November/December 2025

RESOURCE

engineering and technology for a sustainable world

Biochar Standards

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AMAA: Two New Collaborative Partnerships
Building Momentum for Circular Bioeconomy Systems
Green Bonding
Looking Back and Looking Ahead

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Embrace Your Story

Are you ready to *Embrace Your Story*? Do you want to share the impact you have had on our world as an agricultural and biological engineer or technologist? Then let other people hear about it!

Building on **Past President Doug Otto's** platform, *Lead the Future*, I'm excited to launch my 2025-2026 platform, *Embrace Your Story*. This past year, Doug encouraged us to find innovative ways to impact our Society. For example, Doug and our Board of Trustees empowered the continued growth of the Alliance for Modernizing African Agrifood Systems and the Circular Bioeconomy Systems Institute.

Doug, along with the ad hoc selection committee, navigated the selection of our new ASABE Executive Director, Cedric Calhoun. Thank you for joining me in voicing a wholehearted welcome to Cedric, and for expressing our gratitude to Darrin Drollinger for his years of service and offering our best wishes for his retirement.

At this year's AIM in Toronto, keynote speaker Julie Borlaug energetically shared how we are "stronger together" by telling our stories and shaping our future. Each of us has a unique story about how we entered this profession and about the impact we are making.

My journey began when I heard a USDA engineer present the work being done in the Sugar Creek Watershed in southwest Oklahoma. I realized that this career path would allow me to help the farmers and ranchers in the community where I grew up, as well as across my state, our nation, and around the world.

You also have a story to share, whether it's about developing an app to help farmers manage their irrigation without wasting water, or creating a cost-effective sensor to gather essential data on soil health, crop yield, or environmental conditions. Don't keep your story to yourself! Shout it from the rooftop! Educate the public about the vital work you do, and explain why it matters.

By sharing your story, you will raise the prominence of our profession, particularly by inspiring young people who are looking for a meaningful career. You will help to cultivate a diverse, thriving, and engaged membership. And you will advance ASABE as the leading source of expertise in agricultural, food, and biological engineering and technology.

"By sharing your story, you will raise the prominence of our profession, particularly by inspiring young people who are looking for a meaningful career.

One way you can *Embrace Your Story* is by taking an active role in our various initiatives, which are supported by the ASABE Foundation. The ASABE Foundation has had tremendous growth since the 2024 Giving Tuesday Campaign, with more than $100,000 raised for ASABE initiatives, scholarships, and awards. To learn more about all that our Foundation does, scan the QR code below.

Another way you can *Embrace Your Story* is by mentoring future biological and agricultural engineers and technologists. For example, the theme of this year's Future City Competition, a hands-on cross-curricular STEM program for middle and high schoolers, is "From Farm to Table" —that's right up our alley!

The student teams will be challenged to design a city that eliminates food waste, while keeping the citizens healthy and safe. To find out how you can get involved at the local, regional, or national level, visit https://futurecity.org.

Thank you for inspiring me with the great work you do, helping people worldwide have access to food, water, energy, fiber, and safe environments. Thank you as well for placing your trust in me to lead our Society over the coming year. With inspiration from Julie Borlaug's AIM keynote, *Embrace Your Story* and we will all be "stronger together."

Sherry Hunt
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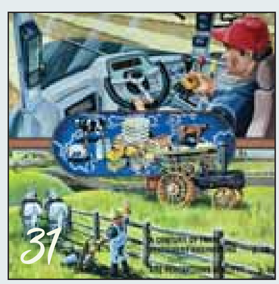

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ON THE COVER:
ASABE is now working on biochar standards. See page 20 for the complete story.

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Update on the Alliance for Modernizing African Agrifood Systems

Announcing Two New Collaborative Partnerships

Senorpe Hiablie, Ajit Srivastava, Margaret Gitau, and Klein Ileleji

With nearly 60% of the world's uncultivated arable land, and with agriculture as its leading source of employment, most of sub-Saharan Africa is uniquely positioned to attain sustainable economic growth through its agriculture sector. Rapid population growth, accelerating urbanization, shifting dietary patterns driven by a growing middle class, and the escalating impacts of climate change highlight the need for this transformation. However, low agricultural productivity remains a significant challenge.

Alliance for Modernizing African Agrifood Systems
An ASABE Global Initiative

Through strategic partnerships, ASABE's Alliance for Modernizing African Agrifood Systems (AMAA) seeks to modernize African agriculture to boost productivity, enhance profitability, and build resilient agrifood systems capable of meeting future needs. This can be achieved by integrating transformative approaches that combine appropriate technologies with local expertise.

Recently signed Memoranda of Understanding (MOUs) between ASABE and two new partner organizations demonstrate how agricultural and biological engineers can help shape this transformation. These two MOUs align with ASABE's mission, and they contribute to raising the prominence of the profession in Africa and beyond.

Building on ASABE's legacy and global vision

Historically, ASABE has played a pivotal role in transforming U.S. agriculture into one of the most productive and technologically advanced sectors in the world. Examples include the mechanization of production systems, efficient irrigation technologies, and industry-wide standards for food processing, human health and safety, and environmental stewardship. Today, with its deep technical expertise, academic leadership, and global network of professionals, ASABE is uniquely positioned to foster international collaborations to promote the modernization of African agrifood systems.

ASABE's AMAA initiative seeks to establish collaborations with key global partners to realize its objectives, which are based on four pillars: (1) Technology, methodology, and innovation;
(2) Business development and entrepreneurship;
(3) Capacity building and workforce development; and
(4) Infrastructure and policy frameworks, as well as cross-cutting themes that are important for modernizing African agrifood systems.

The two recent MOUs are an important step in establishing the necessary collaborations.

MOU #1: Regenerators Limited

Regenerators Limited is an agricultural technology company dedicated to developing environmentally sustainable mechanization tools for hire by farmers and farming communities. It envisions a future in which African smallholder farmers can access affordable, appropriate-scale mechanization tailored to their local conditions.

By adapting proven technologies and service models from Asia, productivity can be boosted and labor burdens reduced on smallholder farms (less than 5 ha in size) without requiring ownership of expensive equipment. The mission of Regenerators Limited centers on inclusive, climate-smart agricultural transformation through custom hiring services and context-appropriate technology deployment.

ASABE's partnership with Regenerators Limited has the following key areas:

- Share information and create targeted collaborations in various fields of mechanization for agrifood systems in Africa.
- Facilitate linkages between ASABE/AMAA and Regenerators Limited toward project development in mechanizing agrifood systems in Africa.
- Schedule consultative meetings and personnel visits between both organizations.
- Exchange materials, publications, and other materials of common interest, and include results in collaborative activities

The roles of Regenerators Limited and ASABE/AMAA in collaborative research will be project-specific, beginning with a Mission Laboratory at Hawassa University in Ethiopia and several farm hubs around Lake Awassa. These will be geared toward creating a mechanization roadmap for the transformation of the Ethiopian agrifood system as a pilot project.

Regenerator Limited's proposed integrated Farmhub model for uplifting of smallholder farmers as land stewards into an ecosystem whose components reinforce each other for generating systemic change.

This partnership aligns with the AMAA's Technology, Methodology, and Innovation pillar, which focuses on promoting appropriate-scale technologies and methodologies, including digitization, aimed at addressing specific challenges in agricultural production and resource management for African agrifood systems. In addition to encouraging adoption of existing technologies, this pillar aims to promote innovation from African researchers in conjunction with innovation hubs located on the continent.

This partnership also aligns with the AMAA's Capacity Building and Workforce Development pillar, which focuses on developing a qualified workforce needed to modernize African agrifood systems.

MOU #2: Impact Fund for Modernizing African Agrifood Systems

The Impact Fund for Modernizing African Agrifood Systems (IF4MAAS) is a U.S.-based, nonprofit, public benefit corporation that connects investors, donors, innovators, and agrifood stakeholders. It serves as an intermediary in enabling blended finance that bridges financing gaps, promotes collaboration, and propels impactful investments.

IF4MAAS envisions enabling inclusive and scalable solutions that drive sustainable transformation across Africa's agrifood systems in ways such as providing loans to small agricultural service providers (ASPs) and other small businesses. IF4MAAS also derisks investments by conducting thorough due diligence and showcasing a repository of impact data.

ASABE's partnership with IF4MAAS focuses on five key areas:

- Strategic program development: Co-developing and implementing regional AMAA innovation hubs across Africa, integrating technology transfer, capacity building, and investment readiness.
- Conference and knowledge platforms: Jointly organizing conferences and other events in collaboration with sister societies and strategic partners to convene stakeholders, promote innovations, and align investments.
- Blended financing and investment facilitation: IF4MAAS will assist the AMAA and its African partners in structuring financing models that blend donor funds, public finance, and private capital.
- Capacity building and training: Joint development of curricula, certification programs, and training modules in agricultural engineering, agribusiness, and digital innovation.

- Joint resource mobilization: Co-pursuit of funding opportunities from philanthropic foundations, development banks, and bilateral donors to support the AMAA initiative.

The role of IF4MAAS in this partnership will be to structure and deploy blended finance mechanisms to support agrifood modernization projects, act as the investment intermediary for key initiatives such as innovation hubs, and engage stakeholders, including development finance institutions (DFIs), foundations, and private sector partners. Through the AMAA, ASABE will offer technical and academic support, guide standards and innovation development, and manage partnerships with global engineering societies and African institutions.

Financing agribusiness is critical to modernizing African agrifood systems, and entrepreneurship and business development are central themes of the AMAA initiative. The AMAA's Business Development and Entrepreneurship pillar focuses on facilitating the evaluation, transfer, and scaling of technology, as well as supporting the development of entrepreneurs and innovators in the agricultural sector.

The AMAA also helps create international public-private partnerships by identifying such opportunities and playing an advocacy role with funders to set investment priorities and allocate funding strategies. IF4MAAS's vision of the creation of an investment fund dedicated to supporting ASPs and smallholders in African agrifood systems holds much promise to support new businesses and complements the AMAA's mission.

Broader implications and outlook

The urgency created by the unique challenges facing African agrifood systems requires bold, innovative value-chain-oriented approaches by all stakeholders and beneficiaries alike to achieve the desired results. These two new MOUs between ASABE, Regenerators Limited, and IF4MAAS reflect a growing recognition that agricultural and biological engineers are central to transforming agrifood systems in sub-Saharan Africa and globally. By combining technical expertise with local knowledge and networks, these collaborations will help to sustainably modernize agrifood systems on the continent by empowering local partners.

Looking ahead, the AMAA will continue to provide a platform for bringing together diverse actors across Africa's agrifood value chain to collaborate toward a shared vision of transforming African agriculture into a driver of economic growth, ensuring food security, and promoting sustainable prosperity across the continent.

Learn more about the AMAA and its burgeoning partnerships at https://asabe.org/amaa.

