The Economics of Adopting Biodegradable Plastic Mulch Films

University of Tennessee Institute of Agriculture
Margarita Velandia, Associate Professor
Aaron Smith, Assistant Professor
Department of Agricultural and Resource Economics
Annette Wszelaki, Associate Professor
Department of Plant Sciences

Washington State University
Suzette Galinato, Research Associate
Department of Agricultural and Resource Economics
Thomas Marsh, Professor
School of Economics

Biodegradable plastic mulch films (BDM) are an alternative to conventional polyethylene (PE) mulches. Like PE mulches, BDM offer multiple benefits for specialty crop production such as weed control, soil moisture conservation and yield improvement, with the additional benefit of being 100 percent biodegradable, with no formation of toxic residues (Miles et al., 2018). BDM do not have to be removed; rather, they will be tilled into the soil at the end of the season. These additional benefits offset challenges faced when using PE mulches such as 1) the negative environmental impacts associated with the way PE mulches are traditionally disposed of (e.g., landfilling, on-farm burning and stockpiling); and 2) costs associated with end-of-season activities such as plastic mulch removal and disposal. The disposal of PE mulches in landfills raises some concerns as the complete decomposition of these mulches in the soils could take more than 300 years, and this process could potentially form chemical byproducts that are harmful to the environment (Ghimire et al., 2018). Also, the disposal of PE mulches by open burning on the farm can release carcinogenic substances and other toxic particles into the air that are harmful to the environment and human health (Moore and Wszelaki, 2016).

It is also important for farmers to understand the short-run economic implications of adopting BDM for their farm enterprises. Some of the economic information growers need to gather before making the decision to adopt BDM are listed below.

Will BDM cost more than PE mulches?

In general, BDM cost more than PE mulches. Traditionally, vegetable farmers in Tennessee use 4 feet x 4,000 feet PE mulch rolls with a thickness between 1 and 1.25 mil.[1] The choice of thickness will depend on production practices and crops grown. The 1.25 mil PE mulch is generally used for long-season crops or double-cropping. Based on information from various mulch suppliers, the cost for a 4 feet x 4,000 feet x 1.25 mil PE mulch roll is estimated to be from $135/roll to $154/roll. Like most agricultural inputs, variability in product prices exists. Producers may be able to buy PE mulches more economically with a large volume discount; therefore, the cost may be lower than the estimate presented above.

Depending on the supplier, BDM costs can also vary greatly. Products could cost between $212/roll and $409/roll for a 4 feet x 4,000 feet x 0.6 mil roll, based on information available on various suppliers' websites.[2] Similar to PE mulches, BDM can be sold at a discounted price through direct negotiation with input suppliers or sales representatives. The BDM purchase costs given above do not include shipping costs that will vary depending on location, supplier, mode of shipping (e.g., ground, second-day air) and size of order (e.g., one vs. 20 rolls). Producers should be aware there may be additional shipping costs that local input suppliers may pass on to growers because many do not carry BDM. An input supplier or a sales representative will be able to provide the grower the exact BDM's cost based on the specifications provided by the grower (e.g., width, length and thickness). As stated above, BDM are generally more expensive, and, therefore, a producer needs to know potential savings associated with BDM in order to assess if those savings could offset the cost of the product.

Table 1. Plastic BDM and PE mulch costs

	Plastic BDM	PE mulch
Roll dimensions	4'x4000'	4'x4000'
Roll thickness (mil)	0.6	1.25
Purchase cost*	$212-$250	$135-$154
Machine application	Yes	Yes

*Information is from various input suppliers and mulch distributors. This cost does not include input suppliers' volume discounts or shipping costs.

How much does it cost to remove PE mulches at the end of the season?

Since a large percentage of the savings associated with transitioning from PE mulch to BDM comes from reduced end-of-season activities associated with mulch removal and disposal, it is important to estimate the removal costs. In particular, the labor costs required to remove PE mulches will help determine potential savings associated with the adoption of BDM.

- ***The amount of plastic to be removed*** is determined by the distance between bed centers. For example, peppers and tomatoes in Tennessee are traditionally grown using 5 feet row spacing, while pumpkins are traditionally grown using 5 to 6 feet or 8 to 10 feet spacing, depending on variety and other farm characteristics. Therefore, for peppers and tomatoes, approximately 8,720 ft of plastic per acre[3] (about 2.2 4 feet x 4,000 feet rolls) needs to be removed, while pumpkins require (using 8 feet row spacing) about 5,440 feet of plastic per acre that (about 1.4 4 feet x 4,000 feet rolls) needs to be removed. Although small differences in row spacing between fields (e.g., 5 feet vs. 8 feet) may translate to only a one man-hour per acre difference for PE mulch removal, this difference will translate into 100 labor hours for a 100-acre operation. Therefore, it important to realistically estimate the amount of plastic to be removed at the end of the season because it directly affects the labor costs associated with removal and disposal of PE mulch.
- ***The labor hours to remove and dispose of PE mulch*** requires estimating both operator and manual labor hours. Based on information collected from three farms in Tennessee and two farms in Washington, labor associated with cleanup activities, including operator and manual labor, varies between eight and 11 man-hours per acre, depending on crop and row spacing. This estimate does not include labor associated with retrieval of PE mulch fragments left behind in the field after manual removal of plastic mulch and drip tape. Not all farmers will make the effort to remove PE mulch fragments for the following reasons: 1) this activity is labor-intensive; 2) the opportunity cost of labor (i.e., alternative uses of labor) is high for some operations; and 3) this activity is considered unnecessary because residual fragments are not perceived to have a negative impact on soil quality and long-term productivity. However, there are studies showing that residual PE mulch fragments harm soil-related ecosystems (Liu et al., 2014; Schirmel et al., 2018; Steinmetz et al., 2016). If BDM are utilized, any residual fragments will degrade over time, serving as a potential benefit of adopting BDM.

