http://biodegradablemulch.org

Biodegradable Plastic Mulch in Organic Vegetable Production Systems

Carol Miles[1], Shuresh Ghimire[1], Annette Wszelaki[2] and Jennifer Moore[2]

[1]Department of Horticulture, Washington State University
[2]Department of Plant Sciences, University of Tennessee

Presented at the New England Fruit and Vegetable Conference, Dec. 17, 2015, Manchester, New Hampshire, USA

This material is based upon work that is supported by the National Institute of Food and Agriculture, under award number 2014-51181-22382. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

Agricultural Plastic Mulch

Benefits of Plastic Mulch

- Weed management
- Reduces some diseases and insect pests
- Warms soil in spring
- Increases yield
- Reduces erosion
- Hastens time to harvest
- Conserves moisture
- Increases crop quality
- More efficient use of water and fertilizer
- Reduces soil compaction
- Efficient double or triple cropping

Biodegradable Plastic Mulch

Has the potential to be a sustainable technology if it:

- Provides equal benefits as plastic mulch
- Reduces labor costs for removal and disposal
- Reduces landfill waste
- Completely biodegrades
- Causes no harm to soil ecology or environment

USDA NOP Rule

Effective October 30, 2014, final rule added **biodegradable biobased mulch film** to list of allowed substances (USDA organic regulation *7 Code of Federal Regulations section 205*)

- To be considered biobased and biodegradable, a mulch film MUST:
  1. Be biobased *ASTM D6866*
  2. Reach ≥ 90% biodegradation in soil within 2 years *ISO 17556* or *ASTM D5988*
  3. Meet compostability specifications of *ASTM D6400, ASTM D6868, EN 13432, EN 14995,* or *ISO 17088*
- Must be produced without organisms or feedstock derived from excluded methods (i.e., synthetic, GMO)
- Must be produced without the use of non-biobased synthetic polymers; minor additives (colorants, processing aids) not required to be biobased
- Grower is responsible for showing mulch biodegrades in production system

Biobased Content

OMRI report to USDA-NOP, June 5 2015: BDMs currently contain 10 – 20% biobased content; remaining content includes polymers derived from fossil fuels (petroleum or natural gas), dyes, minerals, and in some cases heavy metals

- **Most common biobased materials:** starch, polylactic acid (PLA), and polyhydroxyalkanoate (PHA)
  - **Starch** starts as natural polysaccharide, processed into thermoplastic material (TPS) by extruding with water and organic alcohols (usually glycerol, a biobased co-product from biodiesel manufacture), or is esterified chemically
  - **PLA** derived from starch, oxidized by yeasts (GMO) or other microorganisms to produce lactic acid, then polymerized synthetically
  - **PHAs** biosynthesized through fermentation by bacterial enzymes (GMO)
  - **Corn starch sourced in U.S.** most likely derived from GMO plants; no cost-effective assays for determining GMO status

Mulch Feedstock

Biodegradable Mulches on the Market

Polymer trade name	Polymers in biodegradable mulch[1]
Bio 360	Mater-Bi (TPS + PCL); PBAT
BioAgri	Mater-Bi (TPS + PCL); PBAT
Biocycle	Sucrose/PHA blend
Bio-Flex	PLA/co-polyester
Biomax TPS	Starch + TPS
Biomer L	PHA
Bionolle	PBS or PBSA; TPS + PLA + PBS/PBSA
Biopar	TPS + co-polyester
Biosafe	PBAT/TPS blend; PBS; PBSA
Eastar Bio	PBAT/TPS blend
EcoCover	Recycled paper
EcoFilm	Unspecified plastic
Eco-Flex	PBAT; TBS
Ecovio	PLA; PBAT/TPS
Eco-One	Unspecified plastic; oxo-degradable
EcoWorks	PBAT + PLA

Polymer trade name	Polymers in biodegradable mulch
EnPol	PBS
Envio	PBAT; PLA; TPS
Garden Weed Barrier	Cellulose (paper)
GreenBio	PHA
Ingeo	TPS/PLA; PBS/PLA
Mater Bi	PCL/TPS; PBAT
Landmaster	Cellulose (paper)
Mirel	PLA + PHAs
Naturecycle	Starch
Paragon	TPS
Planters Paper	Cellulose (paper)
ReNew	PHAs
Skygreen	Terephthalic acid co-polyester
Weed Block	Cellulose (paper)
WeedGuard	Cellulose (paper)

[1] Abbreviations: PBAT polybutylene adipate terephthalate; PBS polybutylene succinate; PBSA PBS-co-adipic acid; PCL polycaprolactone; PHA polyhydroxyalkanoate; PLA polylactic acid; TPS thermoplastic starch

Adapted from: Hayes et al. 2012. Biodegradable agricultural mulches derived from biopolymers. In Degradable Polymers and Materials, Principles and Practice, 2nd Edition. Am. Chem. Soc.

