Degradable Agricultural Mulch, a Technical Textile: Year 1 of a Comprehensive Field Study

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Introduction: Over the past two decades there have been significant technological innovations advancing textile processes and product technologies, and increasing both the diversification and number of applications for technical textile products and nonwovens (Chang and Kilduff, 2002). Technical textiles have been grouped into 12 application areas, one of which is Agrotech and this area includes all activities concerned with the growing and harvesting of crops and animals. Since agricultural land is declining while the demand for food is increasing, there is a need for more intensive agricultural production, including season extension (David Rigby Associates, 2001). Thus, protective crop covering systems are being used to optimize the production of fruit and vegetables and a key component in these systems are plastic mulch. Traditionally, mulch has been comprised of non-renewable petroleum-based plastics. For many growers, there are no suitable alternatives to plastic mulch, however, there are drawbacks to use including product cost, disposal concerns and the labor for removal from the field. In 2004, Schogren and Hochmuth estimated that 143,300 tons of plastic mulch was used in the U.S., with average disposal costs reaching $600/acre. Researchers estimate that about 50% of used agricultural plastics are burned on-farm, which releases high levels of toxic pollutants into the air, and is illegal in most areas (Levitan, 2005; Lemieux, 1997). Although controlled incineration or recycling of used plastic mulches might one day become viable, these approaches would still require costly removal and transportation. There is a critical need for crop mulch that can be effective during the growing season and tilled into the soil after a crop harvest, to then fully biodegrade without negatively impacting the soil ecosystem.

A three-year, multistate and multidisciplinary research project, funded by NIFA Specialty Crops Research Initiative is focusing on the evaluation of experimental and currently available biodegradable mulch (BDM) products, in both high tunnels and open field tomato production systems, at three sites in the U.S. (TN, TX, WA). The results of the degradation of the BDM’s during Year 1 of this study, completed in 2010, are presented here.

Materials & Methods: The experimental design for this study was 5 x 2 x 3 x 4 with five mulches, two field conditions, three field sites and four sampling times. The mulches include an experimental white spunbond (SB) poly(lactic acid) (PLA) product, two commercially available BDM starch-based black film products (BioAgri and BioTelo), a black cellulose-based product (WeedGuardPlus) and conventional black polyethylene (PE) film (Pliant Corporation). The experimental mulch material was developed for the study using fibers of PLA and nonwoven
fabric production techniques (Kahn, Wadsworth, and Ryan, 1995). Its inclusion is helping to determine if a fibrous structure of nonwoven biopolymer with its corresponding higher surface area and porosity will result in an accelerated rate of biodegradation as compared with film structures. Field conditions included companion high tunnel and open field experiments. The field sites were in western Washington, eastern Tennessee and central Texas. The test crop was tomatoes. Mulch samples were taken prior to the mulch being laid in the field and then at three times during the production cycle. Selected physical properties indicative of degradation were measured at each sampling time. In accordance with ASTM test methods properties of breaking strength, elongation, tearing strength [5] were determined. Pore size and molecular weight (MW) were measured and specimens were observed by scanning electron microscopy (SEM).

Results and Conclusions: All products evaluated in this study, both BDM and non-BDM mulches, showed a loss of physical properties (strength and elongation) after exposure in high tunnel and open field environments. There were changes in MW indicating degradation of the products. SEM micrographs showed cracks and pitting of the starch based BDMs which is also indicative of degradation. There were no other degradation patterns with regard to location or environment that could be determined based on mulch type. In comparing the influence of open field and high tunnel environments on strength loss, almost two-thirds of the samples had increased strength loss when in the open field. This result was expected as sunlight intensity and other weathering factors are thought to increase degradation. Cellulose had the greatest loss of strength in the open field indicating that it was more readily degraded by sunlight and other weather factors when compared with the starch-based mulch products, SB PLA and PE film. The SB PLA did not show increased degradation compared with other BDMs studied here. Future work, evaluating a SB product with PLA of lower MW, finer fibers in the SB structure and colored with black pigment, is planned.

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References:
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