# Sustainable Mulch MANAGEMENT

## Plastic Mulches in Horticulture Production

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# Improved End-Of-Life of Plastic Mulches

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## In This Issue...



**Cover photo** Ben Andros (Andros Engineering) demonstrates equipment for mulch-film collection during a strawberry field day. Photo by L.W. DeVetter.


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# Project Director's Note


**Lisa Wasko DeVetter, Project Director, Professor, Washington State University**


As we continue advancing innovative solutions for sustainable mulch management, the impact of our collaborative efforts is becoming increasingly clear. In this edition of *Sustainable Mulch Management*, we're excited to share recent accomplishments and new insights that bring us closer to our shared goal—expanding viable, environmentally responsible mulch options for growers and stakeholders.

One major highlight was our presence at this year's American Society for Horticultural Science Annual Conference, where our team led an informative workshop titled *"Mulch Matters! Lessons Learned on Improving End-of-Life Outcomes of Plastic Mulch."* This event brought together researchers, growers, and industry leaders to exchange ideas and explore the use of soil-biodegradable plastic mulches (BDMs) and strategies for recycling conventional plastic films in horticultural systems. Building on the success of this workshop, we're planning a webinar in 2026 to share similar content. Stay tuned by following us on social media for updates.

From field trials to lab experiments, our team is closely tracking the journey of BDM fragments to better understand their behavior and impact in agroecosystems. In our experimental strawberry field sites, our team is monitoring how BDM fragments move and degrade over time. In controlled lab settings, the decomposition processes are being monitored to identify key factors that influence biodegradability. These efforts are helping us build a clearer picture of how BDMs interact with soil and affect soil health.

Our team is also exploring the human dimension of mulch use. Research into consumer willingness to pay (WTP) for strawberries grown with sustainable plastic disposal practices shows encouraging trends—consumers increasingly value environmental stewardship, which may help drive broader adoption of BDMs.

In California, where mulch use is extensive, our team is identifying both challenges and opportunities for integrating BDMs into existing production systems. Economic modeling is also helping us understand how growers make decisions about mulch use and what influences their willingness to transition to biodegradable options.

To support informed decision-making, our Extension team recently wrote a factsheet on commercially available BDMs in the United States. This resource outlines key information on product performance, certification, and application, empowering growers with practical knowledge as they consider sustainable alternatives.

Lastly, we're proud to share several recent publications that highlight our progress, and we invite you to join us at upcoming events where we'll continue the conversation around mulch, sustainability, and agricultural innovation.


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# Mulch Matters! Workshop at ASHS Annual Conference

**Carol Miles. Washington State University**

Our SCRI team presented a workshop, *Mulch Matters! Lessons learned on improving end-of-life outcomes for plastic mulch*, at the American Society for Horticultural Science (ASHS) 2025 annual conference in New Orleans, LA, on 29 July. The workshop was hosted by the ASHS Plasticulture working group and provided our team an opportunity to highlight some industry perspectives of plastic mulch management as well as present some research highlights from our project. Through the discussion with participants, we learned that there are few efforts in the U.S. to reduce plastic mulch use or facilitate recycling. Yet plastic mulch is foundational to modern production systems for many food crops. With the expansion of extended producer responsibility, circularity, and sustainability initiatives, the horticultural industry needs new technologies that reduce persistent plastic waste generation. Recycling polyethylene mulch through mechanical and chemical methods, and alternatives such as soil-biodegradable plastic mulch, provide promising answers to this situation. The workshop sessions and speakers included:

1. *Identifying the problem and possible solutions* presented by Lisa DeVetter, Carol Miles, and Gene Jones.
2. *Lessons learned and recommendations from industry* presented by Shuresh Ghimire, Ben Andros, and Hillary Thomas.
3. *Socioeconomic considerations and future prospects* presented by Jessica Goldberger, Sam Wortman, and Pierre Sarazin.

The industry presentations were very informative as our speakers shared lessons learned and experience-shaped strategies to reduce plastic mulch waste generation. To take advantage of these excellent presentations from the workshop and to enable recycling, our team is organizing a webinar series in the new year that will have open registration to reach a broad national audience. Stay tuned!


*Gene Jones*


*Ben Andros*


*Pierre Sarazin*


# Tracking Fragments of Soil-Biodegradable Plastic Mulch in Strawberry Fields

**Xueyu Zhou and Markus Flury, Washington State University**

After the growing season, soil-biodegradable plastic mulch is tilled into the soil. This process breaks the mulch into fragments, which are then dispersed in the soil. Some fragments remain on the surface, while others are incorporated into the soil or entangled on the tillage implement. Over time, these fragments continue to deteriorate, becoming smaller and smaller. However, the exact size and persistence of these fragments remain unknown. To address this, we conducted an experiment to track and quantify the mulch fragments after tillage into the soil.

