Biodegradable Mulches for Specialty Crops Produced Under Protective Covers

Year 3, September 1, 2011 – August 31, 2012


ACCESSION NO: 0219841 SUBFILE: CRIS
PROJ NO: WNP03375 AGENCY: NIFA WN.P
PROJ TYPE: OTHER GRANTS PROJ STATUS: NEW
CONTRACT/GRANT/AGREEMENT NO: 2009-51181-05897
PROPOSAL NO: 2009-02484
GRANT AMT: $1,999,002

OUTPUTS

Activities: Final year (Yr 3) of a field experiment under three contrasting agricultural environments in TX, TN and WA, evaluated a modified (based on Yr 1 & 2 results) black, blended experimental spunbond (SB) polylactic acid/polyhydroxyalkanoate (PLA/PHA) nonwoven fabric (PLA-12) as a biodegradable mulch (BDM) for specialty crops grown in high tunnel (HT) and open field (OF) settings. Comparisons to two leading commercial BDMs (BioAgri, BioTelo), cellulose mulch (WeedGuardPlus), and conventional black plastic were made. A bare ground control treatment, four replications of HT and OF plots, and tomato as the test crop were included. Field experiments on adaptability of six cultivars each of lettuce, strawberry, and tomato to HT vs. OF production, and a two-year mesh bag study investigating biodegradation following mulch incorporation into soil, also completed at each location. Greenhouse tests on soil additives to enhance mulch biodegradation carried-out at UTK in TN and investigations on mulch biodegradability coordinated with internationally-renowned scientific advisor at Michigan State University. The inherent biodegradability of the SB-PLA and Meltblown-PLA/PHA investigated using American Society Testing & Materials International D5338. Greenhouse soil burial studies assessed the performance of PLA/PHA experimental nonwovens as mulches. Several BDM products investigated using weatherometry to better understand effects of sunlight and soil moisture on degradation.

Events: Information about BDMs and HTs delivered to local, regional, national and international audiences via (i) classroom settings; (ii) extension presentations, field tours, radio programs, and workshops; and, (iii) scientific abstracts, colloquia, keynote address, meetings, seminars, and invited presentations. Mesh bag, mulch, plant, and soil sampling completed regularly by project working groups (WGs) per research protocols. The team and advisors (23 total) met Mar 13-15 at UTK in Knoxville, TN where WG presentations, graduate student symposium, statistics training, and tour ofSCRI field trials took place. Five team members participated in team-sponsored colloquium, “Biodegradable Plastic Mulches for Specialty Crop Production: Current Status and Future Directions” at American Society Horticultural Science meeting in Miami, FL, Jul 31-Aug 3. The team was represented by Wszelaki (PI) at 6th Annual National Small Farms Conference in Memphis, TN, Sep 18-20, via a presentation and poster, and Wszelaki now invited to give research presentation on high tunnel research at Kentucky Fruit and Vegetable Conference in Lexington, KY in Jan 2013. A two-year field demonstration with stakeholder focus group participants now underway at WA field site to contrast two post-harvest management systems for BDMs: soil incorporation vs. leaving on soil surface for one year.
Services:
Six graduate students and 23 undergraduate students trained by project personnel. One senior capstone design project on “Improving Design of High Tunnels to Withstand Strong Winds” accepted at UT-K. Two Engineering Technology Senior Projects on “Characterization of Degradation of Biodegradable PLA” and “Engineered Macro-structure and Micro-structure of Polylactic Acid” advised at WWU. A group of three graduate students did a class project on “Evaluating Evaporation and Soil Temperature and Moisture Variations under Various Biodegradable Mulches” at UTK. One undergraduate intern on “Risk of Postharvest Infestation of Botrytis cinerea for Lettuce Grown in High Tunnels and Open Field” advised at WSU.

