Soil-Biodegradable Mulches:
Course Lecture

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Presenter Notes **September 2020**

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Synopsis:
Soil-biodegradable mulches (BDMs) are increasingly used in agriculture to replace conventional plastic mulch. This is an introduction to BDM.

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

What is soil-biodegradable mulch?

This course lecture 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 the basic information on the standards and feedstocks of soil-biodegradable mulch, and crop production with BDM.
2. BDM is an alternative to polyethylene (PE) mulch as it provides comparable crop production benefits: weed control, moisture retention, soil temperature modification, early harvest, increased yield and quality. BDMs are designed to be tilled into the soil after use, eliminating waste and disposal challenges. Note that BDMs should NOT go into recycling facilities as they will contaminate other recycled material.
3. European Standard EN 17033 released by the European Committee for Standardization (CEN) in January 2018 was the first standard put forth for certification of biodegradable plastic mulch films. Its requirements regulate composition, biodegradability in soil, and ecotoxicity, as well as dimensional, mechanical and optical properties; and test procedures are included for each. A major criterion of EN 17033 is the requirement of ≥90% biodegradation under aerobic conditions in a natural topsoil from

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an agricultural field or forest at 20 to 28°C conditions within 2 years, using a standardized test to measure CO_2 evolution. The reasons that 90% biodegradation and not 100% is used as a criterion in standards is that a) a significant portion of the plastic incorporated into microbial biomass is difficult to measure, and b) the limited precision of biodegradability lab tests.

4. BDMs are made from feedstocks that are: (i) biobased, (ii) derived from fossil fuels, or (iii) a blend of the two. Biobased polymers are divided into 3 categories (Table 1): **a)** extracted directly from natural materials such as starch, thermoplastic starch (TPS), and cellulose; **b)** produced by chemical synthesis from biologically derived monomers, such as synthetic polymerization of lactic acid into polylactic acid (PLA); and **c)** produced by microorganisms, such as polyhydroxyalkanoates (PHA). Most common biobased BDM feedstocks are TPS, PLA, and PHA.
5. High-amylose starch is processed into TPS by extrusion with water and alcohols at relatively high temperatures. TPS costs less than other starch feedstocks and now is the most common biobased feedstock used in plastic BDMs. PLA can be produced relatively inexpensively in large quantities compared to other biobased biopolymers. Poly(hydroxybutyrate) (PHB) and poly(hydroxyvalerate) (PHV) are the two most important commercial PHAs. Polymers such as PLA or PHA have low mechanical properties compared to PE. Plasticizers are additives that improve the mechanical properties of the plastic during processing, and can affect post-extrusion characteristics of the plastic. The primary plasticizers that are added to TPS are alcohol (principally glycerol), polyoxyalkenes, and surfactants.
6. Crop production with BDMs is shown in Table 2. Yield is greater compared with bare ground and essentially the same as with PE mulch. Weed control varies between BDM and PE mulch depending on crop and location.

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)
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

Table 2. Crop production with BDM.

	Yield		Weed Control
Crop	**vs. Bare ground**	**vs. PE**	**vs. PE**
Broccoli	+[1]		
Cucumber	+	=	=
Eggplant	+	=	-
Lettuce		-=[2]	
Melon	+	+=	≅
Pepper	=	=	-
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