

OPTIMIZING PROTECTED CULTURE ENVIRONMENTS FOR BERRY CROPS

Report to Advisory Committee, January 2016

PERSONNEL

Michigan State University: Eric Hanson (Co-Project Director), Rufus Isaacs, Annemiek Schilder
The Pennsylvania State University: Kathy Demchak (Co-Project Director), Dennis Decoteau, William Lamont, Kathleen Kelley, Richard Marini
Cornell University: Lois Levitan, Laura McDermott, Marvin Pritts
University of Minnesota: Emily Hoover, Mary Rogers
University of New Hampshire: Becky Sideman
University of Vermont: David Conner
Rutgers University: AJ Both

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Moore, Patty	President and CEO, Moore Recycling Associates

BACKGROUND:

National demand for fresh raspberries and strawberries is strong and growing, but most domestic production occurs in select regions of the U.S with the most suitable climate. Concentrated production in specific regions can tax local resources such as water, increase costs of transporting produce to distant markets and perhaps elevate risks to supplies due to adverse local weather.

Farmers in the upper Midwest and Northeast are keenly interested in supplying more berries to local markets, but producing profitable yields and consistently high fruit quality is difficult in a region with cold winters and short, humid growing seasons. Protective structures or tunnels appear to mitigate many aspects of our climate that hinder berry production. However, we learned through an earlier planning grant that producers need information on many topics including which type of structure and plastic to choose, how they should be managed and what benefits they can provide. An enormous array of protective structures and covering plastics is available, including specialty “smart” plastics that can diffuse light and alter the spectrum reaching plants. Modifying light quality and intensity – basic conditions to which all organisms have adapted – can directly impact the yield and quality of berry crops while presenting unique opportunities for non-chemical pest management methods. Our goal is provide growers with the knowledge necessary to select structures and plastics that optimize productivity and pest management, while increasing profits and minimizing the generation of plastic waste.

PROGRESS IN 2015 AND PLANS FOR 2016

Michigan (Eric Hanson, Rufus Isaacs, Heather Leach, Annemiek Schilder)

We are measuring light quality in multi-bay tunnels (Haygrove Tunnels Ltd.) in East Lansing and Benton Harbor Michigan. A portable spectroradiometer (PS200; StellarNet, Inc., Tampa, FL) was used to record mean photon flux at different positions and times of day. Each site consists of three 200 foot long adjacent bays of high tunnels (Haygrove Tunnels Ltd.) oriented north to south. In East Lansing, we are comparing two films from BPI-Visqueen; partial UV-blocking Luminance THB (south 100 ft of tunnels) and UV-transparent Lumisol (north half of tunnels). The second site is at the Southwest Michigan Research and Extension Center in Benton Harbor, MI, and also consists of three adjacent 200 foot long bays. Here the north half of bays was covered with an experimental film that is opaque to UV light and the south half with an experimental film that is fully transparent to UV. The experimental films were provided by Jason Moore with Arid AgriTec.

Plastics had clear effects on light quality. Typically, total light in the visible range was reduced by 15 to 20 % relative to open areas. The most distinctive differences in the UV range were observed under the experimental plastic in Benton Harbor. The UV-blocking material eliminated most light in the UV range (<400 nm). Differences between the partial UV-blocking Luminance and UV-transparent Lumisol were also apparent but less dramatic.

Effect of experimental films that either block or transmit ultraviolet (UV) light on light quality inside and outside of multiple bay high tunnels, Benton Harbor, Michigan. Data are means of 6 observations taken in the center of tunnels (12 feet from the edge of the 24 foot-wide tunnels) and 35 feet from the end of plastics. Measured 10 July, 2015, between 11:40 and 11:58.

Flux ($\mu\text{mol m}^{-2} \text{s}^{-1}$)	Outside (control)	UV blocking	UV transmitting
Total (300-800 nm)	2419.1	2048.9	2140.4
300-315 nm	3.0	0.2	2.4
316-400 nm	134.5	7.6	110.2
401-700 nm	1728.4	1529.6	1525.8
701-800 nm	553.2	511.5	502.1

Effect of Luminance THB (partial UV blocking) and Lumisol (UV transmitting) films on light quality inside and outside of N-S oriented, multiple bay high tunnels, East Lansing, Michigan. Data are means of 6 observations taken in the center of tunnels (13 feet from the edge of the 26 foot-wide tunnels) and 35 feet from the end of plastics. Measured 15 July, 2015, between 11:33 and 11:53.

