Activities:

Three field experiments under contrasting environments in TX, TN and WA, tested a white experimental spunbond (sb) polylactic acid (PLA) nonwoven fabric as a biodegradable mulch (BDM) for specialty crop production under high tunnel (HT) and open field settings. Comparison was made to two leading commercially-available BDM products (BioBag, BioTelo) and conventional black plastic, using cellulose mulch and no-mulch treatments as reference controls. The experiment had four replications of HT and open field plots and tomato as the test crop at all three sites. Experiments on adaptability of six cultivars each of lettuce, strawberry and tomato to HT production at each location were also included.

Extensive soil sampling and analysis and environmental monitoring were completed at all three sites in Year 1 to secure baseline data for future soil and environmental quality assessment. Crop performance and productivity, and disease and pest pressures were also assessed.

Two post-doctoral associate, 6 graduate, and 5 undergraduate students were hired.

Events:

The team and its advisory committee met on June 24 to 25, 2010 in Mount Vernon, WA. The team's project directors participated in the SCRI Session at ASHS meeting in Palm Desert, CA on August 2 to 5, 2010. The team sponsored two focus group meetings and field tours in Mount Vernon, WA on July, 8, 2010 to identify values, norms, beliefs, attitudes, and knowledge of HTs and BDMs among invited stakeholders.

Information on the project, BDMs and HTs was delivered from three areas of the U.S. (Mid-South, High Plains, Pacific Northwest) to local, regional and national audiences via
classroom settings, extension and focus group meetings, workshops and field tours, radio programs, media articles, seminars, and scientific conferences.

**Services:**

WSU Undergraduate Senior Design Project on Improving design of high tunnels to withstand strong winds accepted by WSU Mechanical & Materials Engineering Dept. Products:

The experimental sb-PLA nonwoven for the project was manufactured in Saxon, Germany, and based on 2010 research, is being modified for 2011 testing.

Extensive field and laboratory protocols for monitoring crop, soil, and environmental interactions with the BDMs as well as assessing BDM properties, performance, and degradation were developed and refined by team and advisory committee members, and posted on the team's website. Synchronous approaches for field plot design; cultural practices; crop and harvest assessments; environmental monitoring; soil sampling, analysis and quality assessment; BDM sample receipt, storage, cleaning and analysis; constructing lettuce, tomato and strawberry crop budgets, and risk management tools, all were developed. The protocols were presented as a proceedings paper at a national scientific meeting.

A glossary of common definitions was created to standardize oral and written communications among team members and to the public.

One website for information sharing among team members and one public website http://vegetables.wsu.edu/plasticulture.html for general outreach were created.

**OUTCOMES/IMPACTS**

**Knowledge:**

a) A total of 9 publications; 65 oral presentations; 17 media interviews; 5,066 people directly educated; nearly 1.9 M people potentially impacted via mass media.

b) The sb-PLA allowed unacceptable levels of weed seed germination and weed growth.

c) The sb-PLA did not biodegrade in soil during the growing season and is not suitable for mechanical tillage at season end.

d) High winds revealed structural weaknesses to the HT model used in WA, and stimulated discussions on risk management for HTs.

e) In TN, commercial BDMs provided weed control throughout the season. The sb-PLA had 70% loss of tensile strength after 29 wk in greenhouse soil with significant biodegradation of meltblown PLA after 10 wk with lime and manure.

f) In TX, the HT installation withstood sustained high winds; flooding from unseasonable rainfall revealed the need for adequate drainage during site selection. Soil temperatures increased under all mulches compared to bare ground and high soil variability existed across the TX study site.

g) In WA, optimization of tomato size and/or quality was achieved by using commercial BDMs. Late blight was managed under wet conditions by growing tomatoes inside HTs, but physiological leaf roll on the crop was not exacerbated because of HTs. For lettuce and tomato, some soilborne pathogens increased under BDM and/or HT treatments. For strawberry, fruit rot was reduced in HTs but Verticillium wilt was more serious on a
susceptible cultivar.
h) Knowledge of HTs and BDMs among stakeholders (N=23) was limited in WA, but increased after field tour and focus group meetings. Participants expressed doubts about HTs and BDMs due to lack of knowledge and experience, and availability, reliability, predictability and short vs. long-term costs. Wind and mulch degradation byproducts were identified as potential barriers to BDM and HT adoption.