ASABE member Senorpe Hiablie, Biofeedstock Researcher, Shell International Exploration and Production, Houston, Texas, USA, senorpe.hiablie@shell.com; **ASABE Fellow Ajit Srivastava,** Professor, Michigan State University, East Lansing, USA; **ASABE member Margaret Gitau,** Professor, and **ASABE member Klein Ileleji,** Professor, Purdue University, West Lafayette, Indiana, USA.

Meet ASABE's new partners in the Alliance for Modernizing African Agrifood Systems

David Moore
Co-Founder
Regenerators Limited

David is a manufacturing engineer by trade. He began his career with Henkel Loctite in 1997 as an industrial engineer. While at Henkel, he was promoted to Operations Manager, where he was responsible for 160 staff members and an annual budget of €16 million. He left Henkel to provide business consultancy services across various areas, including strategy, operations, and manufacturing. In 2013, David co-founded MagGrow (a technology that improves pesticide spraying applications), and he helped grow the business to over 30 employees working in five countries. David left MagGrow in December 2021 to launch Regenerators Limited, whose vision is to leverage agricultural mechanization to develop a thriving rural Africa.

Abel Girma
Founder and Managing Director
Impact Fund for Modernizing African Agrifood System (IF4MAAS)

With a focus on strategic planning, risk analysis, and market assessment, Abel is committed to identifying investment opportunities with potential for transformative impact. His experience in supply chain management and ESG integration has equipped him to evaluate projects that deliver financial returns as well as social and environmental benefits. He continually seeks opportunities at the forefront of emerging trends in impact investing and sustainable development. Through his leadership of IF4MAAS, Abel is driving change by tackling the financing gap and fostering stakeholder alignment. With his unwavering dedication to sustainable development and his ability to mobilize resources and forge strategic partnerships, Abel is poised to make a lasting impact on Africa's agri-food system.

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update

Bioreactors reduce phosphorus from agricultural drainage water

In brief: *A study at the University of Illinois evaluated data from ten bioreactors in Illinois to determine whether they are a source of phosphorus pollution.*

Tile drainage is a common practice for removing excess water from agricultural fields, but it also transports harmful nutrients into water bodies, contributing to algal blooms that deprive aquatic life of oxygen. Woodchip bioreactors are an efficient way to reduce nitrogen pollution by treating the water as it exits the field. However, these denitrifying bioreactors may leach phosphorus from the woodchips into the environment.

A new study at the University of Illinois Urbana-Champaign evaluated data from ten bioreactors in Illinois to determine whether they are a source of phosphorus pollution.

“Illinois has a goal of reducing the amount of nitrogen we send into the Mississippi River basin by 45%,” said lead author and **ASABE member Laura Christianson, P.E.**, who conducted the study as an associate professor in the Department of Crop Sciences. “Woodchip bioreactors are one of the conservation practices that are recommended to remove nitrate pollution from agricultural drainage water. However, we don’t want to create a problem with phosphorus instead.”

Denitrifying bioreactors typically consist of a large basin of woodchips installed at the edge of a field. When nitrogen-enriched water flows through the basin, naturally occurring bacteria consume the carbon in the woodchips, fueling a process that converts nitrate to a harmless gas.

“There’s phosphorus in the woodchips, because that’s one of the nutrients that trees take up when they grow,” said Christianson. “We wanted to assess whether or not woodchip bioreactors are leaching phosphorus, because it’s also important to reduce the amount of phosphorus we’re sending downstream.”

The researchers assessed data from ten full-size bioreactors in Illinois for a total of 23 site-years, that is, each research site multiplied by the number of years it was included in the study. Bioreactor inflow and outflow were measured to calculate daily water flow rates. The researchers analyzed water samples to determine the content of dissolved reactive phosphorus (DRP), a form of phosphorus available for plant and algae uptake.

The results showed that, rather than an increase, there was a small reduction in DRP concentrations for 15 of the 23 site years, indicating that the bioreactors provided a net benefit for phosphorus removal. However, the results fluctuated over the course of a year.

A woodchip bioreactor being installed at a University of Illinois research farm.

"When there was heavy rainfall, there was a spike in phosphorus removal, especially after manure application in the field," said co-author and **ASABE member Richard Cooke,** professor in the Department of Agricultural and Biological Engineering at the University of Illinois.

In addition, in the first few months of a bioreactor's life, a significant flush of phosphorus leached from the woodchips. After that, phosphorus mainly came from the field's tile drainage water. The data also indicated that as the bioreactors aged, they became less effective at removing phosphorus.

The life of a bioreactor is about ten years. "If a bioreactor removes more phosphorus than it releases for most of its lifespan, then it's worth it, even if there's a brief phosphorus surge in the first few months," said Cooke.

Christianson explained that bioreactors are a valid practice for nitrogen removal, so that they also provide some phosphorus removal is an added benefit. "First, when phosphorus gets into waterways, it's difficult and expensive to remove. Second, bioreactors aren't supposed to provide this benefit at all, so it's like we're getting a freebie," she said.

Denitrifying bioreactors are a relatively new conservation practice, and with nine million acres of tile-drained farmland, Illinois has many opportunities to implement them. Once installed, a bioreactor requires minimal maintenance. The producer only needs to check it a few times a year to make sure that nothing is blocking the flow.

Other practices to reduce nitrogen include reducing fertilizer rates, better timing of fertilizer applications, and planting cover crops. "Producers should consider what would be the best option for their farm, and maybe use a combination of practices," said Cooke. "In my experience, farmers are good stewards of the land. They think about their legacy, and what they will leave for their children, so they are interested in practices that work well."

For more information, contact Marianne Stein, mfstein@illinois.edu.

"Mist opportunity" reveals how onions make us cry

In brief: *A new discovery showing how cutting onions can eject pungent aerosols up to two-thirds of a meter into the air has led to practical advice for reducing the spray. Past research has identified that a chemical irritant called propanethial S-oxide can bring chefs to tears. This study explains the underlying mechanics of how that chemical, and potential pathogens, can spread.*

This cutting-edge research used high-speed cameras and a simple computer model to reveal how pressing a knife against an onion pressurizes the layered tissue within the onion. Each layer of an onion is encased in a top and bottom skin. When a knife penetrates the top skin, the pent-up pressure within the layer forces out a mist of tiny droplets at speeds of up to 40 meters per second.

That was a surprise because professional chefs, who were filmed as they sliced onions, moved their knives at only one meter per second.

A study finds that cutting onions can eject pungent aerosols up to two-thirds of a meter into the air.

"We found that the speed of the mist coming out was much higher than the speed of the blade cutting in," said **ASABE member Sunghwan "Sunny" Jung,** professor of biological and environmental engineering in the College of Agriculture and Life Sciences at Cornell University. Post-doctoral researcher Zixuan Wu is the lead author of the study, which has been published in the *Proceedings of the National Academies of Science*.

Jung said that onions have been known to harbor pathogens, and limiting the spray mist could help prevent bacteria from spreading around a kitchen. In 2024, the Centers for Disease Control investigated an *E. coli* outbreak linked to onions served at McDonald's that led to 104 cases of illness across 14 states and one death.

While slicing onions can eject mist at up to 40 meters per second, human coughing can propel droplets at only 20 meters per second. "Suppose there are pathogens on the top layer of an onion," Jung said. "By cutting the onion, those pathogens can become encapsulated in spray droplets, where can then spread."

For more information, contact Krishna Ramanujan, *Cornell Chronicle*, ksr32@cornell.edu.

Harvesting in sync: Purdue and Deere develop Auto Unload technology

In brief: *Harvest is one of the most demanding times in a farmer's year. The clock is ticking, and any grain spilled or time wasted is profit lost. One of the most intricate maneuvers during harvest is unloading grain from a combine to a grain cart while both vehicles are moving. It's a task that requires near-perfect synchronization between the combine and the tractor pulling the cart.*

A similar kind of close collaboration has played out in a project between Purdue University and John Deere. Combining industry experience with research expertise, the two organizations developed an initial demonstration of Auto Unload, a precision technology that improves productivity, reduces operator fatigue, and saves valuable time during harvest.

It's a partnership that mirrors the technology: two parts moving in sync toward a shared goal.

During harvest, efficiency is everything. Unloading grain on the go can improve combine productivity by as much as 23%, but it's a complicated procedure that demands tight focus and coordination between the combine and tractor operators.

"It's like airborne refueling," explained **ASABE member Corwin Puryk, P.E.,** staff engineer and Deere's principal investigator for the project. "The two operators face intense pressure to align their machines with precision, sometimes up to ten times per hour over a 12-hour workday."

Deere's existing Machine Sync system offered a partial solution to keep a combine and grain cart aligned during unloading. However, it required constant attention and manual adjustments by the combine operator to distribute grain evenly across the cart.

Purdue and Deere had been discussing opportunities to collaborate, and the development of an automated unloading system was the perfect chance to do so. In addition to technical expertise, Purdue offered agricultural insight and the facilities for testing new technologies in real-world conditions.

"We see Purdue as one of the leading universities to look to in agriculture," said Jennifer Preston, vice president at John Deere Electric Powertrain and CEO of Kriesel Electric. Her Purdue ties run deep. She holds a degree in electrical engineering from Purdue and serves as Deere's executive focal to Purdue.

While Deere's engineers brought practical insights from the field and a track record of building dependable machinery, Purdue contributed deep agricultural roots, broad technical knowledge, and access to a perfect test site at the Agronomy Center for Research and Education (ACRE).

Greg Shaver, professor of mechanical engineering and the director of Purdue's Herrick Labs, served as the university's principal investigator. He assembled a team of faculty and students from several disciplines, including aerospace engineering, agricultural and biological engineering, agronomy, and mechanical engineering.

Greg Shaver, professor of mechanical engineering and director of Purdue's Herrick Labs, was the principal investigator for the Auto Unload project (*photo courtesy of Andrew Griswold*).

ASABE member John Evans, assistant professor of agricultural and biological engineering at Purdue, contributed his farming experience and his background in agricultural robotics (*photo courtesy of Andrew Griswold*).

Shaver's expertise in vehicle automation was complemented by **ASABE member John Evans,** assistant professor of agricultural and biological engineering, who contributed first-hand farming experience as well as a background in agricultural robotics.

"This was a unique opportunity to work with Deere on a multi-year effort," Shaver said, "And I knew that Purdue could help." Much like the machines themselves, the people behind the project had to work together. Shaver and Evans, together with their Purdue colleagues Daniel DeLaurentis and Tony Vyn, guided graduate students in developing and testing the technology.

At Deere, the efforts were equally cross-departmental. Puryk, an engineer in Crop Harvesting Advanced Engineering, worked closely with Ryan White, **ASABE member Brandon McDonald,** and other colleagues in the Intelligent Solutions Group to ensure that Purdue's upgrades were compatible with existing hardware.

Working together, they tackled challenges one by one: overcoming visibility issues caused by dust, light, and weather; maintaining alignment over uneven terrain; and detecting fill levels in the grain cart to maximize each load.

The auto-unload system was built on Deere's Machine Sync and Machine Vision technology, using sophisticated algorithms to automatically measure the amount of grain and autonomously reposition the cart to distribute the load evenly. Extensive testing in Purdue's ACRE fields proved its viability.