## HOW TO TRACK PLASTIC MULCH FRAGMENTS IN THE SOIL

Quantification of mulch fragments after tillage is not straight-forward. Because mulch fragments after tillage are usually large (several inches in size) and randomly dispersed around the field, it is not easy to collect them in a representative manner. The best way to quantify the mulch fragments is to collect them from an area as large as possible. Here, we recommend collecting the plastic fragments from an area of at least 1 m by 1 m (Ghimire et al. 2020; Yu and Flury 2021). In our study, we collected one sample per plot, but to sample a field we suggest at least three samples collected from random but representative areas in the field. Because plastic fragments are incorporated into the soil during tillage, the soil must be excavated to the tillage depth in order to quantitatively collect mulch fragments.

Figure 1 shows a 1 m by 1 m square used to delineate the sampling area for plastic collection. Visible mulch fragments are collected by hand and the soil is turned over repeatedly within the tillage depth to collect buried mulch pieces (Figure 2). A grab soil sample (two random scoops of 500 mL of soil were taken with a Pyrex kitchen pitcher) can also be collected to analyze soil for invisible mulch pieces (Figure 3). This protocol can be applied anytime during a growing season to track the degradation of mulch pieces over time. Collected mulch pieces can then be quantified by measuring weight (after washing off adhered soil), surface area, and size distributions of the pieces (Ghimire et al., 2020; Griffin-LaHue et al. 2022). Plastic fragments are often categorized into macro- and microplastics: Macroplastics are defined as fragments >5mm, and microplastics are defined as fragments <5 mm. A 5-mm sieve can be used to separate these two fractions of plastics.

## SOIL-BIODEGRADABLE PLASTIC MULCH FILM IN STRAWBERRY FIELDS

In our experiment, soil-biodegradable plastic mulch film (Black Bioguard 00, Mater-Bi based) was used in a strawberry trial. Strawberries were planted into mulch-covered raised beds (Figure 4) at the Northwestern Washington Research and Extension Center in Mount Vernon, WA. This field had a history of soil-biodegradable mulch use between 2015–2018. After the growing season, strawberry plants and soil-biodegradable plastic mulch were tilled into the soil with a rototiller. Both soil and visible plastic fragments were then collected from the experimental site as described above. These samples were subsequently analyzed in the laboratory using wet sieving and image processing analysis. The same sampling protocol was repeated one year later in a different location in the same plot prior to tillage of the second season of soil-biodegradable plastic mulch film. A comparison of the two datasets allows us to assess the degradation of plastic fragments over the course of one year.

*Figure 1. A 1 m by 1 m wooden square frame used to delineate the sampling area for plastic mulch collection in the field. Visible mulch fragments are collected by hand.*

*Figure 2. The soil within the sampling area is turned over repeatedly to recover buried mulch pieces within the tillage depth. Visible mulch fragments are collected by hand.*

*Figure 3. Collection of grab soil samples (two random scoops of 500 mL of soil were taken with a Pyrex kitchen pitcher) for laboratory analysis to detect and quantify mulch fragments not visible to the naked eye. Soil is collected with a glass jar and placed into a paper bag.*

*Figure 4. Strawberries planted into raised beds covered with soil-biodegradable plastic mulch during the field trial.*

## TILLAGE BREAKS MULCH FILM APART

Figure 5 shows the visible plastic fragments from the soil-biodegradable plastic mulch film recovered right after tillage and one year later. Right after tillage, the plastic mulch film had been broken into fragments of different size, varying from 2 mm to 15 cm in size. Most of the mulch film fragments were larger than 5 mm, with only a few pieces between 2 and 5 mm. This suggests that the tillage operation caused significant mechanical fragmentation of the mulch, breaking large sheets into numerous smaller pieces. Tillage operations are thus effective in fragmenting soil-biodegradable plastic mulch films.

## PLASTIC FRAGMENTS REMAINING AFTER ONE YEAR

One year after tillage, a notable decrease in both the quantity and mass of mulch fragments was evident (Figure 5). The reduction was most prominent in the >5 mm category, implying substantial deterioration of the soil-biodegradable mulch. This supports the intended function of soil-biodegradable mulches, which are designed to break down under field conditions over time, minimizing long-term plastic accumulation.

## WHAT THIS MEANS FOR FARMING

Our findings show that soil-biodegradable plastic mulch films deteriorate in soil—just not overnight. Under favorable conditions, they provide a promising substitute for traditional polyethylene mulch film, which degrades into smaller and smaller fragments but always persists such that fragments will accumulate in the field or surrounding environment. For farmers, switching to soil-biodegradable plastic mulch films can reduce long-term plastic accumulation—especially in places where it is difficult to remove mulch. But not all soil-biodegradable plastic mulch films are created equal, nor are all soil and environmental conditions the same, so deterioration of soil-biodegradable plastic mulch films will differ from place to place. Farmers and policymakers should consider these real-world findings when evaluating the use of soil-biodegradable plastic mulch films.

## LOOKING AHEAD

Although large fragments of mulch are easier to find and remove, smaller fragments— even tiny ones, can spread through soil and water. Future research should explore how far these micro- or even nanoparticles can spread and what risks they pose to the broader ecosystem.

