

## Progress Report

<b>Title:</b>	<b>Performance and Adoptability of Biodegradable Plastic Mulch for Sustainable Specialty Crop Production</b>		
<b>Sponsoring Agency</b>	NIFA	<b>Project Status</b>	ACTIVE
<b>Funding Source</b>	Non Formula	<b>Reporting Frequency</b>	Annual
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**Program Code:** SCRI**Program Name:** Specialty Crop Research Initiative**Project Director**

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**Non-Technical Summary**

Mulching with plastic materials is standard practice for specialty crop growers throughout the U.S. to reduce weeds and conserve water and soil, among many benefits. Unfortunately, most plastic mulch after use is stockpiled or burned illegally due to poor biodegradability of conventional plastic mulch materials, and limited recycling options, releasing harmful residues into the environment. Biodegradable plastic mulches (BDMs) have been developed to address the environmental deficiencies. However, concerns by growers and key intermediaries (e.g., suppliers and county extension agents) have limited the widespread use of BDMs based on perceived barriers: lack of knowledge, high cost, and unpredictable breakdown. To overcome these hurdles, we will implement an integrated and transdisciplinary science- and application-based research design to improve crop production, reduce post-harvest and environmental costs, and increase economic vitality for growers and consumers by using BDMs. Specifically, we will address multiple objectives: 1) evaluate the impacts of long-term BDM deployment (diverse scales of operation and climates) and environmentally-friendly disposal options (tilling into the soil vs. retrieving followed by composting) on soil quality, microbial communities, pests, diseases, and crop production; 2) assess the economic feasibility of BDM utilization (cost and benefits) for growers and consumers; and 3) engage with relevant stakeholders to increase interest in sustainable deployment and disposal of BDMs leading to increased adoption and economic and environmental benefits for growers and consumers.

**Accomplishments****Major goals of the project**

- A.** Evaluate the impacts of long-term use of BDMs on 1) the soil ecosystem (i.e., soil quality, microbial communities, and long-term storage of carbon); and 2) on a specialty crop production system along with its associated growers and consumers.
- B.** Identify BDM degradation mechanisms (e.g., changes at the macroscopic and molecular levels) and interrelationships among the life stages of BDMs: their origin (fossil fuel-derived vs. biobased), service life (role of weathering), and potentially sustainable end-of-life outcomes (ambient soil degradation vs. retrieval followed by composting).
- C.** Compare diverse scales of operation (field vs. laboratory studies), climate regions, and methodology for evaluating the soil degradation of BDMs to improve performance regulations.

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**D.** Identify steps along the supply chain for BDMs to better understand the bridges and barriers to BDM adoption by growers and intermediaries (e.g., extension agents, agricultural input suppliers, and crop consultants,) as related to economic relevance and regulation; and educate growers, intermediaries, consumers, and the general public on BDMs and biobased mulches and plastics, especially as related to sustainable and organic agriculture.

**E.** Assess the economic feasibility of agricultural products grown with BDM technologies through the entire supply chain to consumers, and identify potential BDM-associated disease and pest problems.

**F.** Interact with a community of stakeholders (consumers, growers, intermediaries, regulators, composters, and scientists) to increase interest in sustainable deployment of BDMs throughout the U.S. and worldwide.

**G.** Educate and train undergraduate and graduate students, postdoctoral research assistants, and principal investigators on skills needed to work on transdisciplinary research problems.

### What was accomplished under these goals?

#### Impact

Biodegradable plastic mulches (BDMs) contribute to sustainable farming practices by replacing conventional plastic mulch which is associated with environmental deficiencies. However, growers, suppliers, and Extension agents' concerns and lack of knowledge about BDMs--costs relative to benefits, and historically unpredictable breakdown--have limited the widespread use of BDMs. This project is working to address these barriers by conducting laboratory and field studies to assess BDM degradation and effects on crops and soils; studying the economic costs and benefits and growers' and consumers' perceptions of using BDMs; and increasing interest in sustainable deployment and disposal of BDMs. The impact of our project on Objectives A-G follows.