After two years of development, Purdue delivered a working prototype at the end of 2020. A variant of the automated unloading system was granted a U.S. patent in 2023, and a fully integrated system with the latest hardware will be available to John Deere customers as a factory option in 2026.

The greatest achievement was the partnership itself, which benefited Deere, Purdue, and importantly, the farmers who will use this technology. "Seeing this have an impact on farmers is one of my proudest achievements," said Evans. "They already have a lot to do. This technology takes one more thing off their hands."

A video of the Auto Unload technology in action is available at www.youtube.com/watch?v=0RMiY9RFbtw&t=4s.

For more information, contact Anna O'Neill Alexander, Purdue University College of Agriculture.

University of Kentucky student builds a better base for 3D-printed foods

In brief: *Josephine Traver, a sophomore at the University of Kentucky, spent her summer turning powders and non-animal gums into something that behaves like Jell-O. She is working with UK's College of Agriculture, Food, and Environment to find an alternative to animal gelatin, the go-to "bioink" used in many 3D food printers.*

"I wanted a project that mixed sustainability and curiosity," Traver said. "Gelatin works great for printing, but it comes from animals. I wanted to see if we could get the same texture, structure, and nutrition from plants instead, so we tested plant-based materials and combined plant/animal materials to come up with a bioink that wasn't completely animal-based."

Her approach was methodical. A total of 16 ingredients, including soy protein powder, konjac root, guar gum, tapioca starch, corn starch, and some plant/animal combinations, were processed and tested using a Rapid-Visco Analyzer, which heated and cooled each sample while stirring and measuring its thickness. Animal gelatin has a standard profile that was already loaded into the instrument, so Traver matched that cycle for every sample.

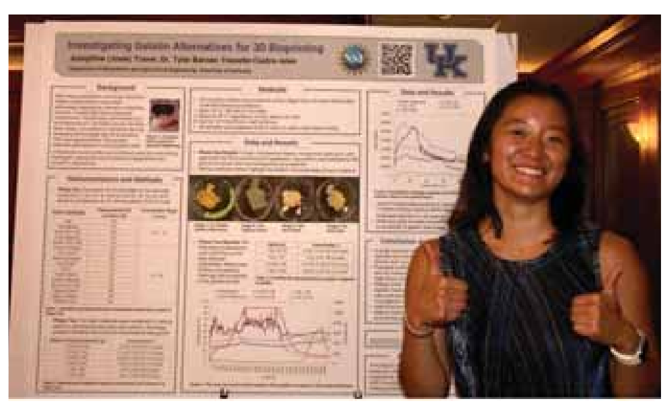
"Josie really impressed me with her ability to excel in a very difficult aspect of research, that is, figuring out how to screen a huge array of options and select a few good candidates for future study," said Traver's mentor, **ASABE member Tyler Barzee,** assistant professor in UK's Department of Biosystems and Agricultural Engineering.

Traver's spreadsheet tells the rest of the story: the concentration, final appearance, photos, and notes for every tested sample. She knows she needs duplicate runs to tighten the data, as well as taste tests to learn what real people think. "We've narrowed the field," Traver said. "Now the plan is to try different mix-and-match ratios, repeat the best ones, and make sure they pass the smell test—literally!"

This work is part of UK's Research Experiences for Undergraduates (REU), which is supported by a $487,000 grant from the U.S. National Science Foundation. The REU brings undergraduate students from across the country together to focus on challenges facing the Appalachian region through research and professional development. The 2025 cohort had 12 undergraduate participants from six universities.

Traver's project also aligns with Barzee's research, which involves combining microbiology and engineering to develop new food products and bioproducts from agricultural and industrial byproducts. He's currently using 3D bioprinting in a project funded by a $295,000 grant from the USDA National Institute of Food and Agriculture.

Much like a 3D printer that builds plastic objects layer by layer, a 3D food printer pushes out an edible mixture, called bioink, to create custom shapes. The bioink is a soft, paste-like material such as chocolate, mashed vegetables or, in this case, plant-based and partially plant-based gels. A nozzle moves across the printing surface, squeezing out a thin layer of the material in a



Josephine Traver showcasing her work 3-D printing food (*photo provided by Josephine Traver*).

programmed pattern. As the layers build up, they take on the shape of a familiar food, such as a burger patty or even a salmon fillet.

To make the process work, the bioink must be thick enough to hold its shape but soft enough to flow through the nozzle. That's where animal gelatin usually comes in. Animal gelatin is a semi-solid that briefly becomes liquid under pressure in the nozzle and then solidifies after being deposited. This means that multiple layers can be stacked to create a sturdy, complicated structure.

Traver said her challenge is to find a plant-based mix that has the same performance without using animal products, and to bring the technology to eastern Kentucky.

This slide will soon be a full-size salmon fillet (*photo by Sabrina Hounshell*).

"One of the goals of this research was to introduce biotechnology to Appalachia," Traver said. "Because the traditional industries, such as coal mining, are in decline and unemployment is high, new technologies, such as 3D bioprinting, could be a catalyst for growth. Local bioprinting facilities could deliver nutritious food products to communities in Appalachia and beyond."

For now, Traver plans to continue her work in Barzee's lab. "We've got a plant-based blend that acts like animal gelatin," Traver said. "Now I want to make sure it tastes good, stores well, and doesn't cost a fortune. I'm excited to keep going!"

For more information, contact Jordan Strickler, jstrickler@uky.edu.

First-ever methane-powered tractor will boost ag research at Penn State

In brief: *Through a partnership with CNH, the industry's first methane-powered tractor will be integral to more than 80 interdisciplinary research projects at the Russell E. Larson Agricultural Research Center, and students in Penn State's College of Agricultural Sciences will have expanded opportunities for hands-on learning.*

The tractor, provided to the college through a partnership between the Penn State Corporate Engagement Center and CNH, incorporates advanced technologies in precision farming, autonomy, and connectivity. The New Holland T6.180 tractor will be available to Penn State for one year, enabling students and researchers to gain hands-on experience with alternative energy technology and its benefits for sustainable farming.

A partnership between CNH and Penn State's Corporate Engagement Center will advance research and learning through the use of a new methane-powered tractor. From left are ASABE Fellow Paul Heinemann, professor of agricultural and biological engineering; Russell Redding, Pennsylvania Secretary of Agriculture; Troy Ott, dean of the College of Agricultural Sciences; Sean Dorosz, CNH tractor marketing manager; Russell Howard, CNH Pennsylvania sales manager; Beth Gugino, associate director of the Pennsylvania Agricultural Experiment Station; John Peterson, director of corporate engagement at Penn State; Philip Eby, CNH hay and forage product manager; ASABE member Andrew Tarman, P.E., CNH haytool hydraulics and driveline test manager; and ASABE member Samanta Cassinera, CNH combine resource and operations manager (*photo courtesy of Michael Houtz and Penn State*).

The tractor will be based at the college's 2,200-acre Russell E. Larson Agricultural Research Center, a hub for research and education in improving food, farming, and environmental health. The tractor will be integral to more than 80 interdisciplinary research projects at the research center, performing operations such as tillage, planting, raised bed preparation, haying, and mowing, all to improve farm profitability and sustainability. Researchers conducting these projects will benefit from the tractor's availability, while CNH will be able to see how the tractor performs in a variety of real-world tasks.

Equally important, the tractor will serve as a valuable teaching resource for faculty, staff, and students in courses such as forage crop management, vegetable crops, weed management, and precision agriculture, while also supporting student clubs and Penn State Extension programs, noted Beth Gugino, assistant dean for graduate education and associate director of the Pennsylvania Agricultural Experiment Station.

"Educating our students about the latest farm technologies through hands-on access will help prepare them to solve real-world problems and understand how alternative energy sources can be part of the solution," she said.

CNH product marketing manager Sean Dorosz explained that the methane-powered tractor was manufactured in the same factory as diesel tractors. It offers an alternative energy solution for farmers while reducing environmental impact by using methane, a potent greenhouse gas, from anaerobic digesters or landfills.

"Our collaboration with Penn State allows real-world data collection versus engineering-controlled tests, which is crucial for understanding the tractor's performance and efficiency," Dorosz said. "It will also give us exposure to the market, so customers can see the tractor in action, realize that it works just like a diesel tractor, and envision how it could fit into their operation. It's also much better for the environment. It's a win-win."

The tractor will be used for daily operations as well as major events including Ag Progress Days and the Pennsylvania Forest Products Equipment and Technology Exposition, as well as other stakeholder activities. The college will use it in demonstrations for farmers, industry partners, and the public and will showcase it during outreach events, such as the college's Plant Yourself in Ag Day, which encourages high school students to explore career paths in agriculture.

"Educating our students about the latest farm technologies through hands-on access will help prepare them to solve real-world problems and understand how alternative energy sources can be part of the solution.

"This is a great example of how major corporations are partnering with universities to advance student success, education, and research through technology and innovation," said John Peterson, director of the Penn State Corporate Engagement Center.

For more information, contact Amy Duke, ajd217@psu.edu.

Transforming waste into an asset: Next-generation anaerobic digestion

In brief: *Michigan State University is developing next-generation anaerobic digestion technologies that convert agricultural and food waste into renewable energy, recover nutrients and water, and can support environmental sustainability across the Great Lakes region.*

As conversations continue among policymakers and industry leaders on how to address nutrient runoff, energy transition, and sustainable waste management, Michigan State University scientists are pioneering solutions that transform organic waste into a public asset.

Last spring, George Smith, director of MSU AgBioResearch, and **ASABE member Wei Liao, P.E.,** director of the MSU Anaerobic Digestion Research and Education Center (ADREC), testified before the

The anaerobic digester breaks down organic wastes such as depacked food waste (shown here) and livestock manure to produce renewable energy and nutrient-rich digestate *(photo courtesy of Wei Liao)*.

The full-scale anaerobic digestion facility on MSU's South Campus *(photo courtesy of Wei Liao)*.

Michigan House Agriculture Committee that, through cutting-edge research in anaerobic digestion, MSU researchers are demonstrating how agricultural and food waste can be used to produce clean energy, recover valuable resources, and protect the Great Lakes ecosystem.

Anaerobic digestion is a biological process in which microorganisms break down organic materials, such as livestock manure and food waste, without oxygen. The result is the production of biogas, primarily composed of methane and carbon dioxide, and a nutrient-rich byproduct known as digestate.

Biogas can be used to generate electricity and thermal energy, and it can be refined into natural gas for transportation or grid injection. Meanwhile, digestate, which gives off less odor than raw manure and greatly reduces the pathogens (such as *E. coli*, salmonella, and listeria) originating from manure and food wastes, can be further treated to produce organic fertilizers and recover clean water that meets U.S. EPA guidelines for reuse.

