Circular use of plastics in open field and horticulture

Glossary

Certifications

About the project

WAGENINGEN
UNIVERSITY & RESEARCH

Introduction

Plastics have been used in agriculture and horticulture since the 20th century, helping to increase productivity and improve crop quality. Today around 4% of the total plastic production in Europe, approximately 2 Mt, is used in agriculture, farming and gardening[1]. The most significant use of agricultural plastics is in mulch films which offer multiple benefits, including weed and pest control, soil moisture conservation, and extension of the cultivation period. As a result, these films help reduce pesticide use, improve water use efficiency, and boost crop yields[2].

Other plastic products with notable environmental benefits include irrigation pipes and drip tapes, which deliver precise amounts of water directly to plant roots, significantly improving water use efficiency. Furthermore, there are plastic products that aid plant growth, either during early growth (e.g. plant propagation products) or in later stages to allow for optimized growing (e.g. support netting and clips). Another, often not directly realized, example of plastics entering the agricultural sector is via polymer-coated fertiliser, which controls the release of nutrients to better match the plant's life cycle. By increasing nutrient use efficiency – particularly nitrogen use efficiency – this technology helps reduce greenhouse gas (GHG) emissions, as nitrogen fertilisers alone contribute to 5% of global GHG emissions[3].

While plastic products in agriculture and horticulture offer numerous benefits, their use also presents significant environmental and potential health risks. Most plastics are fossil-based, rely on finite resources and contribute to global warming through GHG emissions. Incomplete collection and disposal lead to the accumulation of macro, micro, and nano plastics, as well as the release of plastic additives into the environment. This can negatively impact soil productivity, water quality, and overall ecosystem health.
A critical concern is the potential for plastic particles and leached plastic additives to accumulate in plants and enter the food chain, posing risks to food safety. The effects of plastic residues in food on human health are still




not well understood, and more research is required to investigate their potential (long-term) health consequences[4].
In response to these issues, across Europe and through initiatives like the United Nations Plastics Treaty, various frameworks and policies are emerging to encourage more responsible plastic use in agriculture. Key measures include reducing plastic use, improving collection systems, and fostering reuse and recycling practices to address plastic pollution. For plastics that cannot be collected after use, compostable or soil-biodegradable alternatives are explored. These biodegradable plastics can contribute to reduce labour and the costs of waste management. To reduce the impact of toxic plastic additives, safer substitutes are explored that do not compromise the product's functionality[5].

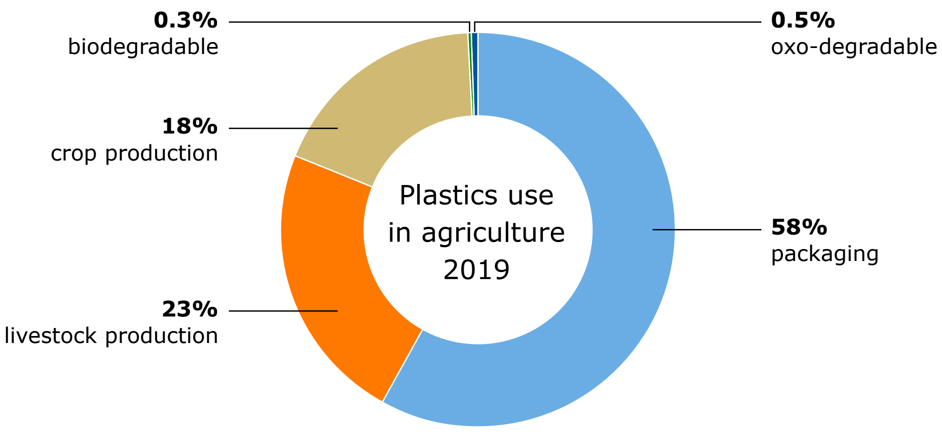
Plastics in numbers

Globally, plastics production accounted for 413.8 Mt in 2023. 90% of this amount was virgin fossil-based while the remaining 10%[6] was either recycled or biobased feedstock.

According to data from Plastics Europe[7] on plastics converters demand, the total demand of plastics in Europe has increased from 46 Mt in 2012 up to 54 Mt/per year in 2022. The share claimed by the agricultural sector has remained in the same range since 2012, varying around 3 to 4% of the total demand of plastics in Europe. This translates in an approximate demand of 1.7 Mt virgin plastics per year for the agricultural sector, including packaging. Figures for 2020 indicate a slight decrease towards a demand of 1.6 Mt till 2019, probably due to the global impact of the Covid-19 pandemic; but it could also be due to the increasing amounts of recycled plastics re-entering the market and replacing virgin raw materials, also in agricultural applications. In relation to other sectors, the plastics demand in the agricultural sector is small. In comparison, the demand for the largest plastic sectors, packaging and building, are around 40% and 20% respectively.

Specific data available on agri-plastics, focusing on non-packaging plastic products that have a direct use in the field in Europe are available from the French association "Agriculture Plastics Environment" (APE).[8] Most recent data originate from 2019 and show an amount of 710 kt virgin conventional plastics marketed for crop and livestock production. A small fraction of these plastics is attributed to (bio)degradable plastics. For instance, a 2018 report states that annually 8 kt oxo-degradable mulching film is used, which represents 0.5% of the total amount of plastics used in the agricultural sector. As these products are banned since July 2021, the current use of oxo-degradable plastics in Europe is unknown. Biodegradable plastics are used for film applications in the agricultural industry. In recent reports[9,11], a yearly demand of 4 to 5 kt biodegradable plastics for film applications is listed representing 0.3% of the total amount of plastics (including packaging) used in agriculture in Europe per year.

In this report, the circularity of plastics for crop production is addressed. Plastic products in open field and horticulture represent 18% of the total amount of plastics entering the agri-sector in Europe. Detailed information on differences between EU members is not available at present, but it is known that plastic use in the agricultural sector differs substantially from one country to another. Nevertheless, the general current situation on an EU level and the identified environmental risks originating from the use of plastics in agriculture underline the urgency to develop specific routes to more sustainable use of plastics on a national level.



Plastic Products

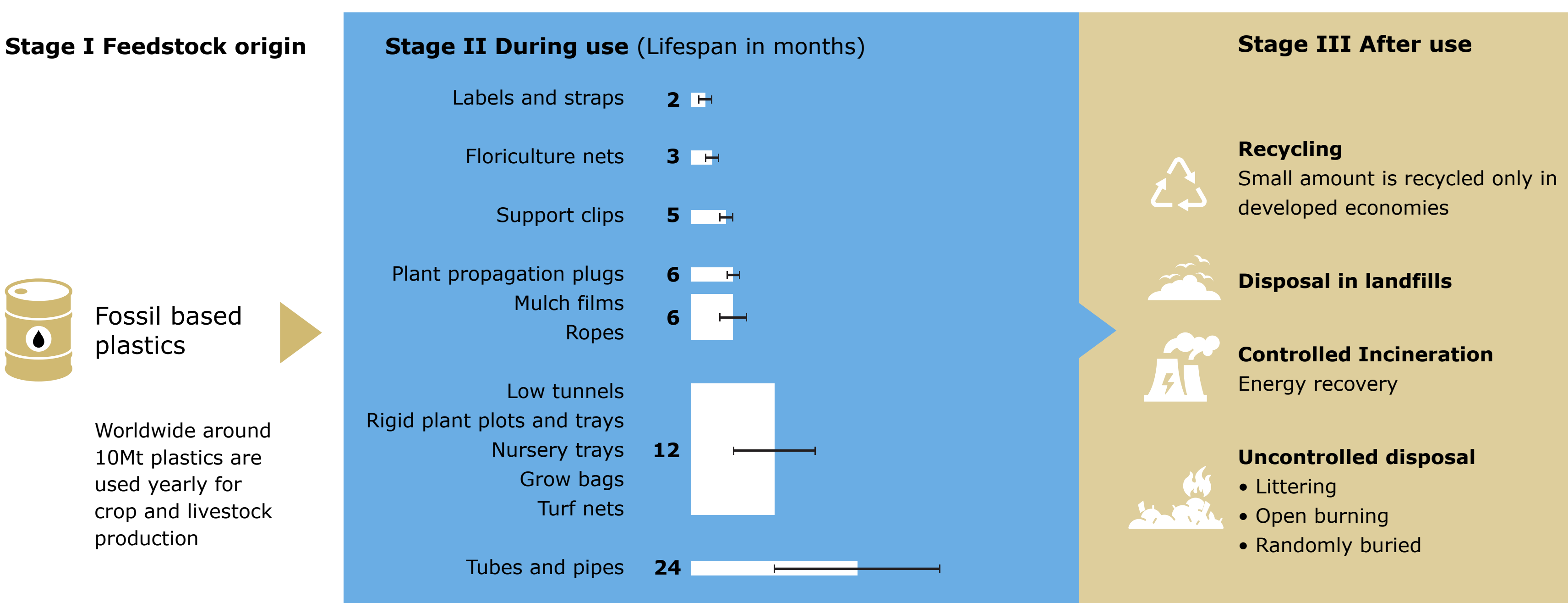
Plastic products are used in all stages of a wide range of crop cultivation processes. The figure below lists some of most common products found in horticulture and on the open field. They are categorised following the classification criteria used by the Food and Agriculture Organization of the United Nations (FAO)[9]. Plastics used for packaging and logistics of production means (e.g. fertiliser bags, pesticide containers, shrink wrap), are not included in this document. Decision tools for sustainable distribution and consumer packaging are available (in Dutch) on the website of Greenport West Holland[10].