Products:
Experimental spunbond (SB) nonwoven mulch for the project (SB-PLA+PHA-12) manufactured at Saxony Textile Research Institute, Chemnitz, Germany, based on 2011 project results. New methods for isolating native soil fungi and bacteria that colonize plastic mulch films after field burial developed, and accepted by Journal of Visualized Experiments (online video journal). Public website on high tunnels and crops mulches maintained specifically for Pacific Northwest, High Plains, and Southeast regional audiences (see http://mtvernon.wsu.edu/HighTunnels/index.html). Year 3 protocols, team presentations, and other information for monitoring crop, environment, mulch degradation and soil quality, archived on team’s internal website. A web survey, entitled “Biodegradable Plastic Mulches: Experiences and Opinions of Intermediaries” sent to Extension personnel, agricultural input suppliers, crop consultants and other intermediaries in the three project regions, completed and summarized and helping to determine research and education directions for the future.

OUTCOMES/IMPACTS

Knowledge:
- 26 abstracts and proceedings (read by at least 80,050+ people)
- 9 book chapters, journal articles, technical reports, theses (read by at least 406,108 people)
- 7 extension publications (all online; readership unknown)
- 47 presentations (attended by ~5,151 people)
- 2 media interviews (both online; readership unknown)
Total people potentially impacted= 491,208 + (minimum estimate)

Actions:
Hayes (team PI) invited and received travel grant to give research presentation at BEPS Research Symposium, Sep 18-21, University of North Texas, Denton, TX, and as a result, UTK graduate student under Hayes’ direction selected for BEPS Poster Award. Inglis (team PD) advised scientist in NZ on controlling late blight on tomato using crop covers. Hayes (team PI) establishing potential new collaboration with scientist in Brazil. One team member served as SCRI Program Panel Reviewer. Two team members provided scientific expertise to National Organic Standards Board regarding biodegradability of plastic mulch. Two team members joined American Society Testing & Materials International to participate in a working group which is developing a new standard for plastic biodegradability in soil. New project team being assembled to discuss submission of future, follow-up SCRI CAPS project using, in part, results from BDM survey by team sociologist.

Change in Conditions:
For Agricultural Norms - HTs accepted for first time into Natural Resources Conservation Service program in TX, based on project results. Team advisor Narayan gave the William A. (“Tex”) Frazier Plenary guest Lecture at ASHS Annual Meeting, Jul 31-Aug 3, Miami, FL, on “The Promise of Bioplastics: Understanding Value Proposition of Biobased and Biodegradable Plastics for Reducing Carbon Footprint and Improving Environmental Performance.” New research emphasis is now being placed on engineering high tunnels for high wind environments. Two major plastic mulch manufacturers intend to hire an agricultural specialist to better integrate bioplastic product development with agricultural needs.
For Community - Case study on “Evaluating biodegradability of biobased plastics buried in soil,” invited and submitted by Hayes (team PI) to Knovel Academic Solutions Stories, with 120,000 potential newsletter subscribers and 10,000 blog views.

For Economics - Eleven plastic manufacturers in CA, CAN, IN, MD, MN, NY, SC, RI, WA, and WV have expressed interest in becoming involved with future research on BDMs for agriculture. New grant award of $90,728 awarded by USDA Risk Management Agency’s Risk Management Education & Outreach Partnership Program to Belasco (team PI) for “Training for Limited Resource and Beginning Farmers and Ranchers in Montana.”

For Environment - WeedGuardPlus and other BDM mulches now accepted for USDA OMRI classification and rule-making is in progress; Inglis and Miles (co-PDs) interviewed on this issue by the Center for Food Safety in Washington D.C. and team extension publication on BDMs used during sub-committee deliberations. Two book chapters on BDMs published. Project team honored by being asked by CRC Press/Taylor to prepare a book on BDMs for Agriculture.

PUBLICATIONS

Abstracts and Proceedings:


Hayes, D.G., Wadsworth, L.C., Dharmalingam, S., Leonas, K.K., Miles, C., and Inglis, D.A. 2012. Poly(lactic)/poly(hydroxyalkanoate) nonwovens as biodegradable agricultural materials. 20th Annual
Meeting BioEnvironmental Polymer Society. University of North Texas, Denton, TX (abstract potentially read by ~150 people).


annual meetings abstracts [CD]. ASA, CSSA, and SSSA, Madison, WI (abstract potentially read by 3,000 people).


