SUSTAINABLE MULCH MANAGEMENT

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Biodegradable Mulches in Horticulture Production

WASHINGTON STATE UNIVERSITY

NEW GRANT AIMS TO REDUCE PLASTIC TAKEN FROM FIELDS TO LANDFILLS

Scott Allen Weybright, WSU CAHNRS Communications

Growers of crops like strawberries, raspberries, pumpkins, tomato, melon, and more depend on plastic mulch to get the most out of their fields. But that mulch is rarely recycled because of contamination with soil and plant debris, and the soil-biodegradable version isn't allowed in organic fields in the United States. Consequently, every year an estimated 2.5 million tons of plastic mulch around the world is either dumped into landfills, tilled into the soil, or even burned leading to pollution of terrestrial and aquatic systems. And that number is rising as more and more growers around the world adopt plastic mulch without viable end-of-life options for sustainable plastic mulch waste management.

Washington State University (WSU) is leading a new project, funded by a nearly $8 million, four-year Specialty Crop Research Initiative grant from the USDA National Institute of Food and Agriculture to advance soil-biodegradable mulches and develop innovative methods to recycle plastic mulches.

Plastic mulch, basically long strips of polyethylene that is usually black, is laid down in fields to suppresses weed growth, optimize soil temperatures, reduce water loss, and overall produce higher yields of clean fruits and vegetables free of soil debris. That leads to reduced usage of herbicides, fewer crop loss to rot from contact with soil, a jump start on the growing season, yield enhancements, and improved profitability.

"Growers are really dependent on plastic mulch," said Lisa DeVetter, an associate professor in WSU's Department of Horticulture based at WSU's Northwestern Washington Research and Extension Center in Mount Vernon. "Every year, mulch is applied on tens of thousands of acres of soil across the country, but the plastic mulch mostly winds

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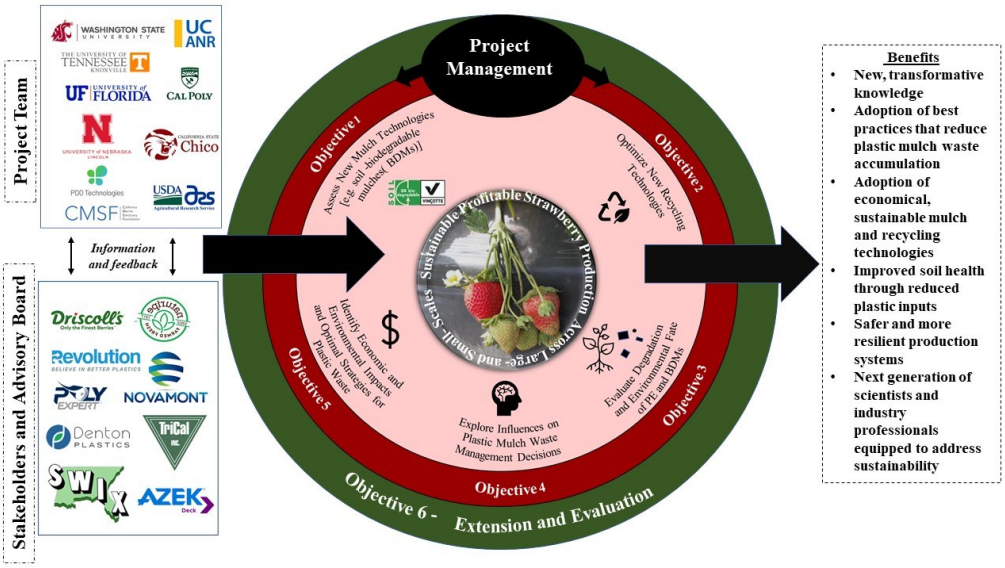


New, collaborative project sets out to look at multiple solutions to reduce plastic mulch waste generation in strawberry systems.

up in landfills and can take hundreds of years to degrade."

DeVetter, the lead investigator on the grant, has worked with her team of collaborators on plastic mulch solutions for several years. Her focus has often been to improve knowledge on soil-biodegradable mulch. Soil-biodegradable mulch currently can't be used in organic fields because it still contains non-biobased and synthetic materials not allowed in certified organic production in the United States. Growers are also concerned about its ability to fully biodegrade in soils, and the long-term economic implications are unknown.

Recycling has been a very limited option because when the mulch is removed from the fields, it's coated with dirt and plant debris.

