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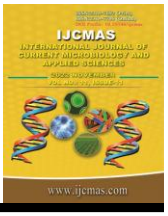

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Formulation and Utilization of Bio Degradable Mulch Films and A Design Considerations of Mulch Film Laying Machine – A Review

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ABSTRACT

The plastic mulch film in agriculture has increased dominantly in the last 20 years in entire world. The use of plastic mulch film thus increases the benefits such as increase in soil temperature, reduced weed pressure, moisture conservation, reduction of certain insect pests, higher crop yields, and more efficient use of soil nutrients. The main problem with the plastic mulch film was disposing of used plastic films, which cause pollution, and this issue led to development of photodegradable and biodegradable mulches. Here, review the use of plastic mulches in agriculture, with special reference to biode- gradable mulches. Major topics discussed are (1) history of plastic mulch and impact on crop yield and pest management, (2) limitations of polyethylene mulches and potential alternatives, (3) biodegradable and photodegradable plastic mulches, (4) field performance of biodegradable mulches, and (5) use of biodegradable plastic mulches in organic production. We found that removal and disposal of conventional polyethylene mulches remains a major agro- nomic, economic, and environmental constrain. polymers such as poly(lactic acid), poly(butylene adipate- coterephthalate), poly(ε-caprolactone), and starch-based polymer blends or copolymers can degrade when exposed to bioactive environments such as soil and compost; The biodegradable materials obtained from petroleum and natural resources, opportunity for using biodegradable polymers as agricultural mulch films has become more viable, and the source of polymer and additives may limit use of some biode- gradable mulches in organic production. More knowledge is needed on the effect of biodegradable mulches on crop growth, microclimate modifications, soil biota, soil fertility, and yields.

Keywords

Mulching film, polyethylene, plastic residues, mechanical properties

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Introduction

The practice of using mulching film to improve the growth and yield of annual and perennial crops has long been recognized (Shogren, 2005). Mulching film preserves heat and moisture, reduces pressure from weeds and pathogens, and conserves water and fertilizer (Liu, 2010; Liu, 2014 and Li, 2014). In these ways, mulching film contributes to sustainable agricultural production. Plastic films (e.g., polyethylene (PE), poly(vinyl chloride), polybutylene, copolymers of ethylene with vinyl acetate) are the most widely used materials because of their excellent mechanical properties and low cost. However, the major problem associated with the use of non-biodegradable plastic films is that they can pollute soil when they are buried in landfills; in addition, the removal and disposal of these plastic residues from the field either before or after harvest is costly and time-consuming (Shogren, 2005; Tocchetto, 2005).

For these reasons, farmers usually incorporate used films into the soil; occasionally, they burn the used plastic films, causing harmful pollution (Briassoulis, 2016). In order to increase the sustainability of agricultural practices and to overcome the disposal problems associated with conventional plastic films, the development and use of mulching films based on biodegradable materials is highly desirable.

Until now, various films capable of being degraded by microorganisms in the soil have been developed, including oxo-degradable plastic film (Corti, 2012), paper film (Anderson, 1995), and biodegradable film (Russo, 2005; Finkenstadt, 2010; Scarascia-Mugnozza, 2006). Oxo-degradable plastic is low-cost and easy to install, but the parts of the film that are buried in the soil do not break down and must be exposed to light and air for degradation (Cirujeda, 2012).

Paper film has been considered as an alternative to plastic film; however, paper film suffers from very rapid degradation and is easily broken down after exposure to soil, rain, and wind (Shogren, 1999). Furthermore, in order to cause no undesirable effects to the performance of agricultural soil, no harmful substances resulting from the degradation of biodegradable materials used as mulching film should accumulate in the soil (Kapanen, 2008).

History of plastic mulch

Plastics are man-made long-chain polymeric molecules (Scott, 1999). The word plastic comes from the Greek word “plastikos,” which means “able to be molded into different shapes” (Joel, 1995). The plastics we use today are made from inorganic and organic raw materials, such as carbon, silicon, hydrogen, nitrogen, oxygen, and chloride. The basic materials used for making plastics are extracted from oil, coal, and natural gas (Seymour, 1989).

According to the American Society for Plasticulture, plasticulture is “the use of plastic in agriculture,” which includes but is not limited to plastic mulch films, drip irrigation tape, row covers, low tunnels, high tunnels, silage bags, hay bale wraps, and plastic trays and pots used in transplant and bedding plant production (Lamont and Orzolek, 2004). Plasticulture is the technology of the use of plastics in the agricultural sector.

Tar-coated paper mulches began to be used in the late 1800s, long before polyethylene was available (Rivise, 1929). The science of plasticulture had its beginning as early as 1924 when Warp (1971) developed the first glass substitute for widespread agricultural use. British scientists first made polyethylene as a sheet film in 1938 (Masey, 1972). The earliest method using organic and inorganic materials to modify the microclimate of crops was mulching (Jaworski *et al.*, 1974). These materials soon gave way to various types of polyethylene films, which revolutionized protected cropping as demon- strated by Emmert (1957) in Kentucky and Hall and Besemer (1972) in California.

Plastics were first introduced on a commercial scale in 1939 (Byrdson, 1970). These include polyethylene, polyvinyl chloride, and ethylene vinylacetate. Polyethylene plastic is made from polyethylene resin, which is in the form of pellets. The pellets are heated and processed into bendable sheets of plastic film.

