CIPA’s preliminary contribution to the Voluntary Code of Conduct for a sustainable use of plastic focused in agriculture

November 2023

The International committee for plastics in agriculture (CIPA) has been created in 2007 to promote at international level the use of non-packaging plastics in agriculture. The CIPA is present in five continents and formerly represented in 23 countries thru national plastic committees for agriculture. The CIPA is the editor of the international revue Plasticulture Magazine.

Towards 0 plastics on field, 100% recycled through a reliable integrated non-packaging agri-plastics management.

A contribution for a worldwide plasticulture strategy

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1. Terms and Definitions

Non-Packing plastics used for agricultural production: films (greenhouses, small tunnels, mulching, crop cover...), twine, net, irrigation pipes...

Converter: agri-plastics products producer

Distributor: cooperatives and traders, directly linked with users

Equipment manufacturer for application, maintenance, retrieval of agri-plastics products.

Users: farmers and growers, in charge of the agricultural animal or vegetable production.

Contamination: content of chemicals (pesticides, fertilizers, ...) on plastics waste.

Soilage: content of mineral, water, organic matter on plastic waste.

Pre-collect: preparation and grouping from the farm of used agri-plastics in view of the collect, including retrieval of used product from their place of use.

Collect: pick-up of used agri-plastics for their final treatment, at farm level or in grouping centres.

Consolidation and recovering: collection of used products from the grouping centre.

Pre-treatment: operations needed to achieve final treatment like baling, washing and shredding

Treatment: final operation ending with the waste statute like reprocessing or energy recovery

NCS: National collection scheme

EPR: Extended producer responsibility

2. Foreword

Plastic is an essential ally for farmers and agricultural production. Plastics increase productivity and production efficiency in all sectors of agriculture, while decreasing the environmental impact of production. However, its usage meets specific conditions that influence the management of its end-of-life. Without a solution for reliable end-of-life management, inappropriate usage and bad practices plastic can cause damage to the environment and pollution. The industry proposes mechanisms to ensure that plastic products are used sustainably.

As a result, any new regulations must favour:

1. A rational use of plastics in agriculture through technical recommendations and good practices, implementation services or shared cooperatives, certification of users.
2. The implementation of end-of-life management through collection schemes that eliminates negative impacts on the environment and provides sustainable solutions for the farmer.
3. Its contribution to a new circular economy, by promoting the development, sometimes the emergence of a sustainable recycling industry. Agri-plastics products rely mainly on finite fossil resources reduction, reuse or alternative solutions need to be maximized to allow these resources to go further and for replacement with sustainable renewable resources when applicable.
4. Provide value-chain actors with practical tools on product's life cycle: design of the product to reduce the amount of plastic used, design for recycling on single polymer products, linking plastics and removal equipment, etc...
Technical and financial tools exist and are already being used in many countries. It is by drawing inspiration from these existing systems and adapting them to specific local conditions that all pollution caused by plastics in agriculture will be eradicated and the agricultural production preserved.

### 3. Executive Summary

#### 3.1. Role of plastics in agriculture

Plastics with agronomic effect used in agriculture are directly linked to the production and cannot be considered as packaging. These plastics have an agronomic effect on the plant growth, increasing productivity and production, enlarging crop season, by preserving soil humidity, favouring root development while limiting water consumption. In addition, plastics allow a reduction of pesticides, fertilizers, infrastructures, and energy. It protects crops, fodders, water tables and limit the usage of arable land and the need of storage infrastructures.

In a period of climatic changes, agri-plastics allow to preserve the agricultural production, by a climate control (greenhouses), preserving soil humidity (mulching, irrigation pipe), protecting crops (small tunnels) and preserving fodders (silage, stretch, bale net...)

Without plastics, the environmental impact of the agricultural production would be deteriorated: increasing inputs consumption (pesticides and fertilizers, water, energy, arable land...) without reaching performance and efficiency in yield and ecological impact, greatly exceeding the impact of plastics use.

The sustainability of the agriculture production depends on a large extend on the usage of plastics in agriculture.

#### 3.1.1. Agri-plastics specificity

Agri-plastics with agronomic effects are considered as non-packaging: films for greenhouses, small tunnels, cover crops, and mulching, protective nets, bales nets, twine, irrigation pipes...

They are made of polyethylene for 80%, high or low density\(^1\), the most common polymer, and polypropylene. In few areas, as east Asia, other polymers may be used for agricultural films.

More recently, biodegradable polymers have appeared on the market in very specific applications (mulching, twines, clips, etc.). These products are assimilated by soil microorganisms and contribute to new biomass.

#### 3.1.2. Waste’s characteristics

Non-packaging agri-plastics are not suspected of chemical contamination because of their usage away from any pesticide’s treatments, as evidence in related studies (see appendix). Mulching, after use and the removing operations, may be heavily soiled (> 70%) by mineral, organic and water, by-products of recycling operation.

In France, non-packaging agri-plastics are classified as non-hazardous wastes.

