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Sustainable Mulch MANAGEMENT

Plastic Mulches in Horticulture Production

Improved End-Of-Life of Plastic Mulches

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In This Issue...

Project Director's Note

Lisa Wasko DeVetter, Associate Professor, Washington State University

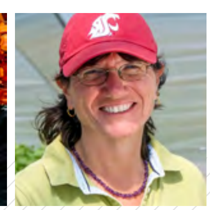
"Mulch matters", as does other sources of agricultural plastics and their impacts on food production systems and the greater environment. This edition of *Sustainable Mulch Management* is packed with articles that address just that. From further exploration into the science and impact of microplastics to broadening our collective understanding of pyrolysis as a way to thermally recycle highly contaminated plastics, this edition seemingly has it all. This edition also highlights the diversity of many individuals all contributing to the collective goal of improving the end-of-life outcomes of agricultural plastics but doing it in a way that minimizes impacts to farmers' bottom line.

This newsletter also highlights the multidisciplinary nature of our project team members and collaborators. I encourage you as a reader to expand your knowledge and awareness of the many nuances related to mulch and agricultural plastics. Additionally, there is coverage on biobased alternatives being investigated to meet certified organic growers mulching needs, how recycled non-biodegradable polyethylene mulch can be transformed into asphalt roadways, the interplay between soil biodegradable plastic mulches and mineral-associated soil organic matter, and the contributions of human dimensions research. This is just the tip of the iceberg and you can continue to stay abreast of all of our accomplishments by following us on social media or subscribing to our podcast.

Also, we remain alert of the federal situation. Academic institutions and scientists are feeling the financial pressures as cutbacks are being made. Our project team to date has not been directly impacted by cuts made to grant programs funding our work centered on improving the end-of-life outcomes of plastic mulch. We remain optimistic that we will continue with our research that hinges on federal grant dollars. Furthermore, we remain committed to our science with the end goal of having our work benefit farmers, the communities that depend on them, and our larger environment.

Cover photo

Machine laying Solar Shrink at Washington State University's Northwestern Washington Research and Extension Center in Mount Vernon, Washington. Solar Shrink is a non-biodegradable plastic mulch under evaluation and is designed to be thinner with improved recycling outcomes. *Photo by Ashley Fincham.*



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Empower Your Knowledge on Biodegradable Mulch

Gracia Puerto and Carol Miles. Washington State University Northwestern Washington Research and Extension Center

We live in a world that demands sustainable agricultural practices that enhance soil and environmental protection. A current issue faced by growers of many fruit and vegetable crops is the accumulation of polyethylene (PE) mulch that is difficult to recycle. As a result, throughout the U.S., non-biodegradable PE mulch is stockpiled, landfilled, buried or burned. Soil-biodegradable mulch (BDM) is an alternative technology that can play a crucial role in sustainable agriculture by reducing plastic waste that otherwise persists in the environment for centuries. BDM is designed to be tilled into the soil at the end of the growing season, where it will biodegrade by naturally occurring soil microorganisms.

Washington State University offers online resources to provide easy access to current information regarding BDM that includes an informative approach for educators who may be interested in expanding their knowledge or using this information in their presentations (see **Teaching Materials**). As an agricultural professional, you know how important it is to provide trusted, relevant learning material. Therefore, all our material is created by world-class scientists with experience in the field and practical applications of BDM. Each slide set is short with a focus on a single topic, and accompanying notes provide useful information in script format paired with each slide. Our goal is to provide agricultural educators easy access to informative material that can be used for oral presentations, workshops, classes, or to meet general educational needs.

Our online teaching materials on BDM include:

Presentations and Course Lectures

- PowerPoint slide sets that focus on a single topic with footnotes that aid in oral presentation.
- Presenter's notes provide a script for each slide to facilitate oral presentation.

Soil-biodegradable mulch-specific topics covered in our online resources:

- What is BDM?
- Biodegradable mulch benefits
- Application of BDM
- Use of BDM in strawberry production
- Impact of biodegradable mulch on soil health and quality
- Economic of BDM use
- Sociology - Perceptions and experiences with BDM

Enrich your knowledge regarding BDM technologies through these materials. Whether you are looking for presentation information, course lecture material, or with general curiosity, our online resources can assist you to enhance your knowledge on BDM.

Please contact **Lisa DeVetter** (lisa.devetter@wsu.edu) and **Nataliya Shcherbatyuk** (n.shcherbatyuk@wsu.edu) if you need help navigating the resources, if you have any questions, or if you have any suggestions regarding new content. We are here to share, collaborate, and support with teaching materials for agricultural educators.

Beyond Plastic: Lignocellulosic Mulch Maintains Plant Growth with Rapid Degradation

Aidan Williams, MS Student, Washington State University

Soil-biodegradable plastic mulch is a great alternative for growers seeking to reduce their plastic waste generation. However, if you are a certified organic grower in North America or Canada, current formulations of soil-biodegradable plastic mulch are problematic. That is because organic programs in both countries require soil-biodegradable plastic mulch to be made with 100% **biobased** feedstock. Presently, no commercial formulations of soil-biodegradable plastic mulch meet these requirements, leaving organic growers with a desire to cut back on their plastic use in a pinch.

> **Biobased** simply refers to materials made with living organisms or their biomass in contrast to fossil-fuel derived materials.