Established in 2008, ADREC has become a national model for anaerobic digestion research, education, and industry engagement. Since 2013, MSU has operated a full-scale anaerobic digestion facility on its South Campus, processing approximately 15,000 gallons of diverse animal and food wastes, including dairy manure, swine manure, fats, oils, grease, depacked food waste, and milk and egg processing waste. From these wastes, the facility generates 6,500 kilowatt-hours per day of renewable electricity and produces 15,000 gallons of digestate daily.

The digestate is land-applied across 1,000 acres of university farmland under Michigan's Generally Accepted Agricultural and Management Practices. Soil test data guide the application to ensure that nutrients, particularly nitrogen, phosphorus, and potassium, are applied in controlled amounts tailored to crop needs. This precise nutrient management helps optimize soil fertility while minimizing the risk of nutrient runoff.

Over 15 years of continuous land application, regular monitoring has shown no evidence of groundwater contamination at any of the 15 on-site wells south of the main campus, a compelling validation of anaerobic digestion's environmental safety when properly implemented.

Recognizing growing public concern about emerging contaminants, including heavy metals, PFAS, pharmaceuticals, and microplastics, in organic waste streams, MSU researchers have also taken a proactive role in managing these risks. Targeted measurements have been conducted on digestate samples to assess the presence of trace elements and regulated substances, with ongoing studies evaluating the fate and transport of contaminants during the digestion process and after land application.

Liao, a professor in MSU's Department of Biosystems and Agricultural Engineering, said that while the concentrations of these substances are often below detection limits, MSU's approach emphasizes science-based application practices, comprehensive waste source assessment, and alignment with state and federal safety standards. "The ongoing efforts reflect MSU's commitment to ensuring that anaerobic digestion remains a safe, responsible, and resilient system for protecting public health and natural resources in the Great Lakes region," he said.

The economic potential of anaerobic digestion in Michigan is vast. Agriculture is a leading industry in Michigan, contributing about $105 billion annually to the state's economy. Because of this and Michigan's proximity to the Great Lakes, anaerobic digestion could be primed for success in the state. "This integrated waste-to-resource approach holds promise in an agriculturally abundant state such as Michigan, where water quality concerns also demand urgent attention," Liao said.

To expand its research capacity for transforming agricultural waste into renewable energy and other resources, MSU is building a state-of-the-art Dairy Cattle Teaching and Research Center with a $30 million investment from the State of Michigan *(photo courtesy of Wei Liao)*.

Michigan's organic waste stream, which includes over 11 million dry tons of livestock manure and more than 3 million annual dry tons of food waste annually, represents an untapped feedstock for energy and nutrient recovery. With full utilization, these wastes could generate 2% to 4% of Michigan's total electricity needs or supply 10% to 15% of the state's gasoline demand in renewable natural gas, contributing to energy independence and decarbonization goals, according to Liao.

To advance knowledge on how anaerobic digestion can play a part in energy production and nutrient recovery, MSU is also building a state-of-the-art Dairy Cattle Teaching and Research Center with a $30 million investment from the State of Michigan. The new dairy center will expand MSU's research capacity for transforming agricultural waste into renewable energy and useful nutrients.

Advanced processes are being developed to extract and reuse nitrogen and phosphorus—critical nutrients that, if improperly managed, contribute to harmful algal blooms and water pollution. MSU researchers are also addressing growing concerns about emerging contaminants in digestate, such as PFAS, heavy metals, pharmaceuticals, and microplastics, while devising best management practices to minimize risks.

By stabilizing and concentrating nutrients in forms that match crop needs, and reclaiming water for agricultural or industrial reuse, anaerobic digestion offers a closed-loop strategy to enhance soil health, reduce chemical fertilizer dependence, mitigate the spread of emerging contaminants, and protect Michigan's freshwater resources, which supply drinking water to over 40 million people.

"Anaerobic digestion is a tool for simultaneously cutting greenhouse gas emissions, recovering nutrients and water, and revitalizing rural economies," Liao said. "At ADREC, we welcome policymakers, industry leaders, philanthropists, and the general public to join us in supporting this transformative work."

For more information, contact Jack Falinski, falinsk2@msu.edu.

Tractor ROPS and seatbelts can save lives

In brief: *An estimated 50% of tractors in use today are not equipped with a rollover protective structure, or ROPS. A properly installed ROPS includes a rollbar or a crush-proof cab. A seatbelt for the operator is also necessary.*

Eleven years ago, Andy Koukol nearly became a statistic. In the summer of 2014, he was a 21-year-old student with a summer job mowing roadways in suburban Kansas City. He was no stranger to operating a tractor. He learned that skill on his grandparents' farm.

"I was assigned to mow the median areas of a highway," Koukol said. Those areas often contain obstacles and vegetation that can conceal ditches and sudden drop-offs. "I was working in an area that was mostly flat," he recalled. However, as he tried to steer around a utility box, the tractor became high-centered. He couldn't maneuver without going down a steep slope.

That's when the ground suddenly gave way, and the tractor overturned. Thanks to the tractor's ROPS, Koukol escaped with only a few stitches for a gash on his arm. He was also wearing a seat belt. "If it hadn't been for the seatbelt, I would have been thrown out," he said.

The U.S. Bureau of Labor Statistics reported that 417 people died in tractor rollovers between 2011 and 2018, an average of 52 every year. Like Andy Koukol, most rollover victims are familiar with heavy equipment. The Northeast Center for Occupational Health and Safety (NEC) reports that most people who die in tractor-related accidents are experienced operators.

The NEC and the National Tractor Safety Coalition have worked for a decade to educate tractor owners about the need for ROPS. Farmers are nearly eight times more likely to die on the job than the average American worker, and tractor rollovers are the leading cause of death for farmers.

However, about half of tractors in use today aren't equipped with ROPS. In 1985, tractor manufacturers adopted a voluntary standard to include ROPS and seatbelts on all new tractors over 20 horsepower, but the long lifespan of tractors means that many non-ROPS tractors are still in use.

When used with a seatbelt, ROPS are 99% effective in preventing injury and death. "Andy Koukol is my nephew," said **ASABE member Ed Brokesh, P.E.,** assistant professor of biological and agricultural engineering at Kansas State University. "When I heard about his rollover, I was struck by how relaxed the family was about it. That means the ROPS did its job. Andy's accident would have ended much differently if the tractor did not have a ROPS."

The National Tractor Safety Coalition is working to reduce tractor rollover fatalities by expanding the current state-based ROPS rebate programs into a national rebate program. The coalition hopes to raise sufficient funds to provide an incentive for owners to retrofit their older tractors. The rebate program can pay up to 70% of the cost to purchase and install a ROPS.

At Kansas State University, K-State Research and Extension is collaborating with the National Tractor Safety Coalition to provide Kansas farmers with ROPS. The average cost of a ROPS is $1200, said Tawnie Larson, program manager for the K-State program, while the estimated cost of a fatal rollover is more than $750,000 for the family and farm.

In the last eight years, ten Kansas farmers have died and another six have sustained serious injury in tractor rollovers. "Approximately 30,000 Kansas farms are operating at least one tractor without a ROPS," Larson said.

While Kansas does not currently have funding for a ROPS rebate program, Larson said K-State hopes that the number of people who sign up on the waiting list will demonstrate the need to state and federal legislators.

Brokesh added, "When I was a kid, in the pre-ROPS days, a tractor rollover meant serious injury, or worse. My nephew's accident wasn't a big deal, and it's all because of the ROPS."

For more information, contact Ed Brokesh, ebrokesh@ksu.edu.

upcoming events

ASABE CONFERENCES AND INTERNATIONAL MEETINGS

To receive more information about ASABE conferences and meetings, call ASABE at 269-932-7029 or email mtgs@asabe.org.

2026

Feb. 8-11 — **Agricultural Equipment Technology Conference (AETC).** Louisville, Ky., USA.

July 12-15 — **ASABE Annual International Meeting.** Indianapolis, Ind., USA.

2027

Feb. 7-10 — **Agricultural Equipment Technology Conference (AETC).** Louisville, Ky., USA.

July 18-21 — **ASABE Annual International Meeting.** New Orleans, La., USA.

Circular Bioeconomy Systems Institute

Update on the Circular Bioeconomy Systems Institute

Building Momentum for Circular Bioeconomy Systems

Erin Webb, P.E.

More than five years ago, a forward-thinking group of ASABE members, led by **ASABE Fellows Jim Jones and Brahm Verma**, began envisioning a community in which engineers, scientists, and innovators could collaborate to apply circularity principles to the bioeconomy. Their conversations planted the seeds for what would become the Circular Bioeconomy Systems Institute (CBSI), which was officially established within ASABE in 2024.

In its first year, CBSI hit the ground running, hosting eight topical workshops and a dedicated CBS Day at ASABE's Annual International Meeting (AIM). Those events brought together experts across disciplines to explore circular strategies for livestock systems, controlled environment agriculture, natural resource management, urban food networks, food processing, and workforce training—laying the groundwork for a more connected, resilient, and sustainable bioeconomy.

While 2025 has brought shifting political priorities and volatile market conditions, enthusiasm for circular bioeconomy systems (CBS) has remained strong. By improving resource efficiency, upcycling waste into valuable products, and extending the life of biobased materials through cascading use, CBS strategies deliver

Attendees of the Schmidt Sciences VIFF Convening met in San Jose, California, on September 17-18, 2025, to share project updates and explore new collaborations in the circular bioeconomy. Erin Webb joined the event to learn more about VIFF activities and build connections between CBSI and the VIFF community (*photo courtesy of Schmidt Sciences*).

environmental gains as well as economic advantages. They strengthen domestic supply chains, spur innovation, and enhance resilience across the bioeconomy.

At the 2025 AIM in Toronto, interest in CBS was on full display. The CBSI-sponsored session, "Advancing Circular Bioeconomy Systems: Opportunities and Challenges," drew strong participation, featuring invited and contributed talks that showcased cutting-edge innovations in circularity, from technologies enabling waste valorization to systems approaches for sustainable food and water management.

Throughout the week, CBSI sponsored sessions on topics ranging from circularity in education and outreach to carbon-negative biosystems and resource-efficient waste management. The excitement carried into the social events as well, with CBSI honored as the beneficiary of the AIM Foundation Dinner, a lively evening that blended networking with a touch of mystery and fun. Across sessions and conversations, it was clear that ASABE's CBS community is energized by a shared commitment to designing resilient, circular biobased systems.

Momentum is also growing beyond ASABE, as partner institutions across the country embrace the circular bioeconomy vision. This fall, I had the privilege of participating in several events hosted by organizations at the forefront of this movement, each fostering innovative partnerships to connect stakeholders, advance new technologies, and accelerate CBS adoption.

In Tennessee, the UT-Oak Ridge Innovation Institute, a joint initiative between the University of Tennessee and Oak Ridge National Laboratory, has launched a convergent research initiative focused on perennial biomass crops and recyclable-by-design biopolymers and biocomposites for advanced manufacturing. To showcase recent R&D progress, UT AgResearch organized the inaugural Bioderived Materials and Chemicals in Circular Bioeconomy Systems Conference in Pigeon Forge, Tennessee, on September 3-4, 2025. I gave a presentation about CBSI and was encouraged by the strong interest from the attendees for engaging with CBSI.

