GREEN PLASTICULTURE

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Abstract— The use of plastic components in agriculture has helped the sector to develop and produce more yield compare to the ancient times. Modern use of plastic in agriculture is defined as Plasticulture and been referred any application of thermoplastic including polyethylene and polypropylene on the soil surfaces, mulching system and green houses. The importance of Plasticulture in modern technique of farming is tremendous especially in improving the soil structure, controlling soil temperature in seasonal countries, controlling weeds and soil-borne diseases and as seedlings carriers from the nurseries to plantation fields. Green Plasticulture refers to sustainable type of polymeric materials used in agriculture that contributes significantly less impact to environment and the soil, especially. Many countries such as Malaysia and Indonesia depend heavily in agricultural sectors thus causing the plastic uses in the field as enormous. This paper review Plasticulture in agricultural and plantation sectors in some important agricultural-based countries.

Keywords— Polyethylene, Plasticulture, Sustainable Agriculture, Photodegradation, Polymer Degradation.

I. INTRODUCTION OF POLYMER AND GREEN POLYMER

The application of polymeric materials has started from the ancient times and examples of important polymers used by humans are cotton, horn, wood, hevea sap and silks [1]. Though there was lack of knowledge on polymer then, its usages were impressive and significant even during pre-historic human lives. People of Ancient Mesoamerican extracted latex from a plant named *Castillaelastica*and processed the latex using other plant based materials and used the end products as rubber balls and figurines [2]. Natural polymers were used in fabric materials, traditional household and tools, building materials and weaponries. Due to physical and chemical strengths of polymer materials, their uses have never been less insignificant and continued to improve with modern knowledge and technology.

The actual chemical modification of natural polymer was recorded in 1862 and hence called 'an artificial polymer' by the industrial sectors at that time [1]. The first so called artificial polymer was named under the trading name of celluloid and has successfully conquered the commercial success until the material was rivaled by newer type of artificial polymer, cellulose acetate, which was invented to overcome the flammability issues of the previous material. However, it was in 1900s that synthetic polymers were actually born and patented, which was Bakelite in 1907. This Bakelite was synthesized from formaldehyde and phenol. Eventually, due to its increasing usages and success, poly(vinyl chloride)was introduced in 1914 and has taken the manufacturing and processing industries by storm. It is in 1930s that the scientists started to fully comprehend the macromolecule knowledge and began to study on how to synthesize more synthetic polymers such as acrylics, polyethylene and polyamides. Since the advancement of polymer technology, the term of plastic and polymers often used interchangeably though polymer is defined broader than plastic. The end of the World War II has marked as a benchmark of the start of 'Plastic Era'. The plastic and polymeric production has grown exponentially and progressively due to the growth of manufacturing and automotive industries. The advances of knowledge in polymeric materials have brought distinction and enlighten to differentiate polymers from other materials such as ceramics, metals and glass [1]. However, too much uses of plastics materials has caused drawback in environmental system and has been blamed to be the origin of many pollution issues such as infertile soil, problematic drainage system and interfere in animal ecosystem and food chain. Though there are numerous issues related to the root of plastic application, its uses has already became part of modern day human and considered as a norm due to its variability in function and management. This has initiated scientists to come with solution and hence 'Green Polymer".

Green polymer is relatively and considered as new advancement in polymer technology. It is part of the often discussed, Green Technology and is expected to contribute in reducing the impact of plastic wastes into environment and sustaining the healthy ecosystem. Green polymer is referred to any advancementor/and innovation of polymeric materials that can reduce environmental impact of its wastes, sustainably recycle able, contribute to the reduction of greenhouse gases and economically imposing a sustaining role in the production of other materials, food products and agriculture. Since the application of polymer is vast, thus in order to consider a polymer technology to be 'green', it must touches a holistic aspect of human lives, especially

