fertilizer applications, and crop production cycles.

2. Ward, E. B., Polussa, A., and Bradford, M. A. (2023). Depth-dependent effects of ericoid mycorrhizal shrubs on soil carbon and nitrogen pools are accentuated under arbuscular mycorrhizal trees. *Global Change Biology*. DOI: 10.1111/gcb.16887

Abstract: Plant mycorrhizal associations influence the accumulation and persistence of soil organic matter and could therefore shape ecosystem biogeochemical responses to global changes that are altering forest composition. For instance, arbuscular mycorrhizal (AM) tree dominance is increasing in temperate forests, and ericoid mycorrhizal (ErM) shrubs can respond positively to canopy disturbances. Yet how shifts in the co-occurrence of trees and shrubs with different mycorrhizal associations will affect soil organic matter pools remains largely unknown. We examine the effects of ErM shrubs on soil carbon and nitrogen stocks and indicators of microbial activity at different depths across gradients of AM versus ectomycorrhizal (EcM) tree dominance in three temperate forest sites…Our study highlights the importance of considering interactions between co-occurring plant mycorrhizal types, as well as their depth-dependent effects, for projecting changes in soil carbon and nitrogen stocks in response to compositional shifts in temperate forests driven by disturbances and global change.

DR. JEREMIAH FOLEY, IV hosted and advised five mechanical and computer engineering students from Northeastern University working to identify early season detection of *Hydrilla* using spectral imagery (July 21).

PLANT PATHOLOGY AND ECOLOGY

DR. LINDSAY TRIPLETT led a data analysis workshop for the Plant Health Fellows program (10 adults) (July 24); participated in a meeting of the Bacteriology committee of the American Phytopathological Society (21 attendees) (July 25); and participated in a meeting of the Soil Predators Working Group (8 adults) (July 26).

DR. WASHINGTON DA SILVA attended the CT Farm Wine Development Council meeting as the CAES representative and the Council Scientist member, via Zoom (10 adults) (July 14). gave a talk titled "Small Things Considered: Using RNAi and Nanotechnology to Control Plant Pathogens" at the UMass-CAES Nano-enabled Agriculture Symposium, UMass - Amherst, MA. **PROF. FRANCISCO FAGGION** from the da Silva Lab gave a talk titled "Development of nanoparticle application methods" at the UMass-CAES Nano-enabled Agriculture Symposium, UMass - Amherst, MA (30 adults) (July 25).

DR. YONGHAO LI participated in the National Plant Diagnostic Network Online Communication & Web Portal Committee meeting via Zoom (8 adults) (July 12); staffed the Station booth at the Connecticut Tree Protective Association Summer Meeting in Farmington (July 20); participated in the Northeast National Plant Diagnostic Network Meeting via Zoom (16 adults) (July 27)

DR. ROBERT MARRA presented a seminar on Beech Leaf Disease as part of the Yale Forestry School Summer Lecture Series, at Yale-Myers Forest, Eastford, CT (50 adults) (July 12); presented a lecture on beech leaf disease at the annual summer meeting of the Connecticut Nursery & Landscape Association, at Monrovia Nurseries, in Granby, CT (200 adults) (July 26).

FELICIA MILLETT exhibited at the CNLA Summer Field Day (July 26) (Granby, CT); participated in the NEPDN Monthly Meeting (12 adults) (July 27); and spoke at the Career Panel for the Plant Health Fellows in Jones Auditorium (15 adults) (July 31).

DR. RAQUEL ROCHA attended the 62nd Annual Meeting of the Society of Nematologists where she presented a talk about her recent MPMI paper "Discovery of Novel Effector Protein Candidates Produced in the Dorsal Gland of Adult Female Root-Knot Nematodes" (50 adults) (July 9).

DR. NEIL SCHULTES conducted joint experiments with Dr. Timothy McNellis at the Dept. of Plant Pathology and Environmental Microbiology at Pennsylvania State University (July 5-15).

DR. STEPHEN TAERUM led a virtual workshop at the Northeastern Organic Farming Association Massachusetts chapter spring meeting titled "Microbial Predators in Soil: Hunting for Healthy Soil Ecosystems" (48 adults) (July 27).

DR. QUAN ZENG presented "Apples and Bees" to a pre-kindergarten class at the Old Grove Park in West Haven with **FELICIA MILLETT** (20 children, 4 adults) (July 11) and at the Pagels School (24 children, 5 adults) (July 19), both events were organized by

the West Haven Department of Parks and Recreation, presented at the UMass-CAES Nano-enabled Agriculture Symposium (30 adults) (July 25).