**A.** Evaluate the impacts of long-term use of BDMs on 1) the soil ecosystem; and 2) on a specialty crop production system along with its associated growers and consumers. Our Team's Working Groups (WGs) successfully completed the large-scale, multi-disciplinary field trials in Tennessee (TN) and Washington (WA) in 2015 to explore the impact of four BDMs and positive and negative controls on crop yield and quality, weed and disease control, and soil quality (4 manuscripts in preparation). Results show that with the suppression of weeds by the BDMs and conventional polyethylene (PE) mulch, comparable pumpkin fruit yields between BDMs and PE were higher than achieved for the bare ground control. Also, there has been no change observed to date in soil quality parameters at either site. The 2016 trials are now successfully initiated. Consistency in experimental approaches between TN and WA, and coordination of multiple tasks among scientists of different disciplines was facilitated by completing a series of comprehensive protocols, a transdisciplinary exercise among the co-PIs and our advisors. The protocols have been slightly modified based on lessons learned from the 2015 studies, such as performing a more thorough evaluation of mulch adhesion to fruit, which occurred unexpectedly at 30-50% for BDM treatments in WA.

**B.** Identify BDM degradation mechanisms and interrelationships among the life stages of BDMs: their origin (fossil fuel-derived vs. biobased), service life, and potentially sustainable end-of-life outcomes (ambient soil degradation vs. retrieval followed by composting). Changes in mulches' physico-chemical properties due to weather exposure during the 2015 field studies, simulated weathering, and in-laboratory storage (control), have been measured according to the Plastics Analysis (PA) protocol. Preliminary findings show that BDMs in the field underwent mechanical strength loss, embrittlement, and depolymerization to the greatest extent in TN, presumably due to higher air and soil temperatures in TN (manuscript in preparation).

A 4-yr mesh bag study for biodegradation of mulches under ambient soil conditions at TN and WA was initiated at the end of the first growing season in Sept. 2015 (Soil Ecology (SE) protocol). Mesh bags will be retrieved every 6 month and mulch samples are being evaluated for changes in physicochemical properties, loss of surface area, and microbial communities. The first of three on-farm composting studies using mesh bag burial also has been completed. Initial results indicate that BDMs undergo size reduction and almost complete macroscopic disintegration after 4 months; however, nm to micron -scale particles still were observed on mesh bag fibers via scanning electron microscopy.

Immediately after BDMs were tilled into the soil (Fall 2015) and 6 months later, BDM fragments were captured from soil samples, and mulch surface area was measured. An interdisciplinary experiment to examine the effect of soil temperature (10, 20, and 30°C) on the biodegradation process for two BDMs at 10 weeks is underway.

**C.** Compare diverse scales of operation (field vs. laboratory studies), climate regions, and methodology for evaluating the soil degradation of BDMs to improve performance regulations. Lab-scale testing of biodegradability for weathered BDMs under ambient soil and composting conditions is in preparation. Specialty crop production in WA vs. TN in 2015 and weathering of BDMs at the field sites vs. simulated weathering is discussed under Objectives A and B.

**D.** Identify steps along the supply chain for BDMs to better understand the bridges and barriers to BDM adoption by growers and intermediaries as related to economic relevance and regulation; and educate growers, intermediaries, consumers, and the general public on BDMs and biobased mulches and plastics, especially as related to sustainable and organic agriculture. Interviews with U.S. strawberry growers indicated low interest in BDM products. Options for recycling PE mulches (e.g., field-side pick-up) are increasing in a few locations, making removal and disposal of used plastic much easier and the higher cost of BDMs more difficult to justify for some growers. In Europe, strawberry growers may be much more interested in BDMs

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because BDMs are more compatible with local production practices and are closer in price to PE mulches. The survey of strawberry growers was completed in Jan-Apr 2016; data cleaning and analysis are underway.

Three farms have been identified in WA and TN for the Farmer Case Studies. Repeated on-farm interviews began in in early 2016. During the first On-Farm Experiential Field Day in WA, participants were interested in BDMs for home gardening use. IRB approval has been given for development of crop enterprise budgets with growers in WA (pumpkin) and TN (pumpkin, tomato and strawberry).

E. Assess the economic feasibility of agricultural products grown with BDMs through the entire supply chain to consumers, and identify potential BDM-associated disease and pest problems. Preliminary data for an enterprise budget of pumpkin production in western WA, evaluating the potential replacement of PE mulch with BDMs, were collected from two growers in Apr 2016, with three additional growers committed to assist. Additional feedback from growers will be collected in Nov-Dec 2016 to validate the preliminary data. Data collection for enterprise budgets in TN will begin in fall 2016. A survey on consumers' willingness to pay for strawberries grown with BDMs has been developed and will be fielded in 2016. An overview of the LCA for BDMs has been completed.

