Biodegradable agroplastics in 21st century horticulture

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Abstract: The paper is a review of the literature on the application of biodegradable materials (agroplastics) in modern agriculture, and particularly in horticulture. Agroplastics are used within the so-called plasticulture system – in mulches, different forms of plant covers, pots for seedlings, strings, and other materials. Although they leave behind a considerable amount of waste, their recycling has been implemented in only some European countries. The positive solution of this environmental problem lies in propagation and implementation of biodegradable plastics in agricultural practice. In order to achieve this, a clear system of classification and assessment has been introduced in the European Union. Results of experiments with biodegradable plastics applications as soil and plant covers, and their impact on the environment are presented.

Keywords: plasticulture, biodegradation, recycling, polylactide, photodegradable polypropylene, mulch, direct cover.

Biodegradowalne materiały polimerowe w ogrodnictwie XXI wieku

Streszczenie: Artykuł stanowi przegląd literatury dotyczącej zastosowania biodegradowalnych materiałów polimerowych w nowoczesnym rolnictwie, w szczególności w ogrodnictwie. Są one wykorzystywane w systemach tzw. plastikultury – ściółkach, różnych formach osłon, doniczkach, sznurkach itp. Ich stosowanie powoduje jednak powstawanie znacznej ilości odpadów, których recykling wprowadzono jedynie w nielicznych krajach Europy. Rozwiązaniem tego problemu jest propagowanie i wprowadzanie do praktyki rolniczej tworzyw biodegradowalnych, a także przejrzysty system klasyfikacji zgodny z zaleceniami Unii Europejskiej. Przedstawiono eksperymentalne próby zastosowania biodegradowalnych tworzyw jako ściółek i osłon bezpośrednich oraz ich wpływ na środowisko.

Słowa kluczowe: plastikultura, biodegradacja, recykling, polilaktyd, fotodegradowalny polipropylen, ściółka, osłona bezpośrednia.

STATUS QUO OF AGROPLASTICS

As hard as that is to believe, half of all polymeric materials in the world have been produced and used over the past 15 years. Agriculture was one of the factors contributing to the growth in their production, which only started in the 1950s. By the year 2017, 8.3 billion tons of polymer materials had been produced, of which 5.7 billion tons became waste that was never subjected to recycling. It will take a minimum of 300–450 years for this waste to disintegrate into the molecules from which it originated. The largest accumulation of plastic waste fills the seas and the oceans, where it kills and damages the animals living there [1, 2]. It also causes considerable pollution of the soil [3].

The term agroplastics came to denote materials that provide support mainly for horticultural production. For the most part, these include films (foils) and nonwoven fabrics for mulching, films for covering tunnel structures, anti-hail and shading nets, pots and containers for seedlings, as well as strings and clips for tying plants. They do not include fertilizers, protective measures or hygiene products [4].

The advantages of this system include "biomimicry" – the imitation of nature, which accelerates plant growth, facilitates the introduction of new species cultivation, helps reduce the use of fertilizers and water, as well as en-

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abling the protection of the soil layer and the root system. According to some calculations, without the use of plasticulture, 60% of horticultural crops and animal products would disappear. Among its main disadvantages, we must indicate environmental pollution, and sometimes also a decrease in the quality of vegetables and fruits grown in this system. Initially, polymer materials were used in highly developed countries (such as USA, Japan, and France), but nowadays they are widespread, and they are found around the world [5]. Currently, plasticulture is a modern agricultural system, which enables yielding "more for less" by falling in with the circular economy, with a debatable impact on the environment. Despite many indisputable benefits that it has brought, it is perceived, especially recently, as a source of environmental pollution [6]. For many years, both low and high density polyethylene (LDPE, HDPE) and polypropylene (PP) dominated in the agroplastics market under the form of film and nonwovens. In the period from 1985 to 2005, the consumption of these materials in the form of mulches, tunnel shields and others multiplied, and at the beginning of the twenty-first century, it amounted to 6.5 million [4]. Currently, European agriculture alone consumes 674 thousand tons from the entire polymer market. From this amount, plant production uses 46%, and animal production is responsible for 54%. In southern Europe, vegetable production dominates in this respect (78%), and in the northern part, animal production prevails (67%). The largest areas are covered by mulches (380 thousand ha), which are used on a large scale in Spain, Italy and France. In these countries, greenhouses (120 thousand ha) and low tunnels (170 thousand ha) are used, mainly for growing vegetables. Large areas are also occupied by anti-hail netting, mounted on supporting structures. In some countries (including Poland), on a large scale, vegetables and strawberries are covered directly (without supporting structures) in the early spring [7].