	Propagation and seedling preparation	**Soil preparation**	**Irrigation**	**Plant growth & protection**	**Greenhouse installations**
Open field & horticultural plastics	• Seed coatings • Seedling plugs • Seedling pots • Nursery trays • Plant propagation plugs • Grafting clips • Nursery pots	• Mulch films • Fertiliser coatings • Foliage pulling mats • Ground covers • Substrate covers	• Drip tape • Dripper lines • Tubes • Pipes • Stakes • Growing gutter film • Irrigation mats • Pond reservoirs liners	• Turf nets • Floriculture nets • Rigid plant pots and trays • Plant labels and other accessories • Growbags • Low tunnels • Non-woven textile covers • Twine • Clips and truss support • Sticky traps	• Screens (shading, energy saving, blackout) • Straps and other accessories • Anti-condensation films • Protective netting • CO_2 distribution hoses • Greenhouse covers

Current situation

Life stages of plastics for crop production

Plastics used in agricultural and horticultural applications require attention at different life stages. The first stage is feedstock origin. Most plastics used in agriculture are based on fossil feedstocks, like petroleum and natural gas. The second stage is the use of plastics. Depending on the plastic application, the lifespan can be different. Some products have a very short lifespan of a few months while other can be used for years. The uncertainty in the lifespan of a plastic is large and it depends on many factors, such as farmer's practices and weathering. During use, plastics can be damaged generating fragments that can pose an environmental risk and reducing their lifespan. After use, plastics are discarded in (un-)controlled manners, only a small fraction is recovered for recycling. The current situation is sketched below.



Data compiled and adapted from FAO, 2021

Environmental risk

Current practices in agriculture result in plastics that can be Damaged, Degraded or Discarded in ways that can pose a risk to the environment. This 3D concept has been introduced by the FAO[9] and it is schematically explained below. Whereas some issues can be prevented by optimized product handling, many effects are intrinsic to the use of cultivation aids. The extent to which they are damaged, degraded or discarded cannot be controlled and subsequently contributes to contamination of the environment. Causes to these contamination risks can be found in the type of material or machinery that is used or a result of the overall efficiency of specific cultivation processes. Farmers most often do not have the capacity for adequate plastic management during use, resulting in plastic fragments entering our soils, waters and food chain. After the cultivation cycle, problems can arise due to the lack of infrastructure and strategies for waste management. This is exemplified by the fact that collection schemes are very different throughout Europe.[11] For instance, in Ireland, Iceland, Norway, Sweden, France and Spain collection rates for plastic cultivation aids are reported to be higher than 70%. In other countries the collection is not regulated, locally organized or inexistent, resulting in high plastic accumulation levels in the fields, farms or in landfills.

Cause	Effect	Risk
Damaged Damaged in-situ, released unintentionally / erratically into the environment	Dispersed into the environment – can injure or kill aquatic or terrestrial animals that ingest the plastics/are entangled in it.	**Macro-, micro- and nanoplastics build up:** • In soil and water, affecting plant growth and terrestrial and marine animals. • Through the food chain, eventually accumulating in humans.
Degraded Fragmented and disintegrated through longterm use and weathering, degraded into the environment	Can fragment into micro- or nanoplastics in soil, or carried by wind/water instead of completely degrading – this can affect soil structure, quality and crop-growth.	
Discarded Erratically disposed in the environment in an unplanned manner, such as littering and burning.	Intact/fragmented plastics are released into environment through littering. Burning releases hazardous substances to the air, which can pollute water and land, and harm human, animal and plant health.	

Circular economy

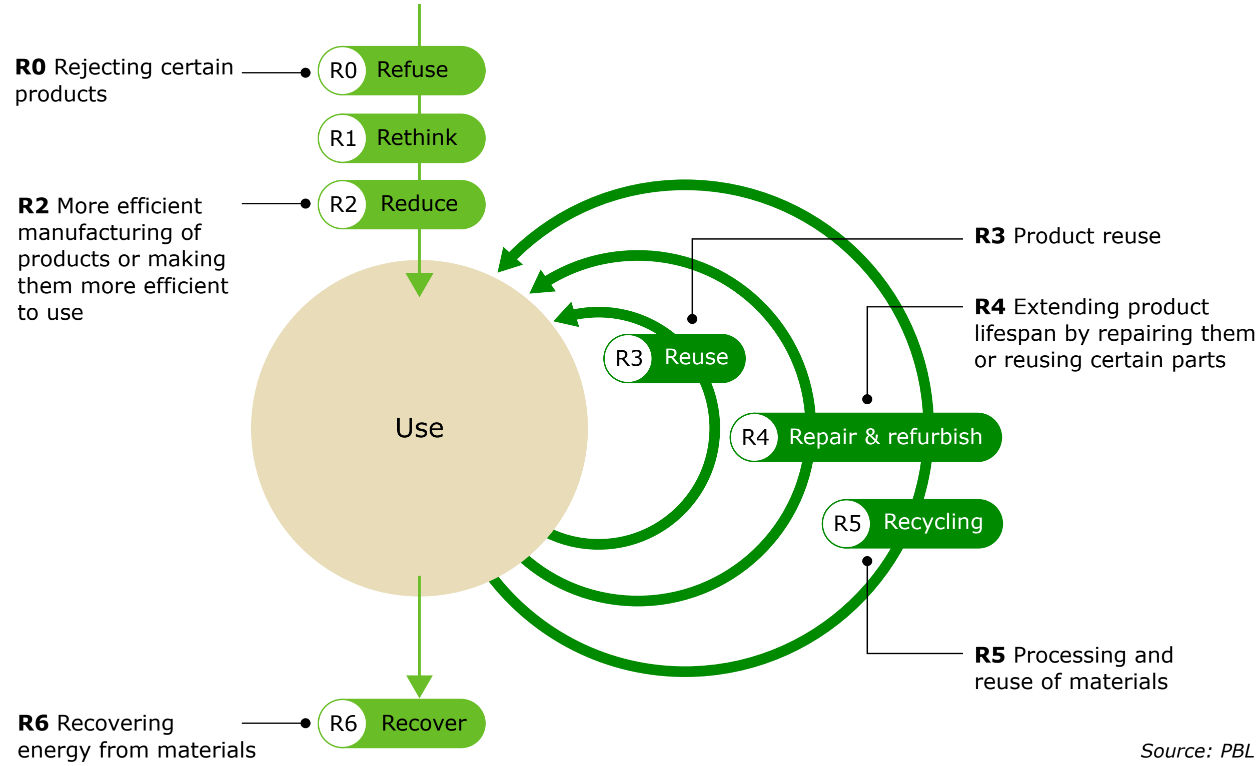
The circular economy model

The circular economy is a system aiming at eliminating waste and at the continual use of resources whilst regenerating nature. It contrasts with the traditional linear economy, which follows a 'take, make, dispose' model. In a circular economy, resources are kept in use for as long as possible, extracting maximum value before reaching the end of their service life.