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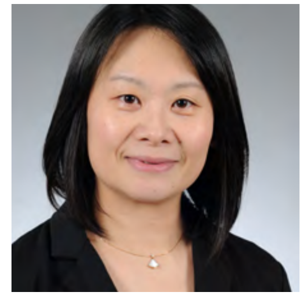
*Figure 5. Photos of soil biodegradable plastic mulch film (Black Bioguard 00; Mater-Bi based) mulch fragments immediately after tillage (left) and after one year in the ground (right). Fragments are separated into 2–5 mm and >5 mm pieces*



# Tracking the Breakdown of Soil-Biodegradable Mulch in the Laboratory

**Hang Liu, Washington State University**

## WHY STUDY POST-HARVEST SOIL-BIODEGRADABLE MULCH FIELD DEGRADATION

Soil-biodegradable mulch (BDM) is developed to serve the same functions as conventional plastic mulch to control weeds, conserve soil moisture, and regulate soil temperature during the growing season, while offering a unique attribute of breaking down naturally after use. This reduces the environmental burden created by nonbiodegradable petroleum-based mulches. BDMs are made of materials that can degrade under normal field conditions, and the materials within each BDM may degrade at different rates and respond to the environment in different ways (Hayes et al. 2017). To control the degradation rate and balance film strength and flexibility, BDMs are often made by blending different materials (Sintim et al. 2020). Understanding how BDMs degrade in the field is important for farmers to select BDMs that match local weather patterns and the length of the growing season, and for industry to develop BDMs better suited to various climates and cropping systems.

## HOW TO EVALUATE BIODEGRADABLE MULCH FIELD DEGRADATION

BDM degradation is studied using techniques to assess physical, mechanical, chemical, and molecular structural changes of BDMs.

### PHYSICAL CHANGES.

The most direct way to study mulch degradation in the field is through physical changes, such as the development of tears, holes, and fragmentation of the mulch film. Assessing mulch thickness and weight change also indicates material loss over time. These physical property changes may result not only from microbial biodegradation but also from environmental stresses, such as strong wind, which often cause tears to develop and spread. For physical changes in mulch that cannot be detected by the naked eye, a high-resolution microscope is used. Figure 1 shows digital photos of a BDM before use and after harvest of strawberry grown in an annual system in Nebraska, along with a scanning electron microscopy (SEM) image (5,000x) that shows the development of small cracks.

### MECHANICAL CHANGES.

Mulch degradation leads to deterioration of and changes in BDM mechanical properties. In some cases, some mechanical properties such as tensile strength can temporarily increase at the beginning of the degradation process (Liu et al. 2022). Common mechanical properties that we evaluate are tensile strength (the film's resistance to pulling), elongation (ability to stretch), tear strength (resistance to the propagation of small tears), and punch resistance (withstand damage from sharp objects, e.g., plant stems or soil particles). In the laboratory, these properties are evaluated following standard test methods. For example, ASTM D882-18 - Standard Test Method for Tensile Properties of Thin Plastic Sheeting and ASTM D1922-15(2020) - Standard Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method, are often used to assess tensile strength and elongation, and tear strength, respectively. The results are compared with pre-season unused films and films weathered under different environmental conditions. Figure 2 illustrates the tensile strength (in the machine direction of the film) and tear strength of a BDM before use and after harvest of strawberry under four different weather conditions (Washington, Nebraska, California, and Florida).

### CHEMICAL CHANGES AT THE MOLECULAR LEVEL.

The most fundamental change that causes mulch property changes during degradation occurs at the chemical and molecular levels, as mulch is ultimately broken down completely into carbon dioxide, methane, water, and biomass. Large polymer molecules are gradually cleaved into small ones, i.e., monomers and oligomers. These small molecules are transported across microbial cell membranes for microbial metabolism and conversion


*Figure 1. Images of a biodegradable mulch (a) before use, (b) after use, and (c) under a microscope with a magnification of 5,000x.*

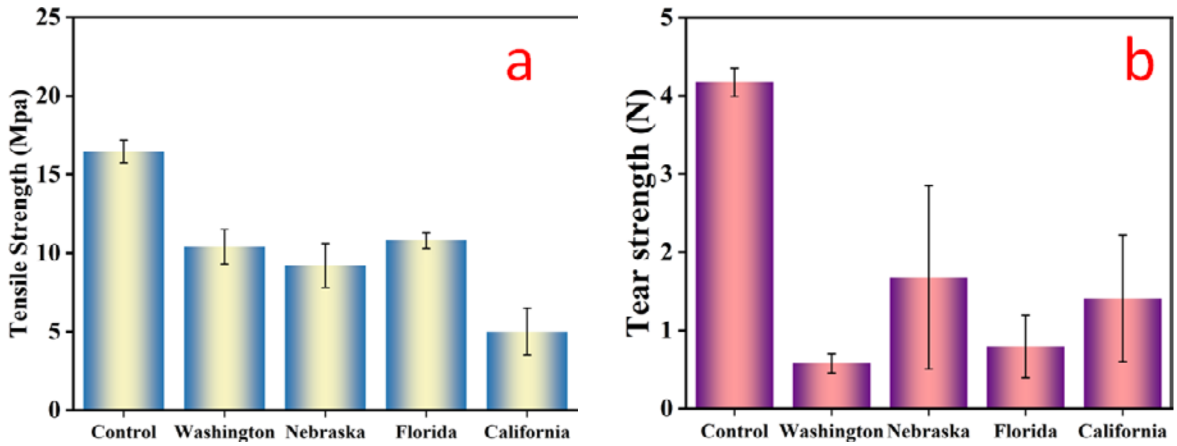



*Figure 2. The tensile (a) and tear strength (b) of a post-harvest BDM from four states.*