PUBLICATIONS:

1. Muthuramalingam, R., Barroso, K. A., Milagres, J., Tedardi, V., de Oliveira, F. F., Takeshita, V., Karmous, I., El-Tanbouly, R., and **da Silva, W. L.** (2023). Tiny but Mighty: Nanoscale Materials in Plant Disease Management. *Plant Disease*. DOI: 10.1094/PDIS-05-23-0970-FE

Abstract: Nanoscale materials are promising tools for managing plant diseases and are becoming important components in the current agritech revolution. However, adopting modern methodologies requires a broad understanding of their effectiveness in solving target problems and their effects on the environment and food chain. Furthermore, it is paramount that such technologies are mechanistically and economically feasible for growers to adopt in order to be sustainable. This Feature Article summarizes the latest findings on the role of nanoscale materials in managing agricultural plant pathogens. Herein, we discussed the benefits and limitations of using nanoscale materials in plant disease management and their potential impacts on the environment and global food security.

2. Kunz, S. **Zeng, Q.**, and Johnson, K. B. (2023). History, efficacy, orchard ecology, and mode of action of *Aureobasidium pullulans*, the microbial agent in Blossom Protect, for suppression of apple fire blight. *Journal of Plant Pathology*. DOI: 10.1007/s42161-023-01448-4

Abstract: *Aureobasidium pullulans*, formulated commercially as Blossom Protect, has become a highly successful biological material for fire blight suppression in apple and pear. This material, which is composed of viable spores of two strains of *A. pullulans*, attained this status with minimal prior knowledge that yeasts could be used effectively for this purpose. In early orchard trials, it was observed that mixing *A. pullulans* in spray tanks with a low pH buffer enhanced disease suppression from very good to outstanding. Prevention of fire blight by Blossom Protect requires that *A. pullulans* colonizes most of the flowers on a tree with populations that exceed 1 × 104 CFU/flower. *A. pullulans* colonizes floral stigmas similar to bacteria used to suppress fire blight biologically; however, unlike these bacteria, the yeast also colonizes the hypanthial surface within the floral cup, which is where the fire blight pathogen *Erwinia amylovora* infects the host. In combination with the buffer, colonization activity by *A. pullulans* on the hypanthium reduces pH of the floral cup and strongly induces host defense genes in hypanthial tissue. A specific risk from use of *A. pullulans* for fire blight control is a potential to contribute to 'russeting' of developing fruitlets. Russeting risk from use of Blossom Protect has been lessened by reformulation of the companion buffer and by use of conventional or organically-approved fungicides in late and post-bloom periods. In large-scale apple production, particularly organic orchards, the use of Blossom Protect requires integration with other sprays that are required for managing crop load and suppression of fungal diseases such as apple scab.

3. Sun, W., Gong, P., Zhao, Y., Ming, L., **Zeng, Q.** and Liu, F. (2023). Outbreak of Fire Blight in China. *Phytopathology*. DOI: 10.1094/PHYTO-05-23-0170-RVW

Abstract: Fire blight, caused by the plant pathogenic bacterium *Erwinia amylovora*, is a devastating disease that occurs on rosaceous plants, including pears and apples, etc. *E. amylovora* is indigenous to North America and was spread to the Eurasian continent in the second half of the 20th century through contaminated plant materials. In 2016, fire blight was first observed in Yili, Xinjiang Province in Northwestern China. Since then, it has spread to most pear-producing regions in Xinjiang Province and parts of Gansu Province. The disease has caused severe damage to China's pear and apple industries, including the 2017 disease epidemic in Korla, Xinjiang, which caused an overall yield reduction of 30% ~50% province-wide and the destruction of over one million pear trees. Over the past few years, a combined effort of research, extension, and education by the Chinese government, scientists and fruit growers has greatly alleviated outbreaks and epidemics in affected regions, while successfully limiting the further spread of fire blight to new geographical regions. Here, we review the occurrence, spread, and damage of this disease to the Chinese fruit industry, the management options used in China and their outcomes. We also discuss future perspectives for restraining the spread and alleviating the damage of fire blight in China.