The European Commission has set various actions and measures through its ambitious Circular Economy Action Plan[12] and European Bioeconomy strategy[13]. They consider the entire life cycle and complete value chain of a product. The goals of these actions are to produce fossil-free and biobased materials for a climate-neutral future by eliminating the dependency from fossil carbon feedstocks. These goals align with the European Green Deal and Paris agreement to achieve climate neutrality by 2050 and halt biodiversity loss, aiming towards a greener future and accelerating sustainable growth.

Plastic products form a key sector with high potential for circularity but with many challenges.[14] In the context of plastic products, the circular economy focuses on redesigning, producing, using, and recycling plastics to minimise waste and environmental impacts. This involves creating plastic products using fewer finite resources and incorporating sustainable materials (e.g. biobased materials), promoting the reuse of plastic products to extend their lifespan, and enhancing recycling systems to ensure plastic waste is effectively collected, processed, and reintroduced into the production cycle. The waste hierarchy as sketched in the R-ladder with circular strategies is an indicative tool to guide more circular approaches for the use of plastics in agri- and horticulture.

R ladder with circular strategies



Source: PBL

The R-ladder

The R-ladder is typically used as the framework to indicate the degree of circularity of a product[15]. The R-ladder encompasses various R – strategies for a more sustainable and circular product design and waste management with a priority order from high to low. The higher the strategy, the more it can avoid using valuable raw materials. The strategies are typically grouped in 4 main paths that can be followed: narrow the loop, slow the loop, close the loop and substitution of materials. The last strategy is important but not a part of the R-strategy. The R-ladder was not developed specifically for plastic use in agriculture, the definitions used in this document for the R-strategies consider some of the aspects of the ladder for biomass and food as described in the National Circular Economy Programme 2023-2030[16].

R0 **Refuse:** This strategy involves critically assessing whether a part of a product or a product is truly necessary and serves a vital function. It encourages rethinking whether this component can be combined with another or made multifunctional to eliminate unnecessary parts.

R1 **Rethink:** This strategy encourages rethinking and reconsidering the design and functionality of a product or its components. The goal is to create designs that are more durable, have a longer lifespan, and can be reused multiple times. Additionally, it involves rethinking the design so that the product or component can serve multiple functions. When biomass is the starting material, the optimal use of natural resources such as soil and water, together with the protection of the biodiversity, is encouraged.

R2 **Reduce:** This strategy focuses on making a product more efficient by reducing the amount of material or number of parts required. For example, decreasing the thickness of agricultural plastic film without compromising its functionality can lead to resource savings.

R3 **Reuse:** This strategy emphasises extending the lifespan of products or components by reusing them multiple times with minimal maintenance, such as cleaning or easy and controlled transportation within the stakeholder chain. This may require redesigning the product to withstand environmental stress and ensure durability.

R4 **Repair, Refurbish, Remanufacture, Repurpose:** This strategy involves extending the lifespan of a product by repairing parts or the entire product, provided that the resources, energy, or effort required do not exceed those needed to produce a new product. For this strategy to be effective, the product must be designed to allow repairs, and spare parts must be available in the market. An example is repairing damaged greenhouse covers with plastic tapes.

R5 **Recycle:** This strategy includes reprocessing the product to transform it into new raw materials that can be converted into new products. These products can be the same as the original (closed-loop recycling) or unrelated objects (open-loop recycling). This process ensures that resources used in the initial product are not lost, allowing them to continue circulating in the economy while reducing the environmental impact of producing virgin resources. When biomass is used, this strategy calls for actions to use and recover the residual streams containing the biomass to recirculate them in the biological cycle. For example, if an agricultural product is compostable, it can be recycled with the biowaste to be returned to the land.

R6 **Recovery:** This strategy is applied after the product has reached the end of its life and is no longer functional or suitable for recycling. The product should be recovered and managed in an environmentally sound manner. An example of a recovery process is collection and subsequent waste incineration. Waste is converted into heat and electricity that can be supplied to the local network. This strategy can also be used for residual biomass streams streams.

Greenport West-Holland

Programme Circular Cultivation Materials & Packaging
The Greenport West-Holland has initiated a programme to take steps towards circular & sustainable use of plastics within the (Dutch) horticulture sector since plastics play a critical role in cultivation and will likely continue to do so in the future due to several advantages:

- Lightweight material.
- Strong and versatile properties.
- Cost-effectiveness.
- Wide use across the horticultural supply chain, including propagation trays, crop wires, transport crates, labels, product packaging, shrink films, etc.

However, the extensive use of plastics is increasingly problematic for the sector, with challenges including:

- Rising waste-processing costs.
- Pollution of products and environment; scientific evidence increasingly demonstrates that plastics contribute to environmental contamination through the gradual accumulation of pollutants over time.
- Contamination of valuable green waste streams by (micro)plastics.
- Growing societal pressure to reduce or eliminate plastic use.
- Stricter legislation and reporting requirements on plastic reduction.

Despite significant strides towards using recycled, reusable, and biobased materials, the sector faces persistent challenges:

- Continued pollution and incineration of plastics.
- Ongoing use of virgin plastics, increasing CO_2 emissions.
- Escalating waste management expenses.

To achieve the Dutch government's goal of a circular economy by 2050, substantial progress is required in the usage and management of plastics. While the sector has various scattered initiatives, their fragmented nature limits their impact. This underscores the need for a coordinated approach, which is the focus of the Circular Cultivation Materials & Packaging Programme.
Since 2020, Greenport West-Holland has collaborated with representatives across the value chain and research institutions to establish an ambition and implementation plan for the responsible use of plastics in a circular economy. This programme aligns with national, international, and regional policy goals and addresses the sector's urgent need to address plastic and circularity issues.

The horticulture sector is highly proactive in addressing plastic-related challenges. The programme provides direction to numerous initiatives, emphasising a value chain approach through partnerships spanning the entire supply chain. Greenport West-Holland is building an innovation ecosystem to tackle circular challenges by addressing value chain, knowledge, and policy issues in close collaboration with its ambassadors.

More information, contact Matthijs Plas or Else Boutkan at Greenport West-Holland

GREENPORT West-Holland

Legislation & Regulation

EU landscape

2006

Regulation (EC)

No 1907/2006 - REACH

- Sets framework for responsible use of chemicals to ensure a high level of protection of human health and environment.
- Regulates the manufacturing and placing on the EU market of chemical substances including plastics and their additives.

2008

Waste framework directive 2008/98/EC

First legal framework for treating waste in EU:

- Promotes separate collection, recycling and re-use, prohibits uncontrolled discarded of waste.
- Introduces recycling and recovery targets.
- Sets minimum requirements for extended producer responsibility EPR schemes.

2012

European Bioeconomy Strategy

Introduces sustainable use of renewable resources for industrial purposes, while ensuring environ-mental protection.

2015

First Circular Economy Action Plan

Plan to help close the loop of product lifecycles through greater recycling and re-use, benefiting both environment and economy. Plan was completed in 2019.

2018

EU strategy for plastics in a Circular Economy

- Supports more sustainable and safer consumption and production patterns for plastics.
- Aims to:
  - make recycling a profitable business by new rules on packaging to improve the recyclability of plastics and increase the demand for recycled plastic content;
  - curb plastic waste by directives on single use plastics and fishing gear and restrictions to microplastics;
  - measures on biobased, biodegradable and compostable plastics;
  - drive innovation and investment in recycling.

New Bioeconomy Strategy

- Contributes to the European Green Deal.
- Reduces dependence on non-renewable, unsustainable resources by developing substitutes to fossil-based materials that are biobased, recyclable and marine biodegradable.

2019

Single-use Plastics Directive 2019/904

- Aims to prevent and reduce the impact of certain plastic products on the environment.
- Prohibits use of oxo-degradable plastics and some products made of expanded polystyrene (EPS).

2020

New Circular Economy Action Plan

- Announces initiatives along the entire life cycle of products.
- Promotes circular economy processes, encourages sustainable consumption, and aims waste prevention.
- Plastics is one of the focus areas.

2022

Communication on EU's policy framework on biobased, biodegradable and compostable plastics

European Commission adopted a policy framework (not legally binding) on the sourcing, labelling and use of biobased plastics, and use of biodegradable and compostable plastics, aiming to improve understanding and clarify environmental benefits.

