Performance and Adoptability
Biodegradable Mulch
biodegradablemulch.org

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Summary

A method to estimate the amount of visible mulch fragments in the soil is presented. This method does not measure the rate or extent of biodegradation, but it does assess the initial stage of mulch degradation after soil incorporation.

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

Soil Sampling Method to Assess the Amount of Mulch Fragments in the Field after Tillage

Biodegradable plastic mulch is designed to be tilled into the soil after use (Fig. 1), and the soil sampling method described in this factsheet can be used to measure the amount of visible mulch fragments remaining in the soil. While measuring the presence of visible mulch fragments does not directly measure the rate or full extent of biodegradation, it does assess the initial stage of mulch degradation after tillage (Ghimire, 2018). If the field under examination has non-biodegradable plastic (polyethylene) present, then the grower should estimate the amount of existing plastic in the field prior to using a biodegradable mulch as this sampling procedure does not distinguish between biodegradable and non-biodegradable plastic.

Figure 1. Fragments of biodegradable plastic mulch are present on and in the soil, as expected, immediately after tillage.

A few standardized testing methods measure the inherent biodegradability of biodegradable plastic mulches or their ingredients in soil under laboratory conditions where temperature, humidity, and oxygen are maintained at optimal levels (e.g., ASTM D 5988, ISO 17556). The new European Standard EN 17033 regulates the requirements for biodegradable plastic mulches and utilizes laboratory-based methods to measure their biodegradation (Hayes and Flury 2018). Biodegradable plastic mulch that meets these standards has the potential to fully biodegrade. However, sunlight, temperature, soil moisture, mechanical stresses, farming practices, and their interactions can affect the rate and extent of mulch degradation (Hablot et al., 2014; Kijchavengkul et al., 2008; Lucas et al., 2008). To determine how long a biodegradable plastic mulch will take to degrade under field conditions, the mulch should be evaluated in the environmental and soil conditions where it will be used.

Collecting Soil Samples

Collect 24 random soil samples from the field you wish to assess. The number of recommended samples is based on a field study carried out in 2018 at Washington State University (S. Ghimire, E. Scheenstra, A. Saxton, and C.A. Miles, unpublished data).

For each soil sample:

- In the field, place soil from an area of 3 ft by 3 ft (9 ft^2) and 6 in. deep on a piece of plywood (≥ 4 ft × 4 ft) using a shovel (Fig. 2).
- Mix the soil thoroughly and spread it out as much as possible on the plywood.
- Reduce the amount of soil in the sample using the quartering method: divide the soil into quarters by creating two lines intersecting at right angles at the center of the pile, discard two diagonally opposite quarters (Fig. 3).
- If large plastic fragments fall on multiple quarters of the pile while quartering, divide the fragments and place them on the respective quarters.
- Re-mix the sample and repeat this quartering procedure a total of three times, so that the final sample size is 1/8 of the original sample size, which is approximately 5 gallons.

Figure 2. Collection of a soil sample from an area of 3 ft by 3 ft (9 ft^2) and depth of 6 in. using a shovel and placed on a piece of plywood (≥ 4 ft × 4 ft).

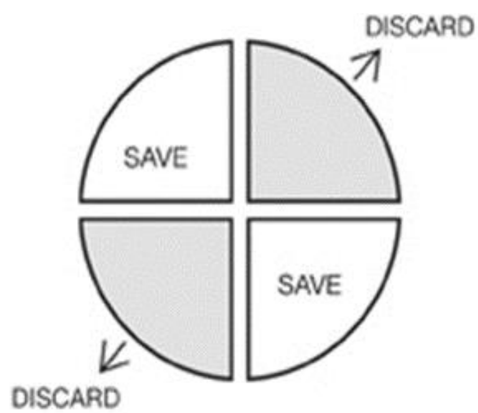

Figure 3. A top view of the quartering method for each sample to reduce the amount of soil to 1/8th of its original amount; repeat the method three times.

Recovering and Measuring Mulch Fragments

Recover the mulch fragments from each of the 24 soil samples separately:

- Wet sieve each soil sample using a number 8 sieve (2.38 mm ≈ 0.1 in) (Fig. 4, left)
- Measure the amount of mulch using one of the three following methods; for detailed methodology, see Ghimire et al. (2017):
  - The **weight method**: record the total weight of the mulch fragments in each sample. Then select relatively intact mulch fragments and cut into 10 rectangles as big as you can. Measure the area and weight of each rectangle, and calculate the weight per unit area. This method requires a precision balance that can read 1 mg to 100 g.

    $$\text{Total area of mulch for each sample} = \frac{\text{Weight of mulch per sample}}{\text{Weight per unit area of mulch}}$$

  - The **Image-J method** requires a digital camera, a computer, and Image J software, which is freely available at https://imagej.nih.gov/ij/download.html. Because this method underestimates the amount of mulch, multiply your value by the correction factor 1.189 to provide a more accurate measure.
  - The **graph paper method** includes a subjective rating, so carefully place mulch fragments as close together as possible (Fig. 4, right). This method overestimates the amount of mulch; so multiply your value by the correction factor 0.868 to provide a more accurate measure. For example, mulch area for the sample in Fig. 4 (right) = 12.5 in. × 5 in. × 0.868 = 54.25 in.^{2} or 31.75 cm x 12.7 cm x 0.868 = 349.99 cm^2.
- Calculate the average amount of mulch per sample.
- Calculate the percent mulch recovered based on the total amount of mulch that was placed in the field and the average area of mulch recovered from the samples.