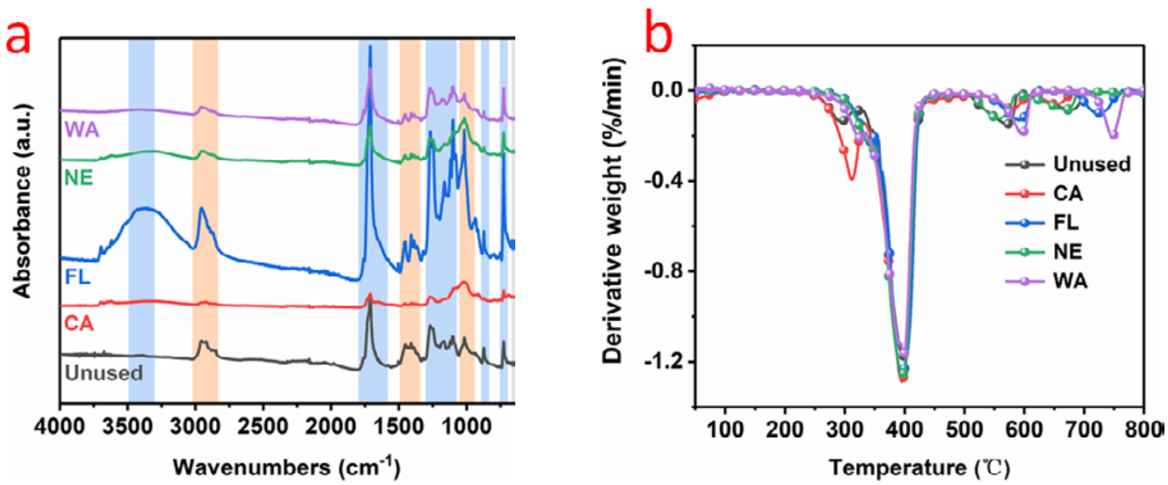



*Figure 3. FTIR spectra (a) and thermal degradation curve (b) of a post-harvest BDM from four states.*

into carbon dioxide, methane, water, and biomass that are stored within the cells of the microorganisms. Common tools to evaluate chemical changes include Fourier transform infrared spectroscopy (FTIR) for chemical bond detection, gel permeation chromatography for polymer molecular weight distribution measurement, thermogravimetric analysis (TGA) for thermal stability analysis, and differential scanning calorimetry (DSC) for evaluating film crystallinity changes at the microstructural level. Figure 3 displays examples of FTIR and TGA data from the same BDM shown in Figure 2. Peaks in the FTIR spectrum show weakened, disappeared, newly appeared, or strengthened features, and the TGA curves show changes in thermal stability behaviors that indicate changes in chemical composition. This analysis provides critical information on understanding the environment-material-degradation relationships of BDMs.

## CONCLUSION

Evaluating post-harvest field BDM samples provides insights into the degradation of BDM products under farming conditions. The results capture the combined influence of various factors in the field, including weather (temperature, rainfall, sunlight), soil properties, microbial activity, and farming practices. This information offers valuable guidance for farmers in selecting BDMs well suited to their climate and farming practices and provides industry with important insights for developing new products.

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# Consumer WTP for Strawberries Produced Under Sustainable Plastic Disposal Practices

Kevin Morris, Thomas Marsh and Suzette Galinato, Washington State University

*Figure 1. At the University of Florida mulch trials, ripe strawberries thrive beneath a patchwork of mulch films. These coverings vary in color, strength, and biodegradability, offering a vivid comparison of how different materials influence plant growth.*

## INTRODUCTION

The use of plastic mulch in agriculture is rising dramatically in the U.S. and across the world (Dada et al. 2025). Plastic mulches present a unique disposal problem as they are difficult and costly to recycle due to their contamination with soil, plant residues, and agrochemicals after being removed from the field (Yu et al. 2023). Besides the disposal issues, plastic mulches can reduce soil quality in the long run due to its propensity to fragment in the soil (Steinmetz et al. 2016). In this study, we are estimating the willingness to pay (WTP) of U.S. consumers for fresh strawberries grown with a commitment to sustainable plastic disposal practices. It is well studied that many consumers have preferences for goods with environmentally friendly, or green, attributes (Laroche et al. 2001; Straughan & Roberts, 1999; Yue et al. 2016). We have asked respondents a series of simple yes-or-no questions about purchasing these 'green-attribute' strawberries at various prices using the nationwide average price as a reference point. From these responses, we can calculate the average WTP and compare that to the current market price for fresh strawberries. If the average WTP exceeds the market price, it suggests that U.S. consumers may reward growers with a premium for their commitment to reduce plastic waste.