Biodegradable Mulch Ingredients

Ingredient[1]	Feedstock	Synthesis	ERBD in soil[2]
Cellulose	Biobased	Biological	High
PBAT	Hydrocarbon	Chemical	Low moderate
PBS	Hydrocarbon	Chemical	Low moderate
PBSA	Hydrocarbon	Chemical	Low moderate
PCL	Hydrocarbon	Chemical	Moderate
PHA	Biobased	Biological	Moderate high
PLA	Biobased	Biological & Chemical	Low
Sucrose	Biobased	Biological	High
TPS/Starch	Biobased	Biological	High

[1] Abbreviations: PBAT polybutylene adipate terephthalate; PBS polybutylene succinate; PBSA PBS-co-adipic acid; PCL polycaprolactone; PHA polyhydroxyalkanoate; PLA polylactic acid; TPS thermoplastic starch

[2] Estimated relative rate of biodegradation; Brodhagen et al. 2015. Biodegradable plastic agricultural mulches and key features of microbial degradation. Appl Microbiol Biotechnol (2015) 99:1039–1056.

Biodegradable and Biobased

Biodegradable: Microbial activity that results in CO_2, H_2O and microbial biomass

Biobased: Feedstocks derived from renewable resources (plant and/or animal mass) via biological processes

Biobased ingredient that doesn't biodegrade in soil: PLA[1]

Synthetic ingredients that biodegrade in soil: PCL, PBS, PBAT

[1] Probably would degrade over 10+ years if thin enough; passes ASTM/ISO compostability standard

Biodegradable Mulches for Specialty Crops Produced Under Protective Covers

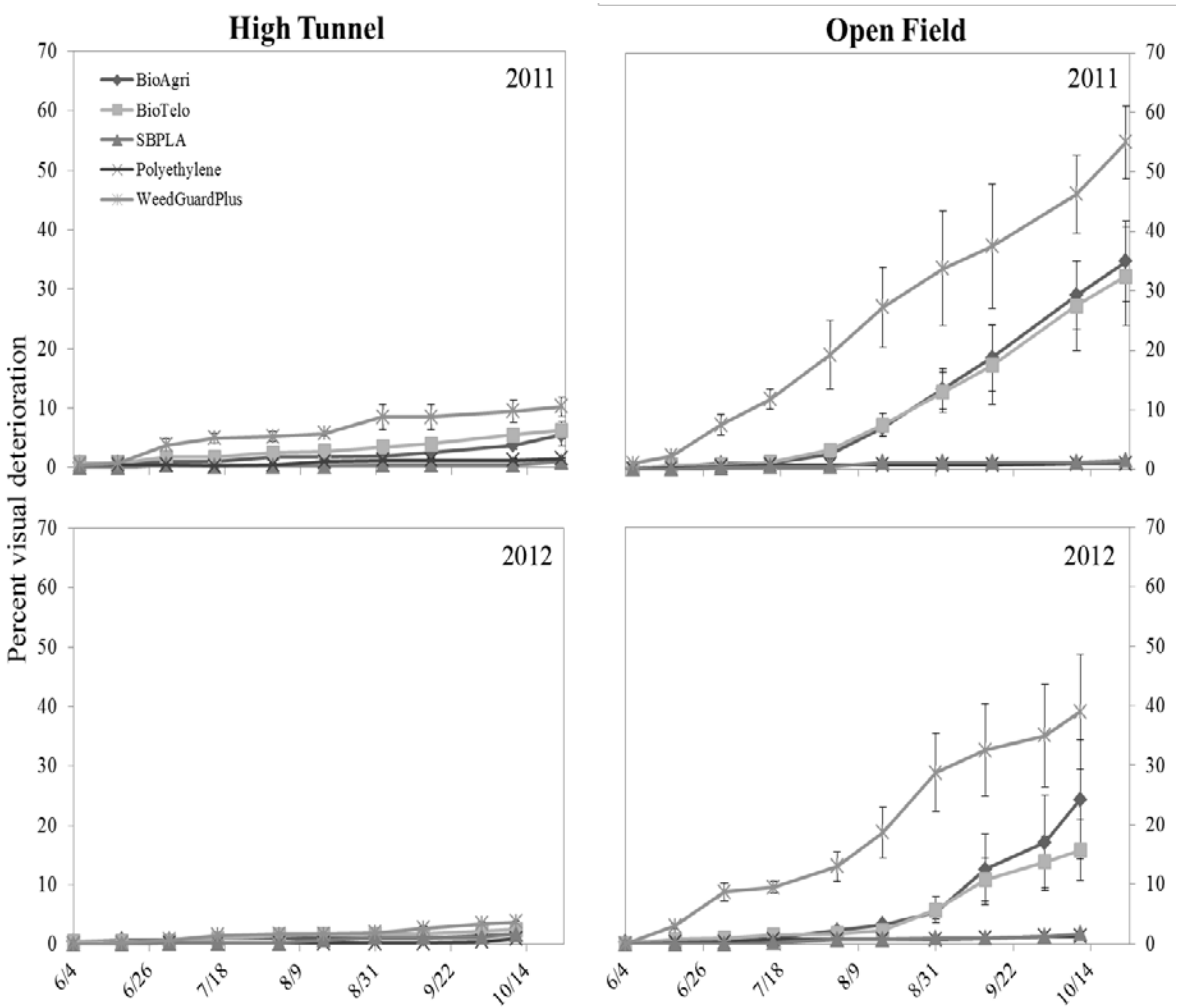
Debra Inglis and Carol Miles (Project Directors)[1];
Andrew Corbin, Jessica Goldberger, Karen Leonas, Tom Marsh and Tom Walters[1];
Doug Hayes, Jaehoon Lee, Larry Wadsworth and Annette Wszelaki[2];
Jennifer Moore-Kucera[3]; Russ Wallace[4]; Marion Brodhagen[5]; and Eric Belasco[6]