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\(^1\) LDPE, HDPE, PP
Made of homogeneous polymer, they are recyclable. However, each product will have its own attitude along the recycling chain. With a significant volume the selective collection allows a specific treatment by products/ polymers, allowing a homogeneous recycling for a better integration of regenerated granule into new products. With national collection scheme (NCS), new formulation or additives should not hinder the product recyclability.

Properly managed and handled, agri-plastics waste represent a resource that cannot be wasted...

3.1.3. Food security and alimentary independence

Plastics in agriculture plays a major role in the country’s alimentary independence. Sun and water are the minimum requirement to allow vegetable production in dry area or extreme weather conditions for a production with agri-plastics (agri-plastics allow food production in the deserts of the Middle East, the Andine cordillera above 4000 m altitude, beyond the artic circle or in the Mongolian dry lands).

3.1.4. Food Safety, Contamination and Soilage

By reducing the environmental impact of the production, the plastics in agriculture allow a better food safety. During their useful life, only greenhouses and mulching films are in contact with chemical and are not subjected to chemical contamination. For greenhouses, quantities of chemical received by the film are considered as negligible (see Square’s project in appendix 7.1). For mulching, due to short period of few weeks of usage in main cases, contamination by chemical is like the fruit’s contamination, if any and, most often washed away by precipitation and later, by the recycling treatment. However, after their useful life, plastics mulching may be heavily soiled by mineral, organic matters, and water, making more difficult and costly their treatment and recycling. Collaboration with equipment manufacturer minimize the soilage contend and ease the reuse or recycling.

The impact of micro and nano plastics and the effect on food safety is still on going and need to be further investigated, since no specific effect has been so far identified.

3.1.5. Protection of the environment

In many countries, farmers are considered as nature’s gardener of our landscape. Moreover, land is the farmer production’s tool, and no professional will jeopardize its future production by an environmental lacking. However, the absence of solution provided to farmers may lead to environmental damage by using practices not seen as sustainable or environmentally friendly (burying or burning...). Professional standards and licensing of farmers will ensure that they use products sustainably.

3.1.6. Contribution to farmers’ activity and agricultural production

Plastics in agriculture is an ally for an agri-ecologic agricultural production. For a small investment, farmers can increase production in quantity and quality, while reducing input’s usage. The lack of effective end-of-life solution and bad practices are responsible for the negative impact on the environment of the agricultural production. In many countries where reliable solutions have been set up, this negative impact have been drastically reduced even eradicated. The industry provides technical recommendations (product data sheet, standards, and norms) for sustainable practices use ensuring
the used product removing before they become a liability for the environment. The growing product complexity advocates for an integrated service where new film is exchanged with the used one, eventually by the way of certification systems or the help of specialized contractors or machinery cooperatives.

3.1.7. Conclusion
There are many solutions to tackle the plastic from agriculture pollution and any decision on the matter will be wise to protect the farmers and growers’ activity of agricultural production. The priority is to provide them a reliable, sustainable, technically, and economically efficient, end-of-life management of agri-plastics they are using daily. Solutions are existing with proven results.

3.2. End-of-life management
The environmental damaging caused by the plastics use is due to the lack of end-of-life solutions for the farmer. Experience showed that, when solutions are available, every farmer is inclined to use them. To be reliable, solutions shall be:

3.2.1. A commitment of an entire profession in many countries
Farmers are surrounded by an entire community involved also in the agricultural production:
   a. Converters, designing and producing recyclable product. Major companies are already involved in many existing national collection schemes to ensure that marketed products have an effective end-of-life solution.
   b. Distributors and traders, having a close technical and commercial relationships with users, supplying products to farmers, providing advice, services and, in some cases, operational support in the collection of used agri-plastics products (grouping, storage, control, shipping...)
   c. Equipment manufacturers for the application and maintenance of films and of their retrieval after use.
   d. Farmers and growers, daily users of agri-plastics, are unable to manage alone properly agri-plastics after their useful life. They require good practices to prepare the waste and operational services to remove it from the farm.
   e. Academics, scientist, technicians, advisors accompanying converters, farmers, and growers.
   f. Collectors equipped with relevant equipment and machinery to load, ship and bale the used plastics waste.
   g. Recyclers having dedicated production line for used agri-plastic.

In many countries, the so called “plasticulture community” is committed to install, develop, and improve programs of end-of-life management.

3.2.2. Adapted to local conditions.
If the agronomic effect of plastic is constant, their conditions of use, and the end-of-life vary:
   a. Climate, having a direct impact on soilage rate and useful service life of agricultural plastics.
b. **Geography**, having a direct impact on the distribution and density of agricultural plastics, determining the type of collection (grouping or at farm) and the distance to recycling facilities.

c. **Economics**, having a direct impact on the value of plastic after use (second use with positive value or negative value) and the cost of retrieval.

d. In addition:
   - The size of the farms and their equipment for deposit, storage and sorting at source.
   - Agricultural practices according to available technologies.
   - The mode of supply (cooperative or direct with or without the existence of a grouping point).
   - Level of awareness among farmers on the proper management of end-of-life products.
   - Recyclers' level of requirement in terms of waste conditioning and soiling rate.
   - Capacity of recyclers' storage (seasonality of the use of plasticulture products).