Flux ($\mu\text{mol m}^{-2} \text{s}^{-1}$)	Outside (control)	Luminance	Lumisol
Total (300-800 nm)	2502.2	1822.1	1860.0
300-315 nm	2.7	0.3	1.6
316-400 nm	124.8	40.1	77.7
401-700 nm	1779.5	1300.7	1300.9
701-800 nm	595.2	480.2	479.8

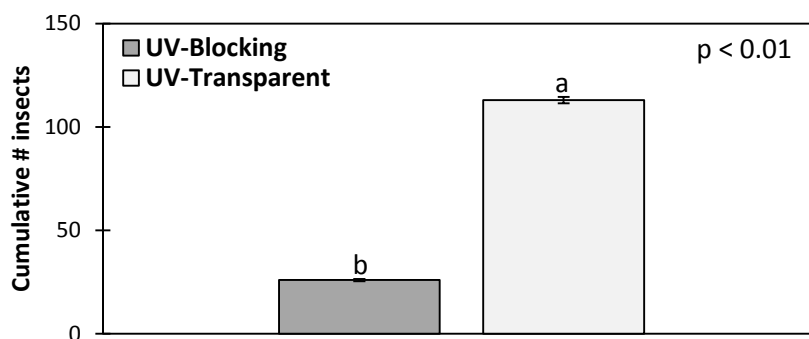
Fruit production and quality. Although plastics at each site were not replicated, fruit of several raspberry cultivars are being assessed at each location to determine if and cultivars varied in their response to the plastics. Three primocane-fruiting cultivars are being grown in the ground at East Lansing (Himbo Top, Joan J, Polka), and managed for production on floricanes and primocanes. At Benton Harbor, 12 cultivars were grown in bags: 3 floricanes fruiting types (Encore, Nova, Prelude) and 9 primocane fruiting types (Clone 62, Imara, Crimson Night, Kweli, Vintage, Double Gold, Nantahala, Josephine, BP-1), although two were pruned to produce on floricanes and primocanes in 2015. Measurements included berry yield, average weight, berry shelf-life and color (data being analyzed).

Fruit color was measured on multiple dates in order to compare cultivars under different plastic types. The expectation is that fruit exposed to ultraviolet wavelengths will develop more intense red color. This may improve the consumer appeal of light red cultivars or reduce the appeal of dark red types.



Raspberries in multiple bay high tunnels in East Lansing (left) and Benton Harbor (right), Mich.

Insects under different plastic types were monitored using yellow sticky traps, direct scouting for insects, trapping for Spotted Wing Drosophila (SWD), and pollinator observations and collections. This was completed at two research farms in Michigan with varying plastic types. At one site with clear UV-blocking and clear UV-transparent plastic, the number of insects observed flying or resting on the underside of the plastic each week was recorded. We found that the number of insects flying against the tunnel under the UV-transparent plastic was significantly higher than under the UV-blocking plastic (Figure 1). However, no differences were found between plastic types at the two sites for pests, natural enemies, or pollinators.



The total number of insects (\pm S. E.) resting or flying at the underside of either clear UV-blocking (dark gray) or clear UV-transparent (light gray) plastic tunnel coverings.

Twelve mini-tunnels were constructed to study the effect of plastics on pesticide degradation. Four tunnels were covered with either diffuse partial UV-blocking plastic, diffuse UV-transparent plastic, or a non-covered control. Two applications containing a mix of insecticides were made in late summer to all plots and leaf samples collected at different times after application were sent to a pesticide analytical lab to compare residue decline curves after application. We are waiting on the results.

The TunnelBerries website was established (www.tunnelberries.org) and is being populated.

2016 Planning - Michigan:

Raspberry harvest times, yields and quality will again be monitored under UV selective plastics in Benton Harbor and East Lansing.

UV-light selective plastics will be installed over raspberry tunnels at K and K Farms in Coloma, MI to assess impacts on raspberry performance, insect activity and disease incidence.

Insect observations under different plastics will be continued using the same sampling techniques as in 2015.