2023

Amending Annex XVII of REACH Regulation

- Adopts measures to restrict the intentionally added microplastics to products under REACH.
- Preventing the release of microplastics in the environment.
- Includes fertilizers and plant protection products.

2024

Ecodesign for Sustainable Products Regulation (ESPR)

Framework on requirements on product durability and reusability, presence of substances that inhibit circularity, recycled content, carbon and environmental footprints, eliminate microplastics release.

Review of regulation (EU) 2019/1009

Laying down rules on making available on the market of EU fertilising products. This includes biodegradability criteria and biodegradable polymers as constituents of fertiliser products.

Dutch landscape

The waste management policy of the Dutch government gradually shifted its focus to a circular economy between 2015 and 2020. In 2015 the VANG-HHA program (Van afval naar grondstof – Huishoudelijk afval) was launched. It aimed to reduce the amount of mixed municipal solid waste that is incinerated and simultaneously to raise the separate rate of recyclable materials. In 2017 the third Dutch national waste plan (LAP3) was released, setting objectives to reduce waste generation and increasing reuse and recycling in 85 sectorial plans. Sector plan 11 on plastic waste management aimed to increase the separate collection and recycling of various types of plastic waste. In 2018 five transition agendas were published, including one for plastics, which aims to transform the entire plastic economy to a recycling economy with biobased feedstock.

Agricultural plastics were not considered explicitly until 2023 when the National Circular Economy Programme 2023-2030[17] was launched.

In this programme, agri and horticultural plastics are explicitly mentioned as one of the sectors with significant potential for reduction, collection, sorting and recycling. However, it is recognised that too little is known about the sector and the complete value chain, to take measures that are holistic and will impact the full sector. A recent report[18] explores the agricultural plastics chain in the Netherlands and gives a comprehensive overview of the current state of plastics in agriculture in the Netherlands.

The first recommendations are to implement an Extended Producer Responsibility (EPR) scheme and to implement biodegradable plastics for short lifespan applications. However, the path to effective policies still has to be drawn.

Timeline for the transition to a circular economy in the Netherlands

2023 – New National Programme on Circular Economy Implementation Programme (2023-2030)

The government has presented the National Circular Economy Programme 2023-2030, which sets out a mix of measures for the years ahead aimed at using products and raw materials more sparingly. Reducing the material footprint of the Dutch economy is the recurring theme. New interventions will be investigated, specific targets will be set on specific product groups as well as stricter norms and pricing incentives, and high value retention of products and materials will be scaled up.

2030 – Reducing use of resources by 50%

The government is working towards a circular economy by 2050. Its guiding ambition is for the Netherlands to use 50% less primary abiotic resources (minerals, metals and fossil carbon resources) by 2030.

2050 – A waste-free economy

The Netherlands wants to have a circular economy by 2050, in which:

- sustainable, renewable raw materials are used again and again wherever possible;
- products and materials are designed for circularity, reused, repaired and refurbished;
- hardly any waste is produced.

Overview

During the project 'Circular use of plastics in agriculture and horticulture', circular demonstration products were developed for three different end-of-life scenarios: recycling, composting and biodegradability in soil. Studies were performed in collaboration with the project partners.
In this part of the document, the advantages, challenges and future perspectives of each end-of-life route are discussed. Examples of how specific products fit within the foreseen (circular) end-of-life scenarios are described. Per product, two pages are included. In the first one, the current use of the product and important characteristics relevant for the end-of-life of the product are sketched. In the second page, highlights of the results obtained during the project are presented. These results are put in perspective by using the Material Circularity Indicator (MCI).

Recycling

- Rigid plant pots and trays
- Mulch films
- Foamed nursery trays

Industrial composting

- Grow bags
- Floriculture netting

Biodegradability in soil

- Plant propagation plugs
- Grass turf nets

Recycling

Introduction: recycling of agricultural plastics

Plastics are being collected for recycling since their introduction in agriculture. Whether discarded plastics are actually being recycled depends on the economic and legislative context. Currently, mechanical recycling processes prevail over more complex and demanding chemical recycling processes. In these mechanical recycling processes plastics are sorted, shredded, washed, dried and re-extruded to recycled pellets. These pellets are traded to converters that produce new plastic products. These products can be similar, as for example with silage films, of which a share of recycled plastic can be used to make new silage films. This is named closed-loop recycling. The opposite is named open-loop recycling, which means that an unrelated object is made of this recycled plastic. For example, the production of railway sleepers from recycled silage film. Currently, only a limited amount of agricultural plastics are being recycled, because it is cheaper to landfill or incinerate the plastics than to recycle them.

Advantages and challenges

Recycling plastics requires much less energy than the production of new plastics. When recycled plastics replace new plastic resources, energy is saved and GHG emissions are avoided. Additionally, when plastics are diverted from incinerators, substantial GHG emissions are prevented. Furthermore, when plastics are collected for recycling they can no longer disintegrate, disperse and pollute the natural environment.

Until 2023, there was no legal obligation to recycle agricultural plastics and it was only executed in case it was attractive for the incumbents. Currently, the prices of virgin plastics are low and recycling without incentives is not competitive. The best plastic resources for recyclers are plastic wastes that are either composed of one single type of plastic (a so-called mono-material) or from which the other plastics / materials / wastes can easily be separated and removed. The most difficult resources are mixed plastic objects and plastics that are contaminated with substances that are either toxic or difficult to remove. Substances that are of particular concern for mechanical recyclers of agricultural plastics are residues of crop protection agents. Furthermore, carriers of animal and or plant diseases, such as micro-organisms and viruses, are an additional concern for the operators of relatively simple recycling processes at which the plastic is not melted and sterilised. Hence, for example used silage film is commonly recycled as it is made from one type of plastic and the residual organic matter can simply be washed off. Whereas mixtures of various plastics, dead plants and crop-protection agents are least attractive.

Future perspectives

Recycling of agricultural plastic waste requires a favouring legal context. There are multiple regulations on EU and national level being prepared to stimulate the change. Also the petrochemical industry has presented future roadmaps which are based on recycling plastic waste via multiple pathways in which agricultural plastic waste is one of the preferred feedstocks.

Rigid plant pots & trays
Mulch films
Foamed nursery trays

Product overview

Rigid plant pots and trays

Cultivation function
Rigid plant pots (and trays) are used in horticulture to contain and protect plant roots, provide a controlled environment for growth and enable mobility within gardens, outdoor spaces and during transportation from greenhouse to consumer.

Current use and end-of-life
Plant pots are typically made of rigid plastics such as polypropylene (PP). After use, the products are typically emptied and collected. In some cases, pots are collected with other cultivation aids such as trays (made from polystyrene (PS)) and flexible films (made from polyethylene (PE)) which results in a mixed waste stream of horticultural plastic products and soil. The high waste processing costs and resource shortage create incentives to optimise recycling.

Transition towards circular plastic use
Mixed horticultural waste streams can typically be collected without the risk of plastic pollution in the environment. Hence, efforts should be taken to cost-effectively sort and recycle these products back into cultivation aids with comparable quality and functionality.

Rigid plant pots & trays
Mulch films
Foamed nursery trays

Case study results

Rigid plant pots

Rigid plant pots & trays

Mulch films

Foamed nursery trays

Case study objective
To demonstrate a new recycling chain from mixed horticultural waste towards a high quality recycled horticultural product. Rigid plant pots, to be sorted from a mixed waste stream with trays and flexibles, were selected as the target product.

Case study results
It was demonstrated that it was feasible to set up a process to manually sort out used plant pots, plant trays and films from a mixed horticultural waste stream. Following a dry mechanical recycling process, plastic flakes were obtained that could be successfully fed to a compounder and subsequently injection moulded into high quality plastic plant pots. The MCI increases from 10 to 53% when recycling the plant pots, supporting the potential impact of this recycling strategy.

Future perspective
As the feasibility of this recycling process has been successfully demonstrated at lab scale for rigid plant pots, the next step would be to translate this result to an industrial relevant process. In addition, recycling demonstration studies need to be performed for the additional fractions (trays and flexible films) that were found in the horticultural mixed waste stream.

Product overview

Mulch films

Rigid plant pots & trays
Mulch films
Foamed nursery trays

Cultivation function
Plastic mulch films are used for a wide range of cultivation processes in order to enhance soil temperature, suppress weed growth and promote healthy root development. This ultimately yields increased cultivation efficiency and improved crop production.