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

SCRI Grant Award
No. 2009-51181-05897

Mulch Deterioration by Environment

Percent mulch deterioration in high tunnel and open field during the summer growing season, Mount Vernon WA



Source: Cowan et al. Visual assessments of biodegradable mulch deterioration are not indicative of changes in mechanical properties. *In review.*

Mesh Bags for Monitoring In-soil Biodegradation


Cutting BDM pieces

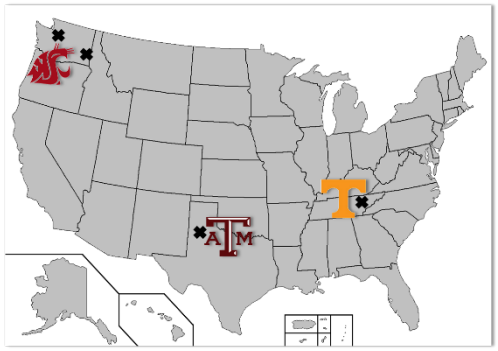

Nylon mesh bags

AFTER final harvest:

- Mulch pieces cut, inserted in nylon mesh bags with soil
- Buried 7-10cm deep
- Extract 1 bag every 6 mo. for 2 yr.

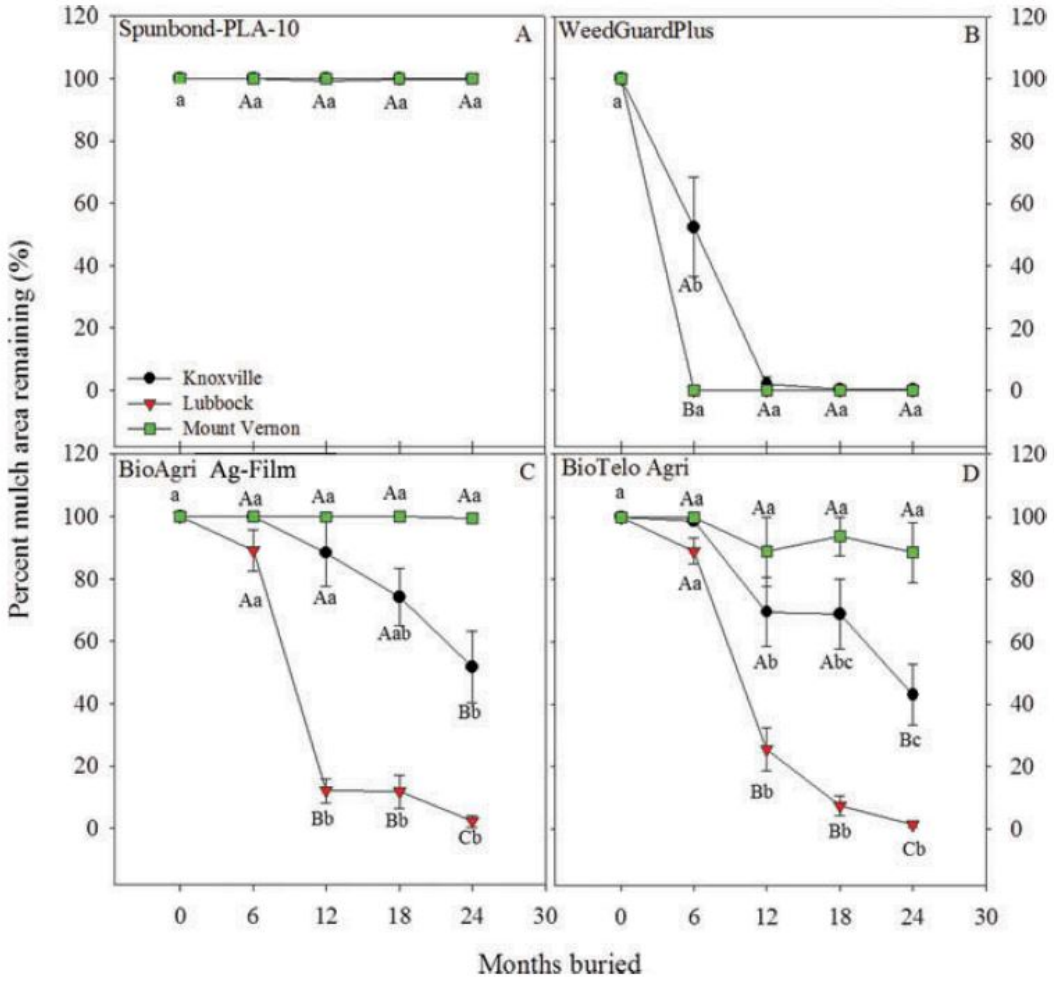

Mesh bags in plot

Biodegradation In 3 Diverse Environments



- **Knoxville TN**
  Hot humid summer
  Dewey silt loam
- **Lubbock TX**
  Hot dry summer
  Acuff clay loam soil
- **Mount Vernon WA**
  Cool humid summer
  Skagit silt loam soil

Source: Li et al., 2014



http://biodegradablemulch.org

Performance and Adoptability of Biodegradable Plastic Mulch for Sustainable Specialty Crop Production

Funded by USDA-NIFA through Specialty Crop Research Initiative (SCRI)

Experiments at Knoxville TN, and Mount Vernon, WA

This material is based upon work that is supported by the National Institute of Food and Agriculture, under award number 2014-51181-22382. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

