



Soil-Biodegradable Plastic Mulch: Overview and Use

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BDM Alternative to PE Mulch

- ❖ Provides crop production benefits comparable to PE mulch:
 - Weed control
 - Moisture retention
 - Soil temperature modification
 - Early harvest
 - Increase crop yield and quality
- ❖ Designed to be tilled into the soil after use, eliminating waste and disposal challenges
- ❖ Can completely biodegrade, has no impact on soil health



What are BDMs Made From

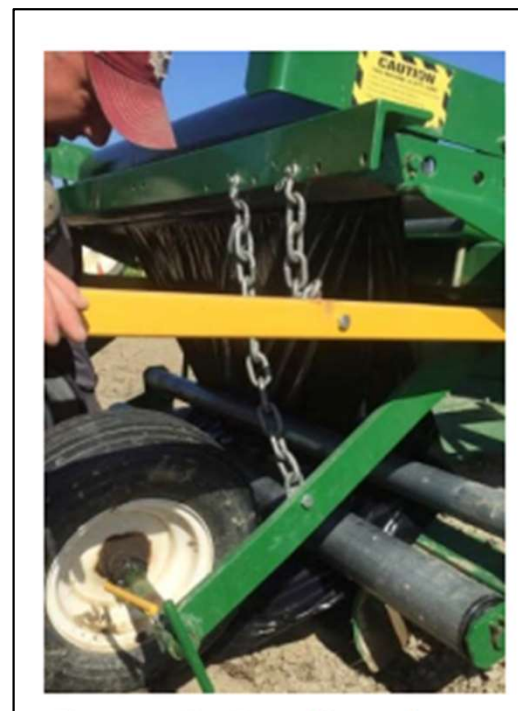
- ❖ Plastic BDMs made from feedstocks that are biobased, derived from fossil fuels, or a blend of the two
- ❖ Biobased polymers divided into three categories:

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)
TPS processed from high-amylose starch, cheaper than other starch feedstocks	PLA produced relatively inexpensively compared to other biobased biopolymers	Poly(hydroxybutyrate) (PHB) and poly(hydroxyvalerate) (PHV) most important commercial PHAs



Laying BDM

- ❖ Feed mulch through roller bar
 - Adjust tension so mulch can easily roll
- ❖ Guide wheels should rest slightly on mulch or float just above
- ❖ Slowly drive forward, increase speed until same as laying PE



Ghimire et al., 2017

Crop-weed Competition and Mulch

- ❖ Weeds compete for:
 - Nutrients
 - Water
 - Light
- ❖ Polyethylene (PE) mulch is good at controlling weeds
- ❖ What about BDMs?



Pumpkin

BDM (BOX 0.6 mil)

PE (1 mil)

July 2019
(6 weeks after
transplanting)



Oct. 2019
(18 weeks after
transplanting)



Crop Production with BDMs

	Yield		Weed Control
Crop	vs. Bare ground	vs. PE	vs. PE
Broccoli	+ ¹		
Cucumber	+	=	=
Eggplant	+	=	-
Lettuce		≈ ²	
Melon	+	+=	≈
Pepper	=	=	-
Pumpkin		=	=
Raspberry	+	=	=
Strawberry	+	≈+ ²	-
Sweet Corn	+	≈	-
Sweet Potato	+	+=	+
Tomato	+	=	≈
Zucchini		=	

¹ + BDM performed better; = BDM performed equivalent to;

- BDM did not perform as well; empty cell not measured.

² Reports provide variable results.