Current use and end-of-life
At present two types of mulch films are widely applied. Traditionally mulch films are prepared from polyethylene (PE) which provides good barrier properties and is relatively cheap. PE is a good material choice when it can be effectively collected, reused and ultimately recycled without the risk of leakage of film (fragments) in the environment. Films for asparagus cultivation are typically reused 5 to 10 times before they are collected for recycling. For cultivation processes in which it is not possible to collect the full plastic product (typical for thin cultivation films), a biodegradable polymer might be a good alternative. In the past decades soil biodegradable films based on polybutylene adipate terephthalate (PBAT) have become the standard material choice for this class of product, but films based on alternative materials such as fully biobased polyesters and starch-based solutions are on the market as well.

Transition towards circular plastic use
After cultivation mulch films should be collected, reused and recycled as effectively as possible. For effective recycling to take place it is important that the products are not contaminated with externally applied chemicals such as crop protection agents. For those cases where biodegradable plastic films are the most circular choice it is crucial to determine whether the accumulation of (micro)plastic is actually avoided.

Case study results

Mulch films (specific for asparagus production)

Rigid plant pots & trays
Mulch films
Foamed nursery trays

Case study objective
Determine the level of contamination of crop protection agents on recyclable asparagus cultivation films based on PE after collection.

Case study results
4 samples of asparagus cultivation films were collected from different locations in the Netherlands. The composition of the collected product was determined and subsequently a molecular analysis was performed to investigate the presence of any crop protection agents on the film. It was found that the majority of the weight of the collected product consists of soil and film and a little bit of moisture. Furthermore, no chemicals that can be associated with crop protection agents could be found, which indicates that the risk of contamination from these products is limited. When films are recycled, the MCI increases from 10% to 54%, indicating the increase in circularity of this recycling strategy.

Future perspective
For both biodegradable and non-biodegradable mulch films the level of plastic accumulation in agricultural soil needs to be investigated in more detail in order to demonstrate that increased circularity does not yield negative side effects.

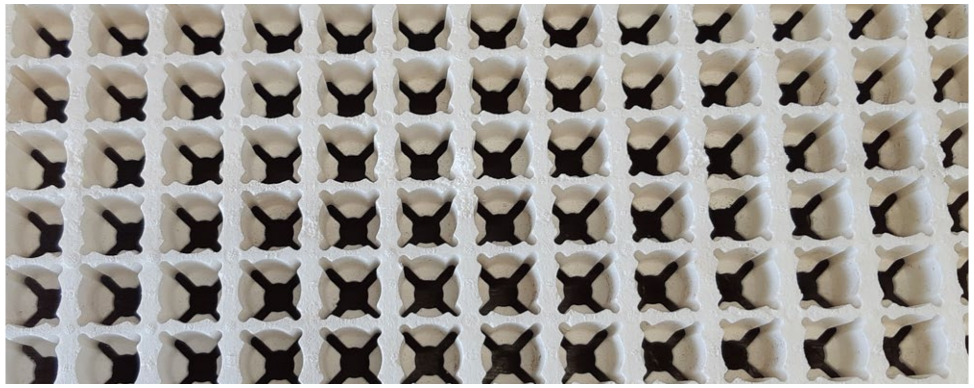
Product overview

Foamed nursery trays

Cultivation function
Due to their good thermal properties. Foamed nursery trays are often used to assist the early growth of plants. Their low weight allows for easy and energy efficient transportation.

Current use and end-of-life
Foamed nursery trays are used in confined environments such as indoor greenhouses. They are typically made of expanded polystyrene as this material shows good processability and functionality. After use, the products are difficult to clean and plant residues might remain present on and in the foamed product. At present these products are recycled into alternative applications such as insulation foams for building applications.

Transition towards circular plastic use
To allow circular recycling of foamed nursery trays back to cultivation products, it is crucial that recycling strategies are developed that guarantee the removal of plant viruses and other potentially hazardous plant waste material.



Rigid plant pots & trays
Mulch films
Foamed nursery trays

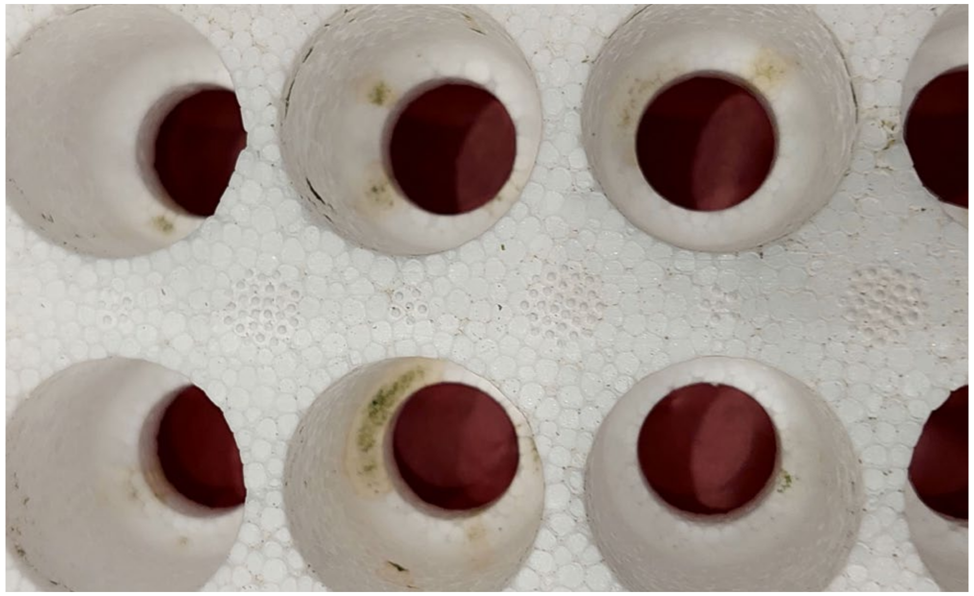
Case study results

Foamed nursery trays

Case study objective
Demonstrate a simple mechanical recycling strategy that enables reprocessing into cultivation products and investigate the potential impact of plant viruses on recycling options.

Case study results
A straight-forward dry-mechanical recycling strategy was developed that removes the majority of the excess soil and dirt that is present on the trays after cultivation. The resulting trays are sufficiently clean for reprocessing at project partner Hordijk. However, it is demonstrated that plant viruses can survive simple dry and wet recycling procedures which illustrates the potential problem in achieving circularity for this specific class of products. An increase in MCI from 10% to 53% supports the potential impact of this recycling strategy.

Future perspective
Investigations are required in order to determine whether thermal treatments can effectively inactivate the plant virus material without destroying the mechanical integrity of the recycled products.



Industrial composting

Introduction

Composting is a method in which fungi and microbes convert organic solid waste into compost which can be used as fertilizer for plants. Composting is a form of biodegradation which means that solid matter is biologically converted into carbon dioxide, water and biomass. Aside from organic waste, certain types of (biobased) plastics are also susceptible for composting or biodegradation. These plastics are subsequently called compostable or biodegradable plastics. Whether a plastic biodegrades depends on both type of plastic and the biological environment in which it is placed. This environment can be controlled or uncontrolled. Industrial composting is an example of a controlled biological environment with a relatively constant biological activity and a temperature that typically lies between 50°C and 60°C. Plastics that are being processed via industrial composting therefore need to be biodegradable in this environment. Plastic products that are certified for industrial composting are marked with the OK Compost INDUSTRIAL label.

Advantages and challenges

Industrially compostable plastics can be fully converted into minerals without leaving any (micro) plastic residue. The main advantage of using industrial composting as an end-of-life route is that it is not necessary to separate the plastic from the organic residues that are produced during the cultivation process. In that respect, industrial compostable plastics are a solution for agricultural and horticultural processes where it is difficult or even impossible to collect, sort and clean the plastic product and where the product has become an integral part of the mainly organic waste stream. Examples of such products can be clips, twines and floriculture netting. It is important to note that plastics that are certified industrial compostable are not always also biodegradable in uncontrolled environments such as soil and water. It is important to verify whether the risk of plastics entering these uncontrolled environments is negligible. When such a risk does exist, a plastic product that is also soil and/or marine degradable might be a better choice.

