Eco-E Project Proposal

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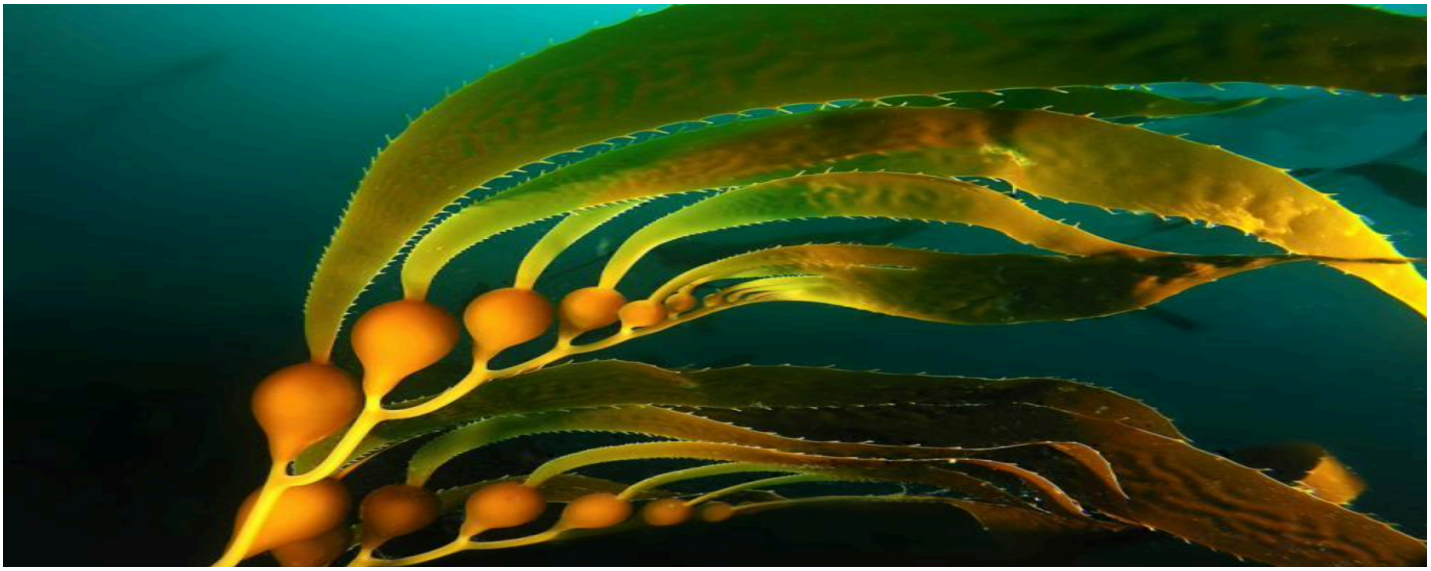

Marine Mulch

A regenerative alternative to agricultural plastic mulch films

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Background

The benefits of mulching with organic and inorganic materials is widely recognized as an effective method for increasing yields of annual and perennial crops.[1] Mulching provides a variety of benefits by acting as a physical barrier that helps to suppress weeds, conserve water, regulate temperature and control erosion. The introduction of plastic technology revolutionized the agricultural industry in the late 1940's and gave rise to the term "plasticulture," which includes all plastics used in farming operations, including plastic films. Polyethylene film was soon considered to be the most effective method of mulching[2] and plastic films now make up the largest volume of plasticulture, totaling an estimated 6.96 million tons of plastic annually and accounting for 2% of global plastic production[3].

One of the reasons why plastic mulch was quickly commercialized and now ubiquitous is due to the fact that natural mulches are not as effective for crop production for the full growing season and present a variety of challenges to farmers in terms of inconsistent impacts to soil composition and nutrient levels[4]. Furthermore, modern technology has allowed plastic film mulches to provide the same benefits as organic mulch while providing additional benefits, such as protecting crops from soil contamination. Most importantly, farmers can incorporate plastic mulch into their fumigation and irrigation systems to better control pests and weeds. Plastic mulch films can be laid mechanically and are relatively inexpensive, considering the benefits and increased yields. Farming cash crops was just not possible in the U.S. until plastic mulch was introduced[5] and according to Jason Lesh at Farm Cart Organics "plants just love these plastics"[6].

However, studies show that agricultural systems are trading the benefits of short-term yields for long term impacts on the environment and human health. For example, studies show that plastic materials increase uptake of toxic chemicals in crops[7i]; degrade soil health[8]; and inhibit carbon sequestration[9]. Furthermore, plastic films break down into micro plastics, which runoff into waterways and the ocean, thus threatening freshwater and marine ecosystems[10]. The impact to the environment is substantial.