A solution may be on the horizon with lignocellulosic film (LCF). LCF is a fully biobased, soil-biodegradable, and environmentally friendly alternative to traditional polyethylene (PE) and soil-biodegradable plastic mulches. LCF is developed using low-cost, renewable woody biomass that is ground into a powder to be incorporated with a molten salt hydrate solution, which dissolves and disperses the lignocellulosic molecules. Once dissolved, it's cast into a sheet, similar to how paper is cast. It's then dried and regenerated, resulting in a biobased film. Biobased colorants, such as biochar, can also be incorporated into the wood powder. Hot press technology can also be implemented as an additional, final step to improve homogeneity and smoothness.

LCF is not yet commercially available, and current research regarding the horticultural performance of it as a mulch is lacking. The main goal of this study is to address this knowledge gap by comparing the functionality of LCF to other mulch treatments using raspberry grown in a greenhouse.

Raspberry tissue culture transplants of the cultivar Cascade Premier were planted in 5 x 5 inch (0.5 gal) square pots. The transplants were potted in a mixture of ~60% field soil and ~40% potting mix, which introduced weed seeds to the trial, making it possible to evaluate weed suppression. The greenhouse trial took place between March and June of 2024. Treatments including LCF, LCF with biochar, and cellulose film (made similarly to LCF) were compared to PE mulch, soil-biodegradable plastic mulch, paper mulch, and a no mulch control. All mulch treatments were carefully applied around the base of the plants, and excess material was tucked between the soil media and the pot, similar to how film edges are buried in the field. There were eight replicates of each treatment that were organized in a randomized complete block design, with drip irrigation lines tucked in the corner of each pot (Figs. 1 and 2).

Figure 1. LCF greenhouse trial, WSU NWREC, March 2024.

Figure 2. LCF greenhouse trial, WSU NWREC, June 2024.

At the conclusion of the trial, it was discovered that mulch treatment did not significantly impact overall plant growth throughout this greenhouse trial, including plant shoot height, node count, as well as root and shoot biomass. Soil temperature did vary across treatments, with LCF trending towards having a slightly higher overall temperature and exceeding PE mulch by 0.2 degrees Fahrenheit on average. Changes in mulch weight before and after the greenhouse trial were also recorded and showed that the cellulose-based treatments (i.e., paper mulch, LCF, LCF with biochar, and cellulose film) decreased in weight, with LCF having the most weight loss associated with degradation. Both PE and soil-biodegradable plastic mulch increased in weight by an average of 12% and 2%, respectively, though this is attributed to soil adhesion or moisture retention within the films. PE mulch, paper mulch, and LCF with biochar all performed similarly in suppressing weeds. Cellulose film had the highest weed count compared to the other treatments, which is likely due to a greenhouse effect, as the cellulose film is light in color and relatively see-through.

A mesh bag experiment was completed next to compare mulch in-soil degradation rates, as biodegradation is an important function of biodegradable mulches. New 1.9 × 1.9 inch samples of all mulch treatments included in the greenhouse experiment were used in the mesh bag experiment. Two additional treatments were also incorporated: LCF made with a hot press and LCF made with biochar and a hot press. Mulch samples were placed in mesh bags (Fig. 3) and buried in two contrasting climates in Washington (Fig. 4). Mesh bags containing the mulch samples were collected approximately every three months and analyzed for visual breakdown. Visual observation of breakdown is a proxy for degradation. The mesh bag experiment is ongoing, but early results show differences in degradation across treatments with cellulose film degrading the most, PE mulch degrading the least, and LCF having intermediate breakdown after three months of in-soil burial regardless of location. LCF had degraded by approximately 50% in both locations after three months.

Figure 3. Mesh bags containing mulch samples and soil are buried in agricultural fields and retrieved at periodic intervals to evaluate in-soil degradation rates.

Figure 4. Mesh bags containing mulch samples were buried in two contrasting locations in Washington State. The image above shows mesh bags being buried in a row of blueberries grown in Mount Vernon, WA.

While this work is ongoing, findings to date indicate that films made with lignocellulose maintain plant growth relative to PE mulch and biodegrade rapidly once incorporated into the soil. In the future, research should focus on scaling up lignocellulose material generation so they may be evaluated in open-field settings.

Dispelling the Microplastic Myths: Separating Facts from Fiction

Nayab Gull, WSU Graduate Student

Concerns are mounting over the potential harm caused by mulch fragments and non-biodegradable microplastics to plant and crop health. Yet, understanding the true impact of commercial mulch films on plant health poses a challenge. This is because microplastic concentrations, sizes, and polymer types used in many published studies do not represent real-world scenarios in agroecosystems, which limits the interpretation of this research (Degli-Innocenti, 2024). Additionally, experiments are typically conducted in highly controlled environments and small containers, limiting the exploration of plant roots and failing to replicate field conditions accurately. While previous research on microplastics has advanced our collective understanding, further work that mirrors real-world conditions is required to gain an improved understanding of microplastic behavior in the environment and inform mitigation measures. External factors like cropping history and location-specific environmental factors should also be considered (Sintim et al.,2019).

