Assessing Degradation of Soil-Biodegradable Plastic Mulches

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Summary:
A method to create mesh bags and use free computer software to assess the degradation of soil-biodegradable plastic mulch (BDM) in the field. This method does not capture micro– or nano-plastics.

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

Introduction

Soil-biodegradable plastic mulch (BDM) can be used as an alternative to polyethylene (PE) mulch in fruit and vegetable production systems. BDM can provide equal benefits as PE mulch to suppress weeds, modify soil temperature and moisture, and increase crop yield and quality (Ghimire et al., 2018). BDM is designed to be tilled into the soil at the end of the cropping season, providing a potential solution to address plastic waste generation and disposal issues. BDM incorporated into agricultural or forest topsoil should achieve ≥ 90% biodegradation in standard laboratory tests within two years without negatively impacting soil health (EN 17033, 2018). However, further testing is essential to assess the degradability of BDM under various field and soil conditions (Fig. 1). This factsheet helps address this need by providing a detailed overview of how to create mesh bags and use free computer software to evaluate how BDM visually degrades in soils.

Figure 1. *Mesh bag containing soil-biodegradable plastic mulch (BDM) sample can be used to estimate in-soil degradation.*

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Supplies Required

Sewing mesh bags:

- Heavy-duty scissors
- Nylon mesh fabric (1 mm mesh size)
- 30 cm ruler (12 in.)
- Polyester or nylon thread
- Sewing machine

Collecting mulch samples:

- Scissors
- 30 cm ruler (12 in.)
- Sealable plastic bags, quart size ≈ 18 cm x 18 cm (7 in. x 7 in.)
- Black permanent marker

Cutting, photographing, and preparing mesh bags:

- Table
- Rotary mat
- Rotary cutter
- Aluminum tags, 1.3-2.5 cm diameter (1-1/2 in.)
- Two 30 cm ruler (12 in.)
- Camera
- ImageJ (available for free at https://imagej.nih.gov/ij/)
- Pre-sown mesh bags
- Plier stapler
- Stainless-steel staples
- Sealable plastic bags, 2 Mil ≈ 5 cm x 5 cm (2 in x 2 in.)

Mesh bag burial:

- Marking/stake/pin flags
- Mesh bags containing mulch sample(s) and aluminum tag(s)
- Shovel
- Nylon rope or string, 0.3 cm thick, 75 cm per 4 mesh bags (1/8 in. thick, 2-1/2 ft per 4 mesh bags)

Retrieval of mesh bag after burial and imaging:

- Shovel
- Scissors
- Paper towels
- Small aluminum loaf pans or light colored tray, 15 cm x 9 cm x 5 cm (6 in. x 3.5 in. x 2 in.)
- Camera
- ImageJ

Figure 2. *Some of the supplies required to evaluate degradation of soil-biodegradable mulch.*

Making the Mesh Bags

- Cut the nylon mesh fabric, perpendicular to the width of the roll, into 12 cm (≈ 5 in.) wide strips (Fig. 3).
- Cut the 12 cm wide strips into lengths of 28 cm (11 in.) (Fig. 4).
- Fold each 12 x 28 cm strip of nylon mesh fabric in half to form a 12 x 14 cm (≈ 5 x 5.5 in.) rectangle. Sew together the two short sides, using polyester or nylon thread (Fig. 5). This creates a mesh bag with one open 12 cm side (Fig. 6).