F. Interact with a community of stakeholders to increase interest in sustainable deployment of BDMs throughout the U.S. and worldwide. A key component of stakeholder interaction has been the meaningful involvement of our Advisory Committee (AC), which spans several stakeholder groups (see Target Audiences). Field days and similar presentations have engaged 345 growers and intermediaries and 170 students. We have also engaged farmers, scientists, and other stakeholder groups through our project website, 13 completed factsheets, and scientific/professional conference presentations (12 to date and 9 accepted).

G. Educate and train undergraduate and graduate students, postdoctoral research assistants, and principal investigators on skills needed to work on transdisciplinary research problems. This project has supported the training of post docs, graduate students and undergraduate students. Students, co-PIs, and AC members have participated in transdisciplinary training exercises (led by AC member Jackson-Smith) at both the 2015 and 2016 annual team meetings. The PD will give a presentation about the training at the 2016 SCRI PDs' Workshop (Aug. 2016). Transdisciplinary training has been augmented by participation in labor-intensive "all hands on deck" activities at the TN and WA field sites, such as soil quality assessments, BDM laying, pumpkin planting, and fruit harvesting, and attendance in quarterly meetings of other WGs. Statistics advice by co-PI Saxton has benefited the team greatly.

#### **What opportunities for training and professional development has the project provided?**

Project members provided and participated in training and professional development opportunities. PIs are currently mentoring 7 graduate students, 2 postdocs, and 10 undergraduate students. Team members, including the PIs, postdocs, and graduate students have led several workshops for Extension agents, provided field day demonstrations and presentations to growers about BDMs, and produced fact sheets and the first of a set of "how to" videos addressing the use of BDMs. (See products list for details.)

Thirty-five team members participated in a transdisciplinary training session, designed by Advisor Jackson-Smith, a recognized leader in the field, at the project's second annual meeting. The purpose of the training was to encourage participants, including advisors, to understand and visually depict how various components of the research and outreach activities interrelate. Wszelaki and Schexnayder also participated in a day-long workshop on mentoring students.

#### **How have the results been disseminated to communities of interest?**

Dissemination of results is incorporated into Objectives D and F. We have shared our results with the scientific communities of interest through our project website, 4 published journal articles, 13 completed factsheets, and scientific/professional conference presentations (13 in the project year ending Aug 28, 2016 and 3 more accepted), and other conference and symposium presentations (6 in this project year). Miles, leader of the EO WG, works with all other WGs to identify opportunities to share research results and general information about BDMs. We disseminated results to growers and intermediaries at several growers' meetings, five field days, and one workshop for Extension agents (by end of Yr2). One field tour was hosted specifically for a Future Farmers of America high school group from Florida, and future efforts will target youth (through 4-H activities). UT team members are working currently to disseminate results through Eureka (news service for science writers). In addition to written works and oral presentations, the team developed three videos this project year as we aim to provide diverse content to reach growers and general audiences.

#### **What do you plan to do during the next reporting period to accomplish the goals?**

In the third year of the project, numerous activities are planned. First, to address adoption and economics issues (Obj. D and E), the TA WG will develop additional case studies, analyze the results of the strawberry producers' survey and begin developing manuscripts, and conduct three focus groups addressing special topics related to adopting BDMs (Task 4a of Research Plan). The SC-LCA WG will implement a consumer willingness-to-pay survey and conduct choice experiments to elicit produce tradeoffs in their willingness to pay for different products (Task 4b). The SC-LCA WG will also continue labor

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data collection through focus groups and interviews for the construction of enterprise budgets and a labor-needs assessment tool. Data collection for the life cycle inventory database for agricultural mulches will continue.

To address Objs. A and C, the Field Activities, Soil Ecology, and Plastics Analysis WGs will collect and analyze crop, weed, disease, soil, and BDM data through the Year 2 field trials (Task 1, 2ac, and 3a; currently underway). The SE WG will continue its mesh bag study of BDM degradation and complete its composting study (Obj. B; Task 2b). Laboratory experiments are planned to measure the biodegradability of BDMs under ambient soil and industrial compost conditions, and better understand the underlying soil microbiology and abiotic factors involved with biodegradation (Objs. B and C; Task 3). The EO WG will continue outreach through the project website, factsheets, and video products and will identify outlets for all team members to disseminate results to all audiences (Objs. D and F; Task 5). The Project Assessment WG will continue to collect and analyze information from the change-in-knowledge surveys administered at project events.