environment and natural ecosystem. The aim of expanding the knowledge in green polymer is to provide foundation for future manufacturer and scientists in inventing environmental friendly products that will not affect natural ecosystem as it is now. Green polymer knowledge and technology can be applied in many field such as automotive industries, medical supplies, food and beverage packaging, agriculture and built environment. It is generally accepted that plastic is impossible to be replaced in human lives. Thus invention of green polymer or green plastic can help to overcome issues related to it. The human population is steadily rising, production of food is increasingly important and thus agricultural sector plays major roles to tackle the turmoil. In many developing countries such as India and Kenya, agricultural sector is one of the major areas given the most attention by the government in order to produce sufficient food source and keep up with the increasing size of population. The use of plastic in agriculture is crucial in order to improve harvest and yields of food products. Polyethylene bags, soil mulching films and greenhouse covers are often seen in farms and plantation area due to their significance in helping farmers controlling weeds, manage soil borne diseases, temperature control and fertilizer management. Even during post-harvest processes, plastic still in use especially in packaging and transporting of the yields as to maintain the quality and quantity before they reach the consumer. Malaysia, a country which was based on agricultural before diverting its major economic focus to industrial, is covered with agricultural surfaces as much as 15% of total land and agricultural sector has contributed 9.2% of Gross Domestic Product (GDP) in year 2015 [3]. Modern country such as the United States is also comprised of million hectares of agricultural surfaces; greenhouses and soil mulching system are commonly seen in country areas [4].

II. PLASTICULTURE AND GREEN PLASTICULTURE

2.1. Plasticulture

Increasing needs of food production is always a major focus especially in the third world countries where food is scarce and infertile soil is too common. In order to increasing yield in agriculture, plastics have played foremost role especially in controlling weeds and to manage the use of fertilizer. Polyethylene soil mulching films are common to tackle weeds and fertilizer leaching problem and polyethylene polybags are common practice in nurseries centers especially to supply seedlings for commodity plants such as oil palm and rubber trees. Million tons of plastic wastes are abandoned every year after the seedlings were transplanted into plantation fields and this can cause serious soil infertility issues. Abandoned plastic wastes in and on soil can disturb fertilizer absorption by plant root and plastic residues can interrupt the plants' root growth.According to long term research by previous researcher, approximately 300 years required to completely disintegrate polymeric chain in plastic and to completely degrade the material in natural environment [5] making sustainable and sound planning of plasticulture more vital. However, despite some crucial issues caused by plasticulture, more benefits are gained from its application and thus motivating scholars to further study the most useful method, technique or polymeric synthesis in order to seize the drawback of plasticulture in general. The application of plastic in agriculture, which is also termed as 'plasticulture' is part of modern agricultural technology and techniques that need to be paid foremost attention in order to support green agriculture or sustainable agriculture. **Fig. 1** shows example of plasticulture in commercial oil palm seedlings cultivation in Malaysia.



Fig. 1 Conventional polyethylene bags used for commercial oil palm seedlings cultivation in Peninsular Malaysia.

In seasonal countries such as European countries and the Americas, soil solarization technique has been implemented in agricultural sector in order to control micro-climate of agricultural soils and to regulate the temperature of the sol accordance to the needs of the plants. Though plastics have solved many issues which were previously hindered optimum production of yield, after-use wastes of the materials has becoming delinquent and needs more attention so that it is can be managed in more proper and sustainable ways. Soil solarization technique which incorporated the use of polyethylene mulches to cover the planting soils has been proved to improve planting condition and yields have increased especially during the winter season [5]. Previous research has reported that soil solarization technique in plasticulture has contributed significant improvement in crop harvest and hence profits. Agronomic aspect of plasticulture supports this fact proven by the fact that mulches and polybags usages are undeniably increasing over the years [6].

There are many advantages of plasticulture. The extensive use of plasticulture can control micro-climate of agricultural land, which includes heat absorbance of plastics, increased soil temperature therefore hasten growth of crops. The use of net for crop protection and greenhouses can protect the crop from meteorological agents such as harsh weather,

insects and birds attacks [7] thus fewer pests and diseases. In other way, plasticulture is technically easy to install, weather resistant due to high plastic strength and eventually reduce the need of root pruningdue to equal spacing planned beforehand. Holistically, plasticulture helps in enhancing the growth of crops be it late or early season by maintaining soil temperature up to 10% [8] thus allowing earlier harvest compared to traditional seasonal growth of crops and eventually increase yields acre over time [5].

In spite of wide range advantages of plasticulture, there are also some drawbacks that need not to be forgotten when considering to implement the technique in agriculture especially in large scale plantation and farming. Compared to traditional agricultural technique which uses no modern system, plasticulture incurs an additional cost which includes purchasing of bags and mulching films, installing greenhouses and piping system if fertigation system is to be installed. In addition, after the installation of plasticulture into farming system, it requires management and maintenance, which also means the labor needs also increases, including specialized equipment and skills altogether. Nevertheless, after used plastics are actually not beneficial and are commonly known as wastes. This is problematic knowing that hundreds of years are needed to naturally degrade the materials and almost 55% of farming area is covered with plastics material in normal practice [8].