The widespread use of polyethylene (the principal type of plastic used today) is due to easy processibility, excellent chemical resistance, high durability, flexibility, and free- dom from odor and toxic. The most commonly used mulch films include low-density polyethylene, linear low-density polyethylene, and highdensity polyethylene. Linear low-density polyethylene resins have high puncture resistance and mechanical stretch properties. High-density polyethylene resins have reliable moisture and vapor barriers. An ideal plastic mulch film should be flexible and rigid enough for easy removal from various growing environments. The main polyethylene used in mulches is low-density polyethylene.

Plastic mulch films were first used in the late 1950s in university research and have been used commercially for vegetable production since the early 1960s (Hussain and Hamid, 2003). Plastic mulch is now used worldwide to protect crops from unfavorable growing conditions such as severe weather, insects, and birds. Utilization of plastics in agriculture started in the developed countries and is now spreading to the developing countries. Early utilization of plastic was in cold regions, and plastic was mainly used for protection from the cold. Now plastic is used in all kind of climates, soils, and seasons for its numerous benefits in addition to enhanced soil temperatures. The use of covering techniques started with a simple system such as mulching, and then row covers and small tunnels were developed and finally plastic houses.

Plastic mulch has made a tremendous increase in peanut (*Arachis hypogaea*) production, which is called as white revolution in China (Hu *et al.*, 1995). Likewise the use of plastic mulch in field crops such as corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.), sugarcane (*Saccharum officinarum*), and rice (*Oryza sativa*) has been successful in many countries. Plastic mulch is reported to be useful to overcome abiotic stresses in many crops in China. Film mulching with varying specifications is currently used in northern China, covering about 7 million ha of field crops. Plastic film mulching has been used in cultivating peanut, corn, cotton, vegetable, and fruit crops (Hu *et al.*, 1995). Commercially, plastic mulches have been used for the production of vegetables since the 1960s. Today, production of fresh market vegetables on raised beds covered with plastic mulch and drip irrigated has become a standard for most growers worldwide. The world consumption of low-density polyethylene mulching films in horticulture is at present around 700,000 tons/year (Espi *et al.*, 2006).

Plastic mulch protects the soil from water and wind erosion and hail damage (Garnaud, 1974). The dominant advantage of using polyethylene mulch is its ability to aid in the retention of nutrients within the root zone, thereby permitting more efficient nutrient utilization by the crop. Constant moisture content, higher temperature, and better aeration of the soil all tend to favor higher microbial biomass in the soil thus ensuring more complete nitrification (Hankin *et al.*, 1982). Plastic mulching has been reported to change the composition of microbial communities and increase microbial biomass C in semi-arid soil under wheat. Zhang *et al.*, (2002) reported that plastic mulching management reduced microbial biomass C and N during corn growth stage. Plastic film mulching can increase soil temperature (Liu *et al.*, 2003; Peng *et al.*, 1999), and higher temperatures can favor not only N mineralization but also plant N uptake (Liu *et al.*, 2003).

Limitations of polyethylene plastic mulch and alternatives

Limitations of polyethylene plastic mulch

Most mulch films are currently produced from petroleum- based plastics, usually polyethylene, and cause a considerable waste disposal problem. Perhaps a major limitation to commercial uses of plastic mulches is the disposal of the plastic film after use, which causes an environmental pollution problem. The dramatic increase in production and lack of biodegradability of commercial polymers, particularly commodity plastics used in agriculture and packaging industry, focused public attention on a potentially huge environ- mental accumulation and pollution problem that could persist for centuries (Albertsson *et al.*, 1987). Removal of the plastic is time-consuming (about 16 h/ha) and despite the use of machines still requires hand labor. The residual film if left in the field may interfere with root development of the subsequent crop. Plastic requires pickup and disposal at the end of the season and its manufacture and disposal entail significant environmental costs (Schonbeck, 1995). Normally the useful life of mulching exceeds the duration of crop cycles, and it is usually left in the soil afterward. Although the part exposed to the light undergoes photo-degradation and contributes to the plastic's decomposition for photodegradable mulches (Gonzalez *et al.,* 2002), the rest of the material is simply broken into pieces during soil preparation for a new crop, some pieces being buried and some remaining on the soil surface. The buried pieces are more difficult to decompose since they are less affected by light and high temperatures, creating serious soil problems whose environmental repercussion has not been fully evaluated.

By the beginning of the 1970s, mulching of vegetable and fruit crops was already widely practiced. The relatively low price of plastic materials did not encourage retrieval and recycling. However, because of the vast amounts of plastic involved, researchers began to develop plastic films, which would self-destruct by suitable chemical modifications (De Carsalade, 1986). Carnell (1978) outlined four methods for removal of plastic mulch namely discing, burning, physical removal, removal, and storage of the plastic mulch. The plastic waste is disposed off through landfilling, incineration, and recycling. Because of their persistence in the environment, several communities are now more sensitive to the impact of discarded plastic on the environment, including deleterious effects on wildlife and on the aesthetic qualities of cities and forests. Improperly disposed plastic materials are a significant source of environmental pollution, potentially harming life. In addition, the burning of polyvinylchloride plastics produces persistent organic pollutants known as furans and dioxins (Jayasekara *et al.*, 2005). Because of the high costs related to the regular process of gathering and discarding films and the recycling process, plastic films are often discarded in a dump or burned with the subsequent emission of toxic substances both to the atmosphere and to the soil (De Prisco *et al.,* 2002).