Currently, China is the world leader in the production and use of soil covers as well as protective covers for low and high structures for growing horticultural plants. It is there that the largest growing areas are found that apply mulching (18.5 million ha), as well as production under low tunnels (1.1 million ha), high tunnels (2.9 million ha) and nets (0.15 million ha). China is facing the task of feeding 22% of the human population, and that in the conditions of declining area of arable land (over the last 30 years, the country has lost 10 million ha of farmland due to urbanization, pollution and changes in consumption), and polymeric materials are one of the means to achieve this goal. If we add 14.5 million ha of farmland irrigated with nutrient solutions to the agriculturally used area, we will obtain the staggering number of 4.8 million tons of these materials used each year [8].

According to reports presented at the 21st Congress of the International Committee for Plastics in Agriculture (CIPA, Arcachon, France 2018), China carried out 765 research studies and 2644 implementations related to mulching, which showed a significant increase in yield. The greatest benefits were obtained in the cultivation of tomatoes, where the yield increase was on average 37%, with water savings of at least 50%. The basic material used in China for mulching is a colorless polyethylene film (*versus* mainly black foil in Europe). The representatives of the world of science dubbed this phenomenon "white revolution – white pollution". It has been calculated that on the area of 1 ha of cultivated soil, between 80 and 200 kg of film are left behind. This is the result of using the cheapest, overly thin foil (10 mm), which is degrading already during use, and the problem is compounded by the lack of legal regulations that still allow the incineration of waste [3]. Numerous authors pointed out problems resulting from the mass mulching with polymeric materials. Listed among the most important threats are the additives included in the films and nonwovens (masterbatches), namely the pesticides that settle on the mulch and react with microplastics, which later may bind other chemical compounds (agrochemicals). Mulching can also cause long-term changes in the biocoenosis of pathogenic fungi, and it can accelerate the metabolism of carbon and nitrogen. Further, it can reduce the level of organic matter in the soil and slow down the release of greenhouse gases. However, monitoring such changes in soil would require totally new analytical methodologies [9].

MODERN RECYCLING SYSTEM

In 2012, around the world, 1.3 million tons of agroplastic waste was generated in agriculture, of which 55% was entered in the recycling system. Only a few countries have mastered the difficult problem of collecting and processing polymeric materials used in plant and animal production and in the form of packaging. Leaders in the field of recycling include Germany and France as well as Canada. This activity is strictly part of the circular economy policy, and the end result may be new items used again in agriculture, construction, and industry. In the National Collection Schemes created in the aforementioned countries, over 90% of the recovered materials can potentially be processed. Thanks to this system, the level of recycling has increased – in France, for instance, to over 75%. At the Congress in Arcachon, the European Association of Plastics Recycling and Recovery (EPRO) presented a concept that had already been implemented in several countries. In France, the A.D.I.VALOR consortium manages to collect 90% of the polymer materials utilized in agriculture every year. Over one thousand collection points receive thousands of tons of waste from 300 thousand producers, and forward it to 30 processing plants located throughout the country. The end result of this chain consists in many products used in agriculture (for instance foils and packaging) and in everyday life (for instance garden furniture or flower pots) [10]. Good organization structure for the recycling of polymer waste from agriculture has also been developed by the USA and Canada. The system of extended liability of producers of polymeric materials which these countries had introduced applies to approximately 170 organizations. In Canada alone, the CLEANFARMS association collects and processes 5 billion packaging units per year, with a total mass of 40 thousand tons annually [11].

In January 2018, the European Commission announced a new strategy for plastics. The goal for 2030 is to achieve recycling or re-use of 60% of all polymer materials. In 2040, the recovery is to reach 100%. At present, 674 thousand tons of new products are manufactured each year to cover the huge demand of agricultural practice, leaving behind about 1 million tons of waste. The mass of the waste is compounded by substantial pollution originating from the soil field and plant debris, and this kind of waste contribution is the highest in the case of mulches [12].