1 1 mil = 1/1000 inch.
2 For a list of BDM suppliers, go to https://ag.tennessee.edu/biodegradablemulch/Pages/biomulchprojects.aspx.
3 Traditionally, farmers refer to linear feet when referring to the amount of PE mulch needed per acre. In reality, 8,720 ft of plastic are equivalent to about 34,880 ft^2 of plastic for 4 feet x 4000 feet mulch rolls.

- ***The cost of labor*** requires estimation of hourly pay rates. Some farms will pay the same hourly rate to machinery operators and manual labor, while others will differentiate hourly rates by activity. It is important to acknowledge that the use of H-2A labor[4] (i.e., temporary agricultural workers) will increase labor costs. Although the hourly wage rates may be the same for H-2A workers compared to local labor, there are additional costs associated with employing H-2A workers including housing, transportation and agency fees to bring them from their countries of origin to the U.S. Therefore, the use of H-2A labor could significantly increase labor costs. All costs associated with H-2A workers should be included to determine hourly wage rates that accurately reflect all labor costs. The estimated hourly rate can then be multiplied by the estimated man-hours required to remove and dispose of PE mulch to provide an estimate of the labor costs associated with these activities. In small operations, the farm owner is often responsible for performing cleanup activities at the end of the season. Generally, owner labor for such activities is not a direct cash expense and can be overlooked when estimating total labor costs. However, owner labor costs should be estimated due to the opportunity cost of the owner's time. Calculating the value of this unpaid labor will not only help assess the monetary value of the end-of-season activities but will also help plan for future scenarios where owners may not be physically able to do this job.

How much does it cost to dispose of PE plastic mulches at the end of the season?

Transportation, labor costs and landfill disposal fees need to be considered when estimating disposal costs for PE mulch. Disposal costs vary by location. There are some counties where the only cost associated with disposal is for the transportation of the PE mulch from the farm to the landfill. In other counties, both transportation costs and disposal fees will be involved. For instance, in Tennessee, disposal fees range from $20 to $50 per ton, while in Washington State, disposal fees could reach more than $100 per ton, depending on the county where the landfill is located. Some landfills may not even accept PE mulch for disposal. When estimating the disposal cost, an accurate measurement of PE mulch weight retrieved from the field is required. The weight of the PE mulch laid at the beginning of the season will significantly increase due to the adherence of soil and crop debris to the mulch during the growing season. Preliminary results suggest PE mulch weight may increase by 80 percent or more after its use in the field (Ghimire and Miles, 2016).

Will all end-of-season activities be eliminated when adopting plastic BDMs?

The answer to this question is "no." Removal of drip tape is required before tilling BDM into the soil. Based on information obtained from one on-farm trial, the authors estimate that removal of drip tape will require 1.6 to 2.4 man-hours per acre for a pepper field using 6 feet row spacing. These estimates may vary due to soil, environmental conditions and other factors.

Also, tilling BDM into the soil will involve operator labor. It is important to acknowledge that although field experiments suggest that the field capacity (e.g., acres per hour) of a rototiller when tilling BDM into the soil is similar to working the soil without BDM incorporation, there is potential downtime associated with cleaning/untangling mulch fragments from the rototiller blades. Based on in-field experiments conducted by the authors in Knoxville, Tennessee, it seems that downtime was not noteworthy (DeLozier, 2018), while for field experiments conducted in Mount Vernon, Washington, downtime was significant due to a large percentage of BDM fragments that adhered to the rototiller blades (Chen et al., 2018). Time associated with tilling BDM into the soil can vary with soil type, rototiller blade conditions, and extent of deterioration and fragmentation of BDM due to environmental weathering, among other factors. It is important to know that most farmers will till the soil at the end of the season; therefore, this activity will not necessarily involve additional costs.

How do I know if BDM is the right economic decision for me?

As suggested above, to answer this question, a farmer needs to know the cost of removing and disposing of PE mulches, particularly labor and disposal costs, as well as the potential costs of end-of-season activities associated with BDM (e.g., tillage). This information will help determine if the labor cost savings associated with eliminating the removal and disposal of PE mulch will recover the higher purchase cost of the BDM compared to PE mulch.