### 3.2.3. There are many areas still to cover

Unfortunately, national collection schemes are not developed everywhere and there is a lot to do in Africa, Latin America, Asia. However, year after year, initiatives appear to implement collection scheme. The Voluntary Code of Conduct will be a good tool to help countries willing to develop adapted solution to ease and accelerate the implementation. On the top of that, countries (Canada, Europe, Australia...) having already experienced with efficiency several ways to install a reliable end of life management for agri-plastics, may share and disseminate their experience and knowledge.

However, it is a necessity to support countries and professionals in the implementation of end-of-life management systems:

- Responsibility for providing a free of charge service (at time of collection) to farmers for collection of used plastic, legally mandated by government.
- Minimize barrier for compliance by users.
- Legal requirement for users to return used products to the scheme.
- Financial mechanism to allow industry forcibly to collect used products after their useful life, to avoid abandon, burning or burying.

### 3.2.4. Why a Voluntary Code of Conduct?

The Code of Conduct on the sustainable use of plastics in agriculture is a decisive tool for the development and implementation of the guidelines.

- The transfer of knowledge is a guarantee of efficiency and makes it possible to accelerate the implementation of collection systems.
  1. The CoC encourages practices such as eco-design, usage, end-of-life management, recycling, and integration.
  2. It is recommended to encourage the participation of economic actors in the value chain of the plastics sector in agriculture: farmers, distributors, plastics and equipment manufacturers, researchers in an integrated approach and a responsible management of agricultural plastics.
  3. It is desirable for agricultural plastics actors to use the CoC relative to their respective field.

- If the CoC is widely implemented, it can significantly facilitate the achievement of the Sustainable Development Goals, the protection of soils, water table, plants and biodiversity.

  1. It is a living document that needs to be regularly updated by FAO whenever necessary. The CIPA recommend the establishing, under the CoC, of a technical committee to review
developments in technologies, scientific, research... to advise FAO members on requirement to update the CoC and to develop subsidiary guidance on specific topics. Committee members should be selected among representatives of all stakeholders and value chain actors. The CIPA and its member will be volunteer to participate to this panel.
4. A Voluntary Code of Conduct for Agricultural plastics

4.1. Element of Context
Agricultural plastics are used for fruits and vegetables, or animal production (fodder protection). They have a multiple effect:
- agronomic (plant growth),
- economic (improvement in the quality and quantity of harvests)
- ecological (protection of soil and plants, reduction of the consumption of chemicals, water, fertilizers, and energy...).
- Social, with the reduction of arduousness, particularly manual weeding

Public opinion and policy makers are focused on the plastic pollution tackling on soil and sea. The purpose of this document is to enlighten decision makers on the specificity of plastics used for the agricultural production, risk, and danger of damage on the environment in the absence of reliable end-of-life management whereas solutions are existing with significant results and performance. It is possible to tackle plastic pollution coming from agriculture production and, by then, protect the production of food and secure the alimentary need. Any coercive policy by banning of heavily taxing agri-plastic products will have consequently the jeopardization of the production and the mankind feeding.

To meet the growing demand for food needs of a growing population, the volumes of plastics used in agriculture will increase in the coming years. Indeed, plastics are essential for countries that aim for food security, independence, and autonomy.

In the absence of end-of life management, these plastics can cause damage to the environment: burning in the open, illegal burial, accumulation in the soil, microplastics, etc. The implementation of post-use collection systems for agricultural plastics in some countries has made it possible to reduce or even eradicate these negative impacts on the environment.

4.2. Preamble
The International Committee on Plastics in Agriculture (CIPA), created in 1955, has as a mission the promotion of the technical use of plastics in agriculture. CIPA benefits from an extensive network on all continents, made up of manufacturers, distributors, professional organizations related to agricultural plastics, researchers. It provides advice and recommendations on scientific, environmental, and societal issues. Once a year, it publishes the Plasticulture Magazine, and, every 3 years, organizes an international congress, which brings together the contributions of recognized experts in their fields, around plastics in agriculture.

Thus, the CIPA has the advantage of accessing the knowledge portfolio of these experts and ensures its dissemination to as many people as possible, for a more efficient and environmentally friendly agriculture.

The aim of the present document is to summarize the knowledge and position of an entire profession, bringing together many specialties along the value chain. It is the result of the experiences accumulated by this international network and aims to contribute as best as possible to the development of the Voluntary Code of Conduct for the sustainable use of plastics in agriculture.
4.3. Objectives of the Voluntary Code of Conduct

4.3.1. A plastic strategy for all
Through their design, manufacturing, usage and end-of-life, agricultural plastics obey to specific rules. Thus, all the actors in the value chain – users, distributors, manufacturers, researchers, collectors, and recyclers – are decisive, each in their own responsibility, in the life cycle of agricultural plastics and its end of life. It is important to clearly identify the role of each and for an agricultural plastics strategy to be applied to everyone. Thus, we will propose a sectorial approach integrating each of the specificities of the value chain.