In Poland, the degree of recycled products from basic polymers (polyethylene and polypropylene) already exceeds the European average (about 30% of the production), and in 2014 it amounted to 44%. Priority is given to the Circular Economy package, in order to protect the environment against contamination resulting from uncontrolled combustion. Polymeric materials occupy one of five important fields of action within the said package. According to the latest statistical data, the packaging is processed in the highest degree (60%), whereas materials from agriculture account for only 5.2% of all recycling. Recycling companies in Poland are usually not interested in buying films and nonwovens from the fields due to the high pollution and heterogeneity of these materials [13, 14].

BIOPLASTICS – AN ENVIRONMENTALLY FRIENDLY ALTERNATIVE

The basic challenge for biodegradable materials – which have been used since the 1990s in many countries in the form of mulches for soil, direct covers, as well as foils (films) and meshes – is how to ensure availability of modern, environmentally friendly materials [15]. Their purpose is to improve the condition of the environment by eliminating waste and stimulating economies, especially in poorer countries. Further targets that biodegradable materials are supposed to address include minimizing the use of pesticides and water, without reducing the impact of these covers on the yield, the earliness, and the quality of vegetables. We are facing a potential ethical problem, springing from the fact that instead of using the valuable biomass to produce food, biopolymer materials are produced instead. The answer to this issue is the use of inedible plants, food waste and substitute plants.

The arguments for the dissemination of biodegradable materials for agriculture (mulches, pots, string, packaging) include the possibility of their production from renewable raw materials [corn plants, sugar cane, food leftovers as well as starch, poly(lactic acid) (PLA), polyhydroblastes, and biodegradable polyesters]; then after use, the possibility of leaving them in the field, and avoiding the whole recycling process. If they enter in the soil, this does not prevent the use of further polymeric materials (mulches). The added value for the environment is the reduction of mineral consumption as well as of CO_2 emissions (consumption by the plants from which they arise). The large cost of removing the remains of non-degradable litter (mulch) from the field (according to CIPA 270–370 euro per hectare, 50 euro per person per day) compensates for the cost of using biomulch, which is twice as expensive as the standard non-degradable plastic film.

Those who oppose the use of biodegradable materials in agriculture argue that the period of degradation is extended (to use PLA mulch as an example, it requires a temperature of 55–60 °C to degrade, which is impossible to reach after the mulch enters the soil), that the awareness of recipients and the communication between producers and practitioners remain unsatisfactory, and that the price of raw materials is high. Technological impediments include the frequent lack of degradation-causing microorganisms on the soil surface, especially in dry years, and the dependence of biodegradation on specific conditions. An objective barrier to the implementation of biodegradable materials is the lack of supporting financial resources from the state (with Spain and France being positive examples to the contrary) [16].

Recent years have also seen the introduction of a new classification of biodegradable materials, and the exclusion of oxo- and photodegradable mulches (PE and PP, which have the addition of the so-called photodegradants, such as iron stearate, which cause photodegradation). In view of significant differences in physical and chemical traits, the items defined to date as biodegradable materials for agricultural purposes have been divided according to Eurostandard EN NF 13432. In contact with the soil, biodegradable mulch is decomposed by microorganisms. Costs of its collection, transport and recycling are then avoided. The definition of biodegradable material posits that it is a polymeric material that can decompose under the influence of microorganisms (bacteria, fungi, or algae). The product of such degradation is water, CO_2 or methane (only under anaerobic conditions), and the possible remains include residues and new biomass, which are not toxic to the environment. This happens as a consequence of breaking down and loss of physical properties, resulting from the impact of climate conditions (heat, humidity, UV radiation and other factors) [16]. Some of the materials used in agriculture are referred to as biodegradable, although in fact they are bioerodible, hydrobiodegradable, photodegradable or partially biodegradable [17]. According to the present authors, polymer materials for agriculture are divided into:

– non-degradable plastics, which are stable for a specific useful life cycle, are strong mechanically and are water resistant, and microorganisms do not attack them;

– readily degradable plastics, whereas usually after the application the degradation is gradual and cannot be controlled, and the time of degradation depends on the amount of stabilizing additives;

– plastics of controlled degradation (programmed degradable plastics) are the materials for particular applications, which degrade in predetermined time during and after the exposure to UV radiation;

– environmentally degradable plastics, a wide group of natural and synthetic polymeric materials, which must belong also under one of the two previous categories – they undergo chemical change followed by microbial assimilation under the influence of environmental factors.