Alternatives to polyethylene plastic mulch

Paper-based mulches have been used in agriculture since 1914, when paper was used to reduce weed pressure in sugar cane fields (Smith, 1931). Asphalt-impregnated paper mulches were successfully used in pineapple (*Ananas comosus*) pro- duction in the 1920s in Hawaii, increasing quality and yields (Smith, 1931). Paper mulches have since been evaluated with varying results. Newspaper mulches represent an available and cost-effective resource and have been frequently trialed (Shogren, 2000). Paper mulches have been considered as an alternative to plastic but suffer from very rapid degradation and usually begin to break apart just a few weeks after expo- sure to soil, rain, and wind (Anderson *et al.,* 1995; Shogren 1999, 2000). Although thicker paper and fiber mats can be used to lengthen lifetimes, these can be very expensive to use. Munn (1992) reported increased yields with shredded news- paper compared with straw mulches in corn and soybean (*Glycine max*). Recently, Sanchez *et al.,* (2008) reported suc- cess when using shredded newspapers as weed-suppressing mulch in organic high-tunnel cucumber production. However, some paper mulches deteriorate rapidly under field conditions, reducing their effectiveness (Shogren, 2000). Several trials have used paper mulches with polyethylene, wax, or vegetable oil coatings used to slow degradation of mulches in the field (Miles *et al.,* 2003; Shogren 1999). Growers interested in using paper mulch on a larger scale may want to lay mulch and drip irrigation tape with a conventional plastic layer and plant using a water wheel transplanter. Miles *et al.,* (2006) used traditional mulch laying equipment, though hand transplanted, to test the performance of several starch and paper-based mulches for organically managed lettuce (*Lactuca sativa*), broccoli (*B. oleracea* var. *italica*), bell pepper, and water- melon in the Pacific northwestern USA with variable results. A mulch mat is made from recycled paper. However, current research indicates that mats do not biodegradable easily and can only partially prevent weed growth (Halley *et al.,* 2001).

Another strategy for reducing plastic mulch waste has been double cropping, which allows growing two (or more) crops on the same mulch (Ngouajio and Ernest, 2004). One of the advan- tages of double cropping is the reduction of the total volume of used agricultural plastic. Unfortunately, this technique cannot be used efficiently in all crops and environments (Ngouajio *et al.,* 2008). More recently, studies have tested the performance of biodegradable materials applied as slurries. These include foam mulches, hydraulic mulches, and hydramulch (Warnick *et al.,* 2006). Those materials are fully degradable but are expensive, difficult to handle, and require specialized equipment for application. Also, they do not provide the level of weed suppression and soil warming generally achieved with plastic mulch (Warnick *et al.,* 2006). In the area of new technologies, preliminary studies have shown that baling used plastic may allow growers to reduce the volume and therefore the cost of disposal. Photodegradable plastics, mulch mats, and biode- gradable plastics have been considered by technologists to replace the petroleum-based plastics (Halley *et al.,* 2001). The use of biodegradable or photodegradable mulch films may satisfy growing needs to find an alternative to petroleum-based products and to reduce labor cost to remove the mulch products after use.

Biodegradable plastic mulches

An alternative solution for reducing waste from polyethylene mulches is to develop biodegradable mulches. In the 1960s and 1970s, scientists started to investigate the possibility of using bio-photodegradation as a self-destructive disposal technique for plastic film (Ennis, 1987). Photodegradable mulch films have been tested intermittently for more than 20 years (Hemphill, 1993). Results have been variable, with many films degrading prematurely (Greer and Dole, 2003; Halley *et al.,* 2001). Furthermore, the ability of photodegradable mulches, which are manufactured with petroleum-based ingredients, to degrade into carbon dioxide and water has been questioned (Zhang *et al.,* 2008).

Suitable alternative methods for the disposal of plastic films include the use of biodegradable materials (Malinconico *et al.,* 2002, 2008). At the end of their life, biodegradable materials can be integrated directly into the soil where microflora transforms them into carbon dioxide or methane, water, and bio- mass. Because biodegradable materials do not produce wastes that require disposal, they could represent a sustainable eco-logical alternative to low-density polyethylene films (Immirzi *et al.,* 2003).

Starch-based polymers have shown enhanced biodegradability but remain too expensive and sometimes too heavy for agricultural applications (Halley *et al.,* 2001). Biodegradable plastics opened the way for new considerations of waste management strategies since these materials are designed to degrade under environmental conditions or in municipal and industrial biological waste treatment facilities (Augusta *et al.,* 1992;). Biodegradable mulch films can biodegrade in the field after plowing, thus eliminating film recovery and disposal.