USE OF FIELD-REALISTIC MICROPLASTIC CONCENTRATIONS

As we delve into existing and emerging literature on this subject, it's crucial to carefully scrutinize experimental methodologies and their limitations to draw generalized conclusions. Take, for instance, the research by Sun et al. (2023), who found that biodegradable microplastics significantly disrupted biochemical and physiological processes in maize (i.e., corn) seedlings. They used commercially sourced PLA and PBAT with concentrations ranging from 1-10% (w/w). The higher 10% concentration is well above the levels typically observed after a single application of soil-biodegradable mulch in agriculture (Dong et al., 2021; Yu et al., 2023; Yu & Flury, 2024). Microplastic concentrations in agricultural soils are generally much lower, estimated to range between 0.001% and 0.04% (w/w) (Yu et al., 2023; Yu & Flury, 2024). Additionally, Sun et al. (2023) explained that the selected concentrations were based on the study by Büks & Kaupenjohann (2020). However, this study estimated that soil microplastic concentrations range from 0.03% to 6.7% (w/w), with particularly high levels in soils affected by industrial activity, sewage sludge applications, and repeated use of plastic mulch. This upper range only reflects extreme cases and does not represent typical conditions in agricultural soils.

Microplastic formation is a natural step during the degradation of soil biodegradable plastic mulches (BDMs), but unlike traditional plastics, these fragments do not persist in soil for generations. Field studies on BDM degradation have shown that biodegradable mulch fragments break down over time (Griffin-LaHue et al., 2022; Sintim et al., 2019; Sintim et al., 2021). This makes it unlikely that biodegradable microplastics will accumulate to harmful levels, even with repeated applications and especially compared to non-biodegradable mulch counterparts.

EXPERIMENTAL RELEVANCE OF MICROPLASTIC SIZE AND TYPE

There is a mismatch between field-relevant size and plastic types used in current studies comparing the environmental impact of biodegradable and non-biodegradable microplastics. The size distribution of predominant microplastics on farms ranges between 1-5 mm with non-biodegradable PE as a primary contributor (Tiwari & Sistla, 2024). In addition to PE, lab studies often report toxic impacts of other non-biodegradable plastics like PS (polystyrene) and PVC (polyvinylchloride) on soil and plant health (Fan et al., 2022). However, PVC and PS are not applied as agricultural mulch films like PE nor tilled in the soil like BDMs. There is a risk of overstating their impacts without considering the specific sources of their introduction to agroecosystems. Therefore, it's important to clarify that some of these plastics may have limited relevance to field conditions when reporting their toxic effects. Moreover, many studies use unrealistically small microplastic size (10-100 µm) and high dosage rates (5-20%) (Zhang et al., 2021). As mentioned previously, these concentrations and sizes are not representative of real-world field conditions. Non-biodegradable plastics are fairly stable and would take several years or even generations to degrade into smaller particles. Thus, using 100 µm sized microplastics in toxicity studies doesn't really reflect their long-term accumulation or the impacts we'd expect to see in the natural environment.

REFLECTING REAL WORLD MULCH BREAKDOWN

Many studies frequently rely on commercially sourced, pristine mulch films, with microplastics manually cut into uniform sized pieces in the lab (Fan et al., 2022; Qi et al., 2018; Sun et al., 2023). This approach skips over the natural weathering that mulch undergoes in the field due to exposure to sunlight, temperature variations, microbial activity, and mechanical stress. Environmental exposure plays a major role in how these materials break down over time (Yu & Flury, 2024). UV radiation, in particular, alters both the physical and chemical properties of biodegradable mulch surfaces (Yang et al., 2022). It is an important environmental factor that's often overlooked in lab-based research. A more representative method would be to include aged or field-weathered mulch fragments with appropriate microplastic sizes (< 5 mm) and commonly used plastic types to better represent the microplastic categories in agricultural soils. Similarly, it is important to acknowledge the well documented differences between biodegradable and non-biodegradable microplastics in terms of their structure and behavior in soil. Keeping these differences in mind can help make research methods and risk assessments well rounded. This is especially the case when looking at how agricultural plastics interact with other pollutants and agricultural stressors.

BEYOND RESEARCH LIMITATIONS

The body of research on microplastics in agriculture is growing, and significant progress has been made over the last decade. However, existing studies often use microplastic dosages, types, and fragment sizes that don't fully capture what is happening in commercial farming systems. This can limit the practical application of research findings. Therefore, an important takeaway for anyone following microplastic research is to interpret published results with this context in mind. To move forward, our project team and others in the field are prioritizing research methods that better mirror real-world conditions. This approach will allow for more translational findings that could lead to evidence-based recommendations. In addition, this will expand our understanding of microplastics behavior in agroecosystems, informing policy formation, and promoting agricultural sustainability.

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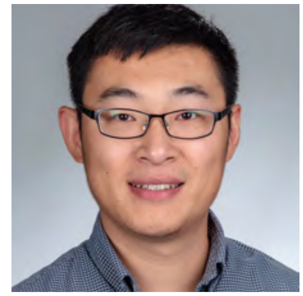


Recycling Agricultural Plastic Mulch into Asphalt Roads

Kun Zhang, Associate Professor, California State University, Chico

Road paving material that includes recycled plastics is NOT a new idea. In fact, various types of plastics have been incorporated into asphalt mixtures to pave roads in California, Missouri, and Virgina. Used polyethylene plastic mulch (PE mulch) could be another suitable plastic source for incorporating into asphalt mixtures that end up on our roadways.

