



IMPORTANT CONSIDERATIONS FOR THE USE OF BIODEGRADABLE MULCH IN CROP PRODUCTION

IMPORTANT CONSIDERATIONS FOR THE USE OF BIODEGRADABLE MULCH IN CROP PRODUCTION

By,

Kuan-Ju Chen, PhD Candidate, School of Economic Sciences, Washington State University; **Suzette Galinato**, Assistant Director and Research Associate, IMPACT Center, School of Economic Sciences, Washington State University; **Shuresh Ghimire**, Vegetable Extension Educator, Department of Extension, University of Connecticut; **Stuart MacDonald**, Vice President & General Manager, Organix Solutions, Minnesota; **Thomas Marsh**, Distinguished Professor of Agricultural & Resource Economics, School of Economic Sciences, Washington State University; **Carol Miles**, Professor and Vegetable Horticulturist, Department of Horticulture, WSU Mount Vernon Northwestern Washington Research and Extension Center, Washington State University; **Peter Tozer**, Associate Professor in Farm Management, School of Agriculture and Environment, Massey University, New Zealand; and **Margarita Velandia**, Associate Professor, Department of Agricultural & Resource Economics, University of Tennessee

Introduction

Farmers use mulch to control weeds, conserve soil moisture, help improve crop yield, and obtain several other benefits during the crop growing season. Several studies have shown that biodegradable mulches (BDM) are comparable to polyethylene (PE) plastic mulches in terms of performance and effects on crop productivity (Cowan et al. 2013; Cowan et al. 2014; DeVetter et al. 2017; Ghimire et al. 2018b; Miles et al. 2012; Saglam et al. 2017).

Mulch is laid in the field before seeding or planting (Figure 1). PE mulches are the most common type of mulch used in the field, and such applications are projected to exceed 4.24 million tons by 2024, at an estimated growth rate of 6.2 percent per year between 2016 and 2024 (Global Market Insights Inc. 2016). However, PE mulch is not considered environmentally sustainable due to disposal processes including landfill, field burning, or stockpiling (Goldberger et al. 2015).

Landfill disposal is currently the typical method of disposal but plastic mulches add to the massive volumes of solid waste already in landfills. Some landfills in agricultural regions will not accept plastic mulch (Levitan 2014;

Moore and Wszelaki 2016). Open field burning is illegal in most areas in the U.S. and releases toxins into the environment. Stockpiling requires additional space on the farm and is not a long-term solution. Recycling would be a good option, but it is not widely available for agricultural PE mulches due to the difficulty of cleaning plastics given the amount of residual pesticides, soil, crop debris, and other contaminants present. Residuals can constitute up to 50 percent of the total weight (Kasirajan and Ngouajio 2012).

More environmentally friendly alternatives are available, particularly, BDM products that come in two basic forms: paper and biodegradable plastic. BDMs are relatively new products in the U.S., compared to PE mulches. While there is commercially available biodegradable paper mulch that is allowable for use in certified organic production systems, at this time there is no plastic BDM that is allowed (Miles et al. 2017). For more information on BDMs and their suitability for organic agriculture see Biodegradable Plastic Mulch and Suitability for Sustainable and Organic Agriculture (Ghimire et al. 2018a).



Figure 1. Laying plastic BDM with a raised bed shaper (left); paper BDM laid by machine (right). (Photos: C. Miles.)

This publication aims to provide the following information to producers who are considering using BDM:

- mulch roll length, thickness, weight, and cost of BDM in comparison to other types of mulches,
- mechanical laying of BDM,
- labor requirements,
- mulch calculator to estimate the costs of using different types of mulches.

Dimension, Cost, and Machine Application

Table 1 compares PE mulch, paper BDM, and plastic BDM in terms of their availability, costs, and suitability for a mechanical mulch layer. The details on roll length, width, thickness, and cost are obtained from mulch distributor websites and include most commonly used dimensions. It is important to note that wider and thicker products are available. A 1000-foot roll of plastic BDM generally weighs and costs more than PE mulch but less than paper BDM.

Table 1. Size of mulch rolls commonly used in crop production, purchase price, and suitability for machine laying.