With material properties similar to those of conventional plastics (Hocking and Marchessault, 1994), biodegradable plastics (polyesters) have been developed successfully over the last few years. These include polyhydroxyalkanoates, polylactides, polycaprolactone, aliphatic polyesters, poly-saccharides, and copolymer or blend of these. The most important are poly(3-hydroxybuty- rate) and poly(3-hydroxybutyrate-co-3-hydroxyvalerate).
Bioplastics (biopolymers) obtained from growth of microorganisms or from plants which are genetically engineered to produce such polymers are likely to replace currently used plastics at least in some of the fields (Lee, 1996).

Biodegradable plastics have been developed from early 1980s particularly biodegradable aliphatic polyesters (e.g., polyhydroxybutyrate or polylactic acid) or starch–polymer blends. However, the high cost of these polyesters prevents their commercialization. Also the starch–polymer blends are actually not 100% biodegradable. Starch-based mulch films have become popular in current research because starch is an inexpensive and abundant natural polymer that can produce a film structure (Liu, 2005). Halley *et al.,* (2001) developed a biodegradable film from a blend of starch and biodegradable polyester polymers. Acceptable behaviors of the films have been achieved for general uses. Otey *et al.,* (1974) investigated the development of degradable mulch film from gelatinized corn starch, polyethylene, and polyethylene–acrylic acid polymers and from starch–poly (vinyl acetate) blending with poly(vinyl chloride). Good film blowing and casting performance was achieved (Halley *et al.,* 2001).

Biodegradable polyesters which have been developed commercially or are in commercial development are polyhydroxyalkanoates, polyhydroxybuty- rate, polyhydroxyhexanoate, polyhydroxyvalerate, polylactic acid, polycaprolactone, polybutylene succinate (PBS), polybutylene succinate adipate, aliphatic–aromatic copolyesters, polyethylene terephthalate, polybutylene adipate/terephthalate, and polymethylene adipate/terephthalate (Anonymous, 2002). Polyhydroxyalkanoates are naturally occurring bacterial products from which plastics can be made (Reemmer, 2009). Polyhydroxyalkanoates' key properties are their biode- gradability, apparent biocompatibility, and their manu- facture from renewable resources. The global interest in polyhydroxyalkanoates is high as they are used in various packaging materials, medical devices, disposable personal hygiene, and also agricultural applications as a substitute for synthetic polymers like polypropylene, polyethylene, etc. (Ojumu *et al.,* 2004; Lee, 1996). In the past 10 years, several biodegradable plastics have been introduced into the market. However, none of them is efficiently biodegradable. For this reason, none of the products has gained widespread use (Anonymous, 1999). At present, biodegradable plastic repre- sents just a tiny market as compared with the conventional petrochemical material. Bioplastics will comparatively prove cheaper when oil prices will continue to hike up. Although not in use today, plastic mulches could be made from polylactic acid a biodegradable polymer derived from lactic acid. This is one form of vegetable-based bioplastic. This material biode- grades quickly under composting conditions and does not leave toxic residue. However, bioplastic can have its own environmental impacts, depending on the way it is produced (Kathiresan, 2003).

Utilization of a Biodegradable Mulch Sheet Produced from Poly (Lactic Acid)/Ecoflex®/ Modified Starch:

Yuya Tachibana *et al.,* (2009) investigated that PLA produced from biorenewable resources, such as corn, has recently been gaining attention for sustainability reasons, because the term "biorenewable" refers to materials made from biomass with absorbed carbon dioxide from the atmosphere (5). However, its most important property is its biodegradability. Ecoflex® is also commercially available as a biodegradable material. It has a poly(butylene adipate/terephtalate) chemical structure and it is made from oil-based compounds. Currently, it is used as a sheet, fiber, and modifier for plastics. Starch is one of the most inexpensive and most available biobased and biodegradable materials, although it is hard to use as a plastic-like material as it lacks moldability and thermoplasticity.

Some modified methods have been developed to confer moldability and thermoplasticity to starch. Thus, a starch is usually treated by hydrolysis and functionalization with a glycol, then the modified starch becomes moldable and thermoplastic, in addition to biodegradable. Generally, modified starch is melted and mixed with other thermoplastics for use as a functional material. PLA, Ecoflex®, and modified starch are all biodegradable materials, therefore, they could solve the problem of mulch sheet biodegradability.

Table.1 Ratios of polylactic acid(PLA)/Ecoflex®/modified starch for inflation molding and their moldability

LA	Ecoflex	Modified Startch	Moldability
100	0	0	unmolding
30	0	70	Unmolding
30	50	20	Unmolding
30	70	0	Good
30	60	10	Good

Aniek Iriany (2018) reported that the research was conducted by employing a completely randomized design. The treatment experiment included compositions of organic mulch sheet materials with six variations and two thickness (twelve combinations), then repeated three times. The variation of organic mulch sheet compositions included M1 = 40% water hyacinth:40% Rice straw:20% banana pseudostem; M2 = 50% water hyacinth:20% Rice straw:30% banana pseudostem; M3 = 50% water hyacinth:30% Rice straw:20% banana pseudostem; M4 = 50% water hyacinth:40% Rice straw:10% banana pseudostem; M5 = 60% water hyacinth:20% Rice straw:20% banana pseudostem; M6 = 0.60%water hyacinth:30% Rice straw:10% banana pseudostem. There are two levels of organic mulch sheet thickness, T1 = 0.5 mm and T2 = 1 m