4 https://www.uscis.gov/working-united-states/temporary-workers/h-2a-temporary-agricultural-workers

For farms using migrant workers, although labor savings are important, it is also important to know the implications of reducing end-of-season activities or allowing workers to leave the farm early. For farms that have overlapping production or harvest of various crops throughout the season, if workers were not removing and disposing of PE mulch, they could be performing other activities that generate revenue for the farm. For other farms, there are no end-of-season activities for the workers to do, other than cleanup activities. If the latter are reduced or eliminated at the end of the season, the workers can be released to go home early. Although such actions will reduce labor costs, they may also have implications for the relationship between owners and workers. If their labor hours are reduced, workers may decide to go to another farm that will employ them for more hours per season. Hence, it is essential to be aware of unintended consequences of reducing workers' hours at the end of the season.

Other Considerations

An important limitation of this publication is the lack of inclusion of economic benefits associated with improved soil fertility and conservation that may occur as a long-term result of using BDM. For example, when PE mulches are removed, some topsoil attaches to the mulches and is lost as a result of mulch disposal. The loss in top soil could result not only in yearly replacement of topsoil (an added expense) but also reduction of soil productivity in the long run. These problems could be alleviated by the use of BDM.

Additional Resources

The following are resources that contain additional information about biodegradable mulches:

- BDM dimension, cost and machine application, labor requirements, and mulch cost calculator — "Important Considerations for the Use of Biodegradable Mulch in Crop Production" (Chen, et al., 2018).
- Organic crop production — "Biodegradable Plastic Mulch and Suitability for Sustainable and Organic Agriculture" (Ghimire et al., 2018).
- Basic information sources, frequently asked questions, videos and publications — BDM project website: www.biodegradablemulch.org.

Acknowledgments

The authors acknowledge USDA-SCRI grant project, *Performance and Adoptability of Biodegradable Plastic Mulch for Sustainable Specialty Crop Production* (Ref. No. 2014-51181-22382). The authors thank D.G. Hayes, E. Belasco, J. S. Cowan and K. Dentzman for critically reviewing an earlier draft of this publication.

References

Chen, K., S. Galinato, S. Ghimire, S. MacDonald, T. Marsh, C. Miles, P. Tozer, and M. Velandia. 2018. "Important Considerations for the Use of Biodegradable Mulch in Crop Production." Washington State University Extension Publication (In Press).

DeLozier, B.J. 2018. Personal communication with farm manager, Plant Science Unit, East Tennessee AgResearch and Education Center, University of Tennessee, March 12.

Ghimire, S., and C. Miles. 2016. "Dimensions and Costs of Paper, Polyethylene and Biodegradable Plastic Mulch." Washington State University Extension. Available at http://vegetables.wsu.edu/Dimensions%20%26%20costs%20plastic%20and%20biodegradable%20mulch.pdf

Ghimire, S., D. Hayes, J. Cowan, D. Inglis, L. DeVetter, and C. Miles. 2018. "Biodegradable Plastic Mulch and Suitability for Sustainable and Organic Agriculture." Washington State University Extension Publication FS103E. Available at http://cru.cahe.wsu.edu/CEPublications/FS103E/FS103E.pdf

Liu, E.K., W.Q. He, and C.R. Yan. 2014. "'White Revolution' to 'White Pollution'— Agricultural Plastic Film Mulch in China." Environmental Research Letters, 9(9). Available at http://iopscience.iop.org/article/10.1088/1748-9326/9/9/091001

Miles, C., S. Ponnaluru, S. Galinato, D. Inglis, T. Marsh, A. Corbin, K. Leonas, T. Walters, D. Hayes, B. Jones, J. Lee, L. Wadsworth, A. Wszelaki, J. Moore-Kucera, R. Wallace, M. Brodhagen, and E. Belasco. 2018. "Glossary of Terms Associated with Biodegradable Mulches for Specialty Crops." Available at https://ag.tennessee.edu/biodegradablemulch/Documents/BDM_glossary_May2015.pdf

Moore, J., and A. Wszelaki. 2016. "Plastic Mulch in Fruit and Vegetable Production: Challenges for Disposal." Report FA-2016-02, University of Tennessee. Available at https://ag.tennessee.edu/biodegradablemulch/Documents/Plastic_Mulch_in_Fruit_and_Vegetable_Production_12_20factsheet.pdf

Schirmel, J., J. Albert, M.P. Kurtz, and K. Muñoz. 2018. "Plasticulture Changes Soil Invertebrate Assemblages of Strawberry Fields and Decreases Diversity and Soil Microbial Activity." Applied Soil Ecology, 124: 379-393.

Steinmetz, Z., C. Wollmann, M. Schaefer, C. Buchmann, J. David, J. Tröger, K. Muñoz, O. Frör, and G.E. Schaumann. 2016. "Plastic Mulching in Agriculture — Trading Short-term Agronomic Benefits for Long-term Soil Degradation?" Science of the Total Environment, 550: 690-705.

AG.TENNESSEE.EDU

W 650 5/18 Programs in agriculture and natural resources, 4-H youth development, family and consumer sciences, and resource development. University of Tennessee Institute of Agriculture, U.S. Department of Agriculture and county governments cooperating. UT Extension provides equal opportunities in programs and employment.