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

UTIA INSTITUTE OF AGRICULTURE THE UNIVERSITY OF TENNESSEE

WASHINGTON STATE UNIVERSITY

MONTANA STATE UNIVERSITY

BDM Field Experiment

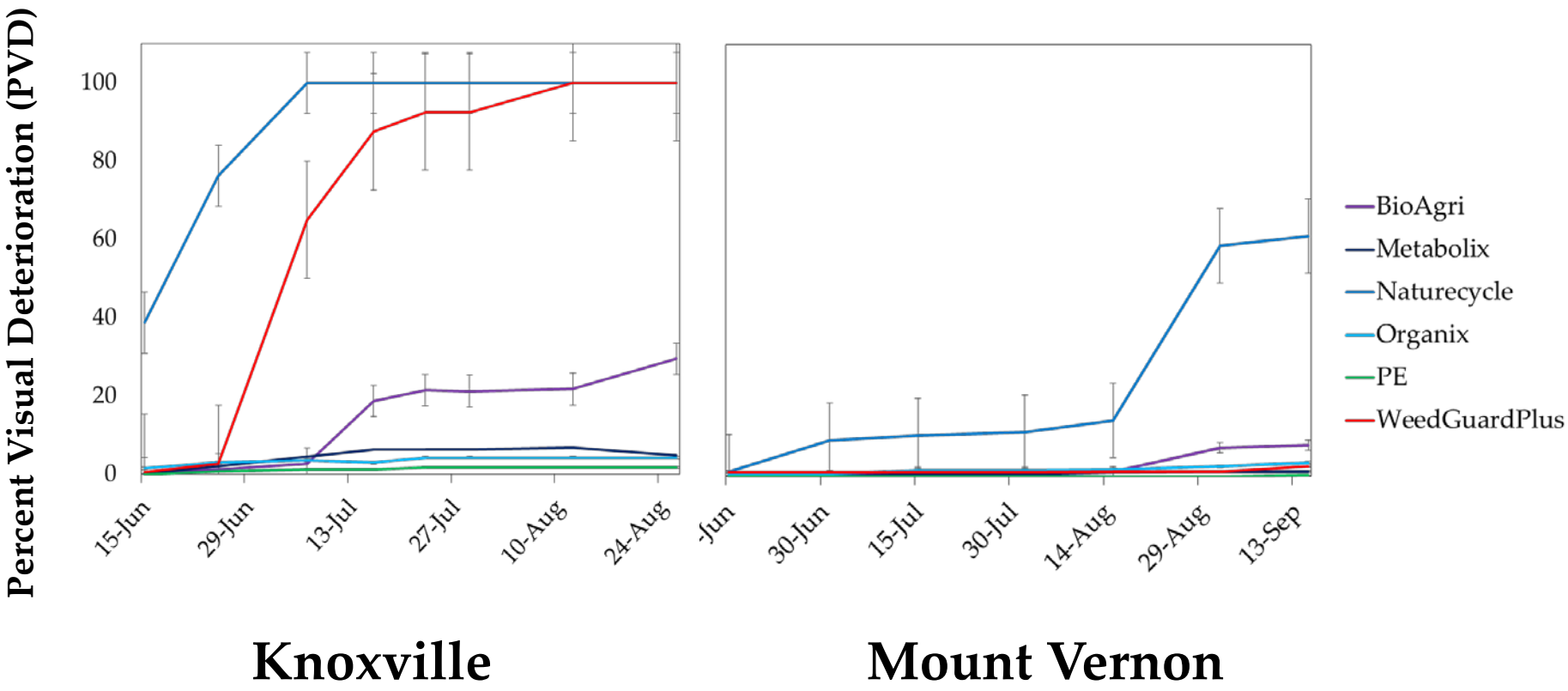
Sites: Mount Vernon WA, Knoxville TN

Crop: Pumpkin cv. Cinnamon Girl

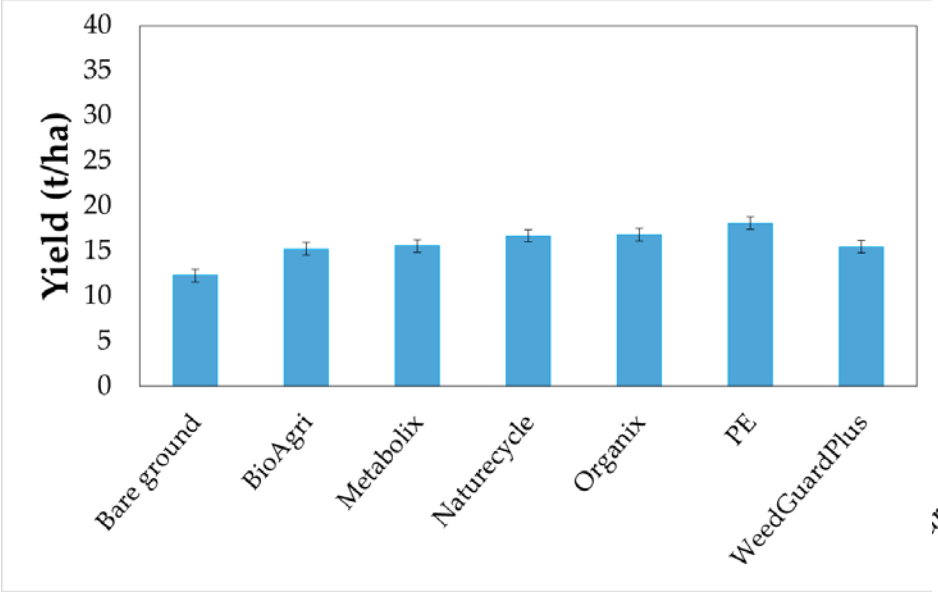
RCBD with 8 treatments and 4 replications