For growers of specialty crops, including strawberry, the benefits of PE mulch lead to improved crop yield and quality. However, most PE mulch after use ends up in landfills due to high levels of contaminants with soil, plant debris, moisture, and/or pesticide residues. This creates challenges to recycling PE mulch using conventional methods.

Our collaborative study between Washington State University and California State University Chico explored various ways to recycle highly contaminated PE mulch, including the use of processed PE mulch as a modifier in asphalt paving materials. Used PE mulch was collected from strawberry fields, processed and pelletized, and we assessed the engineering performance of incorporated PE mulch waste as a modifier for asphalt binder and mixtures (Figure 1).

We found that the addition of recycled PE mulch can physically stiffen asphalt binders, which benefits roads' rutting resistance and may help prevent the negative impacts of climate change on asphalt pavements. For example, as air temperature rise and the frequency of summer heatwaves increases, severe rutting and deformed road markers at city intersections can result when combined with heavy traffic loads (Figure 2). The use of PE mulch-modified asphalt binders could potentially lessen the impact of these stressors and provide safer and more durable road surfaces. However, our results showed stiffer asphalt also had slightly higher susceptibility to low-temperature thermal cracking and aging-induced cracking.

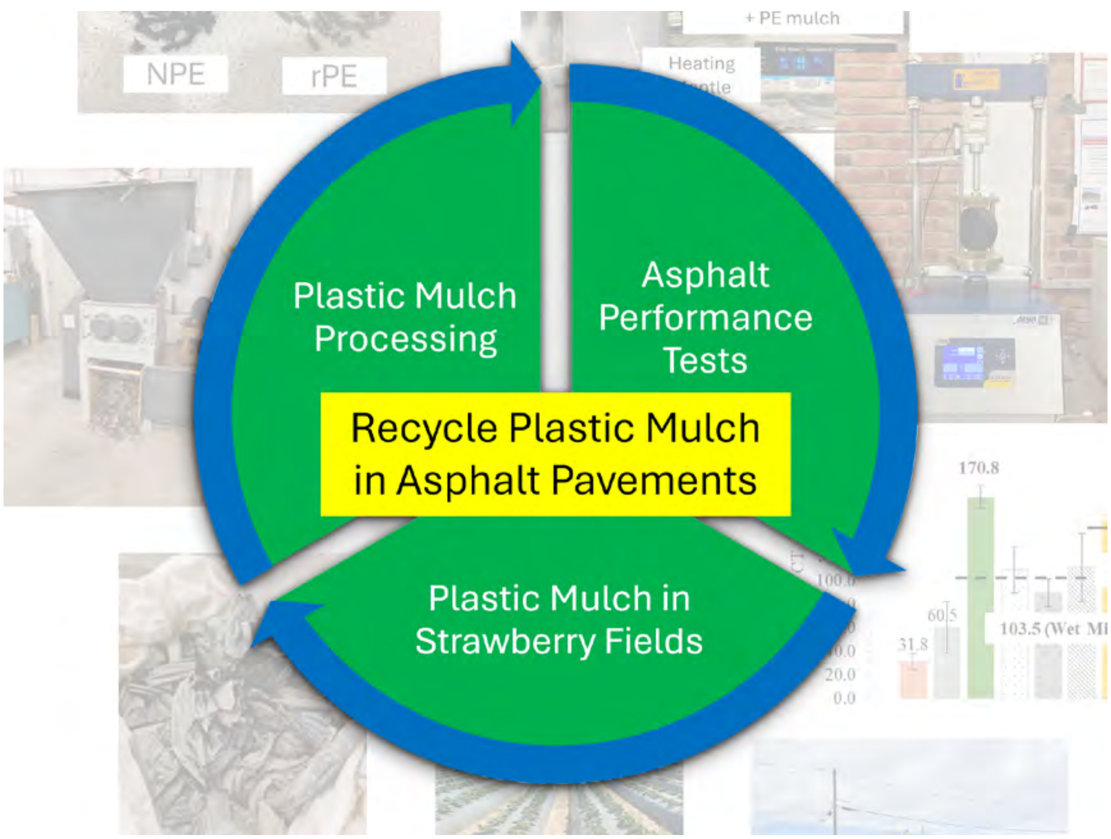


Figure 1. Polyethylene mulch (PE mulch) waste was collected from strawberry fields, processed, and the engineering performance of incorporated PE mulch waste as a modifier for asphalt binder and mixtures was assessed. In the future, results from this project may support use of recycling used PE mulch into asphalt mixtures for roadways.

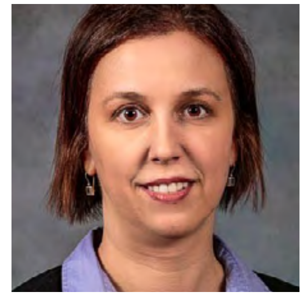
Figure 2. Severe rutting and deformed road markers at an intersection is due to reduced rutting resistance from extreme heat and heavy traffic loads. Recycled polyethylene (PE) mulch stiffens asphalt binders and can improve rutting resistance.

Our research team also assessed both wet and dry mixing methods to produce PE mulch-modified asphalt mixtures in the laboratory. The dry mixing method is recommended for incorporation of PE mulch waste into mixtures as it has a lower adverse effect on the cracking resistance than the wet mixing method. The dry mixing approach does not require significant manufacturing modifications; thus, it would have a lower additional cost than the wet mixing method.