In addition to estimating U.S. consumer WTP for fresh strawberries produced with sustainable plastic disposal practices, we are interested in how a randomized information treatment, along with various socio-economic variables such as respondents' age, income, education, and region, correlate to increased WTP for these strawberries. This approach not only quantifies the average premium consumers would be willing to pay, but also identifies the factors driving the willingness to pay a premium. If the information treatment has a significant effect, it would suggest that greater awareness of plastic waste in agriculture influences WTP. Ultimately, besides quantifying the premium, our analysis will clarify whether information, education, income, or other factors are the key drivers of consumer's willingness to pay more.

## DATA COLLECTION

The surveys were distributed through Qualtrics online to 1,500 U.S. consumers. Qualtrics selects consumer-respondents with quotas placed on different socio-demographic variables such as age, income, and geographic region of residence, ensuring alignment with U.S. Census estimates. This approach ensures that respondents will be representative of the U.S. population by avoiding over- or under-sampling across U.S.

consumers of various ages, incomes and locations of residence. As the survey involves human subjects, it was reviewed by the Institutional Review Board by Washington State University and received exempt status (IRB 20841-001, “Evaluating Consumer Willingness to Pay for Strawberries Grown with Sustainably Recycled Plastic Mulch”).

## RESULTS

The average WTP for the 1500 respondents is $5.13 per 1-lb box of green-attribute fresh strawberries (p=0.039), which is a 13% premium for strawberries grown with a commitment to reducing plastic waste in agriculture. This result aligns with a similar WTP study by Chen et al. (2019) that used similar methodology and survey design to estimate mean WTP among U.S. strawberry consumers for fruit grown with soil-biodegradable mulch. They reported an average WTP of $3.86 per 1-lb box of fresh strawberries, which was about a 10% premium as the market price was $3.50 at the time of their research. Our survey was aligned with the latest U.S. census demographics and shows that, on average, U.S. consumers of fresh strawberries are willing to spend more money if it contributes to reducing plastic waste.

We can gain more insights from our survey by breaking down the reported WTP of the respondents to capture the variation in responses, and by examining the responses with experimental information treatments and individual factors of age, income, and region of residence (Northwest U.S., Southeast, etc.). For example, some respondents indicated zero or negative WTP for the green-attribute strawberries. Our survey allows us to determine whether these responses reflect price sensitivity among lower-income consumers or a potential ideological factor that exists in certain regions of the U.S.. For other respondents, highlighting the specifics of the plastic waste problem (an information treatment) significantly increased WTP. We can therefore determine how both demographics and information influence respondents’ stated WTP.

An increase in understanding of the plastic waste problem could shape demand for these green-attribute strawberries. This finding is important because a market for strawberries grown with a commitment to reducing plastic waste requires sufficient demand to justify the supply produced in this way. Ultimately, one of the main goals of the survey is to understand the factors (region, income, information) that influence WTP for green-attribute strawberries. This work is ongoing, so stay tuned for updates in future newsletters.

Why this research matters: Being able to characterize demand for these green-attribute strawberries is valuable information for growers interested in reaching this new market. If we can communicate to growers the types of consumers interested in this market (e.g., age, income, region of residence, etc.) and the types of information factors that drive demand, we can facilitate the development of this new market opportunity. This approach benefits both sides: growers gain an opportunity to increase their business, and consumers gain access to a product that otherwise might not exist—a product that contributes to reducing plastic waste.

Quantifying consumers preferences for environmentally friendly attributes of agricultural goods is critical for both policy makers and stakeholders, as well as growers. For policy makers, understanding the demand for environmentally friendly products could guide policies that mitigate the negative impacts of plastic waste and that generate social benefits by incentivizing growers to adopt practices that reduce plastic waste. From a grower’s perspective, this research can potentially identify profitable opportunities to market differentiated products that satisfy consumer preferences for environmentally beneficial goods. An indirect benefit to growers is that their efforts to reduce plastic waste would also improve soil health.

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# Challenges and Opportunities for Soil-Biodegradable Mulch Use in California

**By Jazmine Mejia-Muñoz, Water Quality Program Manager, California Marine Sanctuary Foundation**

*Figure 1. An aerial view of the Pajaro River mouth as it feeds into the Monterey Bay National Marine Sanctuary, surrounded by agricultural systems using plasticulture. Photo Source: Ralph Pace.*

Monterey County, a world renowned innovative coastal agricultural hub, located in California's Central Coast (Figure 1), has a gross agricultural production value of $4.99 billion (County of Monterey, 2025). With an estimated 8 million pounds of mulch used annually, plasticulture is key for high quality production and operational safety (Krone 2020). Four years after initiating soil-biodegradable mulch (BDM) trials at commercial farms, the adoption of BDM is at best in its infant stage.

> "...challenges and opportunities that need to be addressed for continued expansion."

BDM has been noted for providing comparable benefits to polyethylene (PE) mulch, including weed suppression, reduced water evaporation, extended harvest period, and soil temperature boosts. The use of BDM can result in a reduction of agricultural waste, and BDM has gained traction in areas such as Italy and in New England, USA. However, in Monterey County BDM has been cautiously studied, revealing a series of challenges and opportunities that need to be addressed for continued expansion.

