Colloquium - Biodegradable Plastic Mulches for Specialty Crop Production: Current Status and Future Directions

2012 ASHS Annual Conference, Miami, FL, USA
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Sponsor: Plasticulture (PLAST) Working Group
Moderator: Carol Miles, Washington State University

This colloquium will focus on the new multi-disciplinary topic of using biodegradable mulches in specialty crop production systems. It will feature speakers who are international leaders in horticulture, soil, polymer, textile, and socio-economic sciences. Important aspects of product development, field application, grower acceptance, and environmental impact/benefit will be explored and shared.

Opening Remarks - Carol Miles

Plastic mulch has long been used for specialty crop production and provides many benefits including reduced weed growth, improved moisture control, increased soil temperature, and enhanced plant growth. However, plastic mulch is costly to retrieve and dispose, and has inherently low biodegradability which limits its use in sustainable agriculture. Biodegradable mulches have the potential to provide the same benefits as plastic mulch with the added advantage of fully degrading at the end of the cropping season. This colloquium will provide an overview of biodegradable plastics in general and biodegradable plastic mulches specifically used in agriculture.

Understanding the Science of Biodegradability and Exploring Misleading Claims - Ramani Narayan

Biodegradability is a measure of the ability of microorganisms present in the disposal environment to utilize carbon substrates for energy. Plastics (carbon substrates) can be engineered to be biodegradable, thereby providing for their removal in an environmentally responsible, safe, timely and efficacious manner. This is a particularly important and valuable attribute for single use, disposable, and short-life products such as plastic mulches used for specialty crop production as well as packaging and other consumer articles. Unfortunately, there are a growing number of misleading, deceptive, and scientifically unsubstantiated biodegradability claims proliferating in the marketplace. Evidence of degradation, fragmentation or partial biodegradation is used to claim that the plastic substrates will not accumulate or persist in the environment. Degradation/fragmentation or partial biodegradation is not a sustainable option, and will lead to potentially serious environmental and human health consequences. Documenting complete biodegradation (microbial assimilation) of the plastic substrate in the targeted disposal environment (soil) within a specified and measurable period is necessary to ensure safe and complete removal of the plastic material. We will review fundamental principles and the science underlying biodegradability and degradability of polymer materials in the environment, and describe the harmonized International Standards that are in place to demonstrate microbial utilization of the plastic substrate. Ways to differentiate the new biobased plastics being introduced in the market place and their value and attributes will be discussed. Participants will learn how to recognize misleading claims regarding plastic biodegradation and bioplastics, and the right questions to ask about these products. Participants will also become

knowledgeable on the International Standards for biodegradability and will gain a fundamental understanding of the issues regarding plastic biodegradation and bioplastics.

Fabricating Biodegradable Mulches - Douglas G. Hayes*, Larry C. Wadsworth, and Karen K. Leonas

Considerable effort has been made in the last 25 years by industry, academia, and government laboratories to develop biodegradable mulches which can be plowed into the soil at the end of the growing season, to subsequently become fully mineralized into carbon dioxide and water during succeeding months. This presentation will provide a review of biodegradable mulch research and development from a historical and materials-related perspective, and present the current state-of-the-art, including feedstock performance and biodegradability. Recent research by the authors on the development of poly(lactic acid) (PLA)-based biodegradable mulches fabricated by using nonwovens textile technology will also be presented. Preliminary findings on performance of these PLA mulches as assessed through soil burial in greenhouse experiments in Tennessee, and in field trials with high tunnels and open fields in Tennessee, Texas, and Washington will also be included.

Biodegradable Mulches and Specialty Crop Production - Michael D. Orzolek

The use of plastic mulch for the production of vegetable crops in the U.S. has doubled in the last 10 years. While energy costs have risen dramatically in the last 5 years, plastic film manufacturers have saved money on the production of mulch film by reducing the thickness of the film; film thickness has gradually gone from 1.5 mil. to 0.5–0.7 mil. during this time period. One disadvantage of the thin plastic film is the retrieval potential for growers after the crop has been harvested in the field. Thin films 0.7 mil. or less do not retrieve from the field very easily and thus are more difficult to remove for recycling or disposal. Plastic mulch films that are biodegradable have been developed, and are being sold commercially in Europe and North America. These new, innovative plastic films biodegrade during composting, and are being evaluated for biodegradability in the field. They can also be rototilled into the soil at the end of the growing season, saving at least $100/A for pick up and disposal. Field research has demonstrated that the biodegradable mulches will produce equivalent marketable yields of most specialty horticultural crops compared to standard plastic mulch. Warm season vegetable crops have performed very well when grown on biodegradable plastic mulch. Two issues that growers may be apprehensive about are the initial cost of the biodegradable mulch compared to standard plastic mulch, and the sometimes unpredictable degradation rate and timing of biodegradable mulch. This presentation will discuss the history of biodegradable mulches in the market place in the U.S., including early products and issues regarding their biodegradability in the field and in composting. Also discussed will be an overview of some current biodegradable mulches and their impact on yield of vegetable crops.

