Soil-Biodegradable Mulches: *Workshop*

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Presenter Notes **May 2021**

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Synopsis:
Soil-biodegradable mulches (BDMs) are increasingly used in agriculture to replace conventional plastic mulch. This is an overview of the suitability of BDM use in organic production system.

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USDA United States Department of Agriculture National Institute of Food and Agriculture

Soil-Biodegradable Mulch for Organic Production

This workshop series provides slide presentations on soil-biodegradable mulches (BDMs). These notes provide additional information for presenters. Numbers in the text correspond to the slides in each presentation. Information in this document was summarized from publications listed in the Reference section.

1. This presentation provides information on the suitability of soil-biodegradable mulch for organic production. This information is very important for certified organic growers. If a certified organic grower uses a product that is not allowed for organic production, the grower will lose certification for three years and this will significantly impact overall farm profitability.
2. All the information in this presentation is available on our website https://smallfruits.wsu.edu/plastic-mulches/. If you have any questions as the presentation proceeds, you can directly access the information from this website.
3. In general, soil-biodegradable mulch (BDM) can be a sustainable alternative to polyethylene (PE) mulch as it provides crop production benefits comparable to PE mulch such as weed control, moisture retention, soil temperature modification, early harvest, and increased crop yield and quality, and it is designed to be tilled into the soil after use, thus eliminating waste and disposal challenges.

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biodegradablemulch.org

4. Although soil-biodegradable mulch has been added to the list of allowed substances for the National Organic Program, it must meet the following criteria: First, it must be biobased. Second, it must be produced without the use of non-biobased synthetic polymers, but minor additives like colorants and processing aids are not required to be biobased. Third, it must be produced without organisms or feedstocks derived from excluded methods. Fourth, it must meet compostability specifications (ASTM D6400, ASTM D6868, EN 13432, EN 14995, or ISO 17088). And fifth, it must reach at least 90% degradation in soil within 2 years (ISO 17556 or ASTM D5988). Now, let's discuss each of these criteria and see how close BDMs are in meeting these criteria.
5. Plastic BDMs are made from feedstocks that are biobased, derived from fossil fuels, and all commercial products are a blend of the two. Biobased polymers are divided into three categories (Table 1): a) Extracted from natural materials such as starch, thermoplastic starch (TPS), and cellulose b) Produced by chemical synthesis such as synthetic polymerization of biologically derived monomers like lactic acid into polylactic acid (PLA) c) Produced by microorganisms such as polyhydroxyalkanoates (PHA). However, it is important to know that percent biobased content is not an indicator of biodegradation. For example, PLA requires high temperature for biodegradation.
6. For plastic BDM to be allowed in organic systems, it must be 100% biobased and it must not include GMOs. Regarding biobased content, synthetic polymers cannot be used in plastic BDMs but non-biobased plasticizers, fillers (e.g., $CaCO_3$), lubricants, nucleating agents, stabilizers and colorants/dyes can be used. Currently, maximum biobased content is 50%. However, this is not commercially available in the United States. In the United States, maximum biobased content is 20%. Regarding GMOs, feedstocks cannot be produced from GMOs but additives can. Most commercially available PLA and PHA are produced through fermentation using genetically modified yeast and bacteria for increased productivity. Biobased mulches are not tested for the presence of GMOs since DNA is degraded following fermentation and processing and is not discernable using tests.
7. Standards are intended to ensure BDM quality and integrity in agriculture. Standards exclude materials that claim to be biodegradable but are not fully metabolized by microbes, which results in plastic fragments in soils, causing pollution. The composting standard is the first critical test of biodegradability. If BDM is not compostable, it likely will not biodegrade under field conditions. Standards do not guarantee a particular degree of performance in the field, as this depends on production system such as crop, climate, soils, etc., and mulch formulation and thickness.

Table 1. Categories of biobased polymer feedstocks.