In current practice, also a wider term of polymeric mulching materials is used, which includes:

– oxo- and photodegradable plastics – made of low density polyethylene (LDPE), polypropylene (PP), or polystyrene (PS), with the addition of covalent metal salts – iron, magnesium or cobalt. The degradation process here involves the oxidation of polymer chains when exposed to light;

– compostable plastics – made of poly(lactic acid) (PLA) or aliphatic polyester from maize starch, tapioca roots, or sugar cane;

– biodegradable plastics – made of poly(butyl succinate) (PBS) or PLA (with biodegradation proceeding at high temperature) [16]. Examples of mulches produced for agricultural purposes for a cultivation cycle of over 120 days include PLA foil (12–15 μm), Mater-Bi (20 μm), and OxiPhoto (15 μm).

The mulch contamination in the field is 100—300% of its initial mass after cultivation. On the other hand, plants are often covered with remnants of mulch, which is an obstacle to their recycling. Therefore, biodegradable mulching materials provide a solution to this problem. They were used for the first time in the 1990s as an alternative to traditional mulch, and they can be considered as biodegradable provided that they contain 90% of biodegradable material in a field test lasting maximum 24 months. This is in accordance with the European Standard NF 13432 on compostability of packaging. In order to check the ecotoxicity of bad molecules (metals), it is necessary to perform tests on soil and plants, and on earthworms, as well as the test of the inhibition of the nitrification process (ISO standard 14238 from 2012). Currently, after approval by the European Commission in 2018, the new standard PR EN 17033 is in print, on "Biodegradable mulch films for use in agriculture and horticulture – Requirements and test methods" [18].

Raw materials and methods of biodegradable materials production as well as the characteristics of products, which are made of these materials for agricultural use, have been described in numerous experimental and review works [17, 19]. In the years 2011–2014, technologies were developed for the production of prototypes of materials for mulching and direct covering of plants [20–22], pots [23], and strings for tying plants, growing under covers or in the field [24]. These materials were then tested in field conditions, and in tunnel conditions when growing vegetable plants (cucumbers, tomatoes, lettuces) as well as fruit plants (raspberries, strawberries) [25].

Research and practice of biodegradable plastics in horticulture

Recent years have seen a huge increase in the use of plasticulture in agricultural context, mainly in the form of film mulches (with Asia being responsible for 60% of mulched areas in the world) [26], and in Europe also in the form of direct covers made of nonwovens (30 thousand ha) [7]. A particularly rapid growth occurred in soil mulching technology, which brings undeniable results and generates conditions for obtaining high yields in various climates [27]. At the same time, the development of social awareness, and the high level of environmental contamination with the remains of plastic film and nonwovens, activate measures to protect the agricultural environment [3]. One of the ways to hope for improvement is to replace commonly used non-degradable polyethylene and polypropylene materials with degradable materials that do not leave harmful compounds on the surface and in the soil. Within this field, a number of experiments were carried out with plants in the field and under covers, which took into account new biodegradable materials, as compared with non-degradable materials [15]. Research in a temperate climate zone has shown a positive effect on the environment around the plants when using mulches made of PP nonwoven, PP with photodegradant, and PLA, regardless of the material, as well as the improvement of yield for cucumber [28], zucchini [29], and raspberries [30]. The cited works have not demonstrated the dependence of the chemical composition of vegetables and fruits on the materials used for mulching. A slight effect, and even the lack of effect of mulching with black polyethylene biodegradable film had been observed in an experiment conducted in several zones of Spain's climate with tomatoes grown for industrial use [31]. The authors report that despite that fact, the treatment using biodegradable mulches (Mater-Bi®, Biofilm®) and oxo-degradable mulches (Enviroplast®) is economically viable due to the high costs of weeding (including mulching with MimGreen® and Saikraft® paper or barley straw). The use of melt-blown nonwoven fabric with PBS (Bionolle®) with a surface mass of 50 to 100 g/m^2 for direct covering of leeks in winter was shown to have a high impact on the winter survival and spring yield. Additionally, under the thinner nonwoven fabric, with more solar radiation reaching through, an increase in the level of sugars was reported [32]. In a similar experiment with the wintering leeks, a nonwoven fabric with a weight of 50 g/m^2 made of PLA and PP with photodegradant was used, and its effect was compared with that of the PP agrotextile [33]. In all cases of the use of covers, the physical parameters of nonwovens made it possible, in spring, to obtain a much higher degree of winter survival and higher yield than in the field without any cover. The nonwovens also had a positive impact on the content of dry matter, sugars and ascorbic acid. Martín-Closas *et al*. [15] have indicated potential use of the pre-tested biodegradable materials in the form of foils and nonwovens – for solarization, for the covering of low tunnels, and for the protection of fruit against the sun.