Pesticide degradation analysis in the small tunnels will be expanded in 2016 with more insecticide applications throughout the year and testing different types of plastic.

TunnelBerries Advisory Board to meet during the Great Lakes Fruit and Vegetable EXPO, Grand Rapids, MI, in December 2016, in conjunction with the North American Strawberry and Bramble Growers Associations.

MSU Beginning Farmer Webinar Series. Feb 8, 2016: “Growing raspberries in high tunnels”

Minnesota Mary Rogers, Emily Hoover, Heidi Anderson. University of Minnesota

Official UMN start date on TunnelBerries project was Sept. 1, 2015. In summer 2015, we performed a microplot pilot study from June-November. In this small scale study, the plastic covers Uvinal, Lumisol, Luminance, Tuff-Lite and Lumivar were used over ‘Albion’ strawberries. The following are notable findings from this pilot project:

- Season harvest totals varied from one plot to another. In order of descending productivity: Uvinal (produced the most), Lumisol, Luminance, Tuff-Lite, Lumivar, open control (produced the least)
- Weekly fruit harvest amounts peaked at different points throughout the growing season for different plots (Uvinal and Lumisol peaked in mid-September; the other plots peaked a few weeks later)
- The amount of UV blocked, as averaged from measurements taken over the course of the season, was greatest for Lumivar, followed by Uvinal, Tuff-Lite, Luminance, then Lumisol. The amount of Photosynthetically Active Radiation blocked was highest for Luminance, followed by Uvinal, Lumisol, Lumivar, and Tuff-Lite.
- In progress: plastic samples taken once per month from each tunnel are being analyzed to determine the extent to which each different material’s ability to block UV changed throughout the season.

Plans for 2016

- Low tunnel strawberry experiment
- Sixty, 10-foot plots, each with 20 plants (1200 strawberry plants total)
- Main plot: 2 plastic treatments (UV-blocking and UV-transmitting) + open control plots
- Subplots: 3 insecticide treatments (PFR 97 WDG, Grandevo, Mycotrol O) + water control
- Gathering data on: fruit yield, fruit marketability, air temperature, transmittance of ultraviolet light, photosynthetically active radiation, insect populations, degradation rate of different insecticides

New Jersey A.J. Both, Rutgers University

2015 activities

Limited activities were conducted during 2015. A (so far unsuccessful) search was conducted to identify an engineering student with appropriate skills (greenhouse engineering, computational fluid dynamics, field measurements and simulation modeling) to work on evaluating ventilation systems and strategies for high tunnels.

For another project, during the month of December, we started construction of a YMCA operated high tunnel on an abandoned housing lot in East Orange, NJ. The construction crew included several military veterans that are enrolled in a work training program organized by Rutgers Cooperative Extension. The 20 by 36 feet tunnel is part of a community garden project and will be completed in the spring of 2016. The tunnel will have roll-up sides, polycarbonate end-walls and a polyethylene roof cover. Raised beds will be constructed inside.



Photograph: Construction of a 20 by 36 feet high tunnel (EastPoint, Rimol Greenhouse Systems, Inc.) in East Orange, NJ.

2016 plans

We plan to identify and attract a student that can work on our main task: Evaluating ventilation systems and strategies for high tunnels. The student will receive training in software techniques including computational fluid dynamics. Using field measurements and model simulations, different designs and strategies will be evaluated. In collaboration with Kathy Demchak at Penn State, we plan to design a series of ventilation systems for high tunnels: roll-up sides, roll-down sides, side and end-walls openings, and ridge vents. These systems will be installed and tested during 2016. Design suggestions for the roll-down and ridge vent systems are welcomed.

New York: Marvin Pritts, Lois Levitan, Laura McDermott, Kasper Kuehn, Cornell University

Progress in 2015

Five sites for low tunnel strawberry production were examined. Two of the sites were at Cornell research farms and three were located at private farms across NYS. Data was collected weekly throughout the growing season to evaluate total yield and quality under the tunnels and in a control plot. In late August and September 3 field meetings were held for grower and extension audience. More than 100 people attended all of the workshops. The dates and locations for workshops are:

Monroe County

Tuesday, August 25th, 2:00-4:00pm
Green Acre & West Wind Fruit Farm
930 Manitou Rd., Hilton, NY 14612

Tioga County

Friday, September 11th, 2:00-4:00pm
Terry's Berry Farm
284 Church St., Barton NY 13734

Albany County

Thursday, September 16th, 3:00-5:00pm
Feura Farm, 210 Onesquethaw Creek Road, Feura Bush NY 12067

One formal workshop was held on Tuesday, October 27th – Small Fruit Workshop, Bath, NY - *Using Day Neutrals and Low Tunnels to Optimize Berry Production* – Marvin Pritts
Additionally Dr. Pritts and Laura McDermott wrote extension articles that have appeared in several publications throughout the state.