## TRIALS IN CALIFORNIA

In 2020, BDM trials were established in Monterey and Santa Cruz counties across five commercial strawberry farms. In collaboration with UC Extension, CalPoly, Washington State University, and the California Marine Sanctuary Foundation (CMSF), two trials of BDM have been conducted as part of the USDA Specialty Crops Research Initiative in California. The first trial included 60 strawberry beds, each 50 feet long. Due to beds that were shorter than normal production, the application of BDM varied in tension.

During the early stages of the trial, Monterey County was struck with multiple atmospheric rivers. Storm intensity combined with open bed fronts and short beds led to much of the BDM detaching and tearing from the beds. This experience led to revisions in the second trial; beds were fully tucked in at the ends and the runs were set at normal length of about 200 feet. Preliminary data from this year's trials show that yield from BDM is comparable to those of traditional PE mulch, with no significant difference in production (Figure 2). Nine months post application, the greatest percent soil exposure we have seen is 15% (Figure 3), indicating the BDM has remained intact. However, the BDM trial reveals other concerns beyond yield production, cost, or use limitations within the row-crop production system.

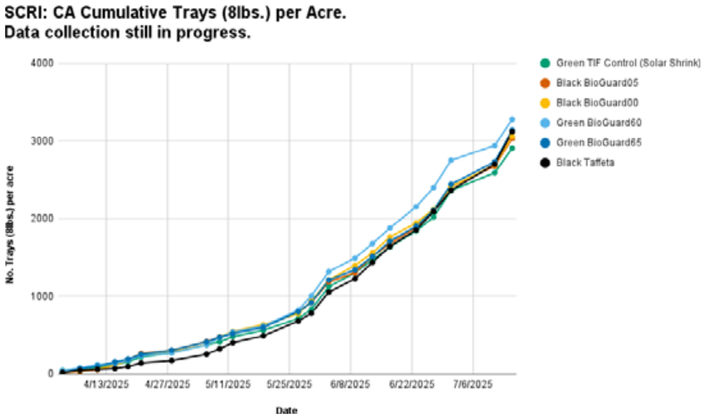


*Figure 2. Yield data was collected weekly in test plots and separated by marketable and non-marketable, 2025. Cumulative trays represent marketable yield produced by the strawberry beds that meet quality standards of the buyer. There was no significant difference between the cumulative marketable trays produced by soil-biodegradable mulches (Black BioGuard05, Black BioGuard00, Green BioGuard65, and Green BioGuard60) and polyethylene (Green TIF Control and Black taffeta) based mulches. Black taffeta is a mulch film partially composed out of recycled post consumer plastic.*

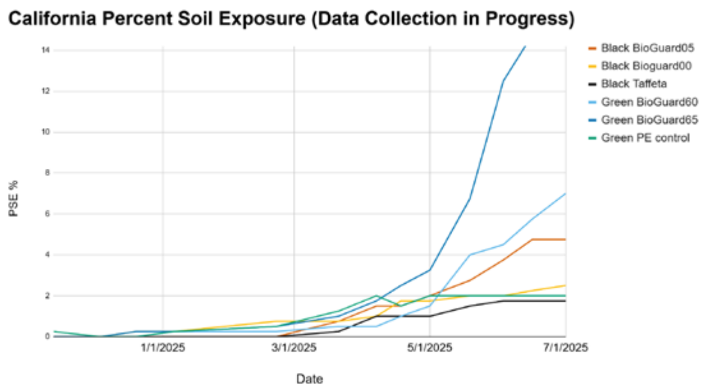


*Figure 3. Percent Soil Exposure (PSE) data was collected monthly, and it refers to the amount of deterioration visible on the mulch films covering the strawberry beds. Zero percent PSE represents intact mulch film on the bed, 100% PSE represents a completely exposed strawberry bed, where the mulch film has completely deteriorated. Soil-biodegradable mulch treatments include Black BioGuard05, Black BioGuard00, Green BioGuard65, and Green BioGuard65. Green TIF Control was the control treatment and Black taffeta is a mulch film partially composed out of recycled post consumer plastic.*

## CHALLENGES AND OPPORTUNITIES

Currently no plastic BDMs meet the standards set by the USDA's National Organic Program, limiting the commercial use of plastic BDMs to conventional farms. In 2021, Washington State University provided a **response to address questions by members of NOSB (pdf)**—however the National Organic Standard Board has not taken this research-based information into account and the rule effectively prohibits the use of BDM in certified organic systems.

The challenge for the adoption of plastic BDM goes beyond regulatory constraints that prevent their use in certified organic production farms, and the perceived cost constraints. There are concerns regarding the slow biodegradation rate of BDM in the fast-rotating agricultural row-crop system prevalent in the region, and its inability to replace totally impermeable fumigation (TIF) films or high barrier fumigation tarps used in bed fumigation.

Under the international biodegradability standard EN-17033, BDMs "need to reach 90% biodegradation within 2 years in an aerobic incubation test at a controlled temperature between 20-80 °C (68-82 °F)" (Griffin-LaHue et al. 2022). In field conditions in Watsonville, CA, which is adjacent to Monterey County, researchers predict it will take 34 months or 2.8 years to achieve this level of biodegradation (Griffin-LaHue et al. 2022). This rate of biodegradation is challenging for Monterey County's fast rotational row-crop systems. For example, once strawberry production is concluded, the field is either cover cropped or fallowed and then rotated with a vegetable crop. Before the field is passed on to the next crop, the soil is worked, leveled, and cleaned from residual plastic. Growers have expressed concerns that if excessive BDM residue is left in the top one inch of soil, there could be potential food safety risk—as the BDM could be trapped in the growing veggie plant (Figure 4). Food safety officers will flag fields that have significant remaining plastic residues in the soil. To reduce food safety concerns, BDM applications could be more suitable in fields rotated with taller crops such as Brussels sprouts.