2.2 Green Plasticulture

Application of plasticulture in agriculture needs improvement in order to offer sustainability to the sector. Understandings on synthesis and processing of polymers lead to polymer technology advancement such as the innovation of degradable polymer material. Degradable polymer can reduce the environmental impact of non-degradable plastics especially post-use in the agricultural field. In general, soil infertility and pollution are the most prominent issues in agricultural sectors which lead to soil degradation and infertility caused by plastic wastes, or technically plasticulture wastes. Thus, a material that degrades after its uses can overcome the prominent issue. There are four types of polymer degradation as explained by previous researcher [9] namely thermal degradation, chemical degradation, biological degradation and photo-degradation. Thermal degradation of polymer materials requires the manipulation of higher or lower temperature that can break the polymeric chain, hence initiate faster breakage for microbial reaction in the natural soil environment. Chemical degradation occurs with help of additional chemical reaction purposely to catalysedisintegration of polymer such as the provision of acidic/alkaline condition. Biological degradation requires biotic reaction which involves microorganisms including fungi and bacteria. These microorganisms commonly eat the starchy compound of the polymers and with help of oxygen and heat, the process is accelerated. The last type is photodegradation or photo-oxidative degradation of polymer. This degradation is characterized with the need of photon energy sourced from ultra violet (UV) lights to initiate breakage of polymeric chain of polymers. The light is absorbed by photoinitiators within the polymeric chains which later photocleaved and turns into free radicals [10] and continue to induce oxidation of the polymers. The radiation of light, which comes from UV-A ranged from 315-400 nm and is the major caused of sunlight weathering of polymers in natural environment [11]. Mechanisms of polymer degradation have been extensively explained and discussed previously [9] [10] [11]. The polymer degradation cycle is described as the destructive chain reaction of initiated free radicals from the energy absorb by impurities or other possible photoinitiators within the polymer material itself. The polymer degradation cycle is as shown in Fig. 2 below [11].

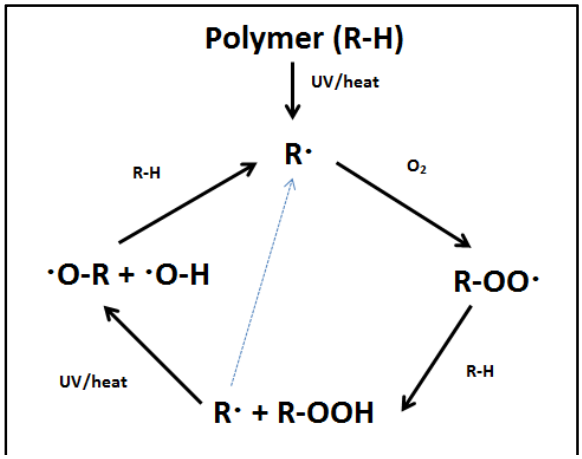


Fig. 2 Polymer degradation life cycle

During the initiation step and the formation of free radical, it is possible to contain further degradation from occurring with addition of photostabilizer. Polymer stabilizing agent might be added in order to refract, absorb or reflect the damaging UV light and to hinder the interaction with polymer molecules.

The use of degradative plastic in agriculture can be utilized in a way that the life time of the polymer can be customized into the needs of the farms or plantation accordingly. Depending on geographical and weather factors, the use of polymers in agricultural sectors vary vaguely due to its application and specific function. Temperate coutnries may use more polymeric materials to build green houses and for soil mulching system in order to provide soil solarization under the sheets while tropical countries may use polymeric materials in agriculture as polybags to cultivate seedlings and soil mulching to control weeds and pests. Seedlings cultivation, for example oil palm requires 14 to 18 months of lifetime while soil mulching will be up to 2

years depending on the crop types. The variation of life time usage suggesting that photodegradable polymers or polyethylenecan to be customized based on the future usage so that wastes can be reduced and the labor required for waste management is lowered. In addition of labor reduction, the degraded polymers will not cause soil infertility because the polymer chains have been disintegrate and defragmented fully into micro sizes. Fertilizers can be absorbed perfectly by plant root and root growth will not be stunted by non-degraded abandoned plastic wastes hence resulting in soil health and sustainable.