The implications of this project are not insignificant. Recycling of PE mulch and its adoption as an ingredient in asphalt paving mixtures could reduce the annual amount of PE mulch that is disposed into landfills in the range of 30% - 40% in California alone. This is based on the assumption that 20% of the asphalt mixtures produced annually in California would contain recycled PE mulch.

Our team presented these project findings in a poster titled *"Recycle Agricultural Plastics in Asphalt Mixtures"* at the 101st Association of Asphalt Paving Technologists (AAPT) Annual Meeting in Reno, NV on March 10-13, 2025. The poster was presented by undergraduate students Clayton Yi and Carlos Medina, and postdoctoral researcher, Dr. Yuefeng Zhu, all from Chico State (Fig. 3). For more information, please contact **Dr. Kun Zhang** (kzhang2@csuchico.edu).

Figure 3. Student Poster Presentation at 101st Association of Asphalt Paving Technologists (AAPT) Annual Meeting in Reno, NV (from left to right: Kayla Hamamoto, Kun Zhang, Carlos Medina, Clayton Yi, Drew Mortenson, and Yuefeng Zhu).



Understanding the Human Dimensions of Plastic Mulch Use in U.S. Specialty Crop Production

Jessica R. Goldberger, Washington State University

When it comes to the use and end-of-life management of plastic mulch—whether polyethylene (PE) or biodegradable alternatives—in U.S. specialty crop production, social scientists have been asking critical questions: What drives farmers' decisions to adopt or reject different types of plastic mulch? How do perceptions of environmental impact, economic viability, ease of use, and performance influence these decisions? To what extent do regulatory policies, infrastructure, and aesthetic concerns shape farmers' behavior? How can we better understand the barriers and opportunities for more sustainable plastic mulch use and end-of-life management? These questions have guided our human dimensions research regarding plastic mulch for nearly two decades, helping us unravel the complex interplay of social, environmental, and economic factors that influence mulching practices and sustainability outcomes in U.S. specialty crop production.

BARRIERS AND BRIDGES TO THE ADOPTION OF BIODEGRADABLE PLASTIC MULCHES

Despite the widespread use and effectiveness of PE plastic mulch, its disposal process is financially and environmentally costly. In contrast, soil-biodegradable plastic mulches (BDMs), can be tilled into the soil or composted at the end of the growing season, reducing the labor and environmental costs associated with plastic removal and disposal. Our early human dimensions research—conducted via surveys and focus groups involving specialty crop growers, agricultural extension agents, agricultural input suppliers, mulch manufacturers, and other stakeholders in Tennessee, Texas, and Washington—focused on the "barriers and bridges" to adopting BDMs (Goldberger et al. 2015). Barriers to adoption included insufficient knowledge of BDMs, perceived high costs, unpredictable or incomplete breakdown of BDMs in the soil, and concerns about soil impacts. Bridges to adoption included reduced waste generation, environmental benefits, and a strong desire among most study participants to learn more about BDMs (Goldberger et al. 2015). Related human dimensions research has explored several key factors influencing BDM adoption, including the role of multisensory learning environments in promoting adoption (Cowan et al. 2015), specialty crop growers' willingness to pay for BDMs (Chen et al. 2020; Velandia et al. 2020a, 2020b), and the impact of perceived risk and uncertainty on BDM decision-making (Madrid et al. 2022; DeVetter et al. 2023).

ORGANIC STANDARDS AND PLASTIC MULCH USE

In October 2014, the U.S. Department of Agriculture's National Organic Program (NOP) added 100% biobased BDMs to its list of allowed substances. However, 100% biobased BDMs products are not commercially available, and despite recommendations from the National Organic Standards Board (NOSB), the biobased percentage has not been lowered (Miles et al. 2023). This has prevented certified organic farmers from using BDMs, pushing them toward an input (PE plastic mulch) that potentially conflicts with their ecological values. Drawing on a national survey and on-farm case studies of U.S. specialty crop growers, human dimensions research found that organic-practicing farmers are eager for an environmentally sustainable alternative to PE plastic mulch and take issue with the NOP's handling of BDMs (Dentzman and Goldberger 2020a). The NOP's BDM regulations highlight the irony of organic standards, which allow the use of PE plastic mulch (derived from petroleum) while mandating that BDMs contain 100% biobased feedstocks—ultimately constraining both the definition and practice of organic farming.

THE AESTHETICS OF PLASTIC MULCH USE

Biodegradable plastic mulches, and to a lesser extent PE plastic mulch, leave unsightly scraps in farmers' fields. BDM fragments are typically tilled into the soil, where they eventually biodegrade, while non-biodegradable PE plastic mulch fragments remain in the soil as trash. Horticultural researchers (Ghimire et al. 2018; Zhang et al. 2020) have studied the extent and impacts of BDM mulch fragments adhering to fruit. Complementing this work, human dimensions researchers (Dentzman and Goldberger 2020b) used photo-elicitation focus groups to explore the visual appeal (i.e., aesthetics) of BDM use. Results showed that conventional farmers, who preferred neat and clean fields, disliked the "messy" appearance of BDM fragments. In contrast, alternative agriculturalists, who wanted to avoid association with PE plastic, were averse to the "plastic" appearance of BDM fragments. Participants suggested various ways to enhance the acceptability of BDMs, such as changing the mulch color from black to brown (Denztman and Goldberger 2020b).