4. Li, G., Gong, Z., Dulal, N., Marroquin-Guzman, M., **Rocha, R. O.**, Richter, M., and Wilson, R. A. (2023). A protein kinase coordinates cycles of autophagy and glutaminolysis in invasive hyphae of the fungus *Magnaporthe oryzae* within rice cells. *Nature Communications*, *14*(1), 4146. DOI: 10.1038/s41467-023-39880-w

Abstract: The blast fungus *Magnaporthe oryzae* produces invasive hyphae in living rice cells during early infection, separated from the host cytoplasm by plant-derived interfacial membranes. However, the mechanisms underpinning this intracellular biotrophic growth phase are poorly understood. Here, we show that the *M. oryzae* serine/threonine protein kinase Rim15 promotes biotrophic growth by coordinating cycles of autophagy and glutaminolysis in invasive hyphae. Alongside inducing autophagy, Rim15 phosphorylates NAD-dependent glutamate dehydrogenase, resulting in increased levels of α-ketoglutarate that reactivate target-of-rapamycin (TOR) kinase signaling, which inhibits autophagy. Deleting *RIM15* attenuates invasive hyphal growth and triggers plant immunity; exogenous addition of α-ketoglutarate prevents these effects, while glucose addition only suppresses host defenses. Our results indicate that Rim15-dependent cycles of autophagic flux liberate α-ketoglutarate – via glutaminolysis – to reactivate TOR signaling and fuel biotrophic growth while conserving glucose for antioxidation-mediated host innate immunity suppression.

VALLEY LABORATORY

GRANTS AWARDED:

1. DR. RICHARD COWLES was awarded a grant of $16,133 from the Christmas Tree Promotion Board for his project "Comparison of long-lasting deer repellents."

DEPARTMENTAL RESEARCH UPDATES:

DR. CAROLE CHEAH, gave an overview of biological control of mile-a-minute weed (MAM) to staff and forest interns (7 attendees) from the Bent of the River Audubon Center in Southbury and then led a field excursion to collect and release *Rhinoncomimus latipes* weevils to control MAM (July 26); gave a presentation on biological control of hemlock woolly adelgid to camp students grades 5-8 and staff from the Northwest Park Nature Center, Town of Windsor (12 attendees) and led a field tour to see hemlock trees where *Sasajiscymnus tsugae* predator beetles had been released (July 27).

DR. RICHARD COWLES was a coauthor with several others on "Management of beech leaf disease" and attended the symposium on this subject at the Society of Nematology annual meeting, Columbus, OH, (100 attendees) (July 10); presented "Insect management" at the Connecticut Christmas Tree Growers' Association Twilight Meeting, Harwinton (36 participants) (July 11); provided the keynote presentation "Small investments while planting have big returns" at the Christmas Tree Farmers' Association of New York, (100 participants) (July 21), and presented "Armored scale management" to the same group, (60 participants) (July 22).

JOURNAL ARTICLES APPROVED JULY 2023

Bui, T., **Zuverza-Mena, N.**, **Dimkpa, C. O.**, **Nason, S. L.**, **Thomas, S.**, and **White, J. C.** PFAS remediation in soil: An evaluation of carbon-based materials for contaminant sequestration. *Environmental Pollution*.

Dai, Y., Yuan, H., Cao, X., Liu, Y., Xu, Z., Jiang, Z., **White, J. C.**, Zhao, J., Wang, Z., and Xing, B. La_2O_3 nanoparticles cause genetic reconstruction that contributes to the cracking of tomato fruit. *ACS Nano*.

Hafeeza, R., Guo, J., Ahmed T., Razab, M., Jiang, H., Shahid, M, Ibrahim, E., Yang, Y., Wang, J., Yand, C., An, Q., **White, J. C.**, and Li, B. Green chitosan nanoparticles enhance disease resistance against rice blast by transcriptional reprogramming and reshaping the microbiome of *Oryza sativa* L. *ACS Nano*.

Linske, M. and **Williams, S.** Evaluation of landscaping and vegetation management to suppress host-seeking *Ixodes scapularis* (Ixodida: Ixodidae) nymphs on residential properties in Connecticut, USA. *Environmental Entomology*.

Loyd, A. L., **Cowles, R. S.**, Borden, M. A., **LaMondia, J. A.**, Mitkowski, N., Faubert, H., Burke, D., Hausman, C., Volk, D., Littlejohn, C., Stiller, A., Rigsby, C. M., Brantley, B., and Fite, K. Exploring novel management methods for beech leaf disease, an emerging threat to forests and landscapes. *Arboriculture and Urban Forestry*.

Sun, K., **White, J. C.**, He, E., Van Gestel, C. A. M., Zhang, P., Peijnenburg, W. J. G. M. Atom vacancies enhance earthworm coelomocyte uptake of MoS_2 nanosheets: Orthogonal analysis of multiplexed imaging, molecular profiling, and computational modeling. *ACS Nano*.

CAES

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Volume 13 Issue 8
August 2023