"As much as 50-80% by weight of the removed mulch is contaminated with debris," DeVetter said. "Most recycling facilities require less than 5% contamination."

The research team will look at methods to remove debris from the plastic, new technologies to recycle plastic even with debris still attached, and approaches to build up the necessary infrastructure to handle the huge volumes of mulch that is used in the United States today and to incentivize more sustainable waste management behavior.

This is the first time a research project will combine recycling and soil-biodegradable efforts to help reduce the tonnage sent to landfills and that contribute to environmental pollution, as they've previously always been separate studies.

"We're leveraging our experience and network of collaborators, both researchers and people in the industry as well as allied non-profit organizations, to come up with viable solutions to make an impact," DeVetter said.

The program will focus on strawberry as a model crop because it is a popular crop grown in many different parts of the country in different weather situations and soil systems. Scientists, extension specialists, and growers in California, Florida, Nebraska, Tennessee, and Washington will all participate. Companies such as Driscoll's and Natureripe are also collaborating on the project.

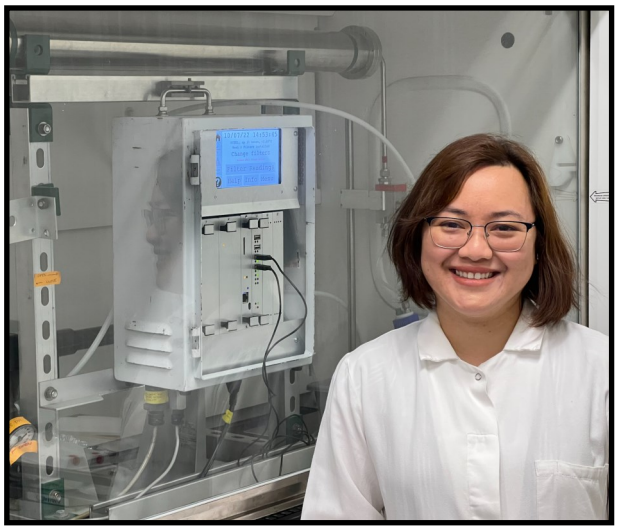
A LESSON ON MICRO-PLASTICS

Marife Anunciado, Postdoctoral Scholar, University of California - Davis

According to United States Nation Oceanic and Atmospheric Administration, a microplastic is any plastic that is less than 5mm in length. Other sources further define them as small plastic particles ranging from 1 µm to 5 mm in size possessing regular or irregular shape and being insoluble in water (Frias and Nash, 2019)

Microplastics don't spontaneously form. They are a product of plastic consumption and disposal practices that cause plastics to be released into the environment. Environmental factors, primarily UV radiation, cause these released plastics in the environment to fragment into smaller pieces. Eventually, this breakdown forms microplastics or even smaller pieces within the nanoparticle size range (<100 nm).

Although microplastics are small in size, they are a big environmental problem. Their small size makes them poorly visible, but despite this they are numerous and have contaminated terrestrial and marine environments around the world. Multiple types of plastics used in everyday lives are sources of these microplastics. Within the household, microplastics can come from cosmetics and beauty products containing microbeads, food containers, and microfibers in clothes and fabrics. Commercial enterprises also inadvertently create microplastics in wastewater, during manufacturing processes, and even when growing food crops using certain fertilizers and agri-



Microplastics are often mentioned in conversations about plastic pollution and the environment. But what are they? Why the concern? What is the science on microplastics? Dr. Marife Anunciado, who is a research scientist that has studied mulch film physiochemical properties and degradation, sheds light on this important aspect of plastics.

-cultural mulch films.

The prevalence of microplastics is certainly a concern. Yet, the big cause of worry is their toxicity and potential harm they can cause to the environment and people. Toxicity can come from the use of certain additives applied during the manufacturing process to give the material desired physical properties. Examples of additives with known toxicity include BPA added to give plastic bottles transparency (BPA interferes with hormonal functioning), DEHP added as a filler/reinforcement to adjust material flexibility or stiffness (DEHP has been associated with causing cancer), and plasticizers like phthalates that soften and aid material processing (phthalates can behave as endocrine disruptors).

Microplastics are small plastic particles ranging from 1 µm to 5 mm. They are persistent, can bioaccumulate, and enter the food chain.