DISPOSAL AND RECYCLING OF PLASTIC MULCH

End-of-life considerations may be a factor in specialty crop growers' decisions to adopt particular types of plastic mulch. For instance, PE plastic mulch must be removed at the end of the growing season and either burned, stockpiled, landfilled, or recycled. Burning may be illegal, landfill tipping fees can be high, and recycling facilities may not be accessible. Our human dimensions research has examined U.S. strawberry growers' practices and opinions regarding PE plastic mulch disposal and recycling. Goldberger et al. (2019) found that most growers in California, the Pacific Northwest, and the Mid-Atlantic acknowledged that the disposal of PE mulch is a big environmental problem, yet they did not see recycling as a feasible option. Transporting used PE mulch from strawberry fields to landfills or other dumpsites was the most common disposal method. Follow-up research in California (DeVetter et al. 2021) revealed that 62% and 30% of strawberry growers landfilled and recycled their used PE mulch, respectively. Ongoing research on plastic mulch end-of-life decision-making focuses on how California strawberry growers, packers/shippers, plastic mulch manufacturers, waste management professionals, and plastic recyclers perceive the value of plastic mulch and how these perceptions influence end-of-life practices and sustainability efforts.

CONCLUSION

Understanding the human dimensions of plastic mulch use in U.S. specialty crop production is crucial for advancing sustainable practices. While BDMs offer environmental benefits, challenges such as cost, knowledge gaps, and regulatory barriers hinder their widespread adoption. Additionally, concerns about organic standards and the aesthetics of plastic mulch highlight the complexity of decision-making among farmers. Continued research into disposal, recycling, and grower behavior will be key to developing strategies that better support sustainable plastic use and waste management in agriculture.

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Building Better Soil: Biodegradable Plastic Mulches and Mineral-Associated Organic Matter

Jacob Clements and Sean Schaeffer, University of Tennessee-Knoxville

Soil organic matter is often cited for its positive impact on crop yields, water retention, and overall soil health. Yet, not all organic matter is the same. One type—mineral-associated organic matter (MAOM)—often goes unnoticed, even though it serves as a long-term reservoir for nutrients and carbon. By binding tightly to soil minerals, MAOM helps improve soil health by maintaining productive, resilient soils that can better withstand stress from extreme weather.

Farmers are exploring biodegradable plastic mulches as a greener alternative to traditional plastic; however, their role in shaping soil health—especially in relation to MAOM—can be overlooked. These mulches offer effective weed management and moisture retention without leaving behind lasting plastic waste. In the sections that follow, we'll explore how farmers can promote MAOM through practical management strategies and how biodegradable plastic mulches can play a role, offering a path toward more sustainable and productive farming systems.

WHAT IS MINERAL-ASSOCIATED ORGANIC MATTER (MAOM)?

Mineral-associated organic matter (MAOM) is the portion of soil organic matter that binds tightly to soil minerals and is stable over time and environmental conditions (Fig. 1). Think of it as a "long-term savings account" for nutrients and carbon that are not likely to wash away or break down quickly. Because MAOM is resilient for years, it helps build healthier soils that hold onto moisture, release nutrients steadily to crops, and resist erosion. **In short, having more MAOM means a healthier soil that better supports productive farming.**

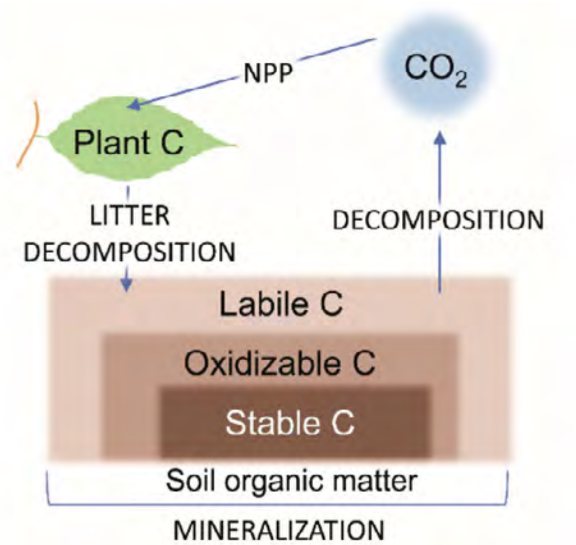

Figure 1. Simplified schematic of soil organic carbon, mineral-associated organic matter (MAOM) is in the Stable C pool of this diagram. Source: Enchilik et al., 2023.

WHAT ARE BIODEGRADABLE PLASTIC MULCHES AND WHY USE THEM?

Biodegradable plastic mulches work much like traditional plastic mulches to manage weeds, retain moisture, and regulate soil temperature—but without leaving behind persistent plastic waste. They're often made from plant-based materials or other biodegradable polymers that break down naturally in the soil. For farmers, this means potential savings on labor and disposal costs (no need to collect and haul away the mulch at season's end) and a smaller environmental footprint. When combined with sound soil management practices, biodegradable plastic mulches can help maintain or even enhance soil organic matter levels, contributing to overall farm sustainability.

HOW DO MAOM AND BIODEGRADABLE PLASTIC MULCHES WORK TOGETHER?