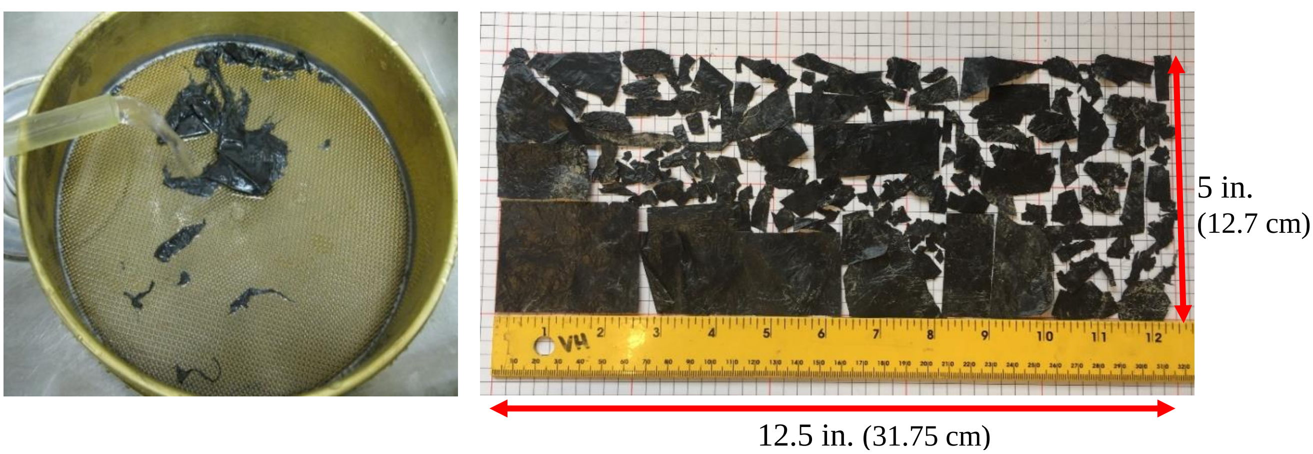

Figure 4. Wet sieving a soil sample to extract mulch fragments (left), and mulch fragments spread on graph paper to measure the area using the graph paper method (right).

Correction factors can be calculated for image and graph methods by measuring the amount of mulch collected in all samples using all three measurement methods, then carrying out regression analysis. See Ghimire et al. (2017) for more information. Otherwise, use the correction factors provided in this fact sheet as this is currently the best information available.

Percent mulch recovery calculation examples:

Using US units

Length of mulch applied to 1 acre (43,560 ft^2) when spacing is 6 ft bed center-to-center

= 43,560 ft^2 / 6 ft = 7,260 ft length

Area of mulch = 7,260 ft length × 4 ft mulch width = 29,040 ft^2

Theoretical maximum amount of mulch in 1 sample: 9 ft^2 (1296 $in.^2$) × 1/8 (the amount of the sample left after quartering) = $\frac{29,040}{43,560} \times \frac{1296}{8}$ = 108 $in.^2$

If average mulch recovered per sample = 54 $in.^2$

Then, percent recovery = $\frac{54}{108} \times 100$ = 50%

Using the international system (SI) units

Length of mulch applied to 1 ha (10,000 m^2) when spacing is 1.8 m bed center-to-center

= 10,000 m^2 / 1.8 m = 5,556 m length

Area of mulch = 5,556 m length × 1.2 m mulch width = 6,667 m^2

Theoretical maximum amount of mulch in 1 sample: 1 m^2 (10,000 cm^2) × 1/8 (the amount of the sample left after quartering) = $\frac{6,667}{10,000} \times \frac{10,000}{8}$ = 833 cm^2

If average mulch recovered per sample = 415 cm^2

Then, percent recovery = $\frac{415}{833} \times 100$ = 50%

References

Ghimire, S. 2018. Biodegradable mulch for pumpkin and sweet corn production: crop yield and quality, and mulch degradation. Washington State University PhD dissertation. p 132.

Ghimire, S., A. Saxton, A.L. Wszelaki, J.C. Moore, and C.A. Miles. 2017. Reliability of soil sampling method to assess visible biodegradable mulch fragments remaining in the field post soil-incorporation. HortTechnology 27:650-658.

Hablot, E., S. Dharmalingam, D.G. Hayes, L.C. Wadsworth, C. Blazy, and R. Narayan. 2014. Effect of simulated weathering on physicochemical properties and inherent biodegradation of PLA/PHA nonwoven mulches. J. Polym. Environ. 22:417-429.

Hayes, D and M. Flury. 2018. Summary and assessment of EN 17033:2018, a new standard for biodegradable plastic mulch films. 22 Aug. 2018. https://ag.tennessee.edu/biodegradablemulch/Documents/EU%20regs%20factsheet.pdf

Kijchavengkul, T., R. Auras, M. Rubino, M. Ngouajio, and R.T. Fernandez. 2008. Assessment of aliphatic-aromatic copolyester biodegradable mulch films. Part II: Laboratory simulated conditions. Chemosphere 71:1607-1616.

Lucas, N., C. Bienaime, C. Belloy, M. Queneudec, F. Silvestre, and J.E. Nava-Saucedo. 2008. Polymer biodegradation: Mechanisms and estimation techniques – A review. Chemosphere 73:429-442.