Degradation in field conditions

With the use of modern mulching materials, their life cycle should coincide with the time of growing plants, which is usually 3–6 months. The ideal situation occurs when the mulch gets fragmented in the field, and then the remains are covered during soil cultivation. Dozens of biodegradable materials available in commercial form are produced not only from renewable raw materials. Some, such as PLA or PBS, are made of bio-based polymers, often with additives of synthetic polymers [15]. According to the content of bio-based carbon, materials are classified into several groups, and only some are certified for use in field crop conditions and are also suitable for composting (including Dupont Biomax®, Mater-Bi®, Mirel®, Plantic®). The long-awaited standard for classifying materials as biodegradable (mostly for mulching purposes) has recently been adopted by the EU Commissions [18]. Over the past twenty years, dozens of projects were carried out, evaluating polymer materials in terms biodegradability. Many authors claim that the decisive role in the progress of surface degradation (above soil) in the field is played by: UV radiation, exposure time, degree of mulch coverage by plants, the amount of rainfall, and irrigation. In soil degradation depends on the chemical compounds present in the soil, as well as the microbial activity [15]. The most objective method of assessing the degree of degradation is laboratory soil simulation in several different variants of environmental factors – temperature, humidity, soil or substrate type [34]. However, in research practice, the assessment of degradation is very difficult. The photodegradable PP bedding was analyzed in 3 stages under field conditions using a simple weight method. It was found that after two months (in the middle of zucchini vegetation period), 40% of the litter weight had disappeared, whereas at the end of the vegetation period, 52% of the weight had disappeared [29]. The method of testing the maximum tensile strength and elongation at break at various stages of tomato growing for industrial purposes (conducted at intervals of 30 days) is more accurate, and it serves to describe the quality of the material [35]. When using standard black PE film and three biodegradable mulches (Mater-Bi®, Biofilm®, Bioflex®), the degree of degradation was assessed on a scale of 1–9, where 1 was the intact film, and the 9 was the phase of strong fragmentation. The analysis of spectral properties and water permeability was also performed, making it possible to characterize the physical parameters of these materials, and to determine the dynamics of degradation in field conditions.

The impact of biodegradable agroplastics on the soil

Although agricultural land management is recognized to affect near-surface physical qualities of soil, little is known about how plastic or biodegradable mulching affects physical and chemical soil parameters. The study [36] provided evidence that land use (system of production: high tunnel *versus* open field production, bare soil *versus* mulching soil) had a significant impact on soil organic carbon (SOC), moisture content and water stable aggregate amount in the soil. Soil organic matter is an important factor of soil quality and a sensitive indicator of ecosystem stress or changes. Management practices include film covering and mulching with a moderate moisture and temperature regime in the soil, modifying the biogeochemical cycling of carbon. Higher temperatures under plastic tunnels during vegetation created favorable conditions for organic matter mineralization. After 3 years of the study, soils under PP photodegradable and PLA covers in the high tunnel system had significantly lower SOC content *versus* the open field production system. Soil mulching enhanced the water capacity expressed as the volume of capillary water content. Mulching improved the soil structure in relation to the bare soil, in particular in open field conditions. Film covering prevents decreases in the amount of large aggregates in soils. This study indicated that soil salinity was found to be higher in the high tunnel system than in the open field conditions. Soils taken from tunnel plots also showed higher contents of P, Mg, Ca, S, Na, and B than soils from the open field system. High tunnel soils are not exposed to regular leaching from rainfall, and soluble salt accumulates over time from the application of hard water.

In another study, with cucumber in open field conditions, the organic carbon content was determined to be higher in the soils mulched with the PP nonwoven enriched with a photodegradation activator. A similar trend was observed in soils mulched with the polypropylene nonwoven PP. Covering the soil with nonwoven PP had an effect on the increase of water resistant macroaggregates. All mulched soils were characterized by a higher concentration of nitrate -NO_3^- in comparison to the bare soil [28]. Mulching increases the biological activity in the soil and in turn – as a result of the mineralization of the organic soil matter – this might lead to increasing the content of the nutrients available in the soil [27]. Moreover, the movement of ions with the rainwater is reduced, which increases the nitrate content in the soil.