Making of mold

Preparing Styrofoam and cloth; one hole was made on the Styrofoam with the size of 30 cm × 50 cm; the upper part of Styrofoam was covered by the cloth. The total weight of mulch for each combination was 1000 g. Water hyacinth, rice straw, and banana pseudostem were weighted based on the set composition in each treatment before finally being cut into the size of 1 cm

Pulping: Water hyacinth was blended for 15 min and banana pseudostems were blended for 20 min by the addition of water before being squeezed to take the pulp. Molding process started by pouring and fattening the hot pulp into the prepared mold. Then, the pulp in the mold was dried while being steadily pressed to eliminate the water. Finally they reported that The organic mulch sheet was made of water hyacinth, banana pseudostem, and tannery waste. It produced a compact and strong structure. The high cellulose content in the water hyacinth and banana pseudostem (over than 60%) and low lignin content (lower than 5%) through the delignifcation process are used to remove the lignin contained in the materials.

Shigetaka *et al.,* (2005) investigated and reported that Rice husk (RH) is an agricultural waste material abundantly available in rice-producing countries. They are the natural sheaths that from on rice grains during their growth. Removal during the refining of rice, these husks have no commercial interest. The rice husk contains 80 percent organic volatile materials and remaining 20 percent silica. The rice husk ash (RHA) contains 85 percent to 95 percent amorphous silica. The chemical composition of the rice husk ash varies from sample to sample which may be due to the different geographical conditions, type of paddy, climatic conditions and type of fertilizer used. Rice husk contains 20% ash, 22% lignin, 38% cellulose, 18% pentosans and 2% moisture. Silica obtained from rice husk ash is highly reactive, depending upon the degree of firing and is used for making insulating materials, refractory bricks, Portland cement, masoriry cement and pottery ware. It is used as filler materials in paints and in fertilizers etc. rice husk ash has also been used in aluminium alloy for increasing abrasion resistance

Epoxy resin

Epoxy is a copolymer; that is, it is formed from two different chemicals. These are referred to as the "resin" and the "hardener". The hardener consists of polyamine monomers. Softener (Araldite LY 556) made by CIBA GEIGY limited and Hardener (HY951), aliphatic primary amines which has a viscosity of 10-20 MPa at 25°c is used along with matrix material used for the preparartion of the sheets.

Kiran *et al.,* (2022) in his review paper on Design and Fabrication of Semi – Automatic Mulching Sheet and Sapling Laying Machine, he reported that the designed, developed and technologically updated range of mulching machine would be available to clients that offer great relief to farmers in best possible and effective manner. The machine thus developed is user friendly with fine finish and easy to operate. Thus time reduction is possible by implementing various new techniques and adoption of new innovations in agricultural field. So from this we get a detailed review on mulching mechanism works and what are steps taken towards minimizing the cost and especially time. This system might not need more human labour, mulch paper avoid the waste water, and Stop the growth of weeds. Also in this method we use some Mechanical Mean so the working time is less as compared to the conventional method. Our new machine thus designed can lay mulching paper and punch hole simultaneously and efficiently

Hivrekar *et al.,* (2018) discussed that, they have designed a “Advance Mulching Paper Laying Machine” application which is in a Agriculture, which is going to Laying a paper with reducing human effort and also cost required for employee for laying Mulch Paper on Bed. This system does not need more human labour, Mulch paper avoid the waste water, and Stop the growth of grass. Also in this method we use some Mechanical Mean so the working time is less as compared to the conventional method.

Bhargava Reddy *et al.,* (2020) revealed in this paper that they have designed, developed and technologically updated range of mulching machine that is available to clients that offer great relief to farmers in best possible and effective manner. The mulching machine meets growing needs of farmers who wish to continuously improve the profitability of their farming by using this machine

Kapilraj R. Nangare *et al.,* (2020) disclosed that, the machine thus designed can successfully lay mulching paper, lay drip line and punch hole simultaneously and efficiently. Time required to laying the mulch paper is 2.5 hours per acre for our machine. Hence, we are reduced time required to lay the mulch paper by 80% and 72% as compared to conventional method and tractor attachment respectively. Operational cost of our machine is Rs 350 per acre and hence we reduce operational cost required to lay the mulch paper 93% and 87% as compared to manual method and tractor attachment respectively. From this time method actual time is reduced.

Amay Tipayale *et al.,* (2017) unveiled that avoiding growth of the weed on farm is very costly and time consuming task. Mulching the plastic paper film near the root area of plants is for eliminating the rise of weeds also to retaining water and avoid de-moisturizing the soil but this process requires lots of capital and time. So ‘Drip irrigation pipe and Mulching paper laying machine’ will reduce the labour cost and time, it will do both the jobs i.e. laying irrigation pipe and mulching paper on the ground at a time. By using various mechanisms, this machine will lay the irrigation pipe and mulching paper at the same time it will make the holes on the paper to provide plantation area after laying the drip irrigation pipe and mulching paper.

Chitra Madhu Sudhan Gowd *et al.*, (2019) indicated that, here they have developed a machine which lays plastic mulch at the exact position on the prepared plantation bed and secure it with the soil. The laying of plastic mulch and hole punching will be done in one pass. So he designed advanced mulch paper laying machine, which can lay the mulching paper on the beds of the soil.