Adapted from Cowan and Miles, 2018

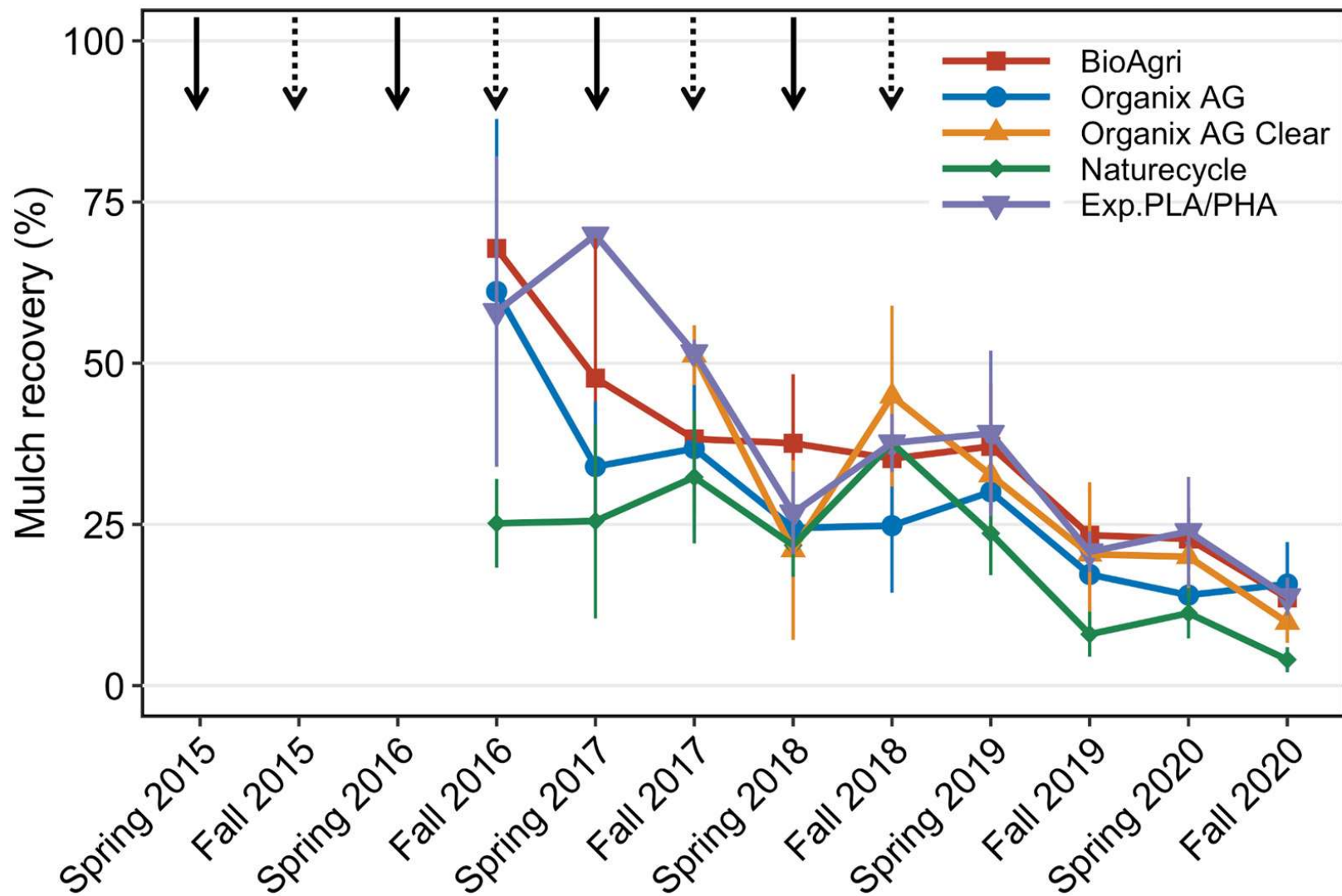


Tillage Incorporation



Video 3:30 min <https://www.youtube.com/watch?v=aMjD4vbr9eA&feature=youtu.be>

Mulch recovery after incorporation



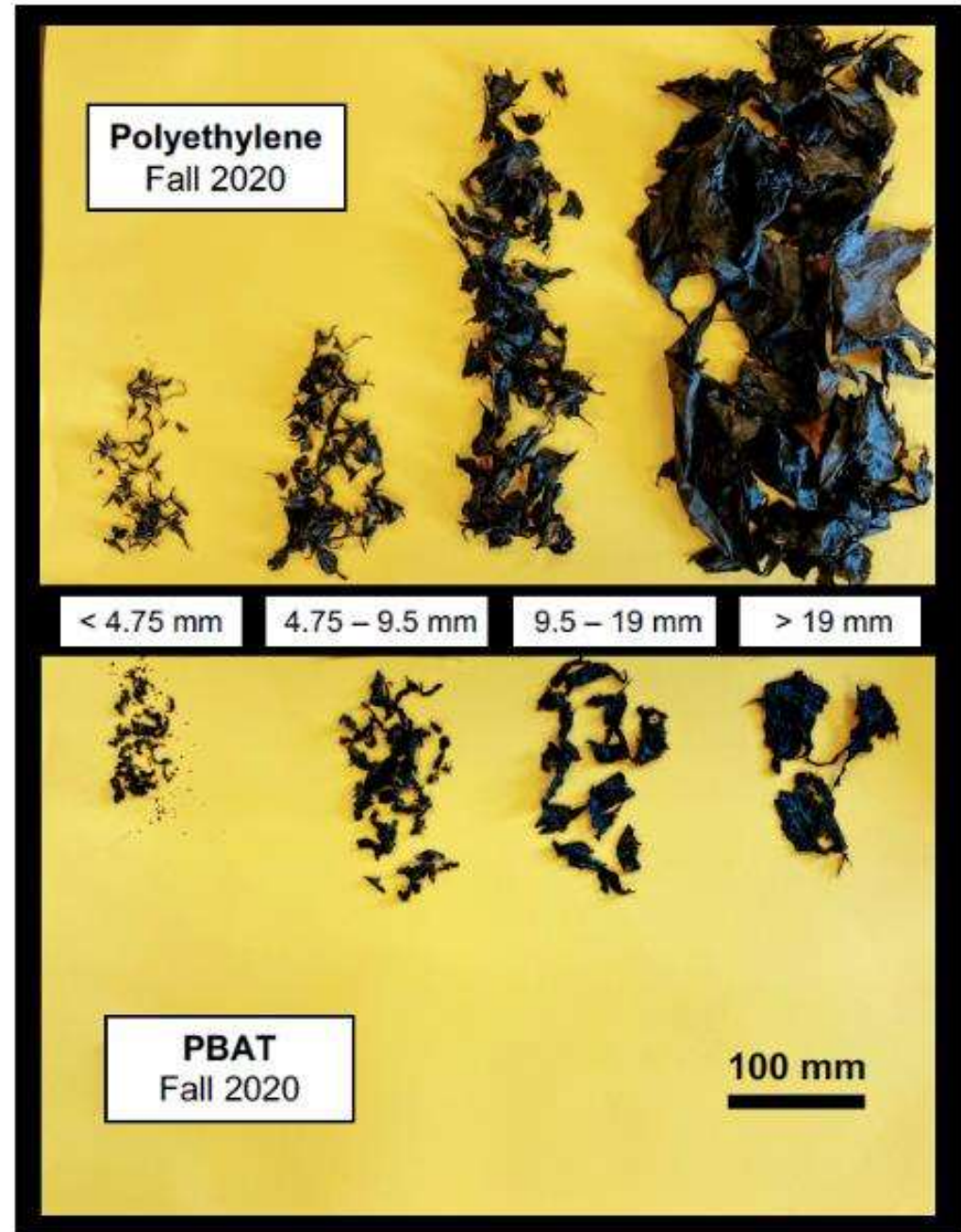
Griffin-LaHue et al., 2022

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), indicated by solid black arrows, plots were rototilled in spring after collecting samples and in fall before collecting samples, indicated by dotted arrows; error bar is \pm one standard error of the mean.

Mulch Recovery

Mulch recovery in Fall 2020:

- PE mulch incorporated in spring 2015 (**1X**)
- BDM (PBAT) mulch incorporated in fall 2015, 2016, 2017, 2018 (**4X**).



USDA National Organic Program

Biodegradable biobased mulch film was added to list of allowed substances on October 2014, but it **MUST**:

1. Be biobased (ASTM D6866) – commercial BDMs $\leq 20\%$ biobased
2. Be produced without synthetic polymers, minor additives (colorants, processing aids) not required to be biobased
3. Be produced without organisms or feedstock derived from excluded methods (i.e., synthetic, GMO) – all commercial BDMs utilize GMO organisms for fermentation, many use synthetic polymers
4. Meet compostability specifications (ASTM D6400, ASTM D6868, EN 13432, EN 14995, or ISO 17088)
5. Reach $\geq 90\%$ degradation in soil within 2 years (ISO 17556 or ASTM D5988)



Oxo- and Photo-degradable

- ❖ Oxo and photo-degradable plastic made with conventional plastic: HDPE, LDPE, PP, PS, PET or PVC
- ❖ Includes additives that cause the material to become brittle and break apart into fragments when exposed to UV light, heat and/or oxygen
- ❖ Oxo and photo-degradable mulches not biodegradable, compostable, or recyclable, and cannot be placed in anaerobic digester
- ❖ EU to prohibit single-use plastic products and products made from oxo-degradable plastic (European Parliament Directive 2019/904 Article 5, passed 5 June 2019 to take effect July 2021)