Further obtained results showed that using biofilms covers with PLA and Bionolle in stenothermal vegetable field production significantly increased the amount of macroaggregates, and decreased the percentage of the smallest size aggregates in soils. Having said that, the observed effects were strongly affected by weather conditions. In this particular study, conducted under wet conditions, mulching with biodegradable materials increased soil bulk density and decreased soil water capacity. The benefits of plastic mulch to crop production are well documented, and they include greater root growth and nutrient uptake. In the cited study, soils under PLA and Bionolle covers had lower ion concentrations as compared to the bare soils. The most probable explanation of these results is that better plant growth and higher plant biomass production on plots where moisture and temperature were most favorable resulted in higher nutrient uptake. After harvest, the ammonium concentration in tomato soils ranged from 1.02 to 3.1 mg -NH_4^+ dm^{-3} for the PLA treatment, and from 0.4–1.9 mg -NH_4^+ dm^{-3} for the bare soils. Nitrate concentration varied, and it ranged between 2.2–6.6 mg -NO_3^- dm^{-3} for the PLA treatment, and 1.5–9.5 mg -NO_3^- dm^{-3} for the control soils [37].

Composting in field conditions

An important aspect related to the development of innovative plasticulture materials for agricultural applications is their utilization. In ideal conditions, the life cycle of the products should be close to the duration of their use, and depending on the purpose, it should range from one season (1–6 months) to several seasons, which is not always easy to attain. The solution lies in the composting of materials after their period of use. The assessment of the compostability of materials in laboratory conditions is conducted, among others, on the basis of the PN-EN/ISO 20200:2016 standard. Due to the composting process being conducted at 58 ± 2 °C with compost moisture content of the sample at 55%, all materials belonging to the biodegradable material group are completely degraded, including nonwoven materials for agricultural applications [22, 38]. Composting in industrial conditions, where average temperatures are around 60 °C, also confirms the effective utilization of the materials made of biodegradable components [39], where the elevated temperature close to glass transition temperature, for instance, for PLA (T_g = 55–65 °C), promotes its hydrolytic degradation [40], which is one of the main breakdown factors in composting. In the case of agriculture, composting can be carried out under field conditions. Due to the influence of temperature on the degradation, this process will be related to the climate zone and it will depend on weather conditions [41, 42]. The effectiveness of composting in field conditions can be supported by implementing the process in anaerobic conditions, with the addition of substances such as chalk, bovine manure, or chicken manure [43]. Different possibilities of waste management from biodegradable polymer materials confirm their environmentally friendly character, whereas the advantages associated with yielding as a result of mulching of the plants are encouraging, leading to the conclusion that this type of products should be implemented in industrial and agricultural practice as soon as possible.

CONCLUSIONS

The use of biodegradable materials in agriculture, in addition to those materials already known and repeatedly described [19], also provides other environmental benefits, resulting from their properties compared to traditional films and nonwovens:

– availability, processability and recyclability [44];

– a lower degree of water retention in the soil, which in the period of rainfall reduces the potential development of fungal diseases and the levels of hypoxia-induced stress (no access for oxygen to the roots) [35];

– waste-free technology, residual materials entering the soil, and their complete biodegradation [27];

– stimulation of the development of biorefinery concepts, to produce raw materials for biodegradable plastics [26].

The future production and use of biodegradable materials potentially also raises some doubts and questions, as to:

– the source of obtaining the polymers – crude oil and natural raw materials are limited, whereas chemical compounds used in production may reduce the rate of introduction of these materials to organic farming [27];

– how do biodegradable materials affect the eutrophication of surface water, and soil acidification? [26];

– correct selection of plant species to the methods of biodegradable materials application to avoid the negative influence on their quality [44, 45].

There are also opinions stressing the threat to the environment and food safety when using biodegradable and degradable materials in other ways [17].

In the report of EU concern Circular Economy Action Plan the problem of plastic wastes from the agriculture and replacing polyethylene and polypropylene with biodegradable plastic are strongly accented. In the frame of the projects Biogratex and Biomasa the application of some prototype of mulches and pots were done. According with the positive results the commercialization of biodegradable nonwovens in Polish market and agricultural practice [46] is expected.

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