Furthermore, microplastics are persistent and don't biodegrade. Therefore, plastics including microplastics just move from one place to another while accumulating in the environment. Most scientists believe all microplastics eventually end up in the ocean. Wastewater treatment plants recovers some of them, but a substantial portion still ends up in the environment. Microplastics can harm marine organisms that ingest them as food and can bioaccumulate. Eventually, bioaccumulation of microplastics in food webs can introduce microplastics to humans that consume fish and other marine organisms.

Microplastic pollution in the marine environment is an important area of study, but attention should also be placed on the terrestrial environment. Unfortunately, agricultural practices are a significant contributor of microplastics to soil. The concern about microplastics in the soil are many. Similar to what has been observed in the marine environment, microplastics could potentially bioaccumulate and enter our food chain. There is also the concern that accumulated plastics will negatively impact agricultural productivity through ecotoxicity effects on soil microorganisms which are beneficial for soil health or as direct impediments of plant growth.

Research on microplastics in soil is developing and we need more effort on this. However, soil is a complex matrix and studying microplastics in soil is technically challenging relative to water.

Current methods entail density separation techniques using saline solutions and recovery tests for microplastic separation. Recovered microplastics from soil can then be identified using microscopic or spectroscopic techniques. FTIR (Fourier-Transform Infrared spectroscopy) can characterize microplastics by comparing their spectra to known polymers in databases. Other researchers use a Raman spectrometer that delivers light onto a sample and the returning wavelength can provide information on the chemical and structure of the material. While these methods exist, there is the need to refine, validate, and ensure findings are translatable.

Microplastics and plastic pollution is a globally important issue. However, there are scientists working with industry and governments on addressing this complex problem. Another reason to hold optimism is the rise of alternatives to conventional plastics that reduce plastic waste generation, such as biodegradable materials.

Reference:

Frias, J.P. and R. Nash. 2019. Microplastics: Finding a consensus on the definition. Marine pollution bulletin, 138, pp.145-147. https://doi.org/10.1016/j.marpolbul.2018.11.022

BIODEGRADATION OF MULCHES

Srijana Shrestha, Washington State University Graduate Student

Incorporation of soil-biodegradable plastic mulch (BDM) in soil.

Polyethylene (PE) mulch is widely used in horticultural crop production for weed control, soil temperature modification, soil moisture retention, earlier harvest, and improved crop quality. However, PE mulch is non-recyclable due to soil contamination after removal from the field, and thus most PE mulch is disposed of in landfills or, in some cases, buried or burned on farm. Soil-biodegradable plastic mulch (BDM) is a sustainable alternative to PE mulch. BDM provides comparable horticultural benefits as PE mulch with an added advantage of being designed to be tilled into the soil at the end of the cropping season, which reduces waste and disposal challenges. After being incorporated into the soil, BDM fragments biodegrade into carbon dioxide and water, and do not impact soil health. Despite these benefits, adoption of BDM has been slow as growers feel uncertain about in-field biodegradation.

The international biodegradability standard EN-17033 requires that all plastics that claim to be biodegradable reach 90% degradation within 2 years in an aerobic incubation test at constant temperature of 20-28 °C (68-82 °F). However, in-field biodegradation of BDM generally will take longer than in the laboratory test. In the laboratory test, 17,568 cumulative °C -days are accumulated over the 2-year period. In a field experiment in Mount Vernon, WA where five BDMs were incorporated into the soil annually for four years (2015-2018), two years after the final incorporation, 4-16% of the total mulch was recovered. In this study it took 45.5 months to accumulate the same amount of cumulative degree days as the laboratory test and hence 21 to 58 months (1.7 –4.8 years) to reach 90% biodegradation. A thermal unit calculation can be used to estimate the amount of time needed to reach 90% biodegradation in the field. In addition, soil type, soil moisture, and mulch fragment size also affect site-specific, in-field mulch biodegradation.

For more information visit https://smallfruits.wsu.edu/plastic-mulches/

THAT'S A WRAP!

BDM PROFESSIONAL DEVELOPMENT PROJECT (2019-2022)

Srijana Shrestha, Washington State University Graduate Student

Agriculture in the United States uses approximately 370,000 metric ton of plastics annually including polyethylene (PE) mulch that is non-degradable and non-recyclable. Increasing agricultural plastic use raises environmental concerns due to PE mulch that is disposed in landfills, stockpiling, or on-site burning. Soil-biodegradable plastic mulch (BDM) was developed as a sustainable plastic mulch alternative that is designed to be tilled into the soil after use at the end of the growing season and will undergo biodegradation. There have been studies of the horticultural benefits, effects on soil health and ecology, sociology and also economics of using BDM that have concluded that BDM is a viable alternative to PE mulch. Despite the benefits and availability of BDMs in the market for over 20 years, the adoption of BDM by growers is low, and insufficient knowledge about BDM was identified as the primary reason.