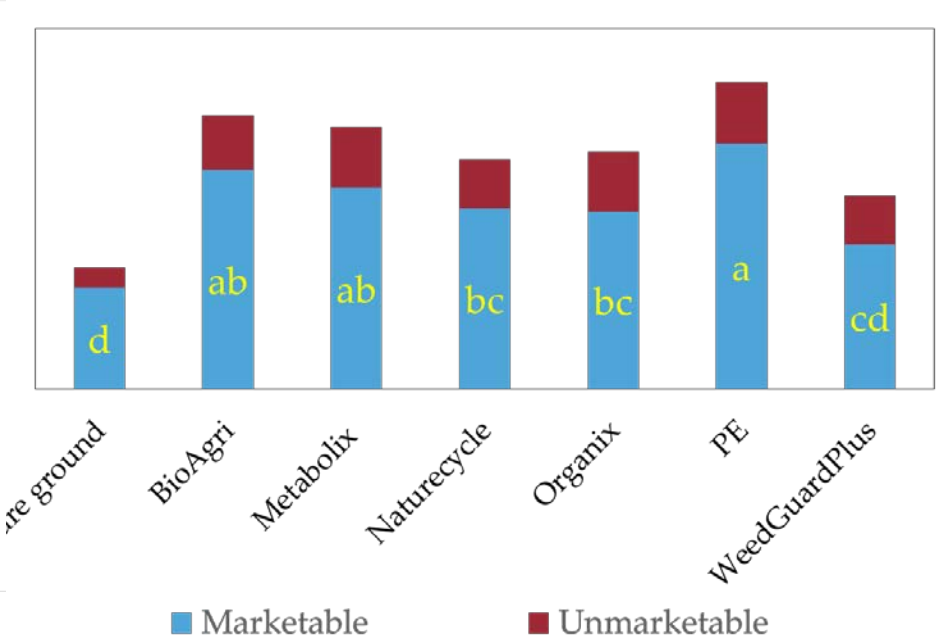
Trt.	Product	Company
1	Bare ground	
2	Polyethylene (PE)	FilmTech Corp.
3	Weed Guard	Sunshine Paper Co.
4	BioAgri	BioBag USA
5	Naturecycle	Custom Bioplastics
6	Organix	BASF/Organix Ag.
7	Experimental	Metabolix
8	BioAgri Removed	BioBag USA