Book Chapters, Journal Articles, Technical Reports (published or in press):

Bailes, G., Lind, M., Ely, A., Powell, M., Moore-Kucera, J., Miles, C., Inglis, D., and Brodhagen, M. 201x. Isolation of native soil microorganisms with potential for breaking down biodegradable plastic films used in agriculture. Journal of Visualized Experiments (accepted and in press; will be published online).


Extension Publications:

Corbin, A., Miles, C., Cowan, J., Hayes, D., Inglis, D., and Dorgan, J. 201x. Biodegradable plastic mulch. Washington State University Extension Fact Sheet: (accepted and in press; to be published online).


Publications Submitted and Under Journal Review:


Publications Completed and Under Internal Review:

Galinato, S.P. and Miles, C. A. 201x. Economic profitability of tomato and lettuce in western Washington under open field and high tunnel production systems. HortTechnology (target submission date Nov 2012).
Powell, M., Gundersen, B., Miles, C., Coates, K., and Inglis, D. 201x. First report of Verticillium wilt on lettuce (Lactuca sativa L.) in Washington caused by Verticillium tricorpus I. Plant Disease: (target submission date is Nov 2012).

PRESENTATIONS – (Local, Regional, National and International Audiences)

Michigan Senior Author:


Tennessee Senior Authors:


Dharmalingam, S. Sep 21, 2012. “Evaluating the biodegradation of polylactic acid (PLA) and PLA-blended-polyhydroxyalkanoate(PHA) nonwovens as agricultural mulches through soil burial studies.” 20th Annual Meeting BioEnvironmental Polymer Society. University of North Texas, Denton, TX (~75 people attended poster session).


Texas Senior Authors:


Moore-Kucera, J. Fall Semester, 2011. Four lectures related to SCRI project delivered to TTU Introductory Soil Science course (50 students attending each time).

Moore-Kucera, J. Fall Semester, 2012. Four lectures related to SCRI project delivered to TTU Introductory Soil Science course (40 students attending each time).


Washington Senior Authors:


Brodhagen, M. Jul 20, 2012. One invited lecture on “Biodegradable plastics in agriculture” to Western Washington University Engineering Technology Department’s Analytical Chemistry course (9 attendees).

Brodhagen, M. Spring Quarter, 2012. One lecture related to SCRI project delivered to WWU Introductory Cell Molecular Biology course (72 students).

Brodhagen, M. Winter Quarter. 2012. One lecture related to SCRI project delivered to WWU Microbiology course (40 students attending).


Project Scientists (2011-2012):

Project Director and Co-Project Director: Debra Ann Inglis and Carol Miles, Washington State University (WSU) NWREC, Mount Vernon, WA.

Crops Working Group (WG): Annette Wszelaki (Leader), University of Tennessee (UTK), Knoxville, TN; Russell Wallace, Texas AgriLife Research & Extension Center, Lubbock, TX; Tom Walters, WSU Mount Vernon NWREC.

Economics WG: Tom Marsh (Leader) and Suzette Galinato at WSU Pullman; Eric Belasco, Montana State University (MSU), Bozeman, MT.

Materials WG: Douglas Hayes (Leader) and Larry Wadsworth at UTK; Eric Belasco, Montana State University (MSU), Bozeman, MT.

Other Project Participants (2011-2012):

Ad Hoc Interest Groups: Terry Phillips, BIOgroupUSA, Inc., Palm Harbor, FL; Eric Menard, Dubois Agrinovations, Waterford (Ontario) CAN; Dick Mathes, Crown Films, Burlington, WA.

Graduate Students: Jeremy Cowan (Ph.D. Horticulture, WSU); Jingze Jiang (Ph.D. Economics, WSU); Chenhui Li (M.S. Soils, TTU); Jeff Martin (M.S. Horticulture, UTK); Marianne Powell (M.S., WSU); Rob Raley (M.S. Soils, UTK).

Industry Advisors: Robert Green, NatureWorks LLC, Cary, NC; Mark Williams, BioBag USA, Inc., Palm Harbor, FL.