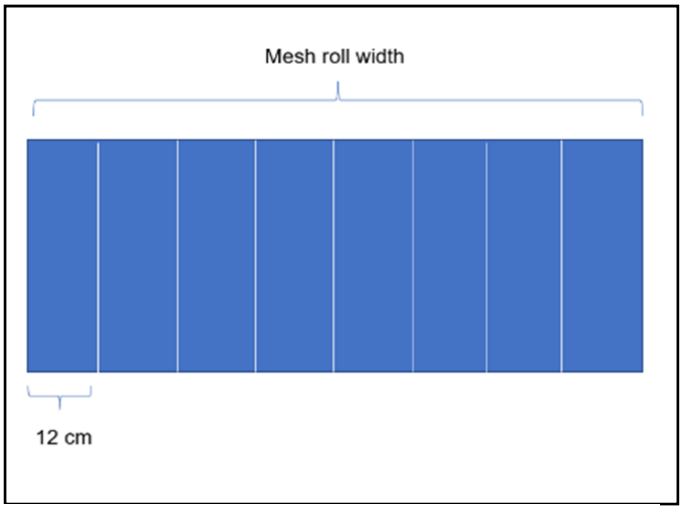

Figure 3. *Cut nylon mesh fabric into strips 12 cm wide.*

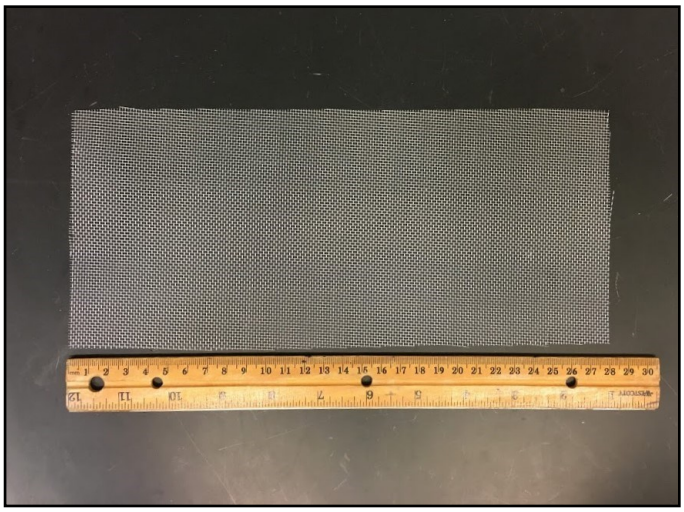

Figure 4. *A 12 x 28 cm mesh piece.*

Figure 5. *Sewing mesh bag.*

Figure 6. *Mesh bag after sewing.*

Adding Mulch samples and burial

- To assess degradation of BDM in soil, new or weathered mulch can be used in this method. Collect one sample at least 18 x 8 cm (7 x 3 in.) of mulch (long side in direction of mulch laying) for each desired plot or representative section of the field.
- *Skip this step if using new mulch samples.* Gather the weathered mulch samples approximately 4 days before planning to add mulch samples to the mesh bags. Collect the mulch samples from the middle top of the

raised bed or row, and place it in a labeled plastic bag.

- *Skip this step if using new mulch samples.* Maintain the samples under ambient temperature conditions during transport. Store samples at 4 °C (39 °F) until ready to place in the mesh bags. Note that the samples (before and after placing in mesh bags) should be stored no longer than 4 days from the date of collection.
- Create a code system using pre-numbered, engraved aluminum tags that corresponds to each plot and retrieval date for each mesh bag that will be buried (Table 1).

Table 1. Example code system for mesh bags. The column furthest to the left represents the aluminum tag code number.

Code Number	Mulch	Plot	Retrieval Date
1	BDM #1	1	10/22/2021
2	BDM #2	2	10/22/2021
3	BDM #3	3	10/22/2021
4	BDM #4	4	10/22/2021

- *Skip this step if using new mulch samples.* Within 4 days of storage, remove the mulch samples from the plastic bags and gently brush off the mulch surface to remove adhered soil. Removing excess soil from the mulch surface will facilitate and improve the accuracy of cutting and imaging the samples.
- Cut each mulch sample into two 8 x 6 cm (3 x 2.3 in.) pieces using a rotary mat and rotary cutter (Fig. 7).

Figure 7. *Mulch samples cut to 8 x 6 cm using a rotary mat and cutter.*

- Photograph each 8 x 6 cm mulch sample at a consistent height between 30-40 cm (12-16 in.), directly above (90° perpendicular), using a flat platform (Fig 8); place the labeled aluminum tag next to the mulch (Fig. 9). Make sure the tag is visible so it can be clearly identified. Place the two rulers in the image for calibration and area determination (Fig. 10).