BDM Information at WSU

❖ Learn more about BDMs:

- What is BDM
- Using BDM in Cropping Systems
- Use of BDM in Strawberry Production
- Applying BDM
- Weed Control with BDM
- Use of BDM with Fumigation
- BDM Deterioration and Degradation
- Soil Sampling for Plastic Fragments
- Economics of BDM
- Sociology of BDM

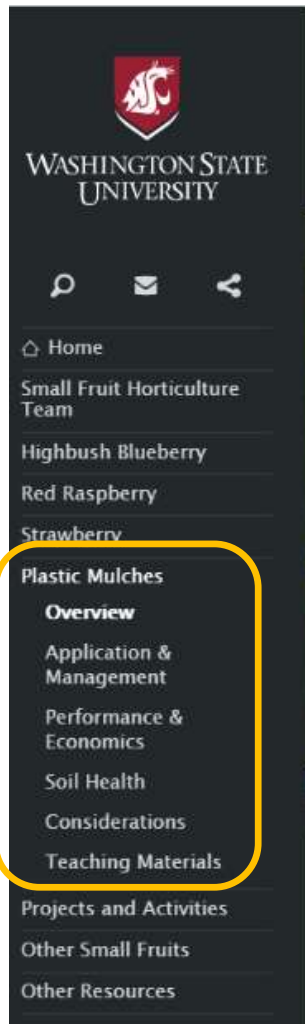


Video on YouTube



WSU BDM Webpage

<https://smallfruits.wsu.edu/plastic-mulches/>



Small Fruit Horticulture Research & Extension Program

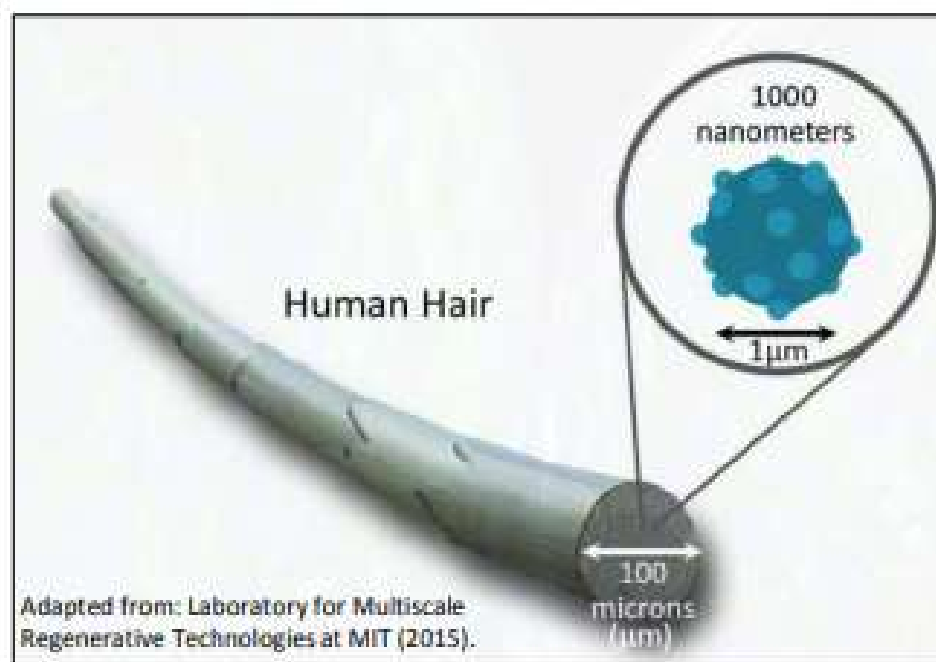
MOUNT VERNON NORTHWESTERN WASHINGTON RESEARCH AND EXTENSION CENTER



Plastic Mulches

Degradation Process

Film → Fragment → Micro-particle → Nano-particle → CO₂ + Biomass



A human hair demonstrates the relative size of microns and nanometers

Hayes, 2019

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. Includes specifications for both biodegradable material/feedstock and biodegradable mulch product such as dimensional, mechanical and optical properties, ecotoxicity, and biodegradation.
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)



Biodegradation of BDM

- ❖ Biodegradation of BDM is affected by both material properties and the degradation environment
- ❖ Material properties – physical/chemical attributes and degradation mechanism:
 - Moisture absorbency
 - Glass transition temperature
- ❖ Degradation environment:
 - Temperature
 - Moisture
 - Microorganisms present