Recycling. Lois Levitan has been pursuing the recycling aspect of the ag plastics.

Communicating with plastic reclaimers and manufacturers of products with recycled content in order to flesh out information about the recycling options available to growers.* This work is in collaboration with Moore Recycling Associates (MRA). The information is being integrated with MRA's PlasticsMarkets.org online directory and behind-the-scenes database of information about plastics recycling markets. My contributions are in identifying reclaimers willing and able to process agricultural plastics, particularly the smaller, emerging processors, and in introducing sufficient detail about agricultural plastics (resin type, quality, color, etc.) to be useful to these markets.

* However, in reality, market information is likely of greater use to organizers of agricultural/horticultural plastic collection and recycling programs because the bigger stumbling block to recycling is in amassing sufficient volumes to be of interest to recycling markets.

Building the network of stakeholders in agricultural plastics recycling, to better connect suppliers (growers and grower organizations) with recycling markets, promote market development, and provide a platform for information exchange about innovations in materials, equipment and recycling infrastructure. In addition to carrying out this work in conjunction with developing the markets database described above, and continuing to develop a stakeholder networking database that has been a work-in-process for the past decade, I am laying groundwork for a new organization for stakeholders in plasticulture stewardship.

The stakeholder organization will be maintained under the auspices of either the Southern Waste Information Exchange (SWIX) and/or their Agricultural Plastics Recycling Conference (APRC). This

effort is in collaboration with Gene Jones, CEO of SWIX and, since 2014, organizer of the annual APRC (which will likely become biennial after the 2016 meeting). The concept is to develop a means for communication/information exchange in the intervening periods between conferences, a role previously played by the Agricultural Plastics Workgroup of The Pesticide Stewardship Alliance (TPSA) and the American Society for Plasticulture (ASP), neither of which still exists. While the organization is envisioned as primarily US- or North America-based, I have also been building a network with European colleagues. Gene Jones and I represented the United States at the November 2015 RIGK/EPRO (European Plastics Recycling Organization) 1st International Recycling Forum on Agricultural Plastics, where I met key European colleagues, gleaned much information about equipment, logistics and markets for recycling high tunnel plastic in Europe, and presented an *Overview from the United States: Collection Systems & Markets for Domestic Recycling of Agricultural Plastics* that is archived on eCommons, Cornell's digital archive.

Website and educational/outreach resources. The website *Recycle Agricultural Plastics* <http://recycleagriculturalplastics.net/> is under development as the repository for the body of knowledge developed over the 10-year history of the Cornell-based Recycling Agricultural Plastics Program. I am in process of updating and revising educational materials developed when we knew less and had fewer options. Resources pertinent to recycling tunnel covers will be posted to the Tunnel Berry website.

Plans for 2016:

Several presentations on low tunnel production are scheduled for the winter farmer meeting season. These include the following:

January 14th, Catskill Regional Ag Conference, SUNY Delhi, *Extending the Strawberry Season Using Day Neutrals and Low Tunnels* – Laura McDermott

January 21st, Empire State Producers EXPO, OnCenter, Syracuse – *Extending the Strawberry Season Using Low Tunnels* – Marvin Pritts and Laura McDermott

February 19th, Hudson Valley Berry School, Kingston – *Extending the Strawberry Season Using Low Tunnels* – Laura McDermott

March 24th, Small Fruit Workshop, Ballston Spa - *Extending the Strawberry Season Using Low Tunnels* – Marvin Pritts

Additionally several growers across the state have expressed interest in evaluating the low tunnels. These include growers in Essex county, Rensselaer county, Montgomery county and Herkimer county. Surveys will be conducted with these growers to evaluate the adoption potential.