Plastic film mulching plays an important role in agriculture owing to its ability to improve grain crop yields and water use efficiency (WUE) by maintaining soil moisture, suppressing weeds and increasing soil temperature. China has the largest plastic film mulching system in the world (Yang *et al.*, 2015). The amount used and the area treated with polyethylene plastic film (PE) has increased steadily to 1.4 million cubic tons or more than 17.8 million hectares in 2018, equivalent to about 15% of the total cropland in China (National Bureau of Statistics of China, 2019). Despite the benefits of plastic film mulch technology, it has also resulted in a number of pollution hazards (Kasirajan and Ngouajio, 2012). As a result, perceptions of the application of plastic film mulch technology are evolving from considering it a 'white revolution' to 'white pollution' (Liu *et al.*, 2014). To overcome negative environmental problems caused by persistent plastic waste from PE, biodegradable plastic mulches (BDMs) have been developed as a promising alternative to PE films, providing a sustainable and environmentally friendly solution for agricultural activities.

References

Albertsson A C, Andersson S O, Karlsson S (1987) The mechanism of biodegradation of polyethylene. Polym Degrad Stab 18:73–87

Amay Tipayale *et al.*, 2017. "Advanced Mulching Paper Laying Machine." International Journal for Scientific Research and Develop (IJSRD): Vol-5, Issue 3,

Anderson, D. F.; Garisto, M. A.; Bourrut, J. C.; Schonbeck, M. W.; Jaye, R.; Wurzberger, A.; DeGregorio, R. Evaluation of a paper mulch made from recycled materials as an alternative to plastic film mulch for vegetables. J. Sustain. Agric. 1995, 7, 39–61. (CrossRef)

Aniek Iriany *et al.*, (2018) Organic mulch sheet formulation as an effort to help plants adapt to climate change, International Journal of Recycling of Organic Waste in Agriculture (2018) 7:41–47 https://doi.org/10.1007/s40093-017-0189-z

Anonymous (1999) Ecological assessment of ECM plastics. Report by Chem Risk—a service of Mc Laren Hart Inc. MicrotechResearch, Ohio, p 14

Anonymous (2002) Biodegradable plastics—developments and envi- ronmental impacts.Webhttp://www.europeanplasticfilms.eu/ docs/AustralianReportonBiodegradablePlastics.pdf. Accessed 10Oct 2011

Augusta J, Müller RJ, Widdecke H (1992) Biodegradable polymers— testing methods and assessment standards. Chem Ing Tech 64:410– 415

Bailey. L. E., "Machines for Laying Mulches." US 1436139, country- US, 15August.

Bhargava Reddy A, Monisha J. B *et al.*, "Design and Fabrication of Mulch Paper Laying Machine." International Journal of Scientific & Engineering Research Volume 11, Issue 6, June-2020 ISSN 2229-5518.

Briassoulis, D.; Babou, E.; Hiskakis, M.; Kyrikou, I. Analysis of long-term degradation behaviour of polyethylene mulching films with pro-oxidants under real cultivation and soil burial conditions. Environ. Sci. Pollut. R. 2015, 22, 2584–2598. (CrossRef) (PubMed)

Byrdson J A (1970) Plastic materials, 2nd edn. Illiffe Books, London, p 597

Carnell D (1978) Photodegradable plastic mulch in agriculture. Proc Nat Agr Plastics Congr 14:143–148

Chitra Madhu Sudhan Gowd *et al.*, "Design and fabrication of manual mulching machine." Vol-5 Issue-3 2019, IJARIIE-ISSN(o)-2395-4396

Cirujeda, A.; Aibar, J.; Anzalone, A.; Martin-Closas, L.; Meco, R.; Moreno, M. M.; Pardo, A.; Pelacho, A. M.; Rojo, F.; Royo-Esnal, A.; *et al.*, Biodegradable mulch instead of polyethylene for weed control of processing tomato production. Agron. Sust. Dev. 2012, 32, 889–897. (CrossRef)

Corti, A.; Sudhakar, M.; Chiellini, E. Assessment of the whole environmental degradation of oxo-biodegradable linear low density polyethylene (LLDPE) films designed for mulching applications. J. Polym. Environ. 2012, 20, 1007–1018. (CrossRef)

De Carsalade B (1986) Plastics and mulching of crops. Plasticulture 72:31–36

De Prisco N, Immirzi B, Malinconico M, Mormile P, Petti L, Gatta G (2002) Preparation, physico-chemical characterization and optical analysis of polyvinyl alcohol-based films suitable for protected cultivation. J Appl Polym Sci 86:622–632

Ennis R S (1987) Plastigone, a new time controlled photodegradable plastic mulch film. Proc Natl Agr Plastics Congr 20:83–90

Espi E, Salmeron A, Fontecha A, Garcia Y, Real A I (2006) Plastic films for agricultural applications. Journal of Plastic Film and Sheeting 22:85–102

Finkenstadt, V. L.; Tisserat, B. Poly(lactic acid) and Osage Orange wood fiber composites for agricultural mulch films. Ind. Crop Prod. 2010, 31, 316–320. (CrossRef)

Garnaud J C (1974) The intensification of horticultural crop production in the Mediterranean basin by protected cultivation. FAO of the United Nations, Rome