Scientific Advisors: John Dorgan, Colorado School of Mines; Lewis Jett, West Virginia University, Ramani Narayan, Michigan State University.
Stakeholder (grower) Advisors: George (Ben) Craft, Alm Hill Gardens, Everson, WA; Elizabeth Malayer, Farm2School, Rogersville, TN; Ashley Basinger, South Plains Food Bank, Inc., Lubbock, TX; Tom Thornton, Cloud Mountain Farm, Everson, WA.

Technical Support: C. Joel Webb (TX Agri-Life); Galina Melnichenko (UTK); Hang Liu (WSU Pullman); Babette Gundersen, Jacky King, Jonathan Roozen, Don Wallace (WSU Mount Vernon); Graham Bailes and Margaret Lind (WWU).

Survey Collaborators: Rose Krebill-Prather and Leona Ding, WSU Pullman Social and Economic Sciences Research Center (SESRC).

Undergraduate Students: Isaac Lucero (TX Agri-Life); Andrew Alleman, Jesus Blanco, Jessica Siewert (TTU); Rachel Dunlap, Sarah Elias, Tim Grant, Emily Hennely, Tara Smith (UTK); Matt Conklin, Deborah Rodriguez, Tasha Totten (WSU Pullman); Holly Gonzales and Ashley Quinby (WSU Mount Vernon); Cory Ashline, Andrew Ely, Kalin Karich, Briana Kinash, Kevin Kinloch, Megan Leonhard, Margaret Lind, Joseph McCollum, Maria McSharry (WWU).

Professional Development: Altogether, 29 team members were involved in 10 national scientific meetings. Twenty-three team and advisory committee members participated in the team meeting at Knoxville, TN where five graduate students presented their research and were critiqued during a symposium, and a workshop on statistics was given. Two team members were promoted from assistant to associate professor rank with tenure. Ten team members contributed to team publications as senior author; all team members contributed to team publications as contributing authors. Hayes (PI at UTK) received professional development award for $4,293 on “Biodegradation testing apparatus to analyze biodegradable agricultural mulches and bioplastics.” Hayes’ grad student received small travel grant to attend BioEnvironmental Polymer Society conference in Texas where he received a poster presentation award.

Targeted Audiences: Targeted audiences were local, regional, national and international, and included both conventional and organic specialty crop growers who use high tunnels and mulches, as well as HT and BDM manufacturers. At least 500,000 people were reached via various publications and a public website; and, via presentations in classroom settings, at extension meetings, during workshops and field tours, by mass media and on-line articles, at seminars; and, via scientific meetings and publications.

Deviations: In personnel - Dr. Jessica Goldberger assumed the role of project sociologist. In methods - Dr. Goldberger in collaboration with WSU’s Social and Economic Sciences Research Center conducted an online survey, “Biodegradable Plastic Mulches: Experiences and Opinions of Intermediaries,” to stakeholders in TN, TX and WA to assess intermediaries’ experiences, opinions, and needs regarding BDMs.

Unexpected Outcomes: Many fungal isolates from native agricultural soils that are capable of degrading BDMs are oligotrophic, and therefore, slow growing; more sophisticated testing is needed to analyze how much carbon is contributed by BDMs in soil, and how much originates from other oligotrophic carbon-scavenging mechanisms. Some fungal isolates from native agricultural soils that are capable of degrading BDMs, are also potential mycotoxin producers. ASTM International is developing a new standard for biodegradability of plastics in soil. New information generated by this project was used by the USDA NOSB to review an appeal to allow biodegradable plastics to be used in certified organic agriculture (the appeal was approved and rule-making is now in progress). The use of high tunnels to manage risk and thereby provide a substitute for crop insurance is a topic of greater importance than initially anticipated, and a growing area of research for the team’s economists. There is greatly increased interest by Extension Agents in strawberry production for West Texas where previously it was thought they could not be grown; also, home gardeners in this region have taken the principles of wind management acquired from this project to create low tunnel gardening.

MEDIA INTERVIEWS