For all activities and across all project WGs, development and publication of conference presentations, journal manuscripts, project and Extension factsheets and videos will continue in Yr 3. In addition, the education of team members will be enhanced through transdisciplinary training during the 2017 annual team meeting in Knoxville. Also, several co-PIs will participate in a trip to Spain and Italy next year to obtain an international context for the use of BDMs in sustainable agriculture. The tour focuses on the manufacturing of bioplastics and differences between the U.S. and European Union with respect to BDM regulation, assessment methods, and growers' rates of adoption and perceptions of BDMs.

**Participants****Actual FTE's for this Reporting Period**

Role	Non-Students or faculty	Students with Staffing Roles			Computed Total by Role
		Undergraduate	Graduate	Post-Doctorate	
Scientist	4.5	1.2	3.6	2	11.3
Professional	0.5	0	0	0	0.5
Technical	2.5	0.2	0	0	2.7
Administrative	0	0	0	0	0
Other	0	0	0	0	0
Computed Total	7.5	1.4	3.6	2	14.5

**Student Count by Classification of Instructional Programs (CIP) Code**

Undergraduate	Graduate	Post-Doctorate	CIP Code
2	1		14.45 Biological/Biosystems Engineering.
3	3		01.12 Soil Sciences.
4	1	1	01.11 Plant Sciences.
		1	45.13 Sociology and Anthropology.
	1		01.01 Agricultural Business and Management.
1			52.02 Business Administration, Management and Operations.
	2		45.06 Economics.

**Target Audience**

Target audiences reached during the second year of the project (Year 2) are specialty crop growers and intermediaries, including Extension specialists and agents; agricultural plastic film and mulch manufacturers; scientists in several different disciplines; agricultural standards committees and regulators; and undergraduate and graduate students.

The project's 24-member Advisory Committee includes specialty crop growers and representatives of grower organizations; Extension specialists; and experts in food safety, polymer science, mulch manufacturing, composting, materials standards, government policy, sociology, agricultural economics, soil microbiology, climate science, various horticultural specialties, and

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transdisciplinary research. Engaging the AC is paramount for our transdisciplinary project and was accomplished through team-wide meetings to review project research protocols and outreach plans, informal consultations with members via email and telephone, and participation of AC members in project Working Group (WG) meetings and conference calls. Specialty crop growers and intermediaries have been engaged interactively through their participation in growers' meetings and field days at which team members discussed biodegradable plastic mulches (BDMs) generally and the project specifically (7 events with 168 participants; 3 additional field days are scheduled before the end of Year 2 (Yr2), Aug 28, 2016). The Technology Adoption (TA) WG engaged growers through the survey of strawberry growers' experience with and perspectives on BDMs (implemented Jan-March 2016) and on-farm case studies (spring and summer 2016). The Supply Chain-Life Cycle Assessment (SC-LCA) WG is reaching growers and suppliers through personal in-depth interviews about costs and supply (Sept 2015 - current), as well as its survey of farmers willingness-to-pay survey (draft; implementation in Yr3). We also reach growers through the project's website (<http://biodegradablemulch.org>) and the basic information provided in factsheets developed specifically for the website. Based on Advisory Committee feedback, the Extension-Outreach (EO) WG is adding interactive features to the website in summer 2016.

We have reached the scientific community through the website, which is a gateway to scientific outputs of the project, and through our journal articles (4 in Yr2 and several more in development) and presentations delivered at professional conferences (13 abstracts and proceedings by the end Yr2; 3 more are accepted for presentation in Yr3).

Postdoctoral, graduate and undergraduate students are engaged in project research, collaborating to design the research, conducting the experiments, and collecting and analyzing data. Two Post-docs, 4 PhD students, and 2 MS students are conducting research projects through support of the SCRI CAP. Several undergraduate students also are involved in research, especially data collection. One field tour hosted 25 Florida Future Farmers of America students.