Gonzalez A, Lopez J, Garcia J, Hernandez M D, Rodriguez R, Fernandez J A, Franco J A (2002) Comportamiento de acolchados biodegrad- ables en cultivo de melon al aire libre. Seminario de tecnicosy especialistas en horticultura. Ministerio de agricultura pescay alimentacion 85–90

Greer L, Dole J M (2003) Aluminum foil, aluminum-painted, plastic, and degradable mulches increase insect-vectored viral diseases of vegetables. HortTechnol 13:276–284

Halley P, Rutgers R, Coombs S, Kettels J, Gralton J, Christie G, Jenkins M, Beh H, Griffin K, Jayasekara R, Lonergan G (2001) Developing biodegradable mulch films from starch-based polymers. Starch 53:362–367

Hankin L, Hill D E, Stephens G R (1982) Effect of mulch on bacterial populations and enzyme activity in soil and vegetable Yields Plant Soil 64:193–201

Hemphill D D (1993) Agricultural plastics as solid waste: what are the options for disposal? HortTechnology 3:70–73

Hivrekar P. D (2018), Automatic Mulching Paper Laying Machine, International Journal of Advance Engineering and Research, Volume 5, Special Issue 04, Feb.-2018

Hocking P J, Marchessault R H (1994) Biopolyesters. In: Griffin GJL (ed) Chemistry and technology of biodegradable polymers. Blackie Academic, New York, pp 48–96

Hu W, Shufen D, Qingwei S (1995) High yield technology for groundnut. International Arachis Newsletter 15:20–30

Hussain I, Hamid H (2003) Plastics in agriculture. In: Andrady A L (ed) Plastics and the environment. Wiley, Hoboken, pp 185–209.

Immirzi B, Malinconico M, Romano G, Russo R, Santagata G (2003) Biodegradable films of natural polysaccharides blends. J Materials Sci Letters 22(20):1389–1392

Jayasekara R, Harding I, Bowater I, Lornergan G (2005) Biodegrad- ability of selected range of polymers and polymer blends and standard methods for assessment of biodegradation. J Polym Environ 13:231–251

Kapanen, A.; Schettini, E.; Vox, G.; Itävaara, M. Performance and environmental impact of biodegradable films in agriculture: A field study on protected cultivation. J. Polym. Environ. 2008, 16, 109–122. (CrossRef)

Kapilraj R. Nangare, Akshay A. Otari, Ganesh I. Patil, Dipak B. Humbe, Jaywant B.

Chougule, Umesh P. Sutar. 2020. Design and Development of Agricultural Mulching Paper and Drip Laying Machine. International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET).

Kasirajan S and Ngouajio M 2012 Polyethylene and biodegradable mulches for agricultural applications: a review Agron. Sustain. Dev. 32 501–29

Kathiresan K (2003) Polythene and plastics-degrading microbes from the mangrove soil. Rev Biol Trop 51:3–4

Kiran, M P *et al.,* (2022) Design And Fabrication Of Semi – Automatic Mulching Sheet And Sapling Laying Machine - Review Paper, International Advanced Research Journal in Science, Engineering and Technology Vol. 9, Issue 2, February 2022□│Impact Factor 7.105 DOI: 10.17148/IARJSET.2022.9251

Lamont W, Orzolek M (2004) Plasticulture glossary of terms. The American Society for Plasticulture, Bellefonte

Lee S Y (1996) Bacterial polyhydroxyalkanoates. Biotechnol Bioeng 49:1–14

Lee S Y (1996) Bacterial polyhydroxyalkanoates. Biotechnol Bioeng 49:1–14

Li, C.; Moore-Kucera, J.; Miles, C.; Leonas, K.; Lee, J.; Corbin, A.; Inglis, D. Degradation of potentially biodegradable plastic mulch films at three diverse us locations. Agroecol. Sust. Food 2014, 38, 861–889. (CrossRef)

Liu E K, He W Q and Yan C R 2014 ‘White revolution’ to ‘white pollution’—agricultural plastic film mulch in China Environ. Res. Lett. 9 091001.

Liu X J, Wang J C, Lu S H, Zhang F S, Zeng X Z, Ai Y W, Peng B S, Christie P (2003) Effects of non-flooded mulching cultivation on crop yield, nutrient uptake and nutrient balance in rice-wheat cropping systems. Field Crops Res 83:297–311

Liu Z (2005) Edible films and coatings from starches. In: Han JH (ed) Innovations in food packaging. Elsevier, Amsterdam, pp 318–337

Liu, E.; He, W.; Yan, C. ‘White revolution’ to ‘white pollution’—Agricultural plastic film mulch in china. Environ. Res. Lett. 2014, 9, 091001. (CrossRef)

Liu, M.; Huang, Z.; Yang, Y. J. Analysis of biodegradability of three biodegradable mulching films. J. Polym. Environ. 2010, 18, 148–154. (CrossRef).