*Figure 4. Leafy green field post BDM tillage with lettuce seedling with mulch fragment. Photo Source: California Marine Sanctuary Foundation*

Beyond food safety concerns, BDM residue could become problematic in vegetable production operations. For example, pieces of PE mulch that are left in the field block the blades that are used weekly to till the top one inch of soil to control weeds between the plants. One grower expressed concerns that the plastic in the blades can knock out the small vegetable seedlings, and thus the PE mulch must manually be pulled from the blade. This grower speculated that BDM fragments could cause a similar issue; this is the first time he is growing following BDM that was tilled into the soil and he has not experienced this challenge thus far. To mitigate these risks and operational challenges, BDM applications would ideally be followed by a cover crop and biodegrade in 4-6 months over the winter.

BDMs face another challenge; they are prohibited to be used as TIF. The use of fumigation tarps as a safety measure for emission controls and risk mitigation associated with soil fumigants are encouraged under standards set by the U.S. Environmental Protection Agency and other standards under the California Code of Regulations (Title 3. Food and Agriculture. Division. 6 Pesticides and Pest Control Operations - Chapter 1-4). While BDMs cannot replace in-row TIF-mulch fumigation, they can be used following flat broadcast fumigation, a practice commonly used in conventional fields.

As BDM adoption is considered to expand at a commercial scale in California, CMSF is gaining a better understanding of the potential role that farming practices can have in preventing BDM residue from escaping fields and entering waterways. Practices such as hedgerows, vegetative in-field windbreakers (grassed end beds), grassed roadways, and vegetative ditches can act as buffers to prevent the escape of BDM fragments. You can learn more about soil-biodegradable mulches at **smallfruits.wsu.edu/plastic-mulches/**.

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# Modeling Economic Decisions for Soil-Biodegradable Plastic Mulch Use by Growers

**Thomas L. Marsh, Washington State University**

Many of the world's most productive agricultural soils have been exposed to decades of plastic mulch usage that has resulted in significant plastic waste and microplastics accumulation, which may threaten environmental sustainability. To address this situation, the European Union supported the development of soil-biodegradable plastic mulch (BDM) that is tilled into the soil after use and biodegrades within a few years. BDM has been commercially available in the U.S. for a few decades, but adoption is low. We have developed a dynamic economic model to analyze production decisions influencing microplastic accumulation on a farm and the adoption of BDMs and applied it to an illustrative case study of tomato production in the state of Washington. The model considers the trade-offs between BDM degradation rates in agricultural production, seeking to balance the cost of BDM and the cost of waste disposal. We consider both private and social perspectives under a deterministic environment (with no random outcomes) and a stochastic environment (with random outcomes). Here we present a summary of our findings to date. For more of the story, see Jiang et al. (2025).

Our economic model analysis reveals that when crop prices are high, growers prioritize long-term soil improvement strategies and will use BDM, which has higher upfront costs. Similarly, higher waste disposal costs incentivize the adoption of BDM to minimize disposal volume and associated costs. Essentially, growers weigh the benefits of BDM (reduced disposal costs and improved soil health) against their potentially higher upfront costs.

Key findings from our case study suggest that BDM can significantly decrease long term plastic pollution from single-use plastic mulch use in agriculture. For example, increasing landfill tipping fees incentivized Washington State tomato growers to use BDM and till it into the soil, reducing plastic waste transport to and accumulation in landfills.

From a social perspective, a tax levied by government on plastic waste at disposal may be one potential policy tool to encourage environmentally optimal behavior such as use of BDM. However, we find that when growers face financial distress (i.e., crop price decreases or higher production costs), higher taxes may be needed to promote BDM adoption. Further, taxes could be a politically infeasible tool. A popular alternative to taxes that also promotes environmentally sustainable choices are subsidies to farmers, which we will study in future research.

Our study also highlights the importance of considering uncertainty in the degradation process itself and in the grower's decision process (risk aversion). In the context of a changing climate, potential variation in the degradation rate due to changes in climatic factors can influence growers' expectation of the functionality for a BDM as well as the long-term accumulation of microplastics in the environment. Furthermore, analysis of grower risk aversion reveals that their high-risk aversion can hinder BDM adoption due in part to uncertainty of profits, while risk-neutral and moderately risk-averse growers are more likely to adopt BDM. These findings suggest that policies addressing both economic and behavioral factors should also be explored. Additional studies are also needed to further understand the cost of BDM and its use compared to PE mulch, from purchase through disposal. Growers would benefit from comprehensive economic scenarios that reflect current production systems and dynamics.