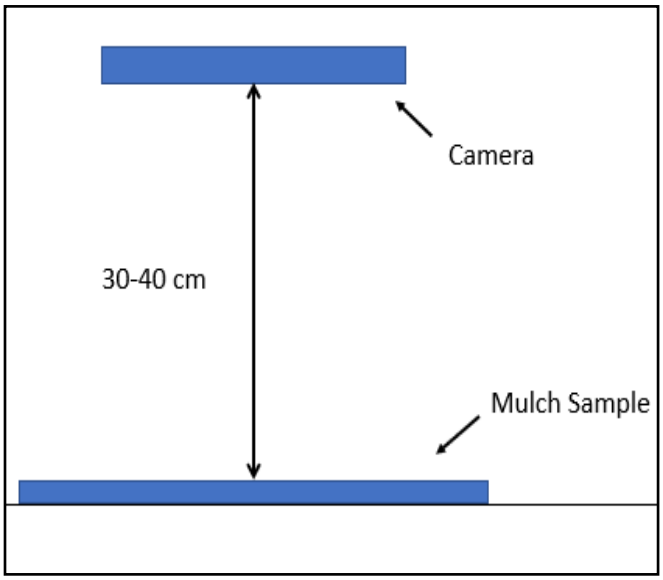

Figure 8*. Platform set up for photographing each 8 x 6 cm mulch sample at a 30-40 cm height and 90° angle.*

Figure 9*. Mesh bag with mulch sample and aluminum tag.*

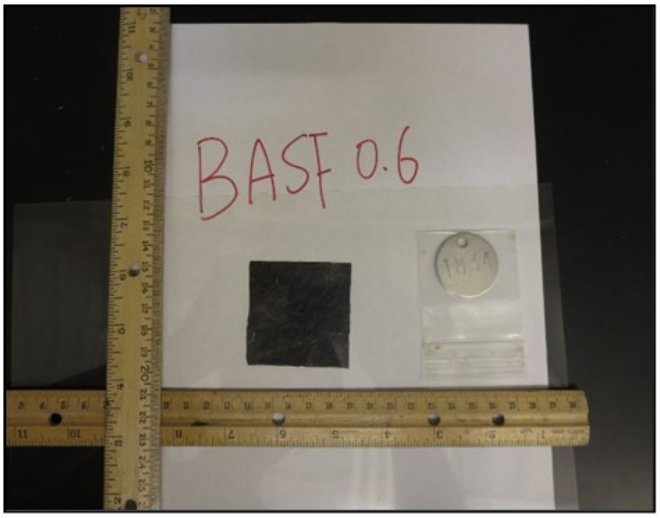

Figure 10. *Mulch sample next to 2 rulers and an aluminum tag ready to be photographed.*

Figure 11. *Mesh bags aligned with rope and stapled with stainless-steel staples.*

- Ensure that the lighting is adequate, and use the same camera settings to photograph each sample. Maintaining consistent camera settings makes digitization of the images easier. To ensure that the surface area measurements are accurate, check the scale settings for every photo. If using a global scale, periodically check the scale settings after the digitization of a few images as a slight change in camera settings can result in measurement errors. Save the images and record the date that the images are collected.
- Use ImageJ (National Institute of Health, USA) to calculate the area of each mulch sample before it is placed in a mesh bag. This will be the initial area measurement, and you will compare with future images to assess degradation.
- After determining the mulch area, place each mulch sample into its corresponding nylon mesh bag and place its designated aluminum tag in a separate 5 x 5 cm sealable plastic bag (2 in. x 2 in.). This will separate the aluminum tag from the mulch sample to prevent an impact on degradation. Staple the plastic bag near the top or side of the mesh bag. Do not add soil to the mesh bag.
- If sampling mulch degradation over time, one mesh bag will be needed for each sample date in every plot. If you are using this method for research purposes, ensure that you have enough replicate mesh bags for statistical analyses.
- Align the mesh bags per plot so that a nylon rope or string runs along the open top of the bags. Fold the open side of each mesh bag

over the rope/string. With stainless-steel staples, staple closed the two corners plus two staples along the seam of each mesh bag. This will keep the mesh bags together and will prevent them from being lost once they are buried (Fig. 11). See our video demonstrating this method (https://s3.wp.wsu.edu/uploads/sites/2181/2020/09/BDMs-Mesh-bag-video.mp4).