	Plastic BDM	Paper BDM	PE mulch
Available roll length	Up to 6,000 ft	Up to 750 ft	Up to 4,000 ft
Available roll width	3–5 ft	2–4 ft	3–5 ft
Roll thickness	0.5–1.5 mil	9.0 mil	0.5–1.5 mil
Purchase cost (per 1,000 ft)	\$46–\$190	\$160–\$390	\$25–\$65
Weight (per 1,000 ft)*	15–35 lb	90 lb	9–29 lb
Machine application	Yes	Yes	Yes

Note: * Refers to the weight of mulch only, and does not include the weight of the cardboard tube used to roll the mulch. A standard cardboard tube of 3-inch inside diameter and 4-ft length weighs approximately 2.5 lb.

Source: Survey of ten mulch distributor websites in 2016. The table above includes most commonly used dimensions.

Table 2 shows the number of rolls of mulch that would be needed per acre based on roll length. Short roll length increases the cost of application since a new roll will need to be placed on the mulch laying machine more often.

Table 2. Number of rolls of mulch for one acre based on roll length and bed spacing (ft, center-to-center).

Roll length (ft)	Spacing (bed center-to-center)			
	5 ft	6 ft	7 ft	8 ft
500	17.5	14.5	12.5	10.9
750	11.7	9.7	8.3	7.3
1,000	8.8	7.3	6.3	5.5
3,000	3.0	2.5	2.1	1.9
4,000	2.2	1.9	1.6	1.4
6,000	1.5	1.3	1.1	1.0

Laying BDM by Machine

Mulch laying equipment can be used for any type of mulch but there are some minor adjustments that need to be made when using BDM, as compared to laying PE mulch. Mulch layers may be flat-bed types or may create a raised bed of 5 to 9 inches in height. For both types of mulch layer, drip tape and plastic mulch are laid in one pass. For newer mulch layers, mulch is fed through the roller bars (Figure 2) and the mulch is pulled out so that it

passes under the guide wheels. For BDM, roller bars should move freely so as not to put tension on the mulch. Make sure roller bars are clean to reduce the risk of mulch ripping or damage (Lluís Martín-Closas, unpublished data). For older mulch layers, the rod that holds the mulch in place should allow the mulch to roll freely over the bed (Figure 2). The guide wheels of the mulch layer should rest lightly on, or float just above, the mulch. This helps to guide it into the furrows that are opened up by the mulch layer but such that the wheels do not apply pressure to the mulch (Figure 3). After pulling the mulch under the guide wheels to the end of the bed, throw soil onto the mulch where it passes under the wheels using a shovel. You may also need to stand on the mulch at the end of the bed to hold the mulch in place once the tractor starts moving forward (Figure 3).

The mulch should be slightly loose on the bed when it is laid (Figure 3); if it is stretched too tight, it will rip. Adjust the tractor driving speed so that it is not too fast as this can also cause the mulch to rip. The mulch is stretched on the roll, and although it will appear to be loose on the bed immediately after it is laid, it will tighten up in a day or two, due to the elastic properties of the plastic. This [video](#) shows how to lay BDM in the field.



Figure 2. Biodegradable paper mulch on a raised-bed mulch layer, showing placement under the roller bars (left), and on a flat-bed mulch layer (right). (Photos: C. Miles.)



Figure 3. Step on the mulch before the tractor starts moving forward to hold the mulch in place (left). Mulch layer roller bars should move freely and wheels should barely touch the mulch (middle). The mulch should be laid loose on the bed to avoid ripping (right), and when the mulch is moistened and then has dried, it will become tight across the bed. (Photos: S. Ghimire.)

Labor Requirements

Laying and removing mulch requires both machinery and manual labor. For PE mulch removal, it may be necessary to loosen the sides of the mulch that are buried during laying (especially in fine texture soil), or cut the mulch down the center of the bed so as to facilitate removal (Figure 4). In order to recycle PE mulch, it is necessary to remove the soil and debris; up to five percent contamination is acceptable for most recyclers. Many landfills in regions where there is extensive mulch use are also requiring growers to clean PE mulch prior to dropping it off.