Most plastic mulch products only last one growing season. So at the end of its lifecycle, farmers are burdened with the labor intensive, cumbersome task of pulling up the soil laden plastic. Then, they generally bury, burn or dump the plastic waste. As farmers are faced with the growing challenges of labor shortages due to COVID, increasing labor costs, competitive global markets, and changes in weather patterns, this leads to even tighter margins in the agriculture industry. The use of conventional plastic mulch poses a significant burden on farmers, the environment and human health over the course of its entire product lifecycle.

There have been a number of business solutions applied to this issue. For example, there are companies that provide plastic mulch recycling services, but there are challenges in dealing with the soil contamination on the plastic. Furthermore, low oil prices have caused many of these business to be short lived. There are however, promising new resource recovery technologies, such as pyrolysis machines that turn plastic into oil[11]. It is promising to know that large-scale farmers, such as Driscolls, are investigating various solutions for addressing their plastic problem. While these end-of-life options may provide a more immediate solution for dealing with the waste, ultimately, these solutions don't address the root environmental and health implications of using plastics in our agricultural systems.

The development of a viable alternative to plastic mulch provides a unique opportunity to mitigate the negative impacts of plastic mulch on farming operations, while also protecting the environment and human health. There are a number of alternative techniques and biodegradable products currently used by farmers in an attempt to remedy this issue. For example, some farmers use paper, burlap, geotextiles and other natural materials as mulch. Yet these methods are not effective at suppressing weeds, managing pests, or conserving water compared to plastic[12]. Some farmers use a "rolling", "crimping" or mowing technique to create a cover crop mulch which adequately supplies nitrogen, suppresses disease, and supports healthy plants; however, weeds still remain a challenge[13]. There are also other materials, such as straw or hay that can be used as mulch. However, there are downsides to using these materials in that they can be a haven for pests, and labor intensive to apply[14].

Biodegradable plastic mulch is another alternative solution and there are a number of companies that have spent the past decade on R&D of new products. One consideration in using biodegradable plastics is the trade-off between durability and biodegradability. The primary criticism of many bioplastics is that they still contain petroleum based additives and plasticizers[15], and therefore only biodegrade under very specific environmental conditions[16]. Many farmers and regulators question the efficacy of these products in regards to the impacts on the soil, durability and timeline for fully biodegrading. There is a GMO-corn based bioplastic that has started to gain traction, but farms that use it cannot meet current organic certification requirements[17]. The

USDA states that "at this time, no biodegradable mulch is allowed on organic farms"[18]. While there are many people in academia and business working on addressing these issues, there is yet to be a solution that has been highly effective or widely adopted.

Eco-E Opportunity

There is a growing body of research on two types of polymers, polylactic acid (PLA) and polyhydroxyalkanoate (PHA), which hold great potential for bioplastics with a wide range of commercial applications[19]. These polymers are relatively inexpensive to manufacture and can be mode in large quantities[20]. These polymers are made from 100% renewable resources, derived from processes involving sugars, starches and microbes.

Many home gardeners and small farms use seaweed as a natural fertilizer and mulch. There are studies that demonstrate promising potential for seaweed to be used as a sugar for making natural polymers[21]. There are a number of companies that are currently making seaweed-based bioplastics, mainly for applications in packaging. While seaweed provides one exciting possibility to investigate, there are also a multitude of other source materials that could be considered for making an alternative product. Ultimately, this project will focus on connecting the needs of the customer to potential new technologies that can be utilized for agricultural mulch films. The goal is to provide the same benefits of conventional plastic mulch, but biodegrade at a reasonable rate and potentially even add nutrients to the soil at the end of the product lifecycle.

Objectives

The objectives of this project are to determine whether plastic mulch films can be replaced by an alternative product. Therefore, this project will involve answering the following research questions:

1. **Understanding the Customer Problem:** What are the most important benefits of using plastic mulch? What are the challenges farmers face in using this product? What do farmers consider in their decision-making process, and what trade-offs are they willing to make in order to switch to using an alternative product?

2. **Business Model:** What customer segments would receive the greatest benefits of an alternative product and would they be willing to pay for it? How will new regulatory and certification requirements as well as consumer perceptions change the need/incentive to address plasticulture? Who are the key customers and how can the value of the product be communicated?

3. **Determining Technological Feasibility:** Is bio-based plastics technology advanced enough to develop a new product that provides the same benefits as current plastic mulch, while potentially providing added benefits and remaining cost competitive.