Evaluating Biodegradable Mulches In Diverse Climates In the U.S. - A.L. Wszelaki*, C. Miles, R. Wallace, T. Walters, J. Cowan, J. Martin, D. Inglis

In a recent study, deterioration, weed control, and tomato yield were evaluated for three commercially available mulches marketed as biodegradable (BioBag, BioTelo, WeedGuardPlus), an experimental spunbond poly (lactic acid) mulch (SB-PLA), and black plastic mulch. This study occurred in three climatically diverse regions of the United States: the subtropical southeast, with a hot and humid summer climate (Knoxville, TN); the High Plains south, with a

hot and dry summer climate (Lubbock, TX); and the Pacific Northwest, with a cool, humid summer climate (Mount Vernon, WA). The test crop was tomato grown in both open field and high tunnel production systems. In all three locations, mulch deterioration (measured visually) was greater in the open field when compared to the high tunnels—likely due to increased moisture, solar radiation, and wind (with associated blowing abrasive soil particles) in open field environments. Mulch deterioration was greatest for the commercially-advertised biodegradable mulches. Weed pressure was greatest under the experimental SB-PLA-10 mulch—likely due to the opaque nature of the fabric, which favored weed seed germination. The SB-PLA-10 was reformulated and recolored to alleviate this problem. Tomato yields were improved with mulch treatments when compared to bare ground in Knoxville and Mount Vernon, whereas in Lubbock, bare ground and spunbond fabric tended to have the highest tomato yield—likely due to the reduced soil temperatures in those plots.

Biodegradable Mulches and Soil Quality - Jennifer Moore-Kucera

Biodegradable mulch films could be desirable alternatives to black plastic in agriculture, however, little is known about their degradability in soil across contrasting environments. The objectives of our study were to: 1) measure % area reduction of four potentially biodegradable mulches for up to 2-year burial in soil following use in tomato crop production; and 2) assess soil biological properties (enzyme assays, microbial biomass, and nitrogen mineralization potential) as soil quality indicators. Four replications of both high-tunnel and open-field sites were established in three distinct eco-regions of the United States (southeastern Tennessee; northwestern Washington; southern high plains Texas). Mulch plots at each site included: experimental spunbond poly-lactic acid (SB-PLA-10), BioBag and BioTelo (two commercially-available starch-based films), and WeedGuardPlus (cellulose-based commercial mulch). No mulch was the control. Following 2010 tomato harvest, used mulches were removed and cut into pieces, soil was tilled, and 161 cm2 nylon mesh bags each containing 103 cm2 of a mulch and ~400 g of resident soil were reburied into each mulch's corresponding plot. To date, mesh bags have been extracted at two 6-month intervals. At 12-month field incubation, 0% reduction was observed for spunbond at all plot locations. Reduction of BioBag and BioTelo was greatest in Texas (84% and 75%, respectively) with no differences between high-tunnel and open-field. In Washington, no obvious reduction was observed among BioBag and BioTelo, with one exception (88% in open-fields); in Tennessee there was also minimal reduction with one exception (87% in high-tunnels). BioBag and BioTelo showed an average of 15% and 57% reduced area, respectively, in open fields in Tennessee. WeedGuard showed 100% area reduction at all sites across all three regions with one exception (81% in TN). WeedGuard also showed enhanced enzymatic potential relative to no-mulch control (11% higher averaged across all plots). Soil biological responses were variable among plot locations, treatments and sampling dates. No specific trends were observed for nitrogen mineralization potential among mulch treatments, but WeedGuard samples generally had higher enzymatic potential than no-mulch with variable responses from the other BDM treatments. The lack of consistent responses among mulches, sites, regions, and post soil incorporation, indicates that other factors (temperature, moisture, soil pH) may play a more important role in soil quality than actual degradation of these materials over time.

Biodegradable Plastic Mulches: Barriers and Bridges to Adoption - Jessica Goldberger and Carol Miles*

Since 2009, the experiences and perspectives of specialty crop growers, Extension personnel, agricultural input suppliers, and others have been assessed in order to better understand the barriers and bridges to the adoption of biodegradable plastic mulches for specialty crop production systems in the United States. This presentation reports the results from a survey of progressive growers (Beus, 2008), six focus groups with individuals involved in biodegradable plastic mulch agro-production systems (Beus, Jones and Kirschner, 2010–11), and a survey of Extension personnel, agricultural input suppliers, and other individuals (intermediaries) who work with specialty crop growers (2012). Surveys and focus group meetings have taken place in Tennessee, Texas, and Washington, three diverse agricultural regions of the United States. Results showed that approximately 30% of progressive growers were using biodegradable plastic mulches, but they were not satisfied because of unpredictable or incomplete biodegradation. Most growers (79%) lacked adequate access to information about biodegradable plastic mulches, and 50% were interested in working with scientists and Extension educators on research related to them. From the focus group meetings, perceived barriers to the adoption of biodegradable plastic mulches included high cost, lack of knowledge, uncertain performance, and uncertain long-term impact on the soil. Perceived bridges to adoption included environmental benefits, reduced waste, and effective weed control. The intermediary survey results are forthcoming. The survey and focus group findings can be used to guide the activities of all those involved in the development and promotion of biodegradable plastic mulches for U.S. specialty crop production systems.

Closing Remarks and Discussion - Debra Ann Inglis and Carol Miles*

Biodegradable plastic mulches represent an exciting new venture in agriculture. There are the anticipated benefits of reducing crop production costs while minimizing undesired plastic waste in the environment. The work of scientists in multiple disciplines is leading to accelerated findings regarding fabrication, microbial utilization in soil, reactions under diverse climatic conditions, impacts on crop yield and quality, and consumer acceptance. As we increase our understanding regarding the claims associated with biodegradability, agricultural scientists are able to contribute to the development of biodegradable plastic products outside of mulches, or even outside of agriculture. Future research may also focus on issues related to the risks and benefits of carbon emissions during microbial break-down, utilization of targeted microbial degraders, and accommodating organic production requirements.