Handling BDM after the crop season also requires labor, which includes removing drip tape, tilling the mulch into the soil, and removing mulch fragments from the tiller blades for some plastic BDMs (Figure 5). Removing compostable BDM mulch that is not soil biodegradable requires the same removal

techniques as PE mulch but must also be managed for composting—requiring additional labor.

Labor requirements and costs for PE mulch removal will depend on the number of beds covered by mulch, the length of the beds, and method used to remove plastic. Costs will also depend on the previous crop and environmental conditions. For example, when the previous crop is of taller plants such as tomato or pepper, or spreading crops such as pumpkin, then crop residue may need to be chopped and removed before the mulch can be lifted and rolled up manually for disposal (Figure 6). Less labor may be needed for plants with lower growth habit or very little plant residue, such as lettuce, as PE mulch can easily be lifted over remaining plant residue. A too-dry or too-wet year may affect soil conditions at the end of the season making it either easier or more difficult to remove plastic.



Figure 4. Using a disk to cut the mulch down the center of the bed (left), and pulling the mulch from the bed (right). (Photos: C. Miles.)



Figure 5. Rototilling BDM and crop debris into the field at the end of the crop season (left); removing pieces of BDM wrapped around rototiller blades (right). Also see the related [video](#). (Photos: S. Ghimire.)

In contrast to removal of PE mulch, there is less labor required for disposal of BDM, unless the BDM requires removal due to lack of degradation under soil conditions (e.g., compostable mulch). Typically, a BDM will be disposed of through tillage into the soil during post-harvest field clean up. This means that disposal costs are integrated into labor cost to operate the tillage equipment, and also fuel, oil, repairs and maintenance costs, and other costs that are incurred for field clean up, depending on the operation and equipment used.

Labor cost calculations for laying mulch will be fairly similar to various mulch products since

the method of laying is similar. However, removal costs will vary depending on the type of crop, size of operation, method used to remove plastic, and environmental conditions, as explained above. Also, time saved in mulch removal may lead to cost savings or an increase in labor efficiency as labor can then be used in other production activities (e.g., harvest). Therefore, to accurately estimate potential labor savings, producers should estimate the costs of mulch removal, specifically how long it takes and how many people are needed to perform the various tasks in removing and disposing mulch.



Figure 6. Using a plastic mulch lifter before removing plastic manually (left), and pulling the mulch from the bed (right). (Photos: M. Velandia.)

Furthermore, there are mulch retrievers on the market that not only cut but also retrieve the plastic, which reduces manual labor associated with PE mulch removal. These machines cost about \$6,500–\$11,000 (Eric Burkholder, unpublished data; Paul Ryan, unpublished data). We did not use these machines in our field studies, so any potential labor cost savings are beyond the scope of this publication.

Mulch Calculator

The basic details provided in Table 1 can help farmers determine which type of mulch may be best suited for their farm. Cost is one of the major factors in a farmer's decision to use a particular type of mulch. The mulch calculator is an interactive tool that estimates the quantity of mulch needed for a given production area (Figure 7), and provides a comparison of the costs of using PE and BDM mulches (Figure 8). The number of feet per acre based on the distance between bed centers (5 ft, 6 ft, 7 ft, 8 ft) was calculated (Table 2) and used to estimate the quantity of rolls of mulch in Figure 7. Individuals using the calculator will be able to choose their preferred system of units—English or metric system.

The calculator shown in Figure 8 accounts for the machinery cost, material cost, as well as the cost of labor to install, remove, and dispose PE mulch. The required machinery and number of labor hours to install plastic mulch or BDM is assumed to be the same. Also, while used PE mulch is taken to the landfill, BDMs are tilled into the soil at the end of the season which eliminates the cost of their removal and disposal.

An Excel version of the mulch calculator is available at the [BDM website](#). Appendix 1 provides a look at the mulch calculator webpage with details of its components and assumptions used to develop the calculator. Crop producers can modify some values to evaluate their own needs and costs. For example, the cost of BDM will vary depending on the product. The labor cost and disposal fee will vary depending on the location of the farm, and attention should be

paid to these and other variable costs in the Cost Calculator of the Excel Workbook.