Extracted from natural materials	Produced by chemical synthesis	Produced by microorganisms
starch, thermoplastic starch (**TPS**), and cellulose	synthetic polymerization of lactic acid into polylactic acid (**PLA**)	polyhydroxyalkanoates (**PHA**)

8. This table (Table 2) shows BDM standards worldwide. The first standard in the table EN 17033 is the first international standard directly applying to biodegradable mulches in the soil. And you can also see a French, Italian, and Austrian standard. However, these have not been used internationally. The ASTM standard has been very important for biodegradable plastic and we will discuss it in the next slide.
9. ASTM D6400 tests biodegradation under industrial composting conditions. It has been the most commonly cited standard for BDM. It employs standardized test method ASTM D5338, which is a laboratory test that simulates industrial composting conditions such as use of a compost-based medium and high temperature of about 58 ℃ (136 ℉). It requires at least 90% conversion of C into CO_2 and microbial biomass within 180 days. EN 17033 released by European Committee for Standardization (CEN) is the first standard for certification of biodegradable plastic mulch films in soil. Its requirements regulate composition, biodegradability in soil, ecotoxicity, dimensional, mechanical and optical properties, and the test procedures for each of these. It requires at least 90% biodegradation under aerobic conditions in natural topsoil from agricultural field or forest at 20 - 28 ℃ (68 - 82 ℉) within 2 years using a standardized test to measure CO_2 evolution. You will note that in both the standards 90% biodegradation and not 100% is used as a criterion. This is because a significant portion of

Table 2. BDM standards.

Standard Organization	Standard Name	Comments
European Committee for Standardization (CEN)	**EN 17033** (2018) Plastics– Biodegradable Mulch Films for Use in Agriculture and Horticulture– Requirements and Test Methods	First international standard directly pertaining to biodegradable mulches by an international organization
Association Francaise de Normalisation (AFNOR)	**NFU 52-001** (2005) Biodegradable Mulches for Use in Agriculture and Horticulture - Mulching Products - Requirements and Test Methods	French standard pertaining to biodegradable mulches
Ente Nazionale Italiano di Unificazione (UNI)	**UNI 11495** (2013) Biodegradable Thermoplastic Materials for Use in Agriculture and Horticulture - Mulching Films - Requirements and Test Methods	Italian standard pertaining to biodegradable mulches
ASTM, International	**ASTM D6400** (2012) Standard Specification for Labeling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities	Pertains directly to biodegradation under industrial composting conditions, and is often misrepresented[1]
TUV Austria (formerly Vincotte)[2]	**OK Biodegradable SOIL** (label)	Certifies that plastic materials will biodegrade fully and will not promote ecotoxicity in the soil

[1] ISO (International Organization for Standardization) has equivalent standards

[2] TUV Austria is not a standards organization but is a certification body authorized by European Bioplastics, an association representing the interest of the European bioplastics industry.