4.3.2. Changing practices
Gone are the days when you just developed a product and sold it. Now, plastics manufacturers must consider the entire value chain, from design to integration, while ensuring that products they are marketing are safe for people and the environment, including food security and safety.

➢ VCoC is intended for users, marketers, manufacturers, public authorities, collectors, recyclers. The voluntary code of conduct must be applicable for the entire value: users, distributors, and manufacturers. The solidarity among economics actor of this value chain is the prerequisite for an efficient end-of-life management. Their proximity with usages, their commercial and technical relationships stay the best vector for the dissemination of best practices and information, as well as the research of the best solution adapted to local conditions.

A specific address should be made to academic and research to aware them on end-of-life issues to have them considering it in reports, analysis and recommendations.

The code of conduct will then encourage the collaboration across the value chain but also across countries and regions since, most of manufacturers intervene in several territory and area.

Recommendations, provided by the VCoC to states, users, traders, converters will accelerate the search of solutions and their implementation.

➢ Products design, product and equipment manufacturing, usage, removal, collection, recycling, and integration are the different steps of the integrated management of agricultural plastics. To cope with recent market conditions, marketers must include the dimension of the sustainable use and the end-of-life management in new products development. This statement should be clearly appearing in the code of conduct.

➢ The proximity distributors/users, make distributors the best vector to disseminate to users information and consulting services on waste preparation and handling good practices. In addition, distributors may organize the relevant collection scheme better adapted to the local condition. From now on, the accompaniment of the user by its distributor is a good way to improve practices and waste’s quality to ease collection, recycling, and integration.

➢ Waste preparation and handling on the farm determine the product attitude on the value chain. Therefore, the farm will use technical recommendation to prepare, handle and store the material before collection.
4.4. Desired results of the Voluntary Code of Conduct
A reliable end of life management of agri-plastics is the best way to consolidate the agricultural production chain for a greater self-sufficiency with a contribution for a better food safety and fostering the circular economy.

If the environmental protection is the expectation for the civil society, it is, necessarily, a major concern for farmers and growers: nature and lands are their production tools, and it is mandatory for them to keep the environment in good shape to allow future production.

The good practices and end-of-life lacking are responsible for most of the plastics pollution coming from agricultural production when occurring.

The code of conduct needs to emphasize actions to take to remove those negative impacts and create favourable conditions for a safer environment:

- Elaborate national technical references to handle properly agri-plastics after use. Technical recommendations provided to users will allow them to deliver wastes of better quality, easing the recycling and the integration.
- Establish national plan to implement a dedicated collection scheme adapted to local situation. Scheme elaboration will involve as much as possible all actors of the value chain to make it acceptable. Organizational modalities are existing in some countries and may be used as a model.
- Inspire governments, academics, and the industry to support and fund R&D programs to improve the development of best practices, technical and economic efficiency, waste quality easing recycling and integration.
- Encourage awareness and dissemination by educational programs and communication thru seminars, conferences, advertising...

4.5. Agri-plastics and environment
Plastics in agriculture are questioned as any other type of plastics. Great is the temptation to ban or heavily taxing those products in the aim to eradicate eventual environmental damage they may cause. However, for more than 6 decades, plastics used in agriculture have proven its utility both in terms of production efficiency, but also with its environmental role.

4.5.1. Agri-plastics plays an important environmental role:

- In vegetable production, plastics allows: Films, twine, net, irrigation pipe…
  ✓ Lowering input consumption as chemical, water, and energy.
  ✓ Better climate control, expending the period of production, releasing arable land.
  ✓ Protecting soil humidity, fostering root developments.
  ✓ Protecting water table.
  ✓ Biomass increase in case of biodegradable products usage.
- In animal production Silage, stretch, twine, bale net…
  ✓ Protecting fodder, increasing the agronomic effect without usage of any additives
  ✓ Avoiding barn building

The usage of plastics in agriculture is an essential ally for farmers and growers for an agro-ecological production, since the production increase in quantity and quality, without additional input.

After their useful life, properly managed, used agri-plastics cause no damage to the environment.
4.5.2. Agriplastics and pollution
Plastics used in agriculture do not pollute the environment by themselves, but only in case of mismanagement or improper use.
The pollution coming from other sources shall be assimilated to the plastics used for their agronomic effect, in a context where civil society is prompt to condemn practices having negative impact on the environment, without any background on usage, utility, and know-how about the importance of plastic in the production process.
Training of user on agri-plastics integrated management if the first step to tackle pollution.