III. PLASTICULTURE IN MALAYSIA

Agricultural sector is the one of major economic contributor in Malaysia despite its declining GDP share in Malaysian economic since 2000s [12]. However, agricultural sector stays important in order to sustain food security, improvement of socioeconomic, employment and economic growth. Agricultural land in Malaysia comprises of oil palm plantation, rice paddy field, rubber plantation, cocoa plantation and cash crop farming. In 2014, oil palm plantation has taken largest land share with 5.39 million hectares, followed by cocoa plantation with 0.86 million hectare and rubber plantation with 0.7 million hectares. **Fig. 3** shows graphic illustration of three major commodity plantations in Malaysia.

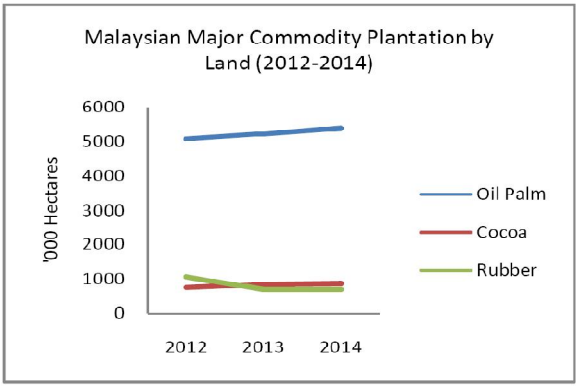


Fig. 3 Major commodity plantations in Malaysia by land acquisition from year 2012 to 2014 [13]

The graphic illustration of commodity plantation in Malaysia has pictured the size of agricultural industry in Malaysia. In addition of commodity plants, Malaysia also consists of commercial farming such as cash crops and vegetable farming. Based on research of Food and Agricultural Organization of the United Nation (FAOUN), Malaysia is heavily rely on conventional agricultural practices [14] where the use of plasticulture is prominent and is applied in almost cultivated land. Farmers depend profoundly on the use of plastic mulching films to help control weeds and pests during farming. They also apply plasticulture in building greenhouses and to cultivate vegetable seedlings in nurseries. The study revealed that 15% of expenditure is used to install and maintain plasticulture related activities among the farmers. This suggests that plasticulture plays important role in maintaining and sustaining agriculture activities in Malaysia. In addition, regarding the cultivation of commodity plants seedlings, millions of seed are to be cultivated using polyethylene bags before the seedlings are able to be transplanted into plantation field. Non-degradable polyethylene bags are used in various sizes and thickness in seedlings nurseries in order to provide optimum growth condition to the plantlets.

Another Malaysian government initiative in order to advance agricultural sector is the commandment of East Coast Economic Region (ECER) which focuses on the development of the East Coast area of Peninsular Malaysia in term of economic support and productivity. Part of the development program is called ‘agropolitan’ where traditional farmers are introduced to modern and conventional farming techniques which require the use of more technical aspects and plastics material in order to increase yield and control weeds and diseases. The farmers are taught to use plastic mulching films efficiently and to manage the waste so that there will be less environmental impact after its usage. However, there is no observed initiative by the Malaysian government to switch the use of conventional plastics into degradable plastics in agriculture though it is obviously help to reduce the release of greenhouse gases and contribute to soil pollution reduction. On top of that, all the mentioned commodity plants require seedlings cultivation in the nurseries before transplanted into plantation field thus causing thousand tons of polyethylene bags wastes. Hence, in order to provide sustainable and green agricultural sector in Malaysia, advancement of green plasticulture must be emphasized in order to create an environmental friendly planting practices not only in Malaysia, but also in other countries.

CONCLUSIONS

Modern European countries such as Greece, Sweden and Germany have long been studied Green Plasticulture and assess its impact on environment. Malaysia at this date has yet to develop the knowledge accordance to tropical weather in order to fit the possible customized plasticulture to be commercially available to agricultural practitioners. Recent studies on Green Plasticulture in Malaysia is in the early stage and more emphasizes are needed in the suggesting the importance of green plasticulture implementation in Malaysia. Thousands of tons conventional plastic materials are being used each days so as the wastes. Thus, in order to sustain the natural environment and to reduce the impact of non-degradable plastic wastes to the environment, degradable polymers must be extensively used especially in huge scale industries such as plantation and product packaging.

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