**Products**

Type	Status	Year Published	NIFA Support Acknowledged
Websites	Published	2016	YES

**Citation**

<http://biodegradablemulch.org>

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2016	YES

**Citation**

Cowan, J.S., A. Saxton, H. Liu, K. Leonas, D. Inglis, and C. Miles. 2016. Visual assessments of biodegradable mulch deterioration are not indicative of mulch degradation. *HortSci* 51(3):245-254.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2015	YES

**Citation**

Jiang, J. T.L. Marsh, and P. Tozer. 2015. "Policy Induced Price Volatility Transmission: Linking the U.S. Crude Oil, Corn and Plastics Markets," *Energy Economics*, 52 Part A: 217-227.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2015	YES

**Citation**

Dharmalingam, S., D.G. Hayes, L.C. Wadsworth, and R.N. Dunlap, J.M. DeBruyn, J. Lee, A.L. Wszelaki. 2015. Soil degradation of polylactic acid / polyhydroxyalkanoate-based nonwoven mulches. *J. Polym. Environ.* 23(3): 302-315. doi: 10.1007/s10924-015-0716-9.

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Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2015	YES

**Citation**

Dharmalingam, S., D. Hayes, L. Wadsworth, R. Dunlap. 2015, Analysis of the time course of degradation for fully biobased nonwoven agricultural mulches in compost-enriched soil, Textile Research Journal, Nov 11. doi: 10.1177/0040517515612358

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2016	YES

**Citation**

Brodhagen, M., J. Goldberger, D.G. Hayes, D.A. Inglis, T.L. Marsh, and C. Miles. 2016. Policy considerations for limiting unintended plastic in agricultural soils. Science. (rejected; another publication outlet is being sought)

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2016	YES

**Citation**

Hayes, D.G., C. Miles, et al. 2016. Long-Term Impacts of Biodegradable Plastic Mulches for Sustainable Production of Fruits and Vegetables, 16th Annual Meeting of the American Ecological Engineering Society, Knoxville, TN, June 7-9.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2015	YES

**Citation**

Sintim, H.Y., S. Bandopadhyay, S. Ghimire, M. Flury, A.I. Bary, S. Schaeffer, J.M. DeBruyn, C. Miles, D. Inglis. 2015 Soil quality, moisture, and temperature evaluation under different biodegradable mulches. American Society of Agronomy (ASA)-Crop Science Society of America (CSSA)-Soil Science Society of America (SSSA)-Annual Meeting, Minneapolis, MN, 15-18 Nov 2015.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2015	YES

**Citation**

Sintim, H.Y., S. Bandopadhyay, S. Ghimire, M. Flury, A. Bary, S. Schaeffer, J. DeBruyn, C. Miles, and D. Inglis. 2016. Soil Quality and Colloid Transport under Biodegradable Mulches. EGU2016-18410, EGU General Assembly 2016, Geophysical Research Abstracts, Vol. 18.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2015	YES

**Citation**

Schaeffer, S., M. Flury, H.Y. Sintim, S. Bandopadhyay, A.I. Bary, J. and DeBruyn. 2015. Assessing soil quality as affected by different mulches. American Geophysical Union (AGU)-Annual Meeting, San Francisco, CA, 14-18 Dec 2015.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Accepted	2016	YES

**Citation**

Lyons, C. and J. Goldberger. U.S. strawberry growers' experiences with and perceptions of biodegradable plastic mulch films. Rural Sociological Society Annual Meeting, Toronto, CA, Aug 7-10, 2016.

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Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Accepted	2016	YES

**Citation**

Wszelaki, A., J. Moore, S. Ghimire, and C. Miles. 2016. Adhesion of biodegradable mulches to pie pumpkins: A production and quality consideration. ASHS National Conference, Atlanta, GA Aug 8-11 2016.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Accepted	2016	YES

**Citation**

Ghimire, S., E. Scheenstra, J. Cowan, H.Y. Sintim, M. Flury, D. Inglis and C. Miles. 2016. Deterioration of Biodegradable Plastic Mulch in Pumpkin Production in Northwest Washington. American Society of Horticultural Science (ASHS) Annual Conference, ASHS National Conference, Atlanta, GA, Aug 8-11 2016.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Accepted	2016	YES

**Citation**

Ghimire, S., A. Wszelaki, J. Moore, H.Y. Sintim, M. Flury, D. Inglis, and C. Miles. 2016. Biodegradable plastic mulch produced comparable yield and quality of pie pumpkin as polyethylene mulch. ASHS National Conference, Atlanta, GA, Aug 8-11 2016.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Accepted	2016	YES

**Citation**

Benedict, C. and C. Miles. 2016. Developing outreach materials for large SCRI project. ASHS National Conference, Atlanta, GA, Aug 8-11 2016.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Accepted	2016	YES