Risk and Dangers

a. Definition:
Risk and dangers are the two factors determining the effective threat in a given situation.
Risk evaluates the level of a threat: it is the probability of occurrence and severity of a hazard.
Example: the risk for a house to be stroke by a lightning in a thunderstorm.
Hazard evaluates the maximum possible danger in a given context: it is the potential to cause harm in a defined space and timeframe. Example: the maximum possible damage of a lightning to a house.

b. Specific case of agri-plastics:
Agri-plastics present two types of potential hazards: fragmentation and accumulation in soil. In fact, plastics that are washed into watercourses terminates buried in the riverbeds or seabed. Such hazards may have various effects depending on the concentration of plastics and the local climate conditions:
- water table disturbance, in case of improper retrieval of recoverable thin mulch (above 250 kg/Ha)
- release of SOVHC, in case of fragmentation of low-quality thin mulch
- ingestion of microplastics by crops, in case of fragmentation of low-quality thin mulch

Such potential hazards can happen only in presence of the following cumulative factors:
- Use of low-quality plastic pellets (not complying with international standards)
- Use of thin recoverable mulch films (under 25 µ thickness), insufficient plastics removing after useful life (cotton, pineapple...), improper retrieval after use (laceration and burying instead of removal)
- Constant repeat of the afore mentioned steps over 20 years.
In the case of uncontrolled landfilling of other plastics, they will remain intact until their removal as they will not be exposed to UV, heat or frost.

b. Specific case of agri-plastics:
High-risk in Agri-plastics happens when recoverable plastic is difficult to separate from its use support. As of today, only a limited range of application is concerned: thin mulch films, horticultural twine, substances dispenser (pheromone, fertilizers, pesticides...)
All other products (small and high tunnels, semi-forcing films, protective nets, plastics used in catling, irrigation pipes...) can be easily retrieved, even if soilage content (mineral, organic, water) may be high.
Others high-risk plastics are not used for agricultural purposes, like packaging, or micro-plastics coming from sewage sludges, textile, or road runoffs.
In the case of high-risk agri-plastics biodegradable alternatives are recommended when commercially available.

1. **Agri-plastics accumulation in soils**
   Accumulation of agri-plastics occurs in case of unproper use, as it happens only in absence of removing, that is obviously contrary to the normal use of the product.
   All other sources of accumulation are coming from external sources and shall be managed by the one responsible of it.
   Accumulation of plastics is not by it-self dangerous, but by the mechanical effects it can have on soil structure and water table behaviour.
   The case change if the plastic is fragmented in micro-plastics that can lead to other types of problems.

2. **Microplastics and nano-plastics risks for food safety**
   Plastics material can have various action modes depending on their shape, size and composition. The same material has a different effect depending on its shape and size, with even positive impact in specific cases. Studies are ongoing to stimulate yields with the controlled use of micro and nano plastics.
   Microplastics (> 2mm in the smallest dimension) do not cause significant problems unless in case of very high concentration, due to their mechanical effect on soil.
   Nano-plastics (<2 mm in the biggest dimension) have a different effect, as they can be eaten by the soil fauna or adsorbed by the plant roots.
   The effect on food safety is still ongoing, and as for nano textile particle, no specific effect has been so far identified.

3. **Chemical contamination**
   Chemical contamination, as for micro-plastics, can come from pesticides used in agriculture or from external sources, like cleaning products or aerial contamination.
   Very few agri-plastics products are directly exposed to pesticides (greenhouse and mulch films, banana sleeves...) and studies made on their recyclates found only traces well below the limits applicable to food contact.
   Other sources of chemical contamination shall be managed by the corresponding responsible.

4. **Additives**
   Additives in agri-plastics are implemented according to regulations applicable to all plastics, in particular compliance with REACH list of SOVHC. Their effects are constantly monitored by the competent authorities.
   The main additives used in agriculture are UV stabilizers and absorbers. In addition, anti-fog and processing additives can be used.
   In the case of biodegradable products, additives shall be biodegradable and, in any case, shall pass the corresponding ecotoxicity test. A whitelist of additives having passed these tests has been established by the certification bodies for biodegradation (EN 17033, ISO 23517 and ISO 23517 standards) and composting (EN 14995 standard).
5. Remediation technics
Considering that plastics are composed of carbon and hydrogen and that they spontaneously degrade in absence of stabilizers, scientists have developed theoretical models and practical solutions to accelerate their degradation and assimilation in case of accidental release in the environment. The principles rely on the hydrolysis power of soil minerals and fauna.

a. Soil analysis
Remediation starts always by the analysis of the soil affected by a plastic contamination. If macro-plastics are presents, they shall be removed before any further operation. Manual or mechanical screening can be applied. Analysis examines microplastics size and composition and soil characteristics (biomass level, fauna, acidity, moisture level...)

b. Diagnostics
Based on the analysis the diagnostic compares the microplastics and the soil capacity to degrade it to determine what is needed to achieve it.

c. Recommendation
Based on the diagnostic and solution available for the farmer, a recommendation of treatment is established. It can be the introduction of specific bacteria, the amendment of soil with specific nutrients or mechanical operations (ploughing, soil aeration, mixing of soil layers...) or the addition of minerals (sand, clay, limestone...). The recommendation can include several steps and extend for several months or years depending on the nature and level of contamination.

4. Implementation
Farmer shall implement the recommendations of soil remediator, ensuring that crops and agronomic operations do not interfere with the soil remediation treatment.

5. Control
Each year the nature and level of microplastics contamination shall be evaluated, repeating the process until full remediation is achieved.