The Tennessee conference also highlighted exciting developments in biomaterial circularity, systems modeling, and partnership-building, with contributions from experts across North America, including the University of Georgia, North Carolina State University, the University of British Columbia, and Penn State, among others.

I was also honored to attend the Virtual Institute for Feedstocks of the Future (VIFF) Convening, hosted by Schmidt Sciences—a non-profit supported by Eric and Wendy Schmidt to advance science and technology for global impact. This annual meeting, held September 17-18, 2025, in San Jose, California, brought together five multi-institutional project teams focused on developing renewable biomass as a foundational feedstock for the circular bioeconomy.

As a special guest, I had the opportunity to learn more about their ongoing work and explore opportunities for future collaboration between CBSI and Schmidt Sciences. Just one year into their five-year efforts, teams

Researchers and partners met in Pigeon Forge, Tennessee, on September 3-4, 2025, for the inaugural Bioderived Materials and Chemicals in Circular Bioeconomy Systems Conference, hosted by UT AgResearch. Erin Webb shared CBSI initiatives and connected with attendees advancing CBS (*photo courtesy of Jessica McCord, University of Tennessee*).

have already advanced the science of characterizing diverse biomass resources, improved systems modeling, and developed innovative methods to convert waste streams into valuable industrial feedstocks.

Later in September, I spoke at the Annual Congress of the University of Illinois Urbana-Champaign's Institute for Sustainability, Energy, and Environment (iSEE). This event, held September 25-26 in Urbana, Illinois, centered on the theme "A Circular Bioeconomy as a Path to Net-Zero." I presented our work in Tennessee, and I had the opportunity to meet with UIUC researchers and students, exchange ideas, and explore collaboration opportunities with CBSI.

A highlight of the iSEE Congress was the announcement of the new Levenick Center for a Climate-Smart Circular Bioeconomy—an interdisciplinary center established through a generous gift to accelerate research and innovation in circular bioeconomy solutions.

Building on this momentum, CBSI is planning for a busy year in 2026. This article launches a new *Resource* magazine series highlighting CBS initiatives and success stories. A complementary webinar series will explore key challenges and innovations, while preparations are underway for CBSI-sponsored sessions, posters, and a technical tour at the 2026 AIM in Indianapolis. CBSI is also the proud new sponsor of the student Bioprocess Startup Competition and looks forward to showcasing innovative product ideas from ASABE students.

The Circular Bioeconomy Systems Institute (CBSI) continues to grow and welcomes new members who are passionate about advancing circular solutions across the bioeconomy. The CBSI Working Teams (WT) offer opportunities for professionals, researchers, and students to contribute their expertise and collaborate on projects with real-world impact. Participants can join any one of the four teams:

- WT 1: Innovate Circular Systems, which focuses on developing and demonstrating new technologies that close resource loops.
- WT 2: Develop Circular Metrics, Models, Methods and Standards, which focuses on advancing tools for consistent evaluation and decision-making.
- WT 3: Organize Meetings, Conferences and Webinars, which connects the CBS community through events.
- WT 4: Publicize and Promote Circular Bioeconomy Systems, which focuses on highlighting success stories and raising awareness, as well as curriculum development.

Each team meets virtually once a month to share ideas, coordinate initiatives, and strengthen CBSI's growing network across academia, industry, and government. Now is the perfect time to join this collaborative effort and help shape a more circular and resilient bioeconomy!

To sign up, scan the QR code and visit the CBSI website (https://cbsi-asabe.org) and complete the brief interest form.

ASABE Fellow Erin Webb, P.E., Chair, ASABE Circular Bioeconomy Systems Institute, and Agricultural Engineer, Oak Ridge National Lab, Oak Ridge, Tennessee, USA, webbeg@ornl.gov.

Engineering the Future: Double Your Impact this Giving Season

Students are at the heart of ASABE. They are the next generation of innovators, problem-solvers, and leaders in agricultural and biological engineering. This Giving Season, we have an extraordinary opportunity to support students:

Every dollar donated to student programs will be matched—doubling the power of your gift.

Two generous matches are available: $50,000 for new donations made through December 31, 2025, and $134,600 for new donations to student competitions. Combined, these two challenges create the potential to raise $185,000 in new support for students.

Your gift means that students with financial needs can pursue their degree through scholarship support.

Your gift means that our annual student competitions—including Robotics, Fountain Wars, and the International Quarter-Scale Tractor Competition—will continue to offer the hands-on, team-based experiences that define ASABE student life.

Your gift means that the Student Rally Leadership Networking Program (SRLNP) will prepare even more students to step into leadership roles, building the professional and personal skills that will serve them throughout their careers.

The impact of these programs reaches far beyond a single event or semester. Scholarships open doors that might otherwise remain closed. Competitions transform classroom learning into real-world solutions. Leadership training equips students to guide teams, organizations, and communities toward innovation and sustainability. Together, these experiences shape the careers of our students and the trajectory of the agricultural and biological engineering profession.

Your gift is an investment in student growth and in the future of ASABE. It's an opportunity to honor the mentors who came before you, to give back to the Society that has shaped your own journey, and to ensure that the next generation of students has the resources to dream bigger, reach higher, and achieve more.

This Giving Season, let's come together to invest in the future. Let's double our impact, empower our students, and fuel the profession we all care so deeply about.

Liz Metts, Director of Development, ASABE, St. Joseph, Michigan, USA, metts@asabe.org.

I was honored to receive the John C. Nye Graduate Fellowship in my final semester of graduate school. That support allowed me to concentrate on completing my dissertation without the added stress of financial challenges. I'm grateful for the difference it made during such a pivotal time in my academic journey. Thank you, ASABE, for investing in my success!

Lisa U., Clemson University

The John C. Nye Graduate Fellowship Fund is one of 15 student-impact funds within the ASABE Foundation.

Two Parallel Paths to Biochar Standards:

Long-term and short-term

Scott Cedarquist

Many of us return from the ASABE Annual International Meeting energized, but we often face a large list of action items and takeaways. Before the energy from Toronto starts to fade, I wanted to share two exciting, ongoing efforts to develop standards for biochar.

For those unfamiliar, biochar is a solid, carbon-rich material produced through the thermochemical treatment of biomass under no or limited oxygen conditions. Biochar can be produced from any type of biomass, including, but not limited to, woody materials, agricultural materials, purpose-grown crops, manures, digestates, wastewater treatment plant biosolids, food waste, and the organic fraction of municipal solid waste.

ARS scientists improved sugarcane yields by amending soil with biochar, a carbon-rich charcoal made from leafy trash and bagasse (*photo by Sophia Wojkowski, courtesy of USDA-ARS*).

Biochar may be physically and chemically similar to, and sometimes identical to, other materials, including biocarbon, biocoal, and charcoal. The differences among these materials are related to the end use.

I first heard about biochar at an ASABE meeting several years ago. That left me wanting to know more, and I sought out additional information. One of the most memorable presentations I heard along the way was given by Steven Vaughn, a research plant physiologist at the USDA-ARS, at the 38th annual Illinois Central College horticultural showcase.

In addition to discussing how this special form of carbon was used centuries ago to transform the poor forest soils of the Amazon Basin and enable food production, Dr. Vaughn provided a modern-day example: golf course greens. Although biochar can be expensive, refreshing the greens on a golf course is also very costly. Anything that can be done to prolong the life of a green is worth careful consideration, including biochar in the soil mix.

After the presentation, Dr. Vaughn demonstrated how easily biochar can be produced in a traveling kiln using wood scraps. I have not yet produced my own biochar, but it's on my retirement bucket list. Until then, I will have to be content that biochar is starting to show up for sale in the big box stores.

In my research, I also discovered that there are no US or ISO standards for biochar. That encouraged me to dig deeper. I learned from **ASABE Fellow Jim Dooley, P.E.,** that there is a US Biochar Initiative (USBI) run by **ASABE member Tom Miles.** I reached out to Tom to explore how USBI and ASABE could collaborate on developing standards for this material. At that point, the industry was not yet ready to pursue standards, but the seed had been planted.

Separate from my discussions about USBI, Canada was planning to phase out the use of coal by 2030 and was seeking solutions for that goal. The most common use of coal is electricity generation, but another grade of coal is used in the production of steel. Canadian steel plants could continue to operate if a biological alternative to coal could be found. In its original state, wood does not have the BTU content needed, but wood can be converted into an energy-dense form of biocarbon known as biocoal.

This possibility led to an evaluation within ISO Technical Committee 238 about which ISO Technical Committee was best suited to undertake the development of fuel standards for biocarbon. Ultimately, it came down to whether ISO Technical Committee 27 (Coal and Coke) or 238 (Solid Biofuels) would be best suited to develop the new standards.

During that discussion, it became apparent that ISO Technical Committee 27 was not interested in expanding its scope to include this new material. Therefore, in 2024, the scope of ISO Technical Committee 238 was expanded to include pyrogenic biocarbon. Pyrogenic biocarbon would include densified fuels, industrial biocarbon, biochar, and similar materials. Currently,

A proposal for a two-part standard covering specification and classification is currently being balloted to the international community: part one covers general requirements, and part two is focused on material-based classification.

29 countries participate as voting members of ISO Technical Committee 238, and 21 countries participate as observing members. Within ASABE, the Energy Systems Technical Committee (ES-238) provides the US voice in the development of these international standards.

ISO Technical Committee 238 has already initiated the first projects for biocarbon. A proposal for a two-part standard covering specification and classification is currently being balloted to the international community: part one covers general requirements, and part two is focused on material-based classification.

While the expansion in scope for ISO Technical Committee 238 provides a path forward, developing a portfolio of international standards for biocarbon will take many years. For perspective, ISO Technical Committee 238 was established in 2007 and has published 48 standards to date. A portion of those existing standards will likely be applicable to biocarbon with little or no modification. In other cases, new standards will be needed, such as the two-part specification and classification proposal.

Meanwhile, in the US, a near-term solution was required, and additional discussions were held with USBI regarding cooperative work on biochar standards. As a result of those discussions, and to address the short-term need for biochar standards, **ASABE member Chris Wiberg,** chair of ES-238, initiated a project proposal in 2024 to pursue an ASABE standard for biochar. Standards project X668, Methods for Measurement and Testing of Biochar, is well underway with anticipated publication later this year.

During the development of X668, the working group participants critiqued all the existing standards that could be used to test biochar and selected the best available option for inclusion in the new standard. Thus, X668 is like a road map detailing the best resources available. Due to the financial resources secured by USBI, the new standard will be made open access upon publication. To recognize the significant role of USBI in developing this document, the designation of the new standard will be ANSI/ASABE/USBI.

If you are interested in participating in standards development, we would welcome your input. Contact me at cedarq@asabe.org or contact Britni Wall, ASABE Standards Administrator, at wall@asabe.org.

ASABE member Scott Cedarquist,
Director of Standards, ASABE,
St. Joseph, MI, USA, cedarq@asabe.