**Citation**

Hayes, D.G., L.C. Wadsworth, A.L. Wszelaki, H.Y. Sintim, M. Flury, and C. Miles. Comparison of weathering at two diverse geographic locations and simulated weathering on the physicochemical properties of biodegradable plastic mulches. ASHS National Conference, Atlanta, GA Aug 8-11 2016.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Accepted	2016	YES

**Citation**

Cowan, J. 2016. Biodegradable mulch films: Their constituents and suitability for organic agriculture. ASHS National Conference, Atlanta GA Aug 8-11 2016.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2016	YES

**Citation**

English, M., S. Bandopadhyay, D.G. Hayes, J.M. DeBruyn, L.C. Wadsworth, S.M. Schaeffer. 2016. Temperature sensitivity of biodegradable plastic mulches to microbial decomposition. ASA-CCSA-SSSA Annual Meeting, Phoenix, AZ, Nov 6-9.

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Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2016	YES

**Citation**

Tymon, L., and Inglis, D.A. 2016. *Pseudomonas syringae* pv. *Syringae* causing lesions on pumpkin fruit in WA, U.S. Ann. Mtg. Pacific Division, American Phytopathological Society, La Conner, WA, Jun 28-30.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2016	YES

**Citation**

Sintim H., et al. Degradation of BDMs in Compost. ASA-CSSA-SSSA-Annual Meeting, Phoenix, AZ, Nov. 6-9, 2016.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2016	YES

**Citation**

Bandopadhyay, S. et al. Effect of BDMs on Soil Microorganisms. ASA-CSSA-SSSA-Annual Meeting, Phoenix, AZ, Nov. 6-9, 2016.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2015	YES

**Citation**

Miles, C., and S. Ghimire. Biodegradable mulch films: their constituents and suitability for organic agriculture. 2015. New England Vegetable and Fruit Conference, Dec. 15-17 2015, Manchester NH, p. 204-206.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2016	YES

**Citation**

Wszelaki, A., S. Ghimire, C. Miles and J. Moore. 2016. Biodegradable Mulches for Vegetable Production Systems, Pick TN Conference, Knoxville, TN, February 11-13, 2016.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2016	YES

**Citation**

Tymon, L., A. Salamone, and D. Inglis. Mar 30, 2016. Fungal endophytes isolated from pumpkin roots grown with agricultural mulches. Year 2 SCRI CAP team meeting, 'Performance and Adaptability of Biodegradable Plastic Mulch for Sustainable Specialty Crop Production.' Mount Vernon, WA (poster). March 30.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2016	YES

**Citation**

Tymon, L. March 30, 2016. Biodegradable mulch project: Plant pathology update. Year 2 SCRI CAP team meeting, 'Performance and Adaptability of Biodegradable Plastic Mulch for Sustainable Specialty Crop Production.' Mount Vernon, WA. Mar 30 (presentation).



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Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2015	YES

**Citation**

Ghimire, Shuresh. 2015, December. "Biodegradable plastic mulch for pumpkin production: crop yield, quality and mulch biodegradation in northwest Washington." Presentation of proposal for PhD dissertation, Washington State University. (30 student, faculty, and technical staff participants present, and broadcast to WSU Pullman campus and other WSU research centers.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2016	YES

**Citation**

Sintim, Henry. 2016, March. "Biodegradable plastic mulches: Degradation and impacts on soil quality and soil microclimate." Proposal for PhD dissertation, Washington State University. (40 students, faculty, and technical staff participants)

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2016	YES

**Citation**

Ghimire, S. and C. Miles. 2016, April. Dimensions of costs of polyethylene, paper and biodegradable plastic mulch. Washington State University Extension. (Extension factsheet)

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2016	YES

**Citation**

Ghimire, S. and C. Miles. 2016. Mechanically laying biodegradable paper and plastic mulch. Washington State University Extension. (Extension factsheet)

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2016	YES

**Citation**

Tymon, L. and D. Inglis. 2016 (April). What Is an Endophyte? Performance and Adoptability of Biodegradable Mulch Report No. FA-2016-01. [https://ag.tennessee.edu/biodegradablemulch/Documents/what\\_is\\_an\\_endophyte\\_formatted.pdf](https://ag.tennessee.edu/biodegradablemulch/Documents/what_is_an_endophyte_formatted.pdf)