4.6. Integrated management of agricultural plastics
Agri-plastics are specifically designed for the agricultural production and meet very precise and differentiated uses. It is necessary to draft the main characteristics to better understand these characteristics, requiring a specific approach.

4.6.1. Product design
Plastics products used for agricultural or horticultural purposes are usually made of mono-polymeric resins with few additives, with a thickness in accordance with the intended condition of use in open air.
These characteristics make them usually especially suitable for mechanical recycling whenever the soilage and moisture content after use and sun exposure during use do not hinder excessively the polymer quality. In a similar way, any adsorption of foreign material should be avoided, as it will be released in a later phase (during collection, cleaning, extrusion, or the useful life in new products). To maximize the recyclability of products after use, they shall be implemented only according to their specifications, especially durability.

4.6.2. Used agri-plastics characteristics.
Made of polymer of a good quality, agri-plastics waste are appreciated by recyclers. However, depending upon their usages, waste quality may be different between different type of products.
Indeed, the usage determine the waste quality after the useful life because of the soilage contend. In Europe, performed analysis by national collection schemes provide the below average chart:

<table>
<thead>
<tr>
<th>Products</th>
<th>Soilage Rate</th>
<th>Soilage coefficient</th>
<th>10 tonnes of plastics = X tonnes of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouses</td>
<td>16%</td>
<td>1,2</td>
<td>12</td>
</tr>
<tr>
<td>Small tunnel</td>
<td>50%</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Mulching</td>
<td>66%</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Silage</td>
<td>20%</td>
<td>1,25</td>
<td>12,5</td>
</tr>
<tr>
<td>Stretch</td>
<td>31%</td>
<td>1,45</td>
<td>14,5</td>
</tr>
<tr>
<td>Twine</td>
<td>20%</td>
<td>1,25</td>
<td>12,5</td>
</tr>
<tr>
<td>Bale net</td>
<td>31%</td>
<td>1,45</td>
<td>14,5</td>
</tr>
<tr>
<td>Irrigation pipe</td>
<td>20%</td>
<td>1,25</td>
<td>12,5</td>
</tr>
</tbody>
</table>

If all those products are recyclable, recycling conditions will vary upon the product characteristics and soilage content. Therefore agri-plastics wastes will have different value, most often negative.

4.6.3. Use of best practices; International Technical References

Regardless of regions and areas where agri-plastics are used, usage conditions are pretty much similar. And so, it is with the end-of-life management as waste preparation, storage, collection, recovering pre-treatment and treatment.

In the present chapter, we will not consider the burning or landfilling, even if such practices may continue in some cases. As the matter of fact, there is no recycling without a reliable collection system. On the top of that, we can consider than the capacity of integration of regenerated granule onto new product will depend on the quality of this secondary raw material and, therefore, from the quality of the waste. These are the reason why collection systems should prioritize a search of quality along the value chain.

In case of energy or chemical recovery, the search of quality will be also a prerequisite for any treatment.

Wastes are handled thru this value chain, and each actor bears the responsibility of the waste’s quality.

✓ The waste preparation at farm will determine the road followed up to its destination. Therefore, it is a priority to provides farmers and growers with technical references on cleaning process to lower the soilage content during removing operation, waste handling, homogeneous storage by polymer and/or product and delivering.
✓ Pre-collection and collection are obviously a critical step to keep the waste quality as high as possible, avoiding adding soilage contend in the collection process and mixing different polymers and products.
✓ Considering a sustainable collection with a regular increase on collected volume and quality, recyclers are responsible to ensure a proper treatment. Most often, this will necessitate investments on better equipment and water treatment.

The elaboration and dissemination of best good practices and technical references will provide actors of the value chain with data, methodology to perform a better-quality service to the chain, easing collection, recycling, and integration, while lowering costs.
4.6.4. Reduction of plastic use and life cycle analysis

As any other commodity agri-plastics are used considering the benefits for the farmer which always look to minimize their use to improve economic efficiency and reduce the removal workload. Nevertheless, such reduction shall not compromise the benefits provided by the agri-plastics, requiring a life-cycle-analysis when considering a change in use, especially in case of an alternative technology.

For agri-plastics such life-cycle analysis shall cover:

- a. Raw material and design of product
- b. Agronomic effect
- c. Convenience in installation, product removing, and pollution of the product (or its various polymers and chemical components) to the environment during use.
- d. End-of-life management: collection, and recycling, biodegradation, composting
- e. Total cost of ownership (purchase price, manpower and machines)

Lifecycle analyses on agri-plastics use must be interpreted with cautiousness. Many assumptions, some with a relevant impact, must be made when carrying them out:

- The definition of the functional unit of the product (production of food on one hectare vs. production of one tonne of food vs. production of food with one tonne of agricultural plastic, etc.)
- Defining the boundaries of the analytical system, which may cover the production system (energy consumption, resources for the manufacture of agricultural equipment, resources for the manufacture of agricultural equipment factories, etc.). These analytical system boundaries will determine the inventory of inputs and outputs of the system, which will have an impact on the environmental results of the study.