Further Reading

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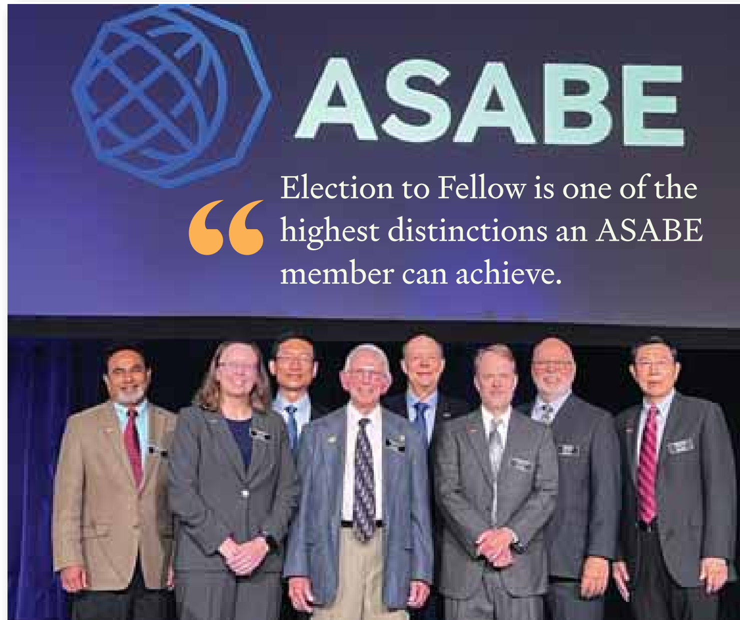
Meet the ASABE Fellows

Honoring the newly elected

ASABE recognized ten new Fellows at the 2025 Annual International Meeting in Toronto, Canada. In this issue of *Resource,* we highlight our first three Fellows from the class of 2025.

Fellows must have a minimum of 20 years of active practice in, or related to, the profession of engineering, the teaching of engineering, or the teaching of an engineering-related curriculum. The designation Fellow has honorary status, to which members may be elected but may not apply.

As the ASABE Constitution states, Fellows are "of unusual professional distinction, with outstanding and extraordinary qualifications and experience in, or related to, the field of agricultural, food, or biological engineering." Election to Fellow is one of the highest distinctions an ASABE member can achieve.



The 2025 class of ASABE Fellows.

Richard Job, P.E., is honored for 40 years of developing engineering products that have benefited the production of food and fiber.

Following a distinguished career in agricultural and industrial engineering, Job now serves as a part-time consultant to the agricultural industry. This role enables him to leverage decades of hands-on experience and deep technical expertise, providing invaluable guidance and problem-solving capabilities. His continued engagement demonstrates a sustained commitment to advancing the industry, even in retirement.

Job's career showcases significant contributions to agricultural and industrial engineering. In the 1970s, he led White Field Boss tractor testing, developing innovative methods to replicate and resolve critical field failures, notably clutch and A/C system moisture problems. This involved creating a specialized test chamber to simulate high-humidity conditions and verify the solutions. He designed test programs to ensure the reliability of power shift transmissions. He also developed a test to verify the solution for a critical wet clutch spline wear issue during his time at White Farm Equipment. His expertise extended to managing test and development groups for White Farm Equipment and Harnischfeger Lattice Boom Cranes.

As a project engineer for the U.S. Navy, Job engineered the replacement MD10 tow tractor, increasing towing capacity by 25% without altering the machine's size. Later, as engineering manager for AGCO, he ensured that imported tractors from various manufacturers met North American safety and liability standards. This required coordinating with international design teams and resolving field complaints.

A 35-year member of ASABE, Job has made significant contributions to the Society, including playing a key role in the transition of US TAG responsibilities for ISO from AEM to ASABE. He actively participated in and chaired numerous ASABE committees focused on standards development. Notably, Job was a crucial member of the ASABE PM23/2/1 committee, leading the development of ASABE Standard S613: Air quality for cabs. His work in developing standards has had a lasting impact on the industry.

Carmen Agouridis, P.E., senior associate dean and associate dean for instruction at the University of Kentucky, is honored for her extension and resident instruction contributions targeted toward protecting and restoring water systems impacted by agricultural, urban, and mining activities.

As senior associate dean, Agouridis oversees internal operations and provides leadership for the Martin-Gatton College of Agriculture, Food and Environment, including program assessments, accreditations, faculty affairs, and major building projects. As associate dean for instruction, she oversees undergraduate and graduate programs, with a focus on student success, curriculum development, and budget management. Agouridis oversees all aspects of the student lifecycle and is responsible for the 22 undergraduate programs, 7 undergraduate certificates, 10 minors, 13 graduate programs, and six graduate certificates that serve over 2,600 students within the college.

Agouridis helps oversee the $500+ million budget for renovation and construction of three new buildings that will support the college's instructional mission and manages the college's $100 million gift from The Bill Gatton Foundation.

Agouridis also has an impactful research career, which involves environmental management, notably through contributions to the forestry reclamation approach and the development of impactful extension programs like Backyard Streams and the Kentucky Climate Consortium. She pioneered the use of GPS tracking for cattle movement and has provided extensive educational outreach on the concept. Her expertise in mined land reclamation led to an appointment on the National Academies of Science, Engineering, and Medicine (NASEM) Committee on Earth Resources, and her work on cattle grazing best management practices resulted in membership on the USDA-NRCS Conservation Effects Assessment Project. Additionally, she created or co-created multiple academic programs, including the Stream and Watershed Science Graduate certificate and the Environmental Engineering Undergraduate certificate.

A 29-year member of ASABE, Agouridis has been actively involved, including serving as an associate editor, ASABE Foundation trustee, chair of the NRES Executive and Steering committee, NRES program chair, lead developer of the ASABE Student Oral/Poster Presentation competition, and member and officer for numerous technical committees.

"The designation Fellow has honorary status, to which members may be elected but may not apply.

Sandun Fernando, P.E., professor and associate department head for graduate programs in the Department of Biological and Agricultural Engineering at Texas A&M University, is honored for his pioneering contributions to biomolecular engineering, sustainable bioenergy, and agricultural biotechnology, including innovations in therapeutic peptide design, antiviral compounds, and advanced biosensor technologies.

Fernando specializes in biomolecular engineering, focusing on nanoscale molecular constructs to regulate catalysis in biological processes. His research integrates nanotechnology, modeling, and simulations to develop solutions that leverage interfacial phenomena and enzyme catalysis, thereby improving agricultural productivity, energy sustainability, and human health. A key aspect of his work is designing molecules with novel catalytic properties. His team develops metal complexes, peptides, and polynucleotides for diverse applications in agriculture, bioenergy, and health-related fields.

Fernando has made significant contributions to biomolecular engineering through his patents and scientific research. His patented method for deoxygenation of biomass oxygenates has advanced sustainable fuel production. He also developed a moisture displacement and algae surface-functionalization technique for biofuel extraction applications. In agricultural biotechnology, his provisional patent for specifically targeted binders and antimicrobial peptides (STAMPs) addresses citrus crop pathogens. His recent disclosure on metal nucleobase coordination compounds as broad-spectrum antiviral therapeutics has introduced novel antiviral compounds. Fernando has also led the development of the Highly Optimized Peptide Engineering (HOPE) algorithm, a state-of-the-art platform for generating highly selective therapeutic peptides against challenging disease targets.

Fernando is a 26-year member of ASABE. He has served as an associate editor for *Transactions of ASABE* and *Applied Engineering in Agriculture* since 2006, receiving service recognition for his work with the Processing Systems and Energy Systems Technical Communities. He also chaired and served as past-chair of the Biobased Energy, Fuels, and Products committee.

ASABE Journals

Recent research from our publications

ASABE has been a trusted source of authoritative research for well over a century. Our peer-reviewed journals contain pioneering research in ag and bio engineering. Here are some highlights from our most recently published journals. All journal articles are available free of charge as a member benefit at elibrary.asabe.org/toc.asp. ***ASABE members are in bold type.***

APPLIED ENGINEERING IN AGRICULTURE

Leveraging Generative AI for Data Analysis in Farm Management

Joshua K. Bailey, Fabio A. Castiblanco, Andrew D. Balmos, Aarav S. Pai, Lionel Y. Loo, Sneha Jha, **Md. Samiul Basir, Dennis R. Buckmaster, James V. Krogmeier, Yaguang Zhang, Upinder Kaur**

Highlights

- Generative AI successfully analyzed data files related to machinery maintenance, financial health, and soil/yield.
- The complexities of APIs and custom GPT integration were demonstrated with live public and private data sources.
- With constrained prompts, Generative AI was able to analyze live weather data, field records, and IoT sensor readings.

Vol. 41(5): 505-519
doi.org/10.13031/aea.16429

Concise Review of the Evolution of Sustainable Nitrogen Fixation Technologies: From Natural Processes to Recent Plasma-Based Innovations

Cesar M. Moreira, Carola Sanchez, **Pratap Pullammanappallil, Bruce A. Welt**

Highlights

- Plasma-based nitrogen fixation offers sustainable alternatives to Haber-Bosch.
- Microwave induction plasma coupled torches achieve high efficiency using air and water.
- Biological fixation remains vital but limited in scalability and consistency.
- Review compares natural and artificial methods for nitrogen fixation.

Vol. 41(5): 573-585
doi.org/10.13031/aea.16424

JOURNAL OF THE ASABE

Positioning Accuracy of RTK-GNSS-Enabled Drones and Their Performance in Agricultural Crop Sensing

Pascal Izere, **Biquan Zhao,** James Schnable, **Yufeng Ge, Yeyin Shi**

Highlights

- The performance of RTK-GNSS-enabled drones without GCPs was assessed in agricultural applications.
- A centimeter-level positioning accuracy was achieved when drones were functioning with RTK-GNSS-enabled.
- RTK-GNSS-enabled drones without GCPs performed competitively with GCP-based methods in plant height estimation.
- Using RTK-enabled drones without GCPs provides a time- and labor-saving solution for agricultural practices.

Vol. 68(4): 559-571
doi.org/10.13031/ja.16306

Algorithms to Process Weighing Lysimeter Data

Paul D. Colaizzi, Gary W. Marek, Steven R. Evett, Karen S. Copeland, Brice B. Ruthardt

Highlights

- Weighing lysimeters can accurately determine water balance components.
- Algorithms were developed to automate processing of lysimeter water storage data.
- The algorithms were tested by comparing results to independent spreadsheet calculations.
- Discrepancies between spreadsheet and algorithm evapotranspiration were small.
- Longitudinal graphs were used to detect uncertain or spurious evapotranspiration.