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2016	YES

**Citation**

Lyons, C., and J. Golberger. 2016 (January). What Is the Technology Adoption Working Group and Why Is It Necessary? Performance and Adoptability of Biodegradable Mulch Report No. TA-2016-01. Online. <https://ag.tennessee.edu/biodegradablemulch/Documents/Fact-sheet-TAWG-FINAL.pdf>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2015	YES

**Citation**

DeBruyn, J., S. Bandopadhyay, D.G. Hayes, D. Inglis, and C. Miles. 2015 (October). Biodegradation – Putting Biology to Work. University of Tennessee Institute of Agriculture (UTIA). Performance and Adoptability of Biodegradable Mulch Report No. SE-2015-02. October 2015. Online. [https://ag.tennessee.edu/biodegradablemulch/Documents/biodegradation\\_factsheet.pdf](https://ag.tennessee.edu/biodegradablemulch/Documents/biodegradation_factsheet.pdf)

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Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2015	YES

**Citation**

Miles, C., S. Ghimire, A. Wszekaki, and J. Moore. 2015 (October). Biodegradable Plastic Mulch in Organic Vegetable Production Systems. 2015. PowerPoint slide presentation. Online.

[https://ag.tennessee.edu/biodegradablemulch/Documents/Miles\\_et\\_al\\_BDM\\_organic\\_conference.pdf](https://ag.tennessee.edu/biodegradablemulch/Documents/Miles_et_al_BDM_organic_conference.pdf)

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2016	YES

**Citation**

Weaver, Bill and Mary Weaver. 2016. Biodegradable mulch research. Country Folks Grower Western Region 9(4, March):5, 17. <http://cfgrower.com/biodegradable-mulch-research/> (popular press article)

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2016	YES

**Citation**

Benedict, C. and V. Alvarez. Performance and Adoptability of Biodegradable Plastic Mulch for Sustainable Specialty Crop Production: Project Introduction (video). <https://ag.tennessee.edu/biodegradablemulch/Pages/Videos-relating-to-Biodegradable-Mulch.aspx>

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2016	YES

**Citation**

Wszelaki, A. Season extension and potential for biodegradable mulches. Knoxville, TN. Growers' meeting presentation. (13 Feb, 2016; 25 growers)

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2016	YES

**Citation**

Wszelaki, A. Biodegradable mulches in vegetable production systems. Knoxville, TN. Extension agents' meeting presentation. (10 Agents)

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2015	YES

**Citation**

Cowan, J. Better farming through plastics: Season extension, mulch and more! Tilth Producers of Washington Annual Conference, Spokane, WA. (13 Nov, 2015; 30 growers)

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2015	YES

**Citation**

Wszelaki, A. Do biodegradable mulches have a place in your production system? Tennessee State University Third Tuesday Field Days and Educational Workshops. (20 Oct, 2015; 20 growers)

## Progress Report

Accession No. 1004366

Project No. TEN2014-07894

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2016	YES

**Citation**

Wszelaki, A. Biodegradable mulches in vegetable production systems. East TN Growers meeting. (27 Jan, 2016; 30 growers)

Type	Status	Year Published	NIFA Support Acknowledged
Other	Published	2016	YES

**Citation**

Bandopadhyay, S. 2016, April. Microbial degradation of agricultural plastics. Presentation of proposal for PhD dissertation, University of Tennessee. 25 students and professors in attendance.

**Other Products****Product Type**

Survey Instruments

**Description**

Goldberger, J. et al., "Use of Plastic Films in U.S. Strawberry Production: Growers' Experiences and Opinions," a survey administered by the Technology Adoption Working Group, for implementation January 2016.

**Product Type**

Protocols

**Description**

Goldberger, J. et al. Technology Adoption Working Group Protocol: On-farm Case Studies. Addresses farm recruitment, IRB compliance, and interview questions (April 2016).

**Product Type**

Protocols

**Description**

Inglis, D., et al. Field Activities and Soil Quality Assessment Protocols.

**Product Type**

Protocols

**Description**

Flury, M., et al. Soil Ecology Protocols (Task 1a, 2a-d, 3d).

**Product Type**

Protocols

**Description**

Hayes, D. and L. Wadsworth. Plastics Analysis Protocols (Tasks 3 a-b)

**Product Type**

Protocols

**Description**

Marsh, T. et al. Supply Chain-Life Cycle Assessment Protocols (Task 4b).