- For the mesh bag burial sites, choose representative areas in each plot (or in the field if this is not a study with an experimental design). Bury the mesh bags at a depth of 10 cm (4 in.) and a 45° angle. Ensure the stapled side of each bag is facing a uniform direction. Mark each burial site with a flag to keep track of each mesh bag location (Fig. 12), and make note of the distance from a physical marker in case flags are inadvertently removed. This will facilitate retrieval of the bags at the desired time intervals.
- Remove one mesh bag per plot every 6-12 months for a minimum of two years. Assess mulch degradation at each time interval by comparing the area of each sample to the area prior to burial.

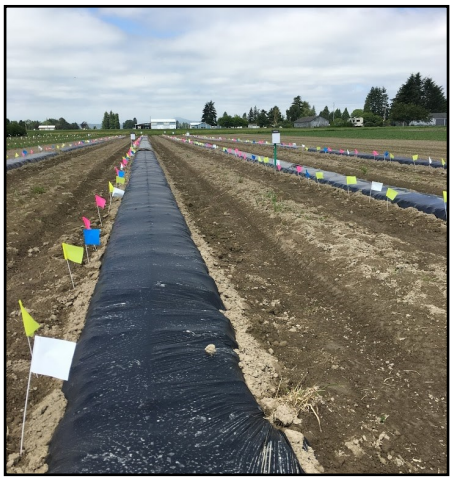

Figure 12. *Field with soil-biodegradable plastic mulch.*

Mesh bag collection and imaging for degradation assessment

- Remove one mesh bag per plot or location at each sampling interval and store at 4 °C (39° F) within 4 days after collection. Clean off adhered soil from each mesh bag with a wet paper towel. One mesh bag at a time, cut open the stapled side and carefully remove the mulch sample. Make sure not to cut the mulch. Place the mulch sample with its corresponding aluminum tag in an aluminum pan, or tray on a flat surface. Be cautious of drafts that could blow away mulch samples.
- Photograph each mulch sample using the method mentioned above via ImageJ. Make sure that the camera settings, angle, and height are consistent to facilitate digitization of the images for surface area measurement.
- Upload the images into ImageJ and calculate the mulch area of each sample.
- Calculate the percent of mulch area loss as:

[(original area – area after burial)/original area] x 100%

- Record the percent of mulch area loss per sample to assess visual degradation over time. The speed and extent of degradation can be influenced by various environmental factors such as soil temperature, moisture, and microbial conditions. A lower degradation percentage could be related to farm-specific factors that limit degradation, which are difficult to simulate using standardized laboratory tests. It could also mean that the mulch does not meet the lab-scale tests and the standards of quality and performance outlined by EN

17033. Report the findings to the mulch manufacturer if less than 90% of mulch degradation is observed after 2 years of soil burial, to determine if further degradation analysis should be carried out.

Literature Cited

European Norms (EN). 2018. Plastics – biodegradable mulch films for use in agriculture and horticulture – requirements and test methods. European Standard 17033, European Committee for Standardization, Brussels, Belgium.

Ghimire, S., D. Hayes, J. Cowan, D. Inglis, L. DeVetter, and C.A. Miles. 2018. Biodegradable plastic mulch and suitability for sustainable and organic agriculture. WSU Extension FactSheet FS103E . Available at:. http://pubs.cahnrs.wsu.edu/publications/wpcontent/uploads/sites/2/publications/fs103e.pdf.