Vol. 68(5): 729-752
doi.org/10.13031/ja.16404

JOURNAL OF AGRICULTURAL SAFETY AND HEALTH

Occupational Safety Research Needs in the Field of Robotics and Autonomous Machines in Agriculture

Jennifer Lincoln, **Serap Gorucu, Farzaneh Khorsandi,** Guy R. Aby, K.C. Elliott, **John Shutske, Salah F. Issa**

Highlights

- Comprehensive view of occupational safety research: Prioritizing topics in robotics and autonomous machines.
- Barriers to safety research: Logistical, intellectual property, timeline, and funding challenges.
- Importance of surveillance or tracking system: Documenting fatalities, injuries, and near misses/good catches.
- Priority safety research needs: human-machine interaction, adoption of automation in the work setting, and surveillance/tracking.
- Collaboration with technology developers: Overcoming barriers and exploring emerging technologies and potential safety implications.

Vol. 31(3): 217-230
doi.org/10.13031/jash.16216

A Summary of Fatalities and Injuries Involving Horizontal Bunk or Open Pile Silos Used in Agricultural Production

Noah J. Haslett, William E. Field, Mahmoud Nour, **James Carrabba,** Martin Huseman

Highlights

- The frequency of horizontal silo-related fatalities and injuries was lower than anticipated, based upon historical media coverage.
- There were 33 cases with 35 victims documented in the U.S. between 1962 and 2023, with 74.3% being fatal.
- Horizontal bunk silos are a safer design than conventional tower silos based upon the frequency of documented cases.
- Implementing prevention strategies should focus on dairy and beef production operations. Consideration should be given to incorporating recommendations on safe work practices in the current ASABE bunk silo design standard.
- Workers should be trained to keep no less than the height of the silage pile away from the face of the silage when entering the silo for any reason, including when sampling silage.
- The frequency of both fatal and non-fatal bunk silo incidents does not justify significant changes to federal workplace safety regulations.

Vol. 31(3): 231-243
doi.org/10.13031/jash.16058

JOURNAL OF NATURAL RESOURCES AND AGRICULTURAL ECOSYSTEMS

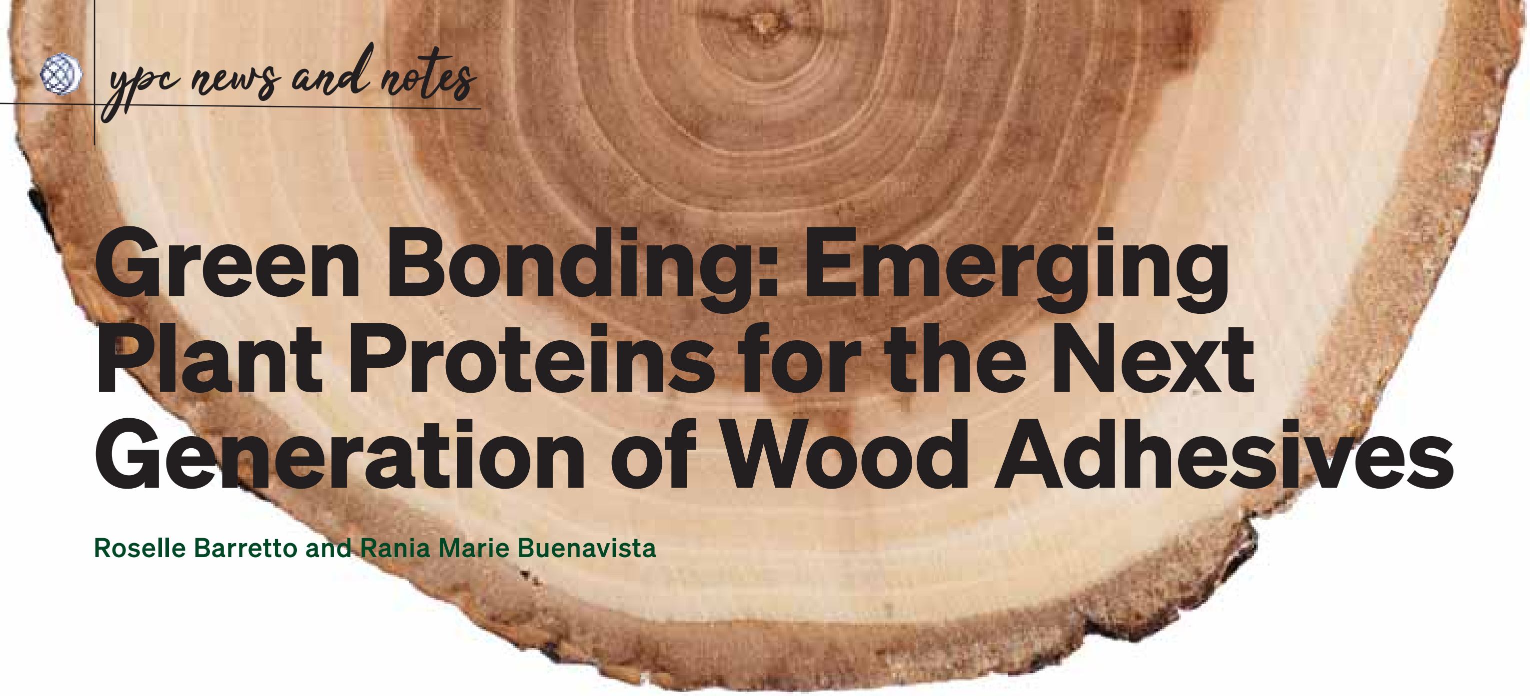
Development of a Machine Learning Framework for an Irrigation Decision Support System

Eric J. Wilkening, Derek M. Heeren, Yeyin Shi, Abia Katimbo, Laila A. Puntel, Guillermo R. Balboa, Kuan Zhang, **Precious N. Amori,** Bruno P. Lena

Highlights

- Machine learning techniques applied to irrigation resulted in accuracies within 1.3 days of the actual date of needed irrigation.
- The spatial and temporal disparity of data did not affect the performance of the ML irrigation model.
- The “latest date” scheduling metric was utilized to incorporate data from different irrigation scheduling strategies.
- Initial model evaluation shows good results, but the model still needs further development.

Vol. 3(3): 121-131
doi.org/10.13031/jnrae.16162



Green Bonding: Emerging Plant Proteins for the Next Generation of Wood Adhesives

Roselle Barretto and Rania Marie Buenavista

Wood adhesives are the hidden backbone of the modern construction and furniture industries. From plywood to particleboard and medium-density fiberboard, adhesives are the essential element that transforms raw veneers and fibers into strong, durable panels.

For decades, the market has been dominated by petroleum-based thermosetting resins, particularly urea-formaldehyde (UF), phenol-formaldehyde (PF), and melamine-urea-formaldehyde. These adhesives deliver strength and low cost, but they also release formaldehyde, a known carcinogen, and depend on non-renewable fossil resources. With increasing regulatory pressure in North America, Europe, and Asia, as well as consumer demand for low-emission products, the search for sustainable, renewable adhesives has intensified.

Plant proteins offer a compelling alternative. As natural macromolecules with abundant reactive functional groups, plant proteins can form networks that adhere strongly to wood surfaces. They are also widely available as agricultural products or byproducts, making them attractive from both a sustainability and supply-chain perspective.

Historically, plant proteins were among the first adhesives used. Casein-based glues have a long history, dating back centuries, and soy flour adhesives dominated the plywood industry in the early 20th century. However, poor water resistance and the superior durability of synthetic resins pushed plant protein adhesives to the margins by mid-century.

Today, the picture has changed. Advances in chemistry, processing, and hybrid formulations are breathing new life into plant protein adhesives. Soy remains the reference material, but new sources are emerging with distinct advantages. Hempseed, peanut, cottonseed, sunflower, canola, potato, corn, wheat, and pea proteins are all being explored as feedstocks for adhesives that meet modern industrial standards.

“Advances in chemistry, processing, and hybrid formulations are breathing new life into plant protein adhesives.

This article reviews these developments, with a focus on the most promising new sources of plant protein adhesives and their potential to transform the wood products industry.

Soy protein: The benchmark and its limitations

Soy protein has served as the foundation for bio-based wood adhesives for nearly a century. By the 1930s and 1940s, soy flour adhesives accounted for the majority of the U.S. plywood market. However, their poor water resistance and relatively high viscosity led to their replacement by UF and PF resins once those synthetic systems became commercially available. Despite this decline, soy has continued to attract research interest.

Modern soy protein adhesives benefit from physical, chemical, enzymatic, and nanomaterial modifications. Alkaline denaturation exposes reactive sites on the protein chains, while crosslinkers, such as glyoxal and epoxies, create covalent bonds that enhance water resistance.

Enzymatic hydrolysis can reduce viscosity and improve spreadability. Reinforcement with nanomaterials such as nanocellulose further enhances mechanical strength and dimensional stability.

Collectively, these strategies have produced soy adhesives with dry bond strengths exceeding 5 MPa and wet strengths above 1 MPa, meeting the requirements for interior plywood and, in some cases, approaching UF performance in exterior conditions.

Nevertheless, challenges remain. Soy protein is subject to supply chain volatility due to its high demand in both food and animal feed. Its allergenic potential also limits acceptance in certain markets. Most importantly, even the best-modified soy adhesives struggle to achieve the long-term durability of phenolic resins in outdoor environments. Soy has set the baseline and provided a rich toolbox of modification strategies, but the industry is now seeking new proteins that can overcome these limitations.

Wheat gluten: A familiar yet underused protein

Alongside soy, wheat gluten is one of the earliest plant proteins explored for wood adhesives. Gluten is composed of two main fractions: gliadins, which provide film-forming capacity, and glutenins, which form disulfide bonds that give the adhesive network cohesion. These structural features make wheat gluten inherently sticky, and under the right conditions, it can deliver bond strengths in the range of 1 to 2 MPa.

That performance is adequate for interior panels, although water resistance has always been the downside. Treatments such as aldehyde crosslinking, esterification of carboxyl groups, and blending with polycarboxylic acids or lignin have been shown to improve moisture resistance and durability. Gluten's natural abundance of cysteine residues means that it can form strong disulfide bridges even without heavy chemical additives, giving it a built-in advantage for cohesive strength when properly processed.

From an industry perspective, wheat gluten is widely available as a byproduct of the wheat starch sector. Its low cost and stable supply make it attractive, although its role in food markets and the perception of gluten as an allergen may limit enthusiasm in certain regions. Even so, when combined with other modifiers or bio-fillers, wheat gluten adhesives have demonstrated real potential in non-structural plywood and particleboard. It remains a classic protein system: familiar, reliable, and worth revisiting as the industry looks for bio-based solutions beyond soy.

Hempseed protein: High hydrophobicity, high potential

Hempseed protein has emerged as one of the most promising alternatives. Hemp meal, generated after oil extraction, contains about 35% to 40% protein. Hemp proteins contain a high level of hydrophobic amino acids—up to 40% of the total. In adhesives, this hydrophobicity is an asset, reducing water absorption and improving resistance to swelling and bond failure. The two dominant fractions, edestin and albumins, unfold readily under alkaline and thermal treatment, exposing amino and carboxyl groups for chemical reaction.