In addition to their demonstrated benefits, new research shows that biodegradable plastics may promote MAOM formation. When used properly, biodegradable plastic mulches can support the formation and maintenance of MAOM by protecting the soil surface and creating a more stable environment for soil microbes. As these mulches break down, they can introduce additional organic residues into the soil, potentially boosting microbial activity. Combined with practices like minimal tillage and regular residue incorporation, biodegradable plastic mulches may help keep nutrients in the soil longer by creating the stable bonds that define MAOM. The key is to pair the right mulch product with good soil management—together, they can strengthen soil health and reduce a farm's overall waste stream (Fig. 2).

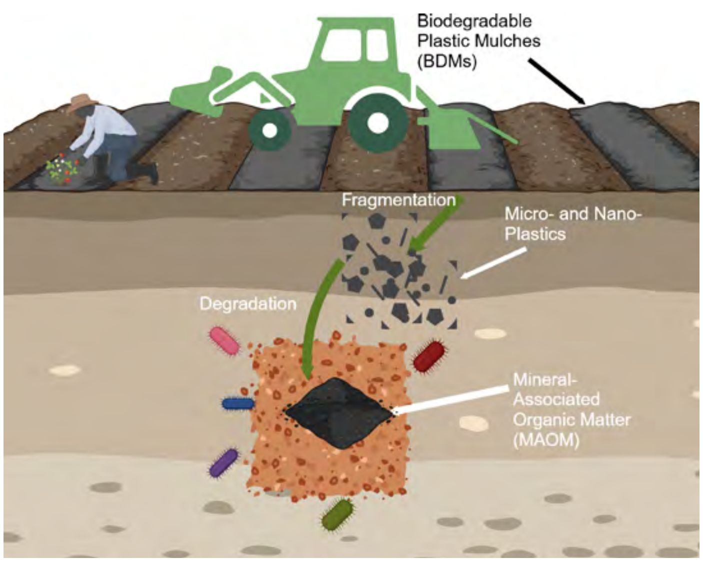

Figure 2: Diagram of how BDMs interact with soil and help form MAOM.

PRACTICAL RECOMMENDATIONS FOR FARMERS

Here are some actionable steps for integrating both MAOM enhancement and biodegradable plastic mulches into farming practices:

MONITOR THE SOIL

Begin with soil testing using a commercial lab that can track organic matter levels. While the organic matter level may not tell you how much MAOM there is in your soil, it helps develop an understanding of baseline soil organic matter and gauge improvements over time with continued use of biodegradable plastic mulches.

ADOPT RESIDUE MANAGEMENT PRACTICES

Leave crop residues in the field or incorporate them into the soil to provide a steady organic input that supports MAOM formation. This organic "bank" works best when combined with minimal tillage to preserve soil structure.

SELECT THE RIGHT BIODEGRADABLE PLASTIC MULCH

Choose a mulch product suited to your region and cropping system. Look for products that meet recognized standards for biodegradability to ensure they break down at a rate that complements your crop cycle. Do not use products labeled as "oxo-degradable" or "oxo-biodegradable" as they are not biodegradable and will leave persistent plastic fragments in the soil.

OPTIMIZE MULCH APPLICATION

Apply biodegradable plastic mulches to suppress weeds and retain moisture. Be mindful of application timing to maximize benefits—apply early in the season to reduce weed emergence and monitor the mulch throughout the season to ensure it degrades appropriately.

INTEGRATE COVER CROPS AND REDUCED TILLAGE

Use cover crops that enhance soil organic matter and maintain soil structure. Reduced tillage minimizes disruption of MAOM, allowing both the organic matter and the mulch residues to work together for improved soil health.

KEEP AN EYE ON COSTS AND BENEFITS

Track inputs and yields to evaluate how these practices affect a farming operation's bottom line. The dual benefits of improved soil fertility and reduced labor for mulch removal may translate into both environmental and economic gains over time.

By following these practical recommendations, **farmers can create a more resilient, nutrient-rich soil environment** while managing weeds efficiently and reducing plastic waste.

CONCLUSION AND KEY TAKEAWAYS

To sum up, combining sound soil management practices with the strategic use of biodegradable plastic mulches can enhance soil health by promoting MAOM buildup. MAOM acts as a long-term reservoir for nutrients and water, helping to sustain crop productivity even under challenging conditions. Meanwhile, biodegradable plastic mulches offer the dual benefits of effective weed management and environmental sustainability, eliminating the need for labor-intensive removal and reducing plastic waste.

KEY TAKEAWAYS FOR FARMERS

SOIL HEALTH IS FOUNDATIONAL

Regular soil testing and residue management build MAOM, leading to improved nutrient retention and water management.

BIODEGRADABLE MULCHES ADD VALUE

These mulches not only manage weeds and conserve moisture but also contribute to a more sustainable farming system by breaking down naturally.

INTEGRATED PRACTICES YIELD THE BEST RESULTS

The benefits of MAOM and biodegradable mulches are maximized when they are part of a broader strategy that includes reduced tillage, cover cropping, and mindful residue management.

Farmers are encouraged to experiment on a small scale, monitor outcomes, and adjust practices to suit their unique soil and climate conditions. For further guidance, reaching out to local extension services can provide tailored support and additional resources. Together, these practices pave the way for a more resilient and sustainable farming future.

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Lessons from the Field: Rethinking Plastic Waste in Agriculture through Local Innovation and Collaboration

Nataliya Shcherbatyuk, Washington State University

CONVERSATION WITH KEVIN DEWHITT, FOUNDER & CEO OF PDO TECHNOLOGIES, INC.