Therefore, life cycle analyses on agri-plastics is a concrete analysis tool and cannot drive a policy making, as too many parameters differ from one situation to another, even in too neighbouring sites:

- Origin of the film material (bio-sourced or Petro-sourced, recycled content level)
- Working system (manual or mechanical cultivation, energy type and origin)
- Crop (depending of the region, the use or films, net or twines can be requested)
- Yield (variety, climatic conditions from one year to the next, production basin, etc.)
- Inputs (water, fertilizers and pesticides consumption, arable land and infrastructure needed)
- End-of-life management (depends on recycling capacity, ability to massify volumes, quality and soilage of used plastics, etc)

Finally, life cycle analysis software has databases that vary, as do the methods used to measure their environmental impact. It is then currently difficult or impossible to carry out an overall life cycle analysis on agri-plastics use and to draw conclusions that can be applied at a political level. This tool must be used at the level of the crop production chain in a given production basin for a given type of farm.

However, life cycle analyses can be used to identify the hotspots - the most polluting stages in a product’s life cycle - on which the plasticulture community needs to work and innovate to reduce its impact.

Practical tools already exist at farm level, like calculators\(^2\) comparing two technical itineraries for agri-plastics for example recoverable mulching film versus biodegradable films or manual removal versus mechanical removal.

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\(^2\) In France the CPA developed a calculator called FIPACOM, see Plasticulture Magazine 2023 N°142.
These tools can also be used to compare alternatives with existing plastics usage, providing figures on economic cost and agronomic effect.

**The case of biodegradable products.**

In several applications as mulching, horticulture twine, clips, biodegradable product is an alternative to conventional PE and PP plastics, applicable with equivalent agronomic and economic results. The use of biodegradable must be encouraged in case of difficulty to remove 100% of plastics after its useful life (cotton⁴, pineapple⁵) or end-of-life system failure or costly. In such cases certified according to EN 17033, ISO 23517 and ISO 14855 soil biodegradable and compostable materials should be applied. These standards ensure that these materials pass comprehensive ecotoxicity tests and do not contain heavy metals, SVHCs, and PFAS.

In consequence, EPR scheme is not applicable to certified soil biodegradable mulch films. These materials do not need to be removed and from the soil after harvesting but are plowed into the soil and mineralized by microorganisms. Therefore, they are not collected.

### 4.7. Collection Scheme design and implementation

Specific collection schemes for agricultural supplies and plastics exist now from over 20 years and the experience in launching them show some constants:

#### 4.7.1. A sectorial approach

Based on experience accumulated for years and due to market’s organization and specificities in terms of product, geographical dissemination and density, any observer will notice the necessity of a dedicated approach. Those sectorial specificities will lead to develop adapted solutions economics actors are the most suitable to promote and develop. Therefore, the sectorial approach is seen as the most efficient way to accelerate the achieving goals.

#### 4.7.2. Stakeholder’s involvement

To achieve this efficiency, it is a prerequisite to invite stakeholder to the scheme preparation and, later to its governance. Giving them the operational responsibility to design and organising the scheme, is the best manner to obtain desired results. Stakeholder’s involvement is therefore a prerequisite.

#### 4.7.3. Individual and collective commitment

In terms of agri-waste management, what a company alone cannot achieve, only solidarity and collaboration of the sector will achieve it. Prior to this, the individual commitment is then necessary. It is not that easy to reach, since in most cases companies are in competition and mistrusting make more

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⁴ See Biodegradable products chapter 7.1.1. in appendix 7 in the European Plasticulture Strategy.

⁵ Chinese Academy of Agriculture Science (CAAS) has recommended the use of biodegradable mulching on cotton field. CIPA congress 2018. Dr He Wenquing.

⁶ The Biodom’s project, French project on the use of biodegradable mulching in overseas department (notably on pineapple) has demonstrated the interest of the use of biodegradable product under tropical and equatorial climate condition.
difficult the achieving of a consensus. However, it is necessary to create favourable conditions to reach this consensus either voluntarily or by obligation. The collective commitment is the best insurance to achieve expected results.

4.7.4. A Shared Responsibility among stakeholders
As said in the “strategy for all”, each actor has its own role to play. The action at each step is determinant for the step to follow. Moreover, the performance guarantee is determined at each level. It is in this context we determine the responsibility as shared among stakeholders.

4.7.5. Sectorization of products & technical data sheet.
Due to products specificity, characteristics and usage, products cannot be considered as a unique stream. Each product is having its own attitude in front of its end-of-life constraint. Therefore, it is recommended to have a specific approach to treat each product the best way as possible. To ease such an approach, it is recommended to draft product’ technical data sheet covering at minimum the usage, the waste preparation and handling at farm, on grouping centre for a better collection, recovering and recycling.

4.7.6. Heavily soiled products
Mulching, and to a lower extend, cover crop and small tunnels, may be heavily soiled by mineral, organic and water, after their useful life. Although they are representing a limited volume all over the world, it is necessary to pay a special attention on them. Heavily soiled (over 70% of soilage contend) will generate difficulties for mechanical recycling.