**Actions:**
a) A new sb-PLA nonwoven of different molecular weight polymer (= different fiber size) and color, is being manufactured for testing in 2011 based on team feedback to industry. Alternative feedstocks are being considered for nonwoven blends that better meet the requirements of agriculture.
b) New efforts to research HT structural stability, educate growers on wind, and develop risk management tools, are underway; and the HT model in WA was modified.
c) Mulch products were not incorporated into the soil at the end of the growing season; instead, pieces were buried in nylon-mesh bags to quantify degradation in situ, and impact on soil quality in Years 2 and 3.
d) Fall-grown, HT strawberries may fill a production niche in late fall/early winter, with a second harvest in spring.
e) New or increased disease and pest pressures inside HTs demand changes from organic to conventional practices at all sites for some pathogens and pests.
f) Mulch physical testing procedures on porosity and abrasion resistance have been modified.

**Conditions:**
a) The NRCS in WA added cost reimbursement options for vegetable growers using plastic mulch or BDMs for 2011.
b) Extension efforts in TN helped increase the number of stakeholders who received HTs through the NRCS cost-share program.

**Publications:**


Participants:
Project Director and Co-Project Director: Debra Ann Inglis and Carol Miles, Washington State University (WSU) NWREC at Mount Vernon.
Crops Working Group (WG) members: Annette Wszelaki (Leader), University of Tennessee (UTK) at Knoxville; Russell Wallace, Texas AgriLife Research & Extension Center at Lubbock; Tom Walters at WSU NWREC.
Economics WG members: Tom Marsh (Leader), Ana Fabiola Espinola-Areddondo, Suzette Galinato and Srinivasa Ponnaluru at WSU Pullman; Eric Belasco at Texas Tech University (TTU).
Materials WG members: Douglas Hayes (Leader) and Larry Wadsworth at UTK; Hang Liu and Karen K. Leonas at WSU Pullman.
Sociology WG members: Robert Jones at UTK, and Annabel Kirschner at WSU Thurston County Extension.

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Materials WG members: Douglas Hayes (Leader) and Larry Wadsworth at UTK; Hang Liu and Karen K. Leonas at WSU Pullman.
Sociology WG members: Robert Jones at UTK, and Annabel Kirschner at WSU Thurston County Extension.
Soils WG members: Jennifer Moore-Kucera (Leader) at TTU; Marion Brodhagen at USDA ARS Corvallis; Andrew Corbin at WSU Snohomish County Extension; Jaehoon Lee at UTK. Scientific Advisors: John Dorgan at Colorado School of Mines; Ramani Narayan at Michigan State University; Mark Radosevich at UTK. Stakeholder Advisors: George (Ben) Craft, Alm Hill Gardens, Everson, WA; Brant A. Baugh, Texas Agri-Life Extension, Lubbock, TX; Lewis Jett, West Virginia University; Elizabeth Malayer, Farm2School; Rogersville, TN; Ashley Basinger, South Plains Food Bank, Inc., Lubbock, TX; Tom Thornton, Cloud Mountain Farm, Everson, WA.

Industry Advisors: Robert Green, NatureWorks LLC, Cary, NC; Mark Williams, BioBag USA, Inc., Palm Harbor, FL. Ad Hoc Interest Groups: Terry Phillips, BIOgroupUSA, Inc., Palm Harbor, FL; Eric Menard, Dubois Agrinovations, Waterford (Ontario) Canada; Dick Mathes, Crown Films, Burlington, WA. Graduate Students: Jeremy S. Cowan and Marianne Powell at WSU Mount Vernon NWREC; Sathiskumar Dharmalingam, Jeff Martin and Rob C. Raley at UTK; Jared Chauncey at TTU.

Professional Development: Attendance of some members at six different national scientific meetings; one team and advisory committee meeting at Mount Vernon, WA.

Targeted Audiences:

Targeted audiences are local, regional and national and include both conventional and organic specialty crop growers who use high tunnels and mulches, as well as high tunnel and mulch manufacturers. Audiences have been reached via various publications and a public website, and presentations in classroom settings, at extension and focus group meetings, for workshops and field tours, by radio programs, mass media and on-line articles, and during seminars and scientific conferences.

An estimated 5,066 people were directly educated via 9 abstracts and proceedings, 65 oral presentations, and 17 interviews. Nearly 1.9 million people were potentially impacted via mass media coverage and online articles.

The NRCS in WA added cost reimbursement for vegetable growers who use current commercially available biodegradable mulch or plastic mulch. Concerns about wind and mulch degradation byproducts were identified by WA stakeholders as potential barriers to BDM and HT adoption.

Deviations:

In personnel: Dr. Tom Marsh has replaced Dr. Hector Saez as an economist on the project, and Dr. Annabel Kirschner has replaced Dr. Curt Beus as a sociologist on the project. Dr. Marion Brodhagen, the soil microbiologist, has recently changed locations, is now with USDA ARS in Corvallis, OR, and a new sub-contract is in progress. The reasons for these changes are all personal.