Recent research has demonstrated the potential of hempseed protein adhesives. When modified with glyoxal, hemp adhesives achieved dry shear strengths of 5.69 MPa, wet shear strengths of 2.68 MPa, and soaked shear strengths of 4.91 MPa. These values not only exceed many soy formulations but also approach the performance of UF resins used in plywood production.

Differential scanning calorimetry showed that glyoxal increased the denaturation temperature of hemp proteins to nearly 147°C, enhancing their stability under hot-pressing conditions. Zinc chloride modification provided additional ionic crosslinking and structural organization, improving thermal stability, although its impact on bond strength was less compared to glyoxal.

Hempseed protein adhesives fit neatly into circular economy narratives. Hemp cultivation is expanding worldwide for fiber, seed oil, and cannabinoids. The residual meal often has low market value, but when transformed into adhesives, it can provide a high-value outlet. For regions promoting hemp as a rotational crop, hempseed adhesives could strengthen rural economies while providing the wood industry with a renewable and formaldehyde-free adhesive option.

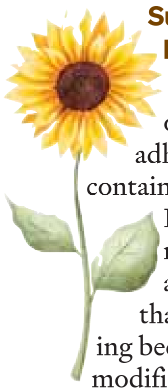
Peanut and cottonseed proteins: Oilseed byproducts with industrial promise

Peanut and cottonseed proteins, byproducts of oil extraction, are also attracting significant interest. Peanut meal typically contains more than 50% protein, while cottonseed meal contains 40% to 45%. Both have abundant reactive groups, including lysine, arginine, and cysteine residues that make them well suited for crosslinking and bond formation.

Recent studies developed adhesives from peanut, soybean, and cottonseed meals using a double-network design in which hydrogen bonding was combined with covalent crosslinking to create denser and more water-resistant matrices. The performance improvements were dramatic. Wet shear strength increased by 246% for soy, 335% for peanut, and 174% for cottonseed proteins.

Cottonseed adhesives achieved wet shear strengths of 1.59 MPa, while boiling water strengths of 0.82 to 0.92 MPa were recorded across all three proteins. These values surpass the Chinese Class I plywood requirement of 0.7 MPa, demonstrating that peanut and cottonseed proteins can meet industrial standards when properly modified.

Cottonseed's sulfur-containing amino acids allow disulfide bond formation, which contributes to adhesive resilience. Peanut proteins, while slightly less reactive, offer a cost advantage in regions with large peanut oil industries. Both proteins exemplify how oilseed meals, often considered animal feed or waste, can be upgraded into adhesives that are potentially capable of replacing synthetic resins in interior and semi-exterior applications.

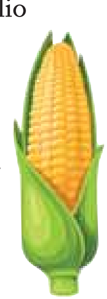


Sunflower and canola proteins: Regional diversification of supply

Sunflower and canola proteins represent opportunities for regional diversification of adhesive feedstocks. Sunflower meal, which contains 20% to 30% protein, is abundant in Eastern Europe and parts of Asia. Canola meal is produced in large volumes in Canada and Northern Europe. While less studied than soy or hemp, these proteins are promising because of their availability and potential for modification.

Experimental adhesives based on sunflower proteins have achieved shear strengths of 2 to 3 MPa. Although these values are low, they demonstrate that sunflower proteins can form effective bonds with wood substrates. Water resistance remains limited; however, chemical modification with polycarboxylic acids or blending with polyphenols, such as tannins and lignin, has been shown to improve performance significantly. Canola proteins, with their higher levels of cysteine and methionine, offer natural opportunities for disulfide bonding, which may reduce the reliance on synthetic crosslinkers.

These proteins may not immediately rival soy in their adhesive performance, but they illustrate the importance of aligning adhesive development with regional agricultural outputs. In Europe, sunflower protein adhesives could reduce dependence on imported soy. In Canada, canola adhesives could provide a sustainable local feedstock. This diversification reduces risk in supply chains while expanding the global portfolio of bio-based adhesives.



Corn zein and potato proteins: Valorizing the starch industry

Corn and potato proteins are byproducts of the large starch industry, and both are being evaluated for adhesive applications. Zein, a prolamin storage protein in corn, is inherently hydrophobic. This gives it an advantage in moisture resistance compared to more hydrophilic proteins like soy and wheat gluten. Experimental zein adhesives have demonstrated higher bond durability under humid conditions; however, the limited supply and high cost of zein restrict its potential for large-scale adoption.

Potato protein, on the other hand, is more abundant and is often recovered from wastewater streams in the starch processing industry. Potato proteins contain functional amino acids such as lysine, aspartic acid, and glutamic acid that contribute to bonding. Adhesives made from potato proteins and modified with glyoxal have demonstrated improved wet strength, particularly at acidic pH values around 4. These conditions promote more effective crosslinking that creates stronger adhesive networks.

The valorization of starch industry byproducts into adhesives provides dual benefits: it reduces waste disposal burdens and creates renewable adhesive feedstocks. Although corn and potato proteins may not fully replace UF or PF resins, they represent valuable niche solutions that could be scaled in regions with significant starch processing capacity.

Pea protein: Riding the plant-based food wave

Pea protein is emerging as a major player in both food and non-food applications. The rapid growth of plant-based diets has led to an expansion of pea protein production, creating opportunities to direct surplus or non-food fractions into industrial uses. Pea protein isolates contain up to 85% protein, while concentrates contain about 50%. Structurally, pea proteins are similar to soy globulins, with vicilin and legumin fractions that can form cohesive films and crosslinked networks.

Early adhesive studies indicate that pea proteins can achieve bond strengths comparable to those of soy in dry conditions; however, water resistance remains the limiting factor. Modification strategies have included the use of tannins, lignin, and polycarboxylic acids, which have significantly improved the wet strength and durability. As with other proteins, alkaline treatment and denaturation are also effective in exposing reactive groups for crosslinking. With further development, pea protein adhesives could serve in interior-grade plywood and veneer applications.

The scalability of pea protein adhesives is tied to the continued expansion of the plant-based food market. As more processing capacity is built worldwide, industrial applications will benefit from a steady supply. With lower allergenicity than soy, pea protein also offers a marketing advantage in applications where consumer perception is a key factor.

Future outlook: Toward a protein portfolio

The development of adhesives from emerging plant proteins demonstrates that the future will not rely on a single feedstock. Instead, a portfolio approach is emerging. Soy remains the benchmark, but hempseed is showing superior hydrophobicity and strength. Peanut and cottonseed proteins demonstrate that oilseed byproducts can meet stringent standards. Sunflower and canola proteins offer regional diversification. Corn zein and potato proteins can valorize starch industry sidestreams. Pea protein benefits from a booming food industry that guarantees supply.

“... plant protein adhesives, especially those from emerging sources, are poised to play a huge role in the future of engineered wood products.

Across all these proteins, common challenges remain: water resistance, feedstock variability, and cost of modification. Strategies to address these issues include aldehyde crosslinkers, such as glyoxal, polycarboxylic acids like citric acid, ionic modifiers like zinc chloride, and hybrid formulations combining lignin and tannins. Reinforcement with nanomaterials and processing innovations such as ultrasonication or enzymatic modification further improves performance.

The global wood adhesives market was valued at $7.03 billion USD in 2023 and is projected to grow at a compound annual rate of 8.6% through 2030. Even capturing a modest share of this market would represent a significant step toward reducing dependence on petroleum-based adhesives. As regulations tighten and sustainability becomes a central driver of industrial decision-making, plant protein adhesives, especially those from emerging sources, are poised to play a huge role in the future of engineered wood products.

ASABE member Roselle Barretto, YPC Publications Council Representative and Doctoral Student, and **ASABE member Rania Marie Buenavista,** Doctoral Student, Department of Biological and Agricultural Engineering, Kansas State University, Manhattan, Kansas, USA, rosellebarretto@ksu.edu.

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Looking Back and Looking Ahead

Wayne Maley

A new era in agricultural production is upon us. From a long history of innovation by ASABE members, I believe our organization should continue to be a key leader.

For centuries, manual labor dominated food and fiber production. Then, in 1837, when John Deere received his patent, the steel moldboard plow became the leading tool for opening the prairies and creating the Cornbelt. Many other innovations followed, with a focus on developing ever more efficient tools to take the drudgery out of farming and improve the economic well-being of farmers.

In the early 1900s, with the second century of agricultural engineering, the focus shifted to developing tractors with greater power and efficiency. Those improvements have continued, and mechanization has reduced farm labor from 70% of the population to less than 2% today. Thus, we can ask the question: Are we now moving into a third century with a different focus?

Consider the increased use of computer-collected data and robotic control, as evidenced by the AE50 awards, especially the Davidson Prize winners. At ASABE's 2025 Annual International Meeting, the staff tested the use of artificial intelligence (AI) to group some of the presentations thematically, prior to the committee program chairs determining the final order. One of the eight presentations in the Cotton Engineering session reported using AI for data gathering.

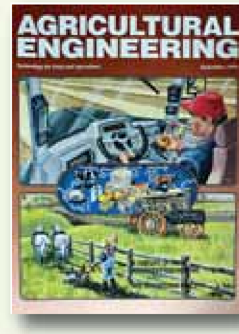
AI has the ability to provide a wide range of information to inform the many decisions that producers must make. Will AI free up brain power for ASABE members to focus on other areas? Will it change our bioresource systems? Earlier this year, an opinion piece in *The Wall Street Journal* put it bluntly: "We're moving toward a world where AI is everywhere and part of everyday life."

As we continue to reduce drudgery and improve economic well-being, I envision routine decisions informed by AI and repetitive work accomplished by robots, while complex problems are tackled by the producer. It appears to me that we are well on our way, in this third century of agriculture engineering, for ASABE members to be known as the innovators in applying brain power to improve bioresource systems around the world.

ASABE Fellow Wayne Maley was born on the family farm in Stanley, Iowa, on March 9, 1927, and died at his home in Las Cruces, New Mexico, on October 5, 2025.

Wayne volunteered for service in the U.S. Navy during WWII and then completed a BS in Agricultural Engineering at Iowa State University. After a career working to improve farming, he contributed his expertise to ASABE as well as to technical aid programs in Michigan, eastern Europe, and Zimbabwe. He retired to Las Cruces, where he volunteered at the Farm and Ranch Heritage Museum for over 20 years.

A New Century of Agricultural Engineering



In 1993, ASABE commissioned an oil painting be created for the Equipment Manufacturers Institute (EMI), the predecessor of the Association of Equipment Manufacturers (AEM), to celebrate the first century of farm equipment development.

In this painting, artist Robert Gernand captured the progress of agricultural engineering since the nineteenth century, when EMI was established and when the horse-drawn, moldboard plow was an essential tool. With a friendly wave and a curious glance, a farmer with his plow greets a passing neighbor, who's driving a new steam tractor, which represents the second century of farm equipment development.

Neither of them can foresee the future, when field operations will be performed from the comfort of an air-conditioned cab. Today, a wealth of agricultural products flows to people all over the world because of the productivity of modern farm equipment.

Now we can add a third element to this painting, representing the third century of innovation by ASABE members. *What would you choose to represent the new century?*

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