Malinconico M, Immirzi B, Massenti S, La Mantia F P, Mormile P, Petti L (2002) Blends of polyvinylalcohol and functionalized polycaprolactone. A study of the melt extrusion and post-cure of films suitable for protected cultivation. J Material Sci 37:4973–4978

Malinconico M, Immirzi B, Santagata G, Schettini E, Vox G, Scarascia Mugnozza G (2008) Chapter 3: an overview on innovative biodegradable materials for agricultural applications. In: Moeller HW (ed) Progress in polymer degradation and stability research. Nova Science, New York, pp 69–114

Masey P H, Jr (1972) Current utilization and new developments in agri- cultural plastics in U.S.A. In Proc. 5th Internat. Coll. Budapest, Hungary

Miles C, Garth L, Sonde M, Nicholson M (2003) Searching for alter- natives to plastic mulch. http://vegetables.wsu.edu/MulchReport03.pdf. Accessed 23 Apr 2011

Miles C, Reed J, Klinger E, Nelson, L, Smith T, Kolker K, Cross C (2006) Alternatives to plastic mulch in vegetable production systems. http://vegetables.wsu.edu/MulchReport06.pdf. Accessed 23 Apr 2011

Ngouajio M, Auras R, Fernandez RT, Rubino M, Counts J W, Kijchavengkul T (2008) Field performance of aliphatic–aromatic copolyester biode- gradable mulch films in a fresh market tomato production system. HortTechnology 18(4):605–610

Ngouajio M, Ernest J (2004) Light transmission through colored polyethylene mulches affects weed populations. HortSci 39(6):1302– 1304

Ojumu T V, Yu J, Solomon B O (2004) Production of polyhydroxyal- kanoates, a bacterial biodegradable polymer. Afr J Biotechnol 3:18–24

Otey F, Mark A, Mehitrette C, Russell C (1974) Starch-based film for degradable agricultural mulch. Ind Eng Chem Prod Res Dev 13:90–95

Reemmer J (2009) Advances in the synthesis and extraction of biode- gradable poly-hydroxyalkanoates in plant systems—a review. Basic Biotechnology 5:44–49

Rivise C W (1929) Mulch paper. Paper Trade J 89:55–57

Russo, R.; Malinconico, M.; Petti, L.; Romano, G. Physical behavior of biodegradable alginate-poly(vinyl alcohol) blend films. J. Polym. Sci. Pol. Phys. 2005, 43, 1205–1213. (CrossRef)

Sanchez E, Lamont W J, Orzolek M D (2008) Newspaper mulches for suppressing weeds for organic high-tunnel cucumber production. HortTechnol 18:154–157

Scarascia-Mugnozza, G.; Schettini, E.; Vox, G.; Malinconico, M.; Immirzi, B.; Pagliara, S. Mechanical properties decay and morphological behaviour of biodegradable films for agricultural mulching in real scale experiment. Polym. Degrad. Stab. 2006, 91, 2801–2808. (CrossRef)

Schonbeck M W (1995) Mulching practices and innovations for warm season vegetables in Virginia and neighbouring states. 1. An informal survey of growers. VA Assoc. Biol. Farming, Blacksburg, 24 pp

Scott G, Gilead D (eds) (1995) Degradable polymers: principles and applications. Kluwer Academic/Chapman and Hall (1995).

Seymour R B (1989) Polymer science before & after 1989: notable developments during the lifetime of Maurtis Dekker. J Macromol Sci Chem 26:1023–1032.

Shigetaka, W., Weerasak, M. and Zhemchai, H. Survey of the Research on the utilization of Rice Husk and Rice Husk Silica‟, Proc. 1st workshop on the utilization of Rice Husk and Rice Husk Silica, (2005), 6-14.

Shogren R L (2000) Biodegradable mulches from renewable resources.J Sustain Agric 16:33–47

Shogren, R. L. Preparation and characterization of a biodegradable mulch: Paper coated with polymerized vegetable oils. J. Appl. Polym. Sci. 1999, 73, 2159–2167. (CrossRef)

Shogren, R. L.; Rousseau, R. J. Field testing of paper/polymerized vegetable oil mulches for enhancing growth of eastern cottonwood trees for pulp. Forest Ecol. Manag. 2005, 208, 115–122. (CrossRef).

Smith A (1931) Effect of paper mulches on soil temperature, soil moisture, and yields of crops. Hilgardia 61:592–601

Tocchetto, R.; Benson, R.; Dever, M. Outdoor weathering evaluation of carbon-black-filled, biodegradable copolyester as substitute for traditionally used, carbon-black-filled, nonbiodegradable, high-density polyethylene mulch films. J. Polym. Environ. 2001, 9, 57–62. (CrossRef)

Warnick J P, Chase C A, Rosskopf E N, Simonne E H, Scholberg J M (2006) Weed suppression with hydramulch, abiodegradableliquid paper mulch in development. Renewable Agr Food Systems 21:216–223

Warp H (1971) Historical development of plastics for agriculture. Proc Nat Agr Plastics Cong 10:1–7

Yang N *et al.*, 2015 Plastic film mulching for water-efficient agricultural applications and degradable films materials development research Mater. Manuf. Process. 30 143–54

Yuya Tachibana (2009) Utilization of a Biodegradable Mulch Sheet Produced from Poly(Lactic Acid)/Ecoflex®/Modified Starch in Mandarin Orange Groves, Int. J. Mol. Sci. 2009, 10, 3599-3615; doi:10.3390/ijms10083599

Zhang C E, Liang Y L, He X B (2002) Effect of plastic film cover cultivation on soil microbial biomass. Acta Ecol Sin 22:508–512.

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