In methods: More emphasis on high tunnel structural stability to withstand unexpected high winds; revised field research and mulch handling and mulch cleaning protocols to improve them; redesigned mesh bag study to better accommodate field tillage requirements over time; postponed focus group meetings in TN and TX until April 2011 to better accommodate
organizers and participants; mulch physical testing procedures on porosity and abrasion resistance modified due to mulch cleaning difficulty after prolonged soil exposure.

**Unexpected Outcomes:**
The experimental sb-PLA mulch manufactured for Year 1 did not biodegrade in soil and allowed unacceptable levels of weed growth so a new formulation is being manufactured for Year 2 based on team feedback; risk management tools to mitigate against adverse environmental conditions i.e., wind and flooding are being developed; greater focus is needed on soilborne disease progression in HT versus open field environments with consideration of both organic and conventional disease control methods.

**PRESENTATIONS – TENNESSEE SENIOR AUTHORS**
*(Local, Regional, National and International Audiences)*


Wszelaki, A., August 19, 2010. Season Extension and High Tunnel Tour. UTK Agent In-Service on Sustainable Vegetable Production. Knoxville, TN. 22 estimated participants.

PRESENTATIONS – TEXAS SENIOR AUTHORS
(Local, Regional, National and International Audiences)

Belasco, E. April 19, 2010. Wind damage to high tunnel structures. SCRI Economics Working Group, Conference Call Seminar. 10 estimated participants.

Moore-Kucera, J. Spring, 2010. Three lectures, one field tour, and one lab class on high tunnel and BDM research delivered to undergraduate soil science students at TTU, Lubbock, TX. 41 estimated participants.


Wallace, R. April 13, 2010. High tunnels for West Texas. Grower and Agent Webinar (conducted online). Lubbock and College Station, TX. 116 estimated participants.


Wallace, R. July 29, 2010. Texas High Tunnels Conference and Tour, Lubbock, TX. (Note: only two growers attended due to catastrophic flooding in region).


Wallace, R. October 14, 2010. High tunnel tour with Dan Rohrer (President of Texas Fruit Growers Association). Lubbock, TX. 1 participant.

PRESENTATIONS -- WASHINGTON SENIOR AUTHORS
(Local, Regional, National and International Audiences)

Brodhagen, M. Fall and Spring Semester, 2009 and 2010. Lectures and discussions on BDM research delivered to undergraduate microbiology students at WWU, Bellingham, WA. 69 estimated participants.

Corbin, A. July 8, 2010. SCRI Focus Group Field Tours held in conjunction with two SCRI Focus Group meetings in Washington. WSU Mount Vernon, NWREC. 24 participants.

Inglis, D., Miles, C., Walters, T. July 8, 2010. SCRI project on HTs and BDMs. WSU Mount Vernon NWREC Field Day. Mount Vernon, WA. 124 estimated participants.

Inglis, D.A. September 10, 2010. SCRI project overview and progress report meeting on biodegradable mulches for specialty crops produced under protective covers with Dr. Dan Schmoldt, National Program Leader, Instrumentation & Sensors, USDA National Institute of Food and Agriculture. Wenatchee, WA. 2 participants (Inglis & Schmoldt).


Miles, C.  February 6, 2010. Specialty crop producer workshop on HTs. WSU Klickitat County Extension. White Salmon, WA. 22 estimated participants.

Miles, C.  April 7, 2010. Specialty crop producer workshop on HTs. WSU Clallam County Extension. Sequim, WA. 16 estimated participants.

Miles, C.  May 10, 2010. HTs and diversified vegetable production. WA Tilth and WSU Small Farms Team Farm Walk, Hedlin Farms, La Conner WA. 100 estimated participants.


MEDIA INTERVIEWS
(Local, Regional, National and International Audiences)


January 6, 2010. Vegetable gardening. 950 AM FoxTalk Radio Show, Lubbock, TX. (HTs and BDMs included in discussion). 5,000 estimated potential listeners.


April 8, 2010. Textiles play a big role in evaluation of mulch project. fibre2fashion.com online. 1,000,000+ estimated potential readers.


May 7, 2010. Vegetable gardening. 950 AM FoxTalk Radio Show, Lubbock, TX. (HTs and BDMs included in discussion). 5,000 estimated potential listeners.


August 2010. Biodegradable Mulch Project Applies Textile Science to Agriculture. AG Power magazine. Author not named. (This article has appeared on several websites.) http://www.agpowermag.com/articles/articles.php?articleid=3246&utm_source=RSSArticles&utm_medium


September 13, 2010. High tunnel production in West Texas. 950 AM FoxTalk Radio Show, Lubbock, TX. 5,000 estimated potential listeners.