2015 Preliminary PVD



2015 Preliminary Yield

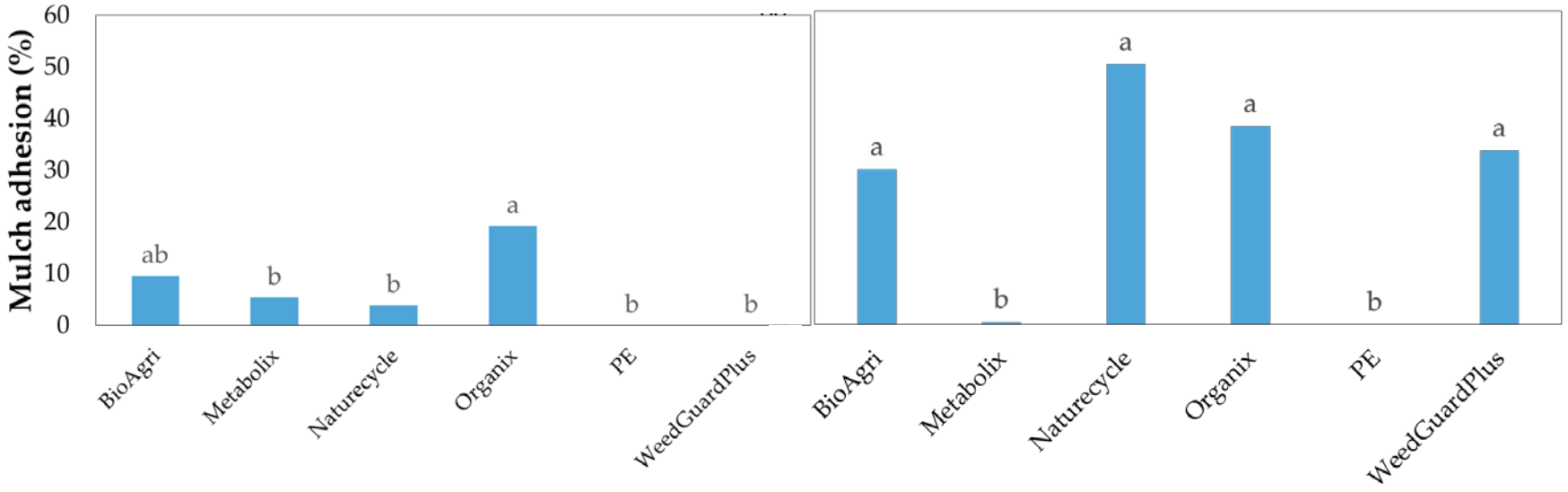




Knoxville **Mount Vernon**

Mulch Adhesion

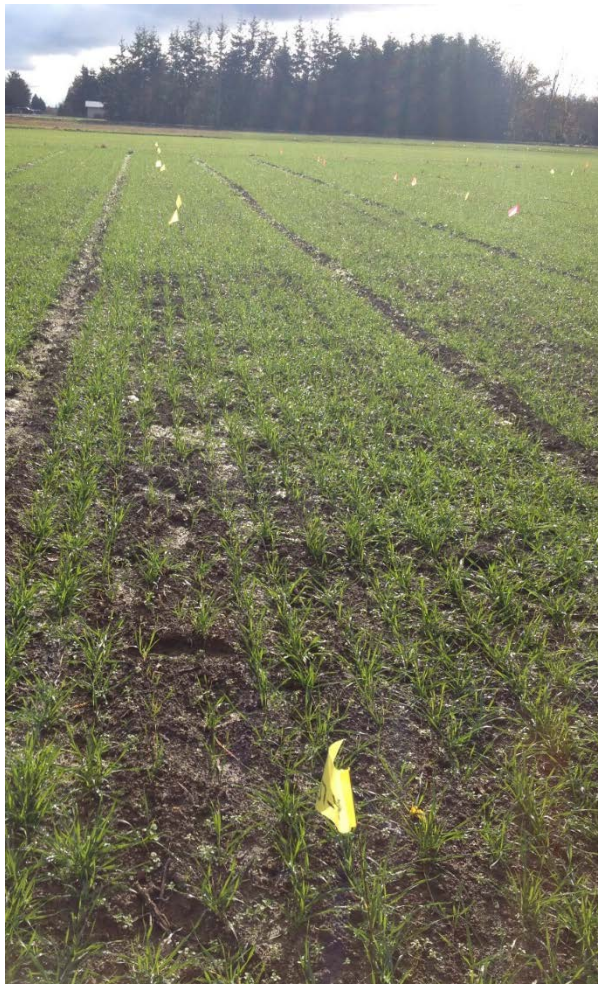
2015 Preliminary Mulch Adhesion

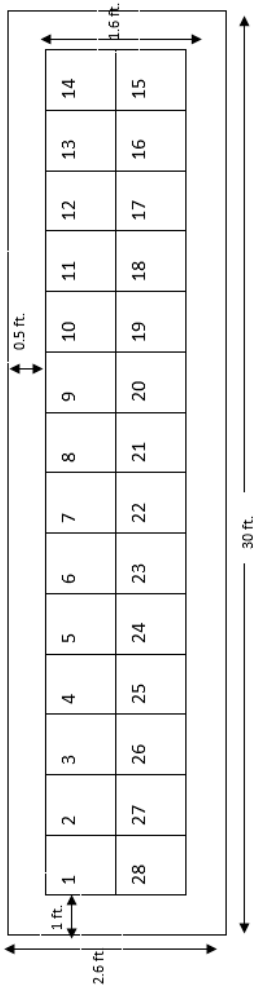


Knoxville **Mount Vernon**

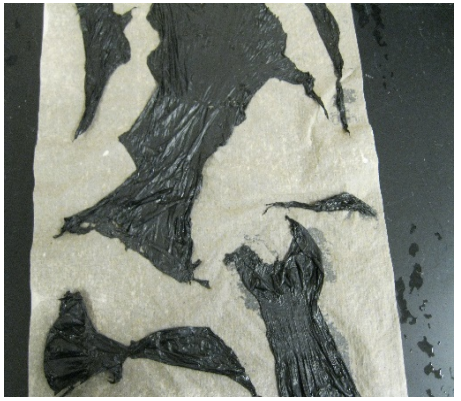
Mulch Soil Incorporation

Soil Sampling BDM Post Tillage





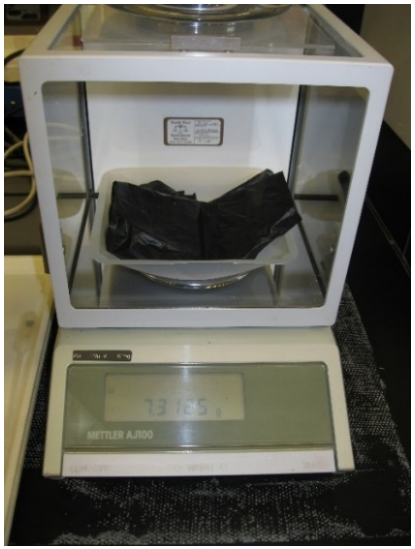