Significance

The principles of regenerative agriculture provide a guide for farming practices that, among many other benefits, aim to reverse climate change. Mainstream media, corporations and citizen action groups are starting to demand these principles be applied in our food systems, especially to address soil degradation. Additionally, there has been significant examination of the food industry for the excessive use of plastics in packaging. That same public scrutiny has not yet focused as strongly on the agricultural sector; yet the topic of plasticulture will likely hit mainstream media in the near future. For example, Driscolls has faced negative publicity about their use of plastic clamshells[ii] and in order to get ahead of this issue on the agricultural operations side of their business, they have taken their own initiative to research options for mitigating the impacts of their plastic waste[22]. Meanwhile, a strong contingency of non-profits, regulatory agencies, and stakeholders has been working to reduce the impacts of plasticulture and microplastics in agricultural runoff. Farm Order 4.0, which is planned to take effect March 2021, will likely establish requirements for farmers that use plastics to implement Best Management Practices and management plans. These new permit requirements will significantly impact operations and increase costs for farmers that use plastic products on their fields. Ultimately, the challenges and burdens for farmers using conventional plastic mulches will only get worse.

Berries, melon, lettuces, tomatoes, peppers, broccoli, cabbage and squash are some of the main crops grown using plastic mulch. Many of California's top agricultural products are grown using some sort of plasticulture. The world looks to California as a leader in the agricultural sector, and considering it has some of the largest growers in the world, the target market will be large organic farms within the state. This target market will likely be early adopters of an alternative product and have the greatest potential to be a catalyst for change within the industry at large. This is based on an understanding that once a specific product is deemed effective, there is quick adoption by the rest of the agricultural industry[22].

Available Data

This project will rely heavily on a literature review of research findings in three main areas. First, a large body of research on the benefits of conventional plastic mulch in the agricultural industry will help inform development of an alternative product. Second, there is a lot of research (mainly from researchers in China) on the impacts of plastics on soils, the environment and human health. Lastly, the literature review will include studies on new bioplastics technologies, including starch, cellulose and protein based materials. This project will require a deep understanding of the biochemical and microbial processes involved in plant growth, soils, decomposition and bioplastics.

Furthermore, databases may provide valuable information for this research topic. For example, the USDA has a number of databases, including the Agricultural Statistics Services database, the Economic Research Services Agricultural Baseline database, and the Web Soil Survey database.

Possible Approaches

1. **Literature review** of secondary sources.
2. **Primary research by conducting interviews** of customers, industry professionals and academic experts.
3. **Cost-benefit analysis** to understand the trade-offs between effectiveness of a product, cost to customers and environmental impact.
4. **Customer survey** to better understand the varied needs of the customer, potential incentives for using an alternative product, and criteria for determining effectiveness of the product.
5. **Pilot test** a concept in collaboration with UCSB materials science engineering students to possibly develop a minimum viable product.

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[22] Athanassiadis, Minos. Founder and Managing Director of Fresh Link Group. Interview by Annie Lovell. 30 November 2020.

List of Interviews

1. Scott, Sarah. Sr. Supplier Quality Specialist; Sustainability Team Member, Amy's Kitchen. Phone interview, November 10, 2020.

2. Mendoza, Becky. Founder, Environmental Activist, Non-Profit Manager, Changing Tides Foundation. Phone interview, October 26, 2020.

3. Harrison, Eliza. Business Operations Coordinator, Ocean Rainforest. Phone interview, October 29, 2020.

4. Miller, Kendall. Programs and Operations, Regenerative Organic Alliance. Zoom interview, November 11, 2020.

5. Heisley-Cook, Taylor. CEO, The Hurd Co. Zoom interview, November 16, 2020.

6. Rodoni, Nikki. Founder and CEO at Measure to Improve, former Director of Sustainability at Gills Onions. Zoom Interview, December 5th, 2020.

7. Lesh, Jason, Owner. Farm Cart Organics. Phone Interview, December 08, 2020.

8. Rowe, Allison. Gleaning and Mobile Market Program Manager, Island Grow Initiative. Zoom Interview, December 08, 2020.

9. Roach, Laura. Owner/Winemaker, Loubud. Zoom Interview, December 4, 2020.

10. Athanassiadis, Minos. Founder and Managing Director, Fresh Link Group. Zoom Interview, November 30, 2020.

11. Home Depot Sales Person. In-person Interview, November 27, 2020.

12. Monper, Kyle. Field Plastics and Water Resources Manager, Driscolls. Zoom interview, 17, 2020.

13. Rodgers, Jason. V.P. Operations, Titan Farms. Zoom interview, February 1, 2021.

14. Krone, Pam. Agricultural Water Quality Coordinator, California Marine Sanctuary Foundation / Monterey Bay National Marine Sanctuary. Zoom interview, December 16, 2020.

15. Miyashiro, Bobby. Master of Environmental Science and Management Candidate 2021, University of California, Santa Barbara. Zoom interview, December 15, 2021.

16. Jack, Lauren. Founder/CEO, Pantry Party. Phone interview, January 8, 2021.

17. Fogg, Sandy. Former Bren Eco-E Student (Highly Cultured) and current Sea Gran Fellow. Phone interview, January 20, 2021.

18. Holden, Dr. Trish. Professor at the University of Santa Barbara, Bren School of Environmental Science and Management. Zoom interview, February 1, 2021.