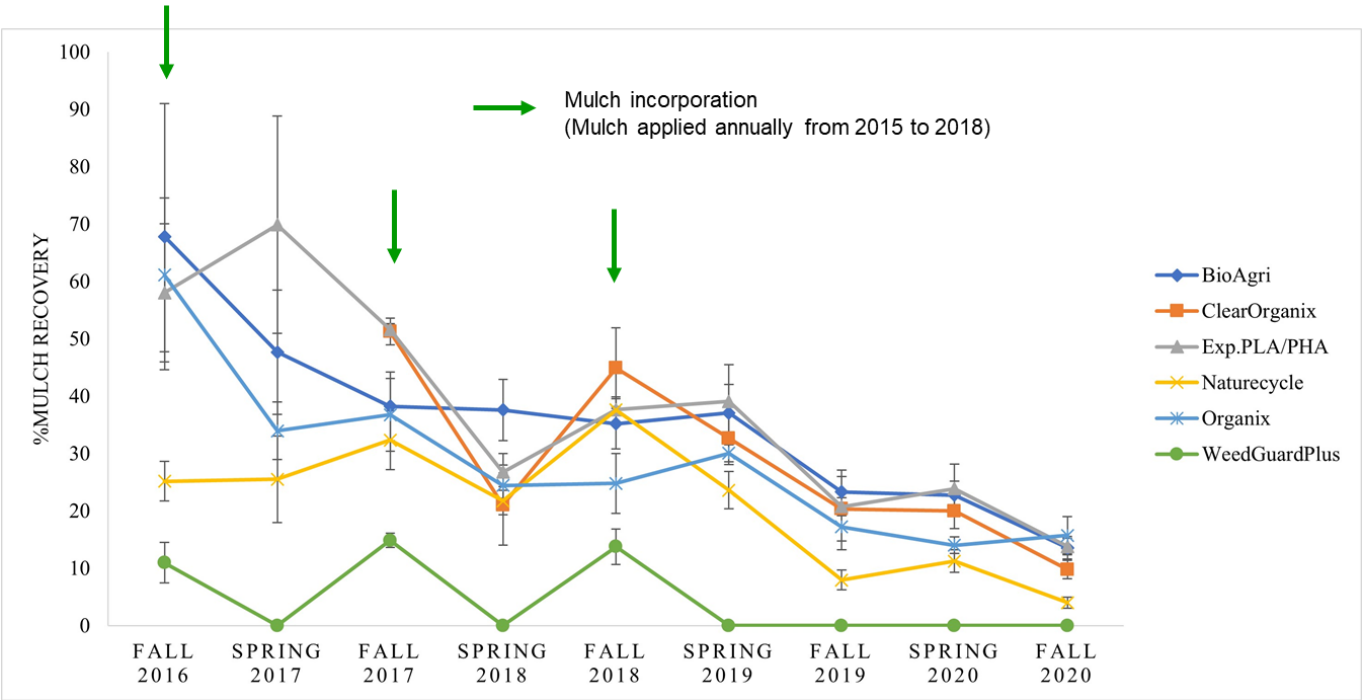
Source: Dentzman and Hayes, 2019

the plastic-derived carbon is incorporated into microbial biomass which is difficult to measure and there is limited precision of the biodegradability lab tests.

10. This (Fig. 1) shows the steps of the degradation process. People often ask, 'Do BDMs form micro and nano particles'? The answer is yes because the natural process of degradation is a decrease in particle size. So, the question is, how long do they remain as micro and nano particles? Currently, soil assay techniques are being developed to distinguish BDM micro and nano particles from biological residues in the soil; this new methodology should be available to research studies within a few years.
11. This graph (Fig. 2) is from an experiment conducted in Northwest Washington where mulch was applied once a year for four years (2015-2018) and mulch was recovered twice a year, in spring and fall. The first application was in 2015, which is not included on the graph as the soil sampling method that year was not accurate. At the last sampling date, fall 2020, average mulch recovery was 11% with the range 4-16%. This shows that mulch is degrading at this site.

Film → Fragment → Micro-particle → Nano-particle → CO_2 + Biomass

Figure 1. Steps of the degradation process.



Ghimire et al., 2020b

Figure 2. Percent recovery of BDM fragments in Mount Vernon, WA using the soil quartering method; mulch was applied once a year for 4 years (2015-2018), plots were rototilled in spring after collecting samples and in fall before collecting samples; error bar is ± one standard error of the mean.

12. This figure (Fig. 3) shows the amount of mulch fragments for each mulch treatment recovered two years after the last soil incorporation. We used a common series of soil screens of these sizes in millimeters and mulch fragment size was categorized accordingly. Note the amount of PE mulch fragments recovered that mostly belong to more than the 12.5 mm size category. In contrast, BDMs do not have any fragments in more than the 75 mm size category. Among BDMs, Naturecycle has the least amount of fragments recovered.

13. What does the label of a soil-biodegradable mulch tell you? If biodegradability test results are not included on the product label, then it must be assumed that the product does not meet the standards. This figure (Fig. 4) is an example of the label for the mulch Bio 360. And you can see that it includes ASTM and several European labels that show compliance with biodegradability standards.

14. So far, we talked about biodegradation and biodegradability labels of BDM. Now, let's discuss about organic labels. The products allowed for certified organic production are reviewed for compliance with NOP standards. Third party review is provided by Organic Materials Review Institute (OMRI) and also some certifiers like Washington State Department of Agriculture (WSDA) Organic Food Program. The pictures (Fig. 5) show a paper mulch with the OMRI label, and CALPRIL lime with both WSDA and OMRI labels. These labels indicate that these products are allowed for organic production. Growers must check with their certifier for their list of allowable products and to confirm a product is allowed before it is applied.