Collecting BDM



Measuring BDM Area

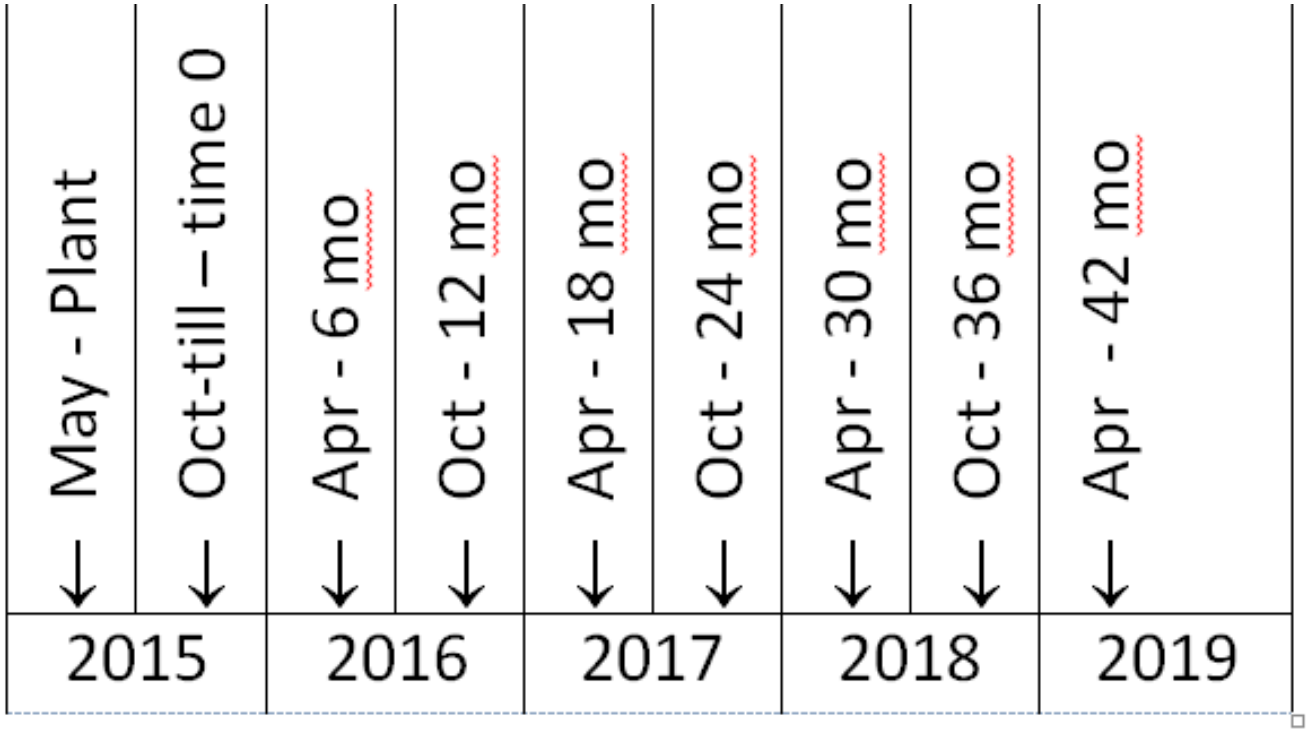
1. Graph paper

2. Photo Image J



3. Weight

Sampling Times for BDM



Acknowledgements

Project Team USDA SCRI Project No. 2014-51181-22382

TN: Douglas Hayes (Project Director), Annette Wszelaki, Jennifer DeBruyn, Sean Schaeffer, Susan Schexnayder, Arnold Saxton, Larry Wadsworth, Margarita Velandia, Mark Fly, Sreejata Bandopadhyay, Nurul Farhana Omar, Marie English, Kelly Cobaugh, Jennifer Moore

WA: Markus Flury, Carol Miles, Debra Inglis, Thomas Marsh, Jessica Goldberger, Chris Benedict, Peter Tozer, Suzette Galinato, Jeremy Cowan, Craig Cogger, Andy Bary, Lydia Tymon, Shuresh Ghimire, Henry Sintim, Ed Scheenstra, Babette Gunderson, Jacky King, Amy Salamone

MT: Eric Belasco

For More Information

www.biodegradablemulch.org