Additional Details

Aside from comparing the material and labor costs associated with installation and end-of-season field activities for PE mulch and BDM, farmers need to consider any benefits from using BDM, such as improved crop yield or input cost savings (e.g., water) and examine whether or not benefits outweigh the costs.

Preliminary information about BDMs, such as their contribution to soil carbon, assessment about deterioration and biodegradation, different mulch products, and application to organic production systems, among others, can be found in the BDM website. Different resources are also available in the website, including videos, factsheets, scientific publications as well as a page on [Frequently Asked Questions](#). The website is maintained and filled with contributions by a group of researchers and Extension specialists from three universities—Washington State University, University of Tennessee, and Montana State University.

There are several plastic mulches in the market that claim to be biodegradable. Oxodegradable mulches are not biodegradable under field conditions and should not be soil-incorporated (Miles 2017). This factsheet is not meant to endorse mulch products that are marketed as biodegradable nor does it imply that these mulch products actually biodegrade in farming systems.

How much plastic mulch do you need per acre?
System of units shown: **ENGLISH UNITS**

This information is used to calculate the number of rolls of mulch that would be needed **per acre** based on roll length.

In the box on the right, enter the spacing based on the distance between bed centers then click the "Calculate" button:

You will need:

500 ft roll, or
750 ft roll, or
1,000 ft roll, or
3,000 ft roll, or
4,000 ft roll, or
6,000 ft roll, or

How much plastic mulch do you need per hectare?
System of units shown: **METRIC SYSTEM UNITS**

This information is used to calculate the number of rolls of mulch that would be needed **per hectare** based on roll length.

In the box on the right, enter the spacing based on the distance between bed centers then click the "Calculate" button:

You will need:

152.4 m roll, or
228.6 m roll, or
304.8 m roll, or
914.4 m roll, or
1,219.2 m roll, or
1,828.8 m roll, or

The length of roll shown here is equivalent to the length of roll that is revealed in the box in the previous section; for instance, 152.4 m = 500 ft.

Figure 7. Calculator for the quantity of mulch required per acre or per hectare given bed spacing.

Please choose the units you prefer: **ENGLISH UNITS** **METRIC SYSTEM**

Please enter your numbers and other information in the blue colored boxes. These are needed to calculate the per acre cost comparisons between the two types of mulches (see gray box on the right). Details in the blue colored boxes you see below are examples only. Please modify them as applicable to your own operation. Numbers in white and gray boxes cannot be changed because the boxes contain the formulas for the calculations. Estimated total costs for installation and cleanup of the two types of mulches are shown and compared in the gray box. Activities listed under Polyethylene Plastic Mulch and Biodegradable Mulch can also be changed as necessary to reflect your own operation.

A. Information about the Field that Uses Mulch

Production area: 4 acres/s
Crop/s grown: pumpkin and other vegetables

B. Mulch Required - Description, Quantity and Cost

1. Polyethylene (PE) Plastic Mulch

Name of product: PG
Color: black
Thickness: 3 mil
Roll length: 3,000 ft
Number of rolls needed: 2.95 rolls per acre
Actual number of rolls purchased: 3 rolls per acre
Cost of mulch per roll: 130 \$ per roll
Weight of mulch: 85.08 pounds per roll

2. Biodegradable Mulch (BDM)

Name of product: BDM
Color: black
Thickness: 3 mil
Roll length: 3,000 ft
Number of rolls needed: 2.95 rolls per acre
Actual number of rolls purchased: 3 rolls per acre
Cost of mulch per roll: 350 \$ per roll

*Information obtained from "Requirement calculator".

Per Acre Cost Comparison

	PE Plastic Mulch	Biodegradable Mulch
Mulch installation		
Machinery	\$108.75	\$108.75
Material	\$405.00	\$1,090.00
Installation labor	\$240.00	\$240.00
End of season		
Mulch removal	\$682.50	\$0.00
Mulch disposal	\$15.59	\$0.00
Mulch tilled into the soil	\$0.00	\$244.56
Total Cost	\$1,451.84	\$1,643.25
Difference in Using Biodegradable Mulch		\$191.41

Figure 8. Snapshot of the calculator for estimating and comparing the costs of using different mulch types. (See [webpage](#) to view the entire calculator: under "Mulch Calculator", click on "Excel worksheet".)