A professional development project was designed to fill information gaps on BDM by developing a training curriculum and educating Extension personnel and other agricultural professionals about BDM. This 3-year project was funded by Western Sustainable Agriculture Research and Education (WSARE) under WPDP19-05 and ended in May 2022. For this WSARE project, we developed educational materials that include: 16 PowerPoint slide sets, 11 for workshop presentations and 5 for course lectures along with presenter notes for each slide set; 3 videos; and 11 fact sheets.

All of these materials are posted on the WSU website https://smallfruits.wsu.edu/plastic-mulches/ where they are freely available. Anyone can use the information materials on the website and conduct BDM workshops or presentations on their own.

The Western SARE project led to the development of 16 PowerPoint slide sets, 11 for workshop presentations and 5 for course lectures along with presenter notes for each slide set; 3 videos; and 11 fact sheets. All information is freely available online.

In addition, we conducted 3 professional development workshops: at the local level in Watsonville, CA, at the regional level for agriculture professionals in the northeastern United States, and at the national level for members of the American Society for Horticultural Science (ASHS).

In Watsonville, CA, the participants' overall level of knowledge on BDM increased 41% due to the training program. In the northeastern United States, 27% of participants responded that they learned a lot from the training session and 41% learned some new information.

In ASHS, 48% of participants responded that they learned a lot from the training session and 48% learned some new information. Furthermore, several posters and talks were presented on this project at national conferences and regional meetings.

On-farm demonstration of strawberry grown with BDMs helped growers in Watsonville, CA gain first-hand experience on the performance of BDM in their climatic conditions. A webinar on 'Global use of BDM' brought together the growers from across the United States and Italy who have been using BDM for 1 to 25 years to share their experience with BDMs.

Altogether, 48 researchers, 80 Extension personnel, 7 government personnel, 31 growers, 12 representatives from agencies, 10 service providers, and 318 general participants including graduate students participated in the educational activities mentioned above.

Approximately 460 participants gained knowledge about sustainable agriculture using BDM while 166 agricultural professionals reported intention to use knowledge learned through this project in their educational activities and service for growers.
This project has raised awareness of BDM among agricultural professionals and provides answers to many of the questions and concerns regarding BDM.

The educational materials can be accessed at https://smallfruits.wsu.edu/plastic-mulches/teaching-materials/.

Graduate students and a grower discussing soil-biodegradable plastic mulches in California.

WESTERN SARE
Sustainable Agriculture Research & Education

BUILDING A BETTER MULCHING INDUSTRY:

A BIODEGRADABLE MULCH Q&A WITH MAY WANG

May Wang with harvested strawberries from her research trial. Photo by May Wang.

Former Washington State University (WSU) graduate student, Dakota McFadden, sat down with another former graduate student to discuss her experiences and opinions on soil-biodegradable mulches (BDMs) and what the future of mulching in agriculture may look like.

Can you tell us a little about yourself and your educational background?

I am originally from China. My agricultural research interest brought me to study here [in the United States]. I obtained my Bachelor's degree at the University of Florida in Plant Science. I completed my Master's degree at Washington State University in Dr. Lisa DeVetter's Small Fruit Horticulture lab studying mulch application in strawberry. I recently started my PhD program at North Carolina State University in August 2022 researching plant virology.

Explain your experiences with mulches in specialty crop production systems.

My Master's project was funded by the Washington State Department of Agriculture. Specifically, I investigated BDM application in double cropping systems with strawberry and lettuce. I also explored how plastic mulches influence splash dispersal of the gray mold pathogen. Through reading the background literature of plastic mulches and observing how mulches perform in my field and lab experiments, I gained a better understandings of mulch characteristics, properties, and application. For my splash dispersal project, we collaborated with researchers in the fields of biofluid dynamics and material science. With this unique opportunity [and collaboration], I was able to focus on the mulch material and learn about mulch properties from an unusual perspective that most horticulturists do not see.

What does the future of mulching in specialty cropping systems look like to you?