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**Product Type**

Databases

**Description**

Inglis, D., C. Miles, A. Wszelaki, et al. Database: Productivity; weed, insect, and disease suppression; fruit quality; and BDM adhesion under different BDM and control treatments, Year 1 trials (2015).

**Product Type**

Databases

**Description**

Flury, M. et al. Database: Soil quality and temperature under different BDM and control treatments, Year 1 trials (2015) and spring Year 2 data.

**Product Type**

Databases

**Description**

DeBruyn J. et al. Database: Soil microbes under different BDM and control treatments, Year 1 (2015).

**Product Type**

Databases

**Description**

Schaeffer, S. et al. Database: Soil carbon under different BDM and control treatments, Year 1 (2015).

**Product Type**

Databases

**Description**

Flury, M. et al. Database: BDM degradation in compost situations. (2015)

**Product Type**

Databases

**Description**

Hayes, D. and L. Wadsworth. Database: BDM and PE mulch degradation, Year 1 trials(2015).

**Product Type**

Databases

**Description**

Goldberger, J. and C. Lyons. Database: Grower responses to "Use of Plastic Films in Strawberry Production" survey (2016).

**Product Type**

Models

**Description**

Velandia, M. et al. Cost model: Removal of PE plastic mulch (2016).

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**Product Type**

Other

**Description**

Field Day, 28 April 2016. UT AgResearch East Tennessee Research and Education Center, Organic Crop Unit Field Day. (Wszelaki)

**Product Type**

Other

**Description**

Field Day, 7 July 2016. WSU Mount Vernon Northwest Research and Extension Center Summer Field Day. (Inglis and Miles)

**Product Type**

Other

**Description**

Field Day, 16 July 2016. Post Farm Field Day, Montana State University. (Belasco)

**Product Type**

Other

**Description**

Field Day, 12 May 2016. "Hands on Biodegradable Mulch Field Day Series, Omache Farm, Pullman, WA. (Lyons)

**Product Type**

Other

**Description**

Student Tour, 26 Oct 2015. Florida FFA. Biodegradable Mulch in Vegetable Production Systems. (Wszelaki)

**Product Type**

Other

**Description**

Team training session. Transdisciplinary perspectives of the "Performance and adoptability of BDMS project." (D. Jackson-Smith et al. leaders; team members and advisors participated)

**Product Type**

Other

**Description**

2nd Annual Project Meeting. Forty-five participants, including 8 graduate student researchers and Post docs and 13 advisors.

**Product Type**

Audio or Video

**Description**

Ghimire, S. Overview of biodegradable mulch experiment conducted at WSU NWREC Mount Vernon in 2015. <https://www.youtube.com/watch?v=yIGcL63ETjc>

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**Product Type**

Audio or Video

**Description**

Ghimire, S. How to lay biodegradable plastic mulch by machine layer.

**Changes/Problems**

There are no significant changes in the research schedule, goals, or research compliance protocols in Yr2. The FA WG is considering a change of test crop for field trials in Yr3 and 4, to reflect typical crop rotation practices and minimize the disease and insect pressure, per advice from AC members. Candidate crops (sweet corn and cabbage) are being tested at both sites in summer 2016. Also, the team (especially SE, FA, and PA WGs) is considering a request by the AC to employ new rolls of BDMs for the Yr3 and 4 field trials, due to concern about deterioration of BDMs during long-term storage. (We have been monitoring BDM deterioration and have observed only minor deterioration to date, covering a 15 month period). This consideration is being weighed against effects on soil quality and BDM degradation research that may result from minor changes in chemical composition between original and new rolls of plastic mulch. To enhance our team's evaluation of the socioeconomic impact of BDMs on growers and other stakeholders, we have added to Task 4b of our research plan 1) an LCA and 2) a grower willingness to pay survey. To lead these new efforts, we have added Chi and Chouinard as co-PIs to our project team. PI Tozer retains some responsibility for supply chain assessment, but transitioned to a consultant role on the project after taking an academic position abroad. By leveraging additional funding provided by WSU, Post doc Tymon will use WA field trial data and new studies in controlled greenhouse conditions to examine the effect of selected mulch treatments on the occurrence of pumpkin root endophytes and *Verticillium dahliae*, a plant pathogen prominent in the production area of the WA trial, as well as on the survivability of microsclerotia of *V. dahliae* in mulched soil (Task 1b).