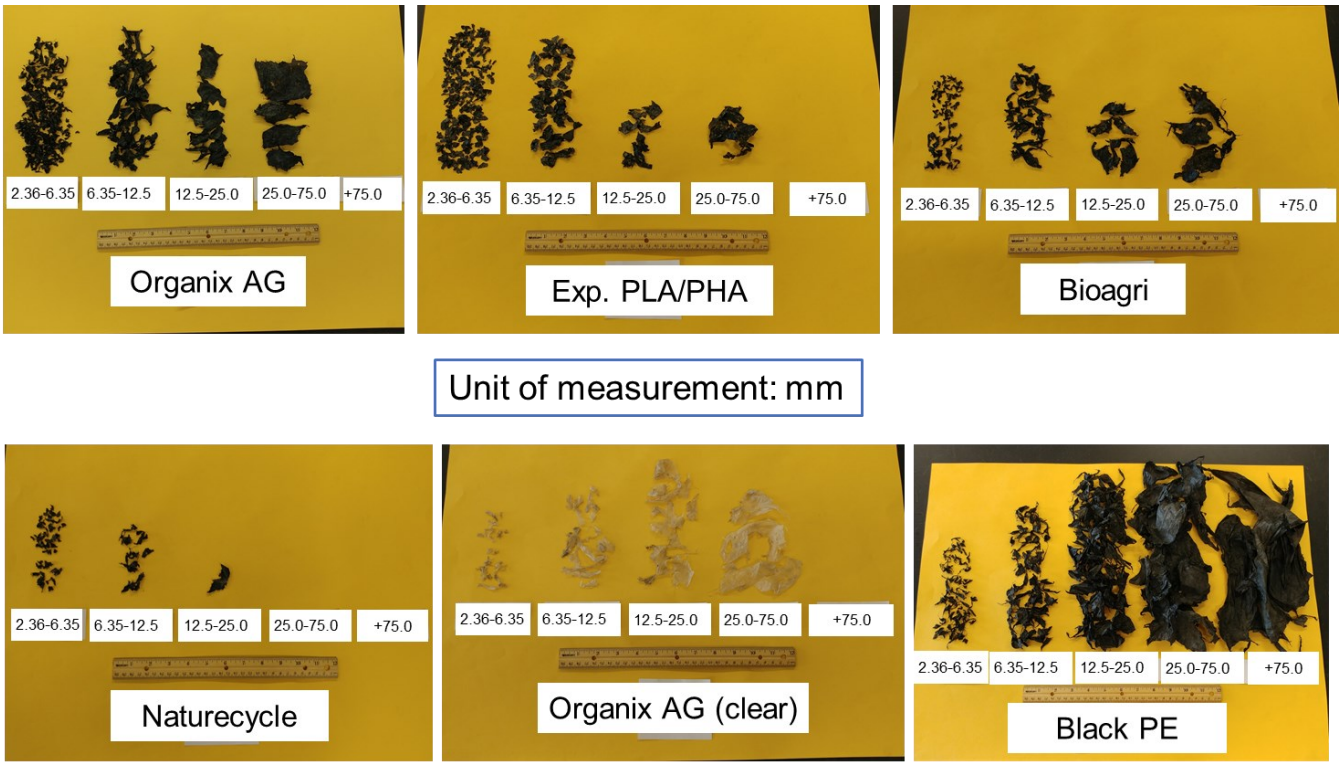


Figure 3. Amount of mulch fragments recovered in Fall 2020 at Mount Vernon, WA .

15. These figures (Fig. 6) are some examples of commercially available BDMs that by their name imply that they are allowed for organic production but in fact they are not. Certified organic growers must check with their certifier before applying a product on their farm.

16. To summarize, no plastic BDMs are approved for use in certified organic production in the United States at this time, only paper BDM (WeedGuardPlus™) is allowed. Growers must check with their certifier before applying a product on their farm.

Figure 4. An example of Bio 360 mulch label.

Figure 5. A paper mulch with OMRI label, and CALPRIL lime with both WSDA and OMRI labels.

Organix A.G. Film
Agriculture Generation

FILMORGANIC
Certified compostable biodegradable mulch film

Figure 6. Examples of commercially available BDMs .

Resources

These information resources provide background information and additional information to help you have a more thorough understanding of this topic. We encourage presenters to view each one so as to be better prepared for your presentation.

Biodegradable Mulch Film for Organic Production Systems https://ag.tennessee.edu/biodegradablemulch/Documents/BDM_for_organic_production_rev_5Apr2016.pdf

Biodegradable Plastic Mulch and Suitability for Sustainable and Organic Agriculture http://pubs.cahnrs.wsu.edu/publications/pubs/fs103e/

Biodegradable Mulch Products https://ag.tennessee.edu/biodegradablemulch/Pages/biomulchprojects.aspx

Summary and Assessment of EN 17033:2018, a New Standard for Biodegradable Plastic Mulch Films https://ag.tennessee.edu/biodegradablemulch/Documents/EU%20regs%20factsheet.pdf

Video - Biodegradable much: a grower's experience of general benefits and disadvantages https://www.youtube.com/watch?v=kyvB1QxHAtE&list=PLuPJ_NR7ZnVuPh7t7erYYXcVw-h4xg0Xm