The study illustrates the role of economic incentives, such as landfill fees and taxes on plastic waste disposal, and the role of risk aversion, in promoting BDM adoption to reduce plastic waste. The framework presented here offers valuable insights for stakeholders and policy-makers seeking to foster sustainable agricultural practices and mitigate global plastic waste.

## REFERENCE

Jiang, J., Blasco, E. and Marsh, T.L. 2025. **Optimizing Microplastic Pollution in a Terrestrial Environment: A Case for Soil-Biodegradable Mulches**. *Agricultural and Resource Economics Review*, First View, pp. 1 – 29, DOI: doi:10.1017/age.2025.20

# Commercially Available Soil-Biodegradable Mulches (BDM) in the U.S.: What Growers Need to Know

**Shuresh Ghimire, University of Connecticut; Carol Miles, Washington State University**

This article summarizes our latest factsheet on commercially available soil-biodegradable mulches (BDMs) and what matters most when choosing products for vegetable and small fruit production. Read the **full factsheet (pdf)** for more detail.

## WHAT ARE BDMS

BDMs are plastic mulch films designed to be tiled into soil and are biodegraded by soil microorganisms over time (Figure 1). Current products are made from polymers such as thermoplastic starch (TPS), polybutylene adipate-co-terephthalate (PBAT), and polylactic acid (PLA). Some resins are biobased (for example, TPS), while others are fossil-fuel based but still are engineered to biodegrade in soil. The key feature of BDMs is verified soil biodegradability, not whether the resin source is biobased.

## WHY DOES CERTIFICATION MATTER

Certification gives third-party verification that a film meets performance and environmental safety criteria. The most common soil biodegradability certifications are TÜV Austria OK biodegradable SOIL and DIN CERTCO under EN 17033 (CEN, 2018). Compostability certifications like ASTM D6400 and EN 13432 are not the same as soil biodegradability; a film can be compostable without meeting soil biodegradation requirements (ASTM International, 2023). Always distinguish soil certifications from compostability certifications and confirm the status for the specific product and thickness you intend to buy. A list of commercial BDMs with third-party certifications is provided in Table 1.

*Figure 1. Vegetable crops grown with soil-biodegradable plastic mulch (Connecticut).*

**Table 1.** List of soil-biodegradable mulches with third-party certification and current U.S. suppliers. Always verify certification and film thickness prior to purchase. Mention of product names does not signify endorsement.

| Product | Supplier(s) | Biodegradable plastic(s) | Certification(s) | Manufacturer |
|---|---|---|---|---|
| Bio360 | • Berry Hill Drip<br>• Dubois Agrinovation<br>• Brookdale Farm Supplies | • Mater-Bi (PBAT + TPS) | • EN 17033<br>• TÜV Austria OK biodegradable SOIL<br>• EN 13432<br>• ASTM D6400 | Houston Poly |
| BioGuard | • Brookdale Farm Supplies<br>• Nolt's Produce Supplies<br>• PolyExpert | • Mater-Bi (PBAT+ TPS)<br>• ecovio (PBAT + PLA) | • TÜV Austria OK biodegradable SOIL<br>• EN 13432<br>• ASTM D6400 | PolyExpert |
| Biosol | • SPR Packaging | • *Not specified* | • TÜV Austria OK biodegradable SOIL<br>• EN 17033 | Solplast |
| Reyfilm Bio | • SPR Agri | • *Not specified* | • TÜV Austria OK biodegradable SOIL | Reyenvas |

## USE CAUTION WITH NON-CERTIFIED PRODUCTS

Some mulches are marketed as biodegradable but lack soil-specific certification. These may be compostable or only partially degradable. Without third-party verification, field performance and environmental outcomes are uncertain. This is particularly important for USDA organic operations—consult your organic certifier before purchase and application of any film labeled as biodegradable.

## PRACTICAL TIPS FOR GROWERS

- **Confirm certification:** Ask for documentation of the exact certification and film thickness. Keep records on file.
- **Avoid oxo- or photo- degradable plastics:** These are not the same as biodegradable and they fragment into microplastics.
- **Match film to crop and season:** Consider durability needed for your climate, crop cycle length, and retrieval plans if any. Film manufacturers and extension agents can provide guidance.
- **Field test before scaling-up:** Trial a few beds in your soil and climate to verify laying, planting, and in-season performance.
- **Talk with your certifier:** Policies and allowances can change; confirm use in your production system.

## REFERENCES

ASTM International (2023) **ASTM D6400-23: Standard Specification for Labeling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities**. West Conshohocken, PA. doi:10.1520/D6400-23

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## Recent Publications

### RESEARCH

Ghimire S., G. Puerto, L. DeVetter, and C. Miles. 2025. **Soil-biodegradable plastic mulches (BDMs) commercially available in the U.S. (pdf)** Washington State University Extension factsheet, 6p. https://smallfruits.wsu.edu/documents/2025/09/soil-biodegradable-plastic-mulches-pdms-commercially-available-in-the-us.pdf/

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## Upcoming Events

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

*No upcoming events.*

If you know of an event you think would be of interest to the agricultural plastics and recycling community, please contact Lisa DeVetter (**lisa.devetter@wsu.edu**) or Nataliya Shcherbatyuk (**nataliya.shcherbatyuk@wsu.edu**).

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