With current global challenges such as climate change, natural disasters, resource shortages, the covid pandemic, and so forth, farmers tend to be more driven to have diverse cropping systems so they can utilize resources maximumly and better save themselves from unexpected crop loss. Mulching can be applied to a lot of essential crops of economic value and are already very widely used in agriculture. In the future, I expect to see a lot more mulched multi-cropping systems.

You have done several research studies on BDMs. What are your personal opinions on their adoption and acceptance in farming? Do you have any suggestions to offer the BDM production industry to make BDMs more appealing to farmers?

BDMs are still relatively new to farmers, but they are not new to researchers. I personally think adoption of BDM in organic farming will be very promising because organic growers would like to invest their money in the technology, but unfortunately there is no single commercial BDM product that can be applied in organic production [in the US]. For most conventional farmers, they seem to find PE or weedmat more appealing, as these materials are relatively more durable. Overall, I am very excited to see how the mulch industry will make BDMs more suitable for US organic agriculture.

Do you see opportunity for other alternative biodegradable mulches, such as water based mulches to be adopted into commercial production?

My previous supervisor, Dr. DeVetter, is also studying hydromulches. Hydromulches have a promising future in agriculture because you can customize your hydromulch formula to better meet your cropping system's needs. They can also be made to meet US organic requirements. But this is still a very new topic, I am looking forward to seeing more research and extension that focus on hydromulch.

Former graduate student, May Wang, enjoying the trees in Washington State. Photo by May Wang/

RECENT PUBLICATIONS

⇒ **In-Field Biodegradation of Soil-Biodegradable Mulch.** D. Griffin-LaHue, S. Ghimire, Y. Yu, E.J. Scheenstra, C.A. Miles, M. Flury, and S. Shrestha. 2022. FactSheet available at: https://smallfruits.wsu.edu/plastic-mulches/.

⇒ **End-of-Life Management Options for Agricultural Mulch Films in the United States—A Review.** Madrid, B., S. Wortman, D.G. Hayes, J.M. DeBruyn, C. Miles, M. Flury, T.L. Marsh, S.P. Galinato, K. Englund, S. Agehara, and L.W. DeVetter. 2022. Frontiers in Sustainable Food Systems. 282. https://doi.org/10.3389/fsufs.2022.921496.

⇒ **Risk and Uncertainty of Plastic Mulch Adoption in Raspberry Production Systems.** Madrid, B., J.R. Goldberger, C.A. Miles, and L.W. DeVetter. 2022. Renewable Agriculture and Food Systems. 1–12. doi: https://doi.org/10.1017/S1742170522000291.

⇒ **Humic and Acetic Acids Have the Potential to Enhance Deterioration of Select Plastic Soil-Biodegradable Mulches in a Mediterranean Climate.** Madrid, B., H. Zhang, C.A. Miles, M. Kraft, D. Griffin-LaHue, and L.W. DeVetter. 2022. Agriculture. 12(6):865. https://doi.org/10.3390/agriculture12060865.

⇒ **Macro-and microplastic accumulation in soil after 32 years of plastic film mulching.** Shitong, L., F. Ding, M. Flury, Z. Wang, L. Xu, S. Li, D.L. Jones, and J. Wang. 2022. Environmental Pollution. 300: 118945. https://doi.org/10.1016/j.envpol.2022.118945.

UPCOMING EVENTS

- National Organic Standards Board Meeting. Oct. 25-27. Sacramento, CA. https://www.ams.usda.gov/event/national-organic-standards-board-nosb-meeting-sacramento-ca-2022.
- Pacific Northwest Vegetable Association Conference. Nov. 16-17. Kennewick, WA. https://www.pnva.org/pnva-conference.html.
- Washington Small Fruit Conference. Nov. 29-30. Lynden, WA. https://www.wasmallfruit.com/.

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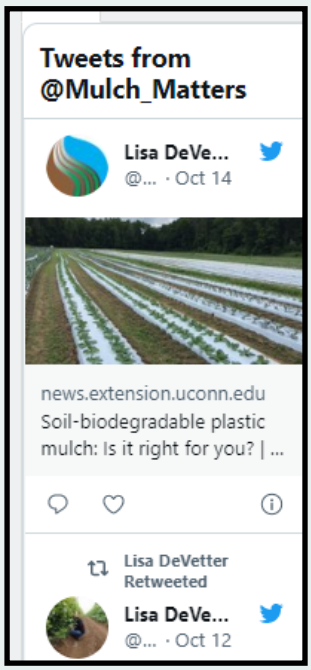

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