Future perspectives

At present, policies and legislation on compostable plastics are limited to a couple of packaging products[19]. Examples of such products are teabags, coffee pads, organic waste bags and fruit stickers and these are therefore often made from industrial compostable plastic. However, upcoming legislation on the use of biodegradable plastics in agri- and horticulture is anticipated. The already announced regulation on fertilizer products (Regulation (EU) 2019/1009)[20] is an example of legislation that promotes the use of biodegradable materials to counter (micro) plastic pollution. Furthermore, as the availability of compostable plastics is increasing while the relative cost price is decreasing, it is to be expected that these types of plastics will start to play a bigger role in the agri- and horticultural landscape in the years to come.

Grow bags
Floriculture netting

Product overview

Grow bags

Grow bags
Floriculture netting

Cultivation function
These plastic bags are typically used for the cultivation of high-wired crops in order to increase the efficiency of the growing substrate. They help to contain a sufficient level of moisture in the substrate and prevent the growth of algae.

Current use and end-of-life
Growbags are used in confined environments such as indoor greenhouses. They typically consist of a polyethylene multilayer material with a white outer layer (to keep sunlight out) and a black inner layer (to protect the growth of the plant roots). After a growth cycle of a couple of months and the crop harvest, the bags are disposed of together with the substrate and the crop waste. This mixed waste typically ends up being incinerated or landfilled.

Transition towards circular plastic use
When selective sorting and product cleaning is not possible, industrial compostable growbags could offer a promising end-of-life scenario as they allow for effective processing of all waste components in a single process.

Case study results

Grow bags

Grow bags

Floriculture netting

Case study objective
Development of an industrial compostable growbag, demonstrate its functionality and EOL in a greenhouse environment and determine its potential sustainability gain.

Case study results
3 types of multilayer growbags were developed at the pilot facilities at WFBR and tested in the greenhouse environment at WPR. The new growbags allowed for tomato cultivation comparable to conventional cultivation processes. In addition, disintegration and industrial compostability within 6 weeks was demonstrated. An increase in MCI from 10% for incinerated PE to more than 80% for compostable materials that are composted can be achieved, supporting the circularity potential of the developed materials.

Future perspective
In order to expand the end-of-life options of these products it would be highly advantageous to develop growbags that are biodegradable in soil after their functional life.

Product overview

Floriculture netting

Cultivation function
Floriculture netting aids the cultivation process of flowers and other crops by providing mechanical stability to vulnerable components of the plants which increases overall cultivation efficiency.

Current use and end-of-life
At present floriculture netting is typically produced from polypropylene(PP). Netting is installed above the sewn flowers and mechanically supports crops during their growth phase. After a growth cycle of a couple of months and crop harvest the netting is disposed of together with the agricultural plant waste. This mixed waste typically ends up being incinerated or landfilled.

Transition towards circular plastic use
When selective sorting and product cleaning is not possible, industrial compostable floriculture netting could offer a promising end-of-life scenario as it allows for effective processing of all waste components in a single process.

Grow bags
Floriculture netting

Case study results

Floriculture netting

Case study objective
To design and develop a floriculture demonstration product that can be industrially composted after use, test both its functionality and end-of-life in industrially relevant environments and determine its potential sustainability gain.

Case study results
Three new industrial compostable material formulations with suitable processing properties for netting were developed at WFBR. These materials were processed into netting by project partner Tenax Spa. The resulting demonstration products were tested within the greenhouse facilities at WPR. In these tests the netting demonstrated to allow crop support and withstand the environmental greenhouse conditions. Finally industrial compostability of the nets was demonstrated. The MCI increased from 10% when using PP and incinerating it to 69% when using and composting the developed compostable materials, supporting the potential circularity of these new materials.

Future perspective
Although product functionality and industrial compostability were successfully demonstrated, additional development work is required to allow for optimal manufacturing of the products.

Grow bags
Floriculture netting

Case Studies
Overview
Recycling
Industrial composting
Biodegradability in soil

Biodegradability in soil

Introduction

Biodegradation is a process in which fungi and microbes convert organic solid matter into carbon dioxide, water and biomass. Aside from solid matter such as organic residues or -waste, certain types of (biobased) plastics are also susceptible for biodegradation. These plastics are subsequently called compostable or biodegradable plastics. Whether a plastic biodegrades depends on both type of plastic and the biological environment in which it is placed. This environment can be controlled or uncontrolled. Biodegradation in soil is an example of an uncontrolled biological environment that comes with a potentially changing biological activity and temperature that can depend on the season and weather. Compared to controlled processes such as industrial composting, the temperature at which the biodegradation process in soil takes place is typically lower. Plastics products that are certified for biodegradability in soil are marked with the OK biodegradable SOIL label that follows testing standard ISO 17556.

Advantages and challenges

Plastics that are biodegradable in soil can be fully converted into minerals and biomass without leaving any (micro) plastic residue. However, plastics that biodegrade in soil are not recycled into new plastic products or compost and in this respect, it is not the most circular waste processing route for most plastic applications. These plastics can however be a good solution for products that are directly placed in soil and cannot be collected from this environment after cultivation. In this respect it replaces plastic products that would otherwise remain in soil and directly contribute to the pollution of the soil. Examples of such products can be plant propagation products, mulch films and turf netting. It is important to note that plastics that are certified biodegradable in soil are not always also biodegradable in other uncontrolled environments such as water. On the other hand, most plastics that are biodegradable in soil will also biodegrade in industrial composting conditions. However, if industrial composting is the intended EOL scenario, industrial compostable plastics that are not biodegradable in soil could still pose a better solution.

Future perspectives

At present policies and legislation on biodegradable plastics are limited to a couple of packaging products[19]. Examples of such products are teabags, coffee pads, organic waste bags and fruit stickers and these are therefore often made from industrial compostable plastic. However, upcoming legislation on the use of biodegradable plastics in agri- and horticulture is anticipated. The already announced regulation on fertilizer products (Regulation (EU) 2019/1009[20]) is an example of legislation that promotes the use of biodegradable materials to counter (micro) plastic pollution. Furthermore, as the availability of soil biodegradable plastics is increasing while the relative cost price is decreasing it is to be expected that these types of plastics will start to play a bigger role in the agri- and horticultural landscape in the years to come.

Plant propagation plugs
Grass turf nets

Product overview

Plant propagation plugs

Plant propagation plugs

Grass turf nets

Cultivation function

Plant propagation products for horticulture are plastic containers for seedlings that assist young plant growth during their crucial first life phase. Once this initial growth phase is finalized the seedling will be transferred to its final location and the functionality of the product is no longer required.

Current use and end-of-life

Plastic plant propagation products are typically made from fossil-based polypropylene (PP) as this material allows for effective processing via injection moulding or thermoforming. At a certain point during the cultivation process, the plant roots will fully take over the functionality of the plug and ideally the plug will be removed to avoid pollution of the soil in which the plant is grown. Due to root entanglement this process is difficult and as a result plastic fragments remain present in soil or the decision is made to not remove the product entirely.

Transition towards circular plastic use

In order to retain the functionality of the product but avoid complex end-of-life handling and plastic pollution of the soil, plant propagation products should be made from materials that are biodegradable in soil.

Case study results

Plant propagation plugs

Plant propagation plugs
Grass turf nets

Case study objective
To design and develop a plant propagation demonstration product with programmed biodegradation in soil so that the onset of biodegradation can start as soon as the product functionality is no longer required.

Case study results
Six new material formulations with programmed biodegradation in soil were developed at WFBR. Laboratory results showed that based on the material formulation the biodegradation process (disintegration) can be either accelerated or decelerated. Hence, the cultivation time of a specific crop can be targeted. The new materials were converted into demonstration propagation products which were successfully tested on its feasibility to be implemented in a greenhouse cultivation process. The MCI will increase from 10% for a PP that is incinerated to 100% for a material that is biodegradable in soil, supporting the potential of these new materials.

Future perspective
As the product functionality and programmed biodegradation in soil were successfully demonstrated, next development trials should couple specific cultivation cycles to specific biodegradation profiles of the newly developed materials. This will serve as a basis for circular design of plant propagation products.

Product overview

Grass turf nets

Plant propagation plugs

Grass turf nets

Cultivation function
Grass turf netting aids the cultivation process and assists to maintain rigidity during harvest, transport and product placement. The netting also allows for a faster settlement of the turf in its application environment (e.g. football stadiums).