Appendix 1

Mulch Calculator

Cost is one of the major factors in a farmer's decision to use a particular type of mulch. The Mulch Calculator is an interactive tool that estimates the quantity of mulch needed for a given production area (Requirement Calculator), and provides a comparison of the costs of using PE mulch and BDM (Cost Calculator). Results are particularly useful for growers who consider transitioning from PE mulch to BDM. Go to the following website to download the [Excel version of the Mulch Calculator](#) (under Mulch Calculator, click on "Excel worksheet". The file should be downloaded as an Excel Macro-Enabled Workbook in order to retain the full features of the calculator.)

Individuals using the calculator will be able to choose their preferred system of units—English or metric system. Additionally, the calculator has two components:

1. The **Requirement Calculator** aims to determine how many rolls of mulch (per acre or per hectare) need to be purchased based on roll length and spacing between bed centers.
2. The **Cost Calculator** accounts for the machinery cost, material cost, as well as the cost of labor to install the mulch, costs associated with clean-up activities at the end of the growing season. The following factors are assumed:
 - The required machinery and number of man-hours to install plastic mulch or BDM is assumed to be the same.
 - Regarding removal of PE mulch, the example in the Cost Calculator shows that the mulch is removed by hand. If machinery is used to remove PE mulch, the machinery cost should be entered in the form.
 - Drip tape is removed simultaneously with PE mulch. On the other hand, drip tape is removed before BDM is tilled into the soil, and it takes about 1.5 hours per acre to remove the drip tape based on information collected from a farm testing BDMs. This number can be adjusted in the calculator as necessary.

- After removing PE mulch in the field, it is taken to the landfill and the grower is charged a disposal fee. On the other hand, BDMs are tilled into the soil at the end of the season which eliminates the cost of their removal and disposal.
- It takes 7 hours per acre (including 1 hour of downtime) and 2 workers to till BDM into the soil based on the field study in Mount Vernon NWREC. This number can be modified in the calculator if needed.

Instructions are provided in the Requirement Calculator and Cost Calculator Excel worksheets. Also, an **important note: the numbers in the Cost Calculator are only examples used to illustrate how the calculator works, and they do not represent any particular farm operation. Crop producers need to modify some or all values in order to evaluate their own needs and costs.** For example, the cost of BDM will vary depending on the product. In the Cost Calculator, we used the average cost of PE mulch and BDM per 1,000 ft based on a survey of 10 mulch manufacturers. Also, the labor cost and disposal fee will vary depending on the location of the farm, and attention should be paid to these and other variable costs in the Cost Calculator of the Excel Workbook.

Please contact *Suzette P. Galinato* (sgalinato@wsu.edu) if you have questions or comments about the Mulch Calculator.

Acknowledgements

This study is part of the project, Performance and Adoptability of Biodegradable Plastic Mulch for Sustainable Specialty Crop Production, which is funded by the USDA National Institute of Food and Agriculture through its Specialty Crop Research Initiative, under award number 2014-51181-22382. The authors wish to thank Chris Benedict (Agriculture Agent, WSU Whatcom County Extension) for providing the videos used in this publication, and the external reviewers for their helpful comments.