A number of extension articles are planned for the 2016 season.

Recycling. Cataloguing and testing equipment for removing tunnel plastic. After considerable thought and discussion, I have changed course somewhat on what had been a key objective for my part of the Tunnel Berry project. I had initially anticipated a need for BMP guidelines for removing plastics for recycling, but then realized that growers already have their systems in place for removing tunnel covers, whether for the winter or for ultimate disposal, and that what is needed instead are (1) criteria for plastic destined for recycling rather than for garbage, and (2) information about options for mechanizing the process. Thus I have been scouring the literature, trawling through trade shows, and in multiple conversations to identify roller and baling equipment that might be suitable for pulling and compacting covers. Contacts made at the RIGK/EPRO conference were useful in this regard. In Spring 2016, I will observe and document use of some of the equipment. The information will be

posted to the Tunnel Berry website and archived on eCommons, probably in the format of a spreadsheet with explanatory notes.

Pennsylvania Kathy Demchak (Co-Project Director), Dennis Decoteau, William Lamont, Kathleen Kelley, Richard Marini, Pennsylvania State University:

Progress in 2015:

Over 100 different plastics films were identified, with about 1/3 of those currently being marketed in the U.S. A listing of the most commonly available coverings and sources was assembled. Samples of 51 different plastics available to growers in N. America were obtained and light transmittance characteristics were identified by Mike Glenn at Kearneysville. The 51 plastics fell into about 8 categories related to transmittance characteristics and 2 related to diffusion. Many were very similar to each other.

Eighteen high tunnels were refurbished at Penn State, and 4 new tunnels were built, with 6 more to be built next spring. Five plastics with varying transmittance patterns were installed on 3 tunnels each. Strawberries were planted in grow tubes in October using 4 different media and 2 fertilizer regimes to determine how to best grow the plants when experiments begin in earnest next year. Fifteen Raspberry Pi dataloggers are in various stages of completion and are being programmed for microenvironmental data collection next year. Until they are deployed, air and soil temperature data is being collected in 10 tunnels with Watchdog dataloggers.

We are beginning to make videos on high tunnel construction that will be made up of a combination of still photos, normal and time-lapse footage, and computer simulations, which sometimes allows us to show much of what we are doing more clearly than "real" footage.

A survey for high tunnel berry growers that focuses on use of plastics and recycling is being developed, and a first draft is undergoing IRB review.

A portable high tunnel setup was developed that allows a quick assembly of a tunnel. The tunnel can then be disassembled and reassembled at a different location. This was first set up at the Pennsylvania Farm Show, but will be useable at hands-on workshops wherever we want to conduct them.

Plans for 2016:

- 1) Conduct tunnel construction workshops in the spring at Rock Springs for extension educators and interested grower groups (new farmers from the Start Farming Project, and Women in Agriculture Network). Which aspects of deciding on which high tunnel to buy, and tunnel construction and establishment was of most interest to growers when were first getting started?
- 2) Plant raspberries and strawberries in high tunnels. Is there anything we should be getting details worked out on? For example, timers and automation – what additional info would be useful?
- 3) Establish a similar experiment under low tunnels. For the advisory committee: What variety is of most interest (currently planning on Albion)? Is there interest in planned treatments (5 plastics on low tunnels, in combination with no mulch, black mulch, and white mulch) and would they be likely to be adopted if they worked?

4) Provide information for project web site.

Vermont, David Conner University of Vermont

Progress in 2015

David's overall responsibility is to provide economic analyses for various components of the project. Kathy will send David data on the costs of tunnels (kits and materials, as appropriate), including costs of different plastic covers. If costs of plants, soil amendments and other production supplies are available, send those too. Research team/technicians will measure in each tunnel the marketable yield of berries and send to David. David will use current price data to calculate revenue and compare to costs of plastic

2016 Plans

Prior to season (e.g., January 2016), David will share with technicians a set of daily and monthly logs and train in their use. Techs will send monthly data reports. David will enter and analyze data.

In the 2016-17 winter, David will convene sessions at ~2 grower meetings to share 2016 data and recruit farmers to collect data. David will also begin interviewing or surveying farmers using different tunnels on growers' perceived ease of use and tunnel efficacy. David will meet with participating and other interested growers to share data and discuss implications.