Current use and end-of-life
At present grass turf netting is typically produced from polypropylene. Netting is installed during the sewing phase and during grass cultivation it is slowly immersed in the soil. After a cultivation period of 10-14 months both grass turf and netting are harvested and transported to their final location. Here, the netting will remain in the soil for an indefinite amount of time.

Transition towards circular plastic use
As it is not feasible to remove the netting from the grass turf, a product that biodegrades in soil would be preferable. The main challenge is to match the onset of the biodegradation with the required cultivation time.

Case study results

Grass turf nets

Case study objective
To design and develop a grass turf netting demonstration product with programmed biodegradation in soil, test this at a professional turf growing facility and determine its potential sustainability gain.

Case study results
Three new material formulations with programmed biodegradation behaviour in soil were developed at WFBR. These materials were processed into netting by project partner Tenax Spa. The best performing net was successfully tested both cultivation functionality as well as the desired programmed biodegradation profile at the facilities of project partner Hendriks Graszoden. The material circularity indicator increases from 10% for the not collected PP up to 87% for the biodegradable materials developed, supporting the circularity of the developed materials.

Future perspective
Although product functionality and programmed biodegradation in soil were successfully demonstrated, additional development work is required to allow for optimal manufacturing of the products.

Plant propagation plugs

Grass turf nets

Decision Support Tool | Plasics during use

This decision support tool is intended for growers who use plastic products. The aim is to stimulate the circular use of plastics by following the principles of the circular economy and the R-ladder.

Click to start the Decision Support Tool

NO

YES

Can the crop be cultivated without the plastic?

R0 Refuse

If the plastic product is not essential, consider to stop using it. This is the first step in the R-ladder, consuming less resources. However, attention has to be paid to the consequences of this implementation in crop production and the practical feasibility.

Can you use less plastic?

NO

YES

R2 Reduce

Consider using less materials, this is the second step in the R-ladder. Reduce as much as possible the plastic use. Using less plastic for the same function is often more sustainable, however considerations on what happens to the materials used after their end-of-life is important. This strategy can only be implemented if there are fundamental changes in the way of working that will result in more efficient use and will not affect crop production. Some examples involve other materials with longer lifetime.

Can you reuse your plastic?

NO

YES

R3 Reuse

Choose plastic products that you can reuse several times and that after use fit in one of the recommendations of the section "Plastics after use".

Can you change the product design?

NO

YES

R1 Rethink

Consider choosing more durable designs or materials that allow multiple use and longer lifespan. Sometimes it can be favourable to use a design that has a higher production footprint but can be re-used many times such that the overall footprint goes down. Examples of such design can be the use of thicker plastic or changing to a material that allows for easier reuse (e.g. metal or glass).

Decision Support Tool | Plastics after use

Are your plastics being collected?

NO

YES

Can the plastics be separated from organic residues?

NO

YES

R5 Recycling

After use, sometimes collection schemes are in place and plastics can be separately collected. If the plastics can be optimally separated from the organic matter, they are suitable for recycling. The current state of recycling is described here. Several successful circular use recycling cases are described for rigid plant pots & trays, mulch films and foamed nursery trays. If your product is not yet recyclable and you are interested in learning more, contact us

Industrial composting

If plastic products can be sorted but cannot be optimally separated from the organic matter and residual crops, the most circular option will be to use a plastic product that is industrial compostable. In this way a single and suitable end-of-life route is created for the whole waste stream. The current state of industrial composting as potential end of life is described here. Successful introduction of industrial composting products is described for grow bags and floriculture netting. If your product is not yet industrially compostable and you are interested in learning more, contact us.

Is your product remaining in the cultivation environment (e.g. soil)?

NO

YES

Biodegradation in soil

When plastic products cannot be retrieved or separated from the organic system (often the cultivated soil) in which they were placed, the most circular solution will be to use plastics that are certified biodegradable in soil. Several product cases that use biodegradation in soil as end-of-life route are described for plant propagation plugs and grass turf nets. For the highest sustainable impact, the biodegradable materials used for these products are made of renewable resources. If you want more information on this topic, contact us.

Glossary

A

Agri-plastics
Products that are used in agriculture as cultivation aids and have a direct agronomic effect on the crop or on its conservation such as irrigation pipes, drainage tubes, films and covers, forage twine and nets, shading and protecting nets, etc.

B

Biobased
Products wholly or partly derived from biomass (EN 16575). Biomass is material of biological origin, excluding material embedded in geological formations and/or fossilised. It refers to the origin of the material. Materials such as cellulose and PLA are bio-based.

Biodegradable
Materials that can be broken down by microorganisms (fungi and microbes) into water, naturally occurring gases like carbon dioxide (CO_2) and methane (CH_4) and biomass (e.g. growth of the microorganism population). Biodegradability strongly depends on the environmental conditions: temperature, presence of microorganisms, presence of oxygen and water. There is a wide range of certifications schemes for biodegradation in different environments.

C

Circularity
Practices that optimise resource use and minimise waste across the entire production and consumption cycle.

Closed-loop recycling
Products that are recycled and converted into the same product

Compostable
Materials and products that disintegrate and biodegrade under composting conditions as specified in the certification schemes "home compostable" and "industrial compostable".

Conventional plastics
Non-official term commonly used for plastics that are fossil-based and non-biodegradable.

E

End-of-life (EOL)
Term use to refer to the fate of the product after use.

Extended Producer Responsibility (EPR)
Policy approach that makes producers responsible for their products throughout the entire lifecycle, including the post-consumer stage.

F

Feedstock
Raw material going into a process to be converted into a product.

Fertiliser
Substance or any other material, applied or intended to be applied on plants for the purpose of providing them with nutrients or improving their nutrition efficiency.

Fossil-based / petrochemical
Adjective that indicates that a material is from fossil feedstocks like petroleum and natural gas. Most plastics used in agriculture are fossil based. Materials such as PE, PP and PET are usually fossil-based.

G

Greenhouse gas (GHG)
A group of gases contributing to global warming and climate change. It includes: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases.

H

Home compostable
Classification that a material can be biodegraded in a composting test at lower temperatures according to AS 5810 (Australian standard), NF T51-800 (French standard) and a soon to be published EN standard. This new standard is a modified version of standard EN-13432 measuring industrial compostability.

I

Incineration
Method of waste treatment that involves the combustion of waste to ashes. The heat generated can be used for energy production under controlled incineration or it can be dissipated in the environment.

Industrial Compostable
Classification that a material biodegrades in an industrial composting plant (at elevated temperatures 55-60°C) within a certain time. It meets the requirements set by standard EN-13432. Industrial compostable products in the market show a certification logo with a corresponding number.

L

Landfill
Method of waste treatment that involves the deposit of waste into or onto land.

M

Material Circularity Indicator
It is an indicator developed by the Ellen MacArthur Foundation. It measures factors such as: recycling rate, recycled content, renewable content and reusability. It has 10% as lower limit. So, a 100% score signifies that the product is fully circular, while 10% signifies that it is fully linear. In this method composting is considered as a fully circular process. Biodegradation in an open environment is classified as composting.

Mechanical Recycling
Mechanical recycling of plastics involves the recovery of plastic waste through mechanical processes (collection, sorting, pre-treatment and compounding) to produce recyclate that can be converted into new products.

Microplastics
Plastic fragments that are smaller than 5 mm in diameter that are intentionally produced or formed during ageing and damaging of plastic products.

Mono-material
Products designed with only one type of plastic.

O

Open-loop recycling
A process in which products are not converted into the same product but into an alternative one (often with a lower value).

Oxo-degradable
Non-biodegradable plastics modified with specific additives in order to instigate oxidation and fragmentation. Complete biodegradation does not take place; hence this class of materials is suspected of contributing to microplastic formation and accumulation. Use of oxo-degradable plastics is forbidden in Europe under the SUP (single use plastics) regulation

P

Plastic
Material which main component is a polymer that can be synthetic or natural. It has the capability of being moulded or shaped.

Plasticulture
Practice of using plastic materials in agricultural applications.