References

- Burkholder, E. n.d. Cost Estimate of Plastic Mulch Lifter/Wrapper. PBZ LLC, Pennsylvania.
- Cowan, J.S., C.A. Miles, P.K. Andrews, and D.A. Inglis. 2014. [Biodegradable Mulch Performed Comparable to Polyethylene in High Tunnel Tomato \(*Solanum lycopersicum* L.\) Production](#). *Journal of the Science of Food and Agriculture* 94:1854-1864. doi: 10.1002/jsfa.6504.
- Cowan, J.S., D.A. Inglis, and C. Miles. 2013. Deterioration of Three Potentially Biodegradable Plastic Mulches Before and After Soil Incorporation in a Broccoli Field Production System in Northwestern Washington. *HortTechnology* 23:849–858.
- DeVetter, L.W., H. Zhang, S. Ghimire, S. Watkinson, and C.A. Miles. 2017. Plastic Biodegradable Mulches Reduce Weeds and Promote Crop Growth in Day-Neutral Strawberry in Western Washington. *HortScience* 52:1700–1706.
- Ghimire, S., D. Hayes, J. Cowan, D. Inglis, L. DeVetter, and C. Miles. 2018a. Biodegradable Plastic Mulch and Suitability for Organic Agriculture. *Washington State University Extension Publication* FS103E.
- Ghimire, S., A.L. Wszelaki, J.C. Moore, D.A. Inglis, and C. Miles. 2018b. The Use of Biodegradable Mulches in Pie Pumpkin Crop Production in Two Diverse Climates. *HortScience* 53(3): 288-294.

Global Market Insights Inc. 2016. [Agricultural Films Market Size is Anticipated to Exceed \\$15.13 Billion & Growing at a CAGR of Above 6.2% by 2024.](#)

Goldberger, J., R. Jones, C. Miles, R. Wallace, and D. Inglis. 2015. [Barriers and Bridges to the Adoption of Biodegradable Plastic Mulches for U.S. Specialty Crop Production.](#) *Renewable Agriculture and Food Systems* 30(2):143–153. doi:10.1017/S1742170513000276.

Kasirajan, S., and M. Ngouajio. 2012. Polyethylene and Biodegradable Mulches for Agricultural Applications: a Review. *Agronomy for Sustainable Development* 32:501–529.

Levitan, L.C. 2014. “Agricultural Plastics: What are They? Why are They 'Hard Stuff'? Can the Challenges be Surmounted?” Paper presented at the Plastics Recycling Conference 2014, Session 1A The Hard Stuff-Recycling Film, Foam and Other Difficult Plastics, Orlando, FL.

Martin-Closas, L. n.d. Notes About Machine Laying of Biodegradable Mulches. Department of Horticulture, Botany and Gardening, University of Lleida, Spain.

Miles, C. 2017. [Oxo-degradable Plastics Risk Environmental Pollution.](#) Report No. FA-2017-01.

Miles, C., L. DeVetter, S. Ghimire, and D.G. Hayes. 2017. Suitability of Biodegradable Plastic Mulches for Organic and Sustainable Agricultural Production Systems. *HortScience* 52:10–15.

Miles, C., R. Wallace, A. Wszelaki, J. Martin, J. Cowan, T. Walters, and D. Inglis. 2012. Deterioration of Potentially Biodegradable Alternatives to Black Plastic Mulch in Three Tomato Production Regions. *HortScience* 47:1270–1277.

Moore, J., and A. Wszelaki. 2016. [Plastic Mulch in Fruit and Vegetable Production: Challenges for Disposal.](#) Fact Sheet.

Ryan, P. Cost Estimate of Mulch Retriever. Kennco Manufacturing Inc., Florida.

Saglam, M., H.Y. Sintim, A.I. Bary, C.A. Miles, S. Ghimire, D.A. Inglis, and M. Flury. 2017. Modeling the Effect of Biodegradable Paper and Plastic Mulch on Soil Moisture Dynamics. *Agricultural Water Management* 193:240–250.



Copyright © Washington State University

WSU Extension publications contain material written and produced for public distribution. Alternate formats of our educational materials are available upon request for persons with disabilities. Please contact Washington State University Extension for more information.

Issued by Washington State University Extension and the US Department of Agriculture in furtherance of the Acts of May 8 and June 30, 1914. Extension programs and policies are consistent with federal and state laws and regulations on nondiscrimination regarding race, sex, religion, age, color, creed, and national or ethnic origin; physical, mental, or sensory disability; marital status or sexual orientation; and status as a Vietnam-era or disabled veteran. Evidence of noncompliance may be reported through your local WSU Extension office. Trade names have been used to simplify information; no endorsement is intended. Published August 2018.