Plastic has long been celebrated as a revolutionary material—lightweight, durable, and adaptable. Yet in agriculture, where plastic is widely used for mulches, drip tape, packaging, and greenhouse coverings, its afterlife poses one of the greatest environmental challenges. The issue isn't plastic itself, but what we do with it once it's served its purpose.

In a **recent episode** of the *Mulch Matters* podcast, I spoke with Kevin DeWhitt, founder of PDO Technologies, who has dedicated over 25 years to addressing plastic waste through chemical recycling innovations. His work presents not only a technological solution, but also a roadmap for rethinking how we manage agricultural plastic—one grounded in practicality, collaboration, and long-term vision.

TECHNOLOGY MUST FIT THE PROBLEM—NOT THE OTHER WAY AROUND

One of the most powerful takeaways from DeWhitt's experience is that big problems don't always require big solutions. While many companies chase large, centralized recycling facilities, PDO Technologies operates on the opposite principle: go small and local. His systems are designed to process plastics at the community level, near the source of waste, especially in rural and agricultural areas. This decentralized approach reduces transport costs, simplifies logistics, and creates local ownership of both the waste problem and opportunities as well.

COLLABORATION OUTPERFORMS COMPETITION

Another crucial lesson is the **value of strategic partnerships**. DeWhitt emphasizes that no one entity can solve the plastic waste crisis alone. PDO doesn't collect plastic—they partner with local recyclers like Agri-Plas, who already understand the complexities of farm-level collection. Universities like Washington State University and Oregon State University bring in agricultural expertise, and together, these players create a complete chain from collection to conversion. The message is clear: working together is more powerful than working in silos.

FARMERS ARE ESSENTIAL STAKEHOLDERS IN THE SOLUTION

A theme that emerged strongly in our conversation was the need to center farmers in the conversation. Too often, technologies are developed without truly understanding on-the-ground realities. By partnering with growers in Washington and Oregon, including onion and strawberry producers, PDO is creating systems that make sense at the field level. Farmers are eager to reduce waste—but it must be simple, cost-effective, and beneficial to them. This underscores a broader lesson: sustainability must be accessible to those doing the work.

CIRCULAR THINKING REQUIRES BEHAVIORAL CHANGE

DeWhitt also spoke candidly about the biggest obstacle to progress—not technology, but human behavior. Changing ingrained habits, whether in households or on farms, takes time and intention. But as he reminded us, small changes—like putting a used plastic jug in a separate bin—add up. The idea isn't perfection; it's progress. As consumers, producers, and policymakers, we all play a role in choosing circular over linear thinking.

PERSEVERANCE IS KEY IN INNOVATION

From his initial experiences with chemical recycling in 2000 to founding his first company (Agilyx) in 2004, to launching PDO in 2014, DeWhitt's journey has been long and not without struggle. He spoke of the many pivots and redesigns his technology has undergone, and how success often comes **not from brilliance, but from persistence**. "You pound away at a problem until you just can't anymore," he said, echoing a truth familiar to many entrepreneurs in sustainability. Innovation is a slow build, and impact takes time.

LOOKING AHEAD: A MORE RESPONSIBLE FUTURE

DeWhitt envisions a future where 100% of plastic is recycled and none enters landfills. It's a bold goal, but not out of reach. With increasing policy support, investment in local infrastructure, and growing awareness among producers and consumers, the path forward is taking shape. PDO's next-generation rotary drum reactor—a simplified, cement mixer-inspired design—is one step closer to making on-farm plastic recycling a practical reality.

In closing, Kevin's story isn't just about plastic or technology—it's about mindset. It's about rethinking waste not as a burden, but as an opportunity. It's about meeting people where they are and designing systems that work for real lives and real landscapes. And above all, it's about believing that change is possible—if we keep working at it, together.

Recent Publications

RESEARCH

Jiang, J., T.L. Marsh, and E. Belasco. 2025. **Optimizing microplastic pollution in a terrestrial environment: a case for soil-biodegradable mulches**. Agricultural and Resource Economics Review. Published online 2025:1-29. https://doi.org/10.1017/age.2025.20

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EXTENSION

RECURSOS DISPONIBLES EN ESPAÑOL

SCRI: Proyecto de Mejoramiento en el Manejo de Acolchado de Plástico en la Producción de Fresas. Incluye presentación educativa de PowerPoint y notas del presentador.

Upcoming Events

Mark your calendars for the following agricultural plastic recycling and waste conversion technology conferences and trade shows:

ASHS 2025 ANNUAL CONFERENCE

Dates: July 28 - August 1, 2025
Location: New Orleans, Louisiana, USA

Details on the **ASHS 2025 conference website** (ashs.org/ASHSAnnualConference).

THE 16TH WASTE CONVERSION TECHNOLOGY CONFERENCE & TRADE SHOW (WCTC 2025)

Dates: August 11-13, 2025
Location: San Diego, California, USA

Details on the **WCTC 2025 conference website** (wasteconversionconference.com).

THE 8TH AGRICULTURAL PLASTICS RECYCLING CONFERENCE & TRADE SHOW (APRC 2025)

Dates: August 13-15, 2025
Location: San Diego, California, USA

Details on the **APRC 2025 conference website** (agplasticconference.com).

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