Polymer
Substance composed of large molecules made of repeating chemical units. Polymers can be fossil-based or biobased. Polymers mentioned in this document:

Biobased	Fossil-based
• PHA's, Polyhydroxyalkanoates • PLA, Poly(lactic acid)	• PBAT, Poly(butylene adipate-co-terephthalate) • PE, Polyethylene • PET, Poly(ethylene terephthalate) • PP, Polypropylene • PS, Polystyrene • PVC, Poly (vinyl chloride)

R

REACH
Regulation that covers Registration, Evaluation, Authorisation and Restriction of Chemicals.

Recycled plastic
Plastic material produced from either post-consumer or post-industrial feedstock.

Recycling
Reprocessing of a used product material into a new product (EN 13430 and EN 16848).

R-ladder
Hierarchal system for waste management consisting of the following steps:
R0 - Refuse
R1 - Rethink
R2 - Reduce
R3 - Reuse
R4 - Repair & Refurbish
R5 - Recycling
R6 - Recover

S

Sustainability
Requirement of our generation to manage the resource base such that the average quality of life that we ensure ourselves can potentially be shared by all future generations (Asheim, 1994).

V

Virgin material
Resin produced directly from petrochemical or natural feedstocks, which has never been used or processed before.

W

Waste
Any substance or object which the holder disposes of.

Certifications

Label 'biodegradable in soil'	Certification scheme	Certification body	Based on standard(s)
	DIN geprüft 'Biodegradable in soil'	DIN Certco	EN 17033
	OK Biodegradable SOIL	TÜV Austria	ISO 17566.2 ISO 11266 ASTM D5988

Label 'home compostable'	Certification scheme	Certification body	Based on standard(s)
	DIN geprüft 'Home compostable'	DIN Certco	AS 5810 NF T 51-800
	OK compost HOME	TÜV Austria	Adapted EN 13432 standard (lower temperature, new EN standard expected soon)

Label 'industrial compostable'	Certification scheme	Certification body	Based on standard(s)
	DIN geprüft 'Industrial compostable'	DIN Certco	EN 13432 EN 14995, ISO 17088 ISO 18606, AS 4736
	OK Compost INDUSTRIAL	TÜV Austria	EN 13432
	Compostable (European Bioplastics)	TÜV Austria DIN Certco	EN 13432
	Compostable (Biodegradable Products Institute, BPI)	DIN Certco	ASTM D6400

References

1 Plastics Europe. (2022). The Circular Economy for Plastics – A European Overview. https://plasticseurope.org/knowledge-hub/

2 Kasirajan, S., & Ngouajio, M. (2012). Polyethylene and biodegradable mulches for agricultural applications: a review. Agronomy for Sustainable Development, 32(2), 501–529. https://doi.org/10.1007/s13593-011-0068-3

3 Gao, Y., & Cabrera Serrenho, A. (2023). Greenhouse gas emissions from nitrogen fertilizers could be reduced by up to one-fifth of current levels by 2050 with combined interventions. Nature Food. https://doi.org/10.1038/s43016-023-00698-w

4 Brouwer, M. T., Post, W., van der Zee, M., Reilink, R., Boom, R., & Maaskant, E. (2024). A predictive model to assess the accumulation of microplastics in the natural environment. Sci Total Environ, 957, 177503. https://doi:10.1016/j.scitotenv.2024.177503

5 Hofmann, T., Ghoshal, S., Tufenkji, N., Adamowski, J. F., Bayen, S., Chen, Q., Demokritou, P., Flury, M., Hüffer, T., Ivleva, N. P., Ji, R., Leask, R. L., Maric, M., Mitrano, D. M., Sander, M., Pahl, S., Rillig, M. C., Walker, T. R., White, J. C., & Wilkinson, K. J. (2023). Plastics can be used more sustainably in agriculture. Communications Earth & Environment, 4(1), 332. https://doi.org/10.1038/s43247-023-00982-4

6 https://plasticseurope.org/knowledge-hub/plastics-the-fast-facts-2024/

7 https://plasticseurope.org/knowledge-hub/

8 https://apeeurope.eu/statistics/

9 FAO. (2021). Assessment of agricultural plastics and their sustainability: A call for action. https://doi.org/10.4060/cb7856en

10 https://greenportwestholland.nl/duurzaamverpakken/

11 Hann, S et al. 2021. Relevance of Conventional and Biodegradable Plastics in Agriculture. Luxemburg: Publications Office of the European Union. https://environment.ec.europa.eu/system/files/2021-09/Agricultural%20Plastics%20Final%20Report.pdf

12 European Commission: Directorate-General for Communication, Circular economy action plan – For a cleaner and more competitive Europe, Publications Office of the European Union, 2020, https://data.europa.eu/doi/10.2779/05068

13 European Commission: Directorate-General for Research and Innovation, Bioeconomy – The European way to use our natural resources – Action plan 2018, Publications Office, 2018, https://data.europa.eu/doi/10.2777/79401

14 https://environment.ec.europa.eu/strategy/plastics-strategy_en

15 National Circular Economy Programme 2023-2030. https://www.pbl.nl/publicaties/circulaire-economie-in-kaart

16 https://www.pbl.nl/sites/default/files/downloads/pbl-2019-circulaire-economie-in-kaart-3401.pdf

17 https://www.rijksoverheid.nl/documenten/beleidsnotas/2023/02/03/nationaal-programma-circulaire-economie-2023-2030

18 https://www.rijksoverheid.nl/documenten/rapporten/2024/04/23/eindrapportage-verkenning-land-en-tuinbouwplastic

19 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0677

20 https://eur-lex.europa.eu/eli/reg/2019/1009/oj

About the Project

This document is a deliverable of the project 'Circular use of plastics in agriculture and horticulture' project number LWV21.192 sponsored by the topsector Agri&food from the Dutch Government and supported by the following consortium partners: Greenport West Holland, Tenax Spa, Tenax USA, Hendriks Graszoden, Hordijk EPS Verpakkingen en Isolatieproducten BV, M-Plastics, Jiffy Products International BV, Repeats NE.

The project had the aim to effectively close the loop for plastic products used in agri- and horticulture, to lower the use of fossil carbon and to prevent plastic contamination of soil or natural waters. Methods and products for applications within both greenhouses and open field have been developed during the project. Three end-of-life scenarios of plastics have been explored, being mechanical recycling, industrial composting and programmed biodegradation in soil. Within all EOL-environment combinations, seven specific case studies were performed and their results are shown as part of this document.

Wageningen Food & Biobased Research (WFBR), Sustainable Plastics Technology

The Sustainable Plastics Technology group focuses on the development of new types of biobased and biodegradable plastics and products made thereof, with the aim to contribute to mitigate each of the elements in the triple planetary crisis. Research activities are centered within the Renewable Plastics programme and typically contains elements both at lab scale and at pilot scale, most often in collaboration with industrial and other partners in the plastics value chain. Their unique plastic formulation, processing and characterisation facilities allow them to form a bridge between academic developments and market uptake.

Biobased Innovation Plant, Wageningen

Wageningen Plant Research (WPR), Business unit Greenhouse Horticulture

The Greenhouse Horticulture business unit works together with companies and governments to create a fully sustainable, economically viable sector that is fossil-free, closes the water cycle, minimises pesticide use, and optimises circular use of resources. Plastic – the focus of this document – is one of the key material flows we research, particularly within our Circular Horticulture programme. With state-of-the-art research greenhouses and labs in Bleiswijk and Wageningen, we are deeply immersed in every aspect of greenhouse horticulture – from crop management, supply chains, technical systems and AI to innovative greenhouse design.

Greenhouse Horticulture, Bleiswijk

Authors
Wouter Post (wouter.post@wur.nl), Fresia Alvarado Chacon, Maarten van der Zee, Ulphard Thoden van Velzen, Van Nguyen, Despoina Barouta, Yarek Workala, Bert Kuijpers, Martin Zijlstra, Alexander Boedijn

WFBR Project number: 6224130100

Version: Final

Reviewer: Karin Molenveld

Approved by: Ben Langelaan

Carried out by: Wageningen Food & Biobased Research and Wageningen Plant Research

Subsidised and commissioned by: the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature

This report is: Public

Design & graphics: Wageningen University & Research, Communication Services

Photography: Shutterstock, Wageningen University & Research
Contact email: Wouter.Post@wur.nl

PO box 17, 6700 AA Wageningen, The Netherlands, T + 31 (0)317 48 00 84, E info.wfbr@wur.nl, www.wur.eu/wfbr.