The first step will be to manage the waste reduction at source, with the cleaning of film during removal operation: the equivalent of 1000 tonnes of polyethylene soiled at 70% requires 150 loads when 50 loads are sufficient when the product is soiled at 70%.
The substitution by biodegradable material

4.7.7. Waste reduction at source
The final goal of the VCoC is to insure as much as possible the sustainable use of the agri-plastics, as well as a full circularity.

Circularity mainly on quality. A good waste quality will allow a better recycling and integration. For agri-plastics quality is synonym of soilage and, we have seen the different scale of soilage content above. As said before, a special attention must be paid to mulching, the fare most soiled plastics use for the vegetable production.

To ease the recycling, the quality improvement is a prerequisite. The soilage reduction during removing operation is the best way to improve waste quality. The reduction at source may be considered in two main ways:

1. The usage of biodegradable products as an alternative as soon as technically feasible. After its useful life, after the harvest, according to the EU 17 033 standards, the biodegradable product

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6 See Chapter 7.1.2. in Appendix 7 The European Plasticulture Strategy.
is digested by soil’s microorganisms, favouring a new biomass. However, the use of biodegradable responds to specific constraints (as original biomass in the soil), it is necessary to identify before use.

| 500t of biodegradable mulch film avoids the use of 700t of plastics and the management 2,100t of waste. Therefore, biodegradable products may be seen in agriculture as part of the overall solution. |

2. Implement cleaning before or during removing operation on field. In France, for over a decade, the RAFU project has developed a specific technology to reduce the soilage contend by a factor 3 or 4 on different crops (carrots, shallots, melon, salad, potatoes...). This has required an R&D program dedicated to this objective of soilage content reduction⁷: it is preferable to leave the soilage content on field.

| 1,000 tonnes of plastics soiled at 70% requires 150 containers to transport it. If the soilage rate is reduced to 30%, only 50 containers are needed. |

4.7.8. Standards and norms
Agri-plastics like any other plastics products are produced according to technical standards, covering raw materials, mechanical properties and often some implementations instructions.
In Europe, a new generation of standards covering the full products lifecycle is in development, including design-for-recycling guidelines, use, removal, collection, and characterization of used products. For instance, the minimum thickness of conventional mulching, already set up at 20µ, is subjected to be increase at 25µ to ease removing operation avoiding any tearing and accumulation in soil. The VCoC may recommend the use of biodegradable mulching film for application below 25µ when technically feasible.
The development of specific standards for use and end-of-life will allow the certification of farmers good practices, ensuring an improvement in waste management and recylates quality.
Technical standards, like in other industries will focus on products specifications.
The implementation and use of standards and norms is recommended for a better environmental sustainability.
Main existing standards in Europe are:
- EN 13206+A1, Plastics — Thermoplastic covering films for use in agriculture and horticulture.
- EN 13207, Plastics — Thermoplastic silage films and tubes for use in agriculture
- EN 13655, Plastics — Thermoplastic mulch films recoverable after use, for use in agriculture and horticulture
- EN 14932, Plastics — Thermoplastic stretch films for wrapping silage bales
- ISO 4591, Plastics — Film and sheeting — Determination of average thickness of a sample, and average thickness and yield of a roll, by gravimetric techniques (gravimetric thickness)
- ISO 4592, Plastics — Film and sheeting — Determination of length and width
- ISO 4593, Plastics — Film and sheeting — Determination of thickness by mechanical scanning
- EN 17033, Plastics — Biodegradable mulch films use in agriculture and horticulture.
- ISO 23517, Plastics – Soil biodegradable materials for mulch films for use in agriculture and horticulture

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⁷ As RAFU project in France: soilage contend divided by 4 on carrots...
EN 13432, Plastics – Compostable products and packaging
The use of standards and norms is of nature to reduce bad practices and the negative impact on the environment. It is recommended to implement standards and norms in all regions of the globe.

4.7.9. The legal framework
Existing national collection schemes refer to the Extended Producer Responsibility (EPR), originally an ODCE concept used in many countries. National laws often consider farmers as professional and, therefore, responsible to insure the eliminating of their waste. The regulation specifies also than burning and buying waste is forbidden and, sometimes, there is no obligation for waste centre (municipality) to accept those wastes. Law may be completed by a “Environmental code” as in France, considering: « It may be made obligation to the producer (products manufacturer, to contribute towards the elimination of the resulting waste ». For the agricultural sector, it is recommended to include importers and distributors in the concept of producer since they can play a determinant role in the EoL management.

4.7.10. Governance aspects
Based on the agri-plastics specificities in terms of products and market organization, based on successful experience, the recommendation is to involve economic stakeholders (farmers, distributors, and converters) in the elaborating process in a shared governance. Notwithstanding their common interest to provides solutions to users, their involvement is a prerequisite for a successful scheme. Involving them in the scheme governance will create favourable conditions to reach the best technical and economic efficiency in a sustainable way.

4.7.11. Economic and financial aspects
The Extended Producer Responsibility integrate the cost internalisation: the new product covering the costs of its end-of-life management. This very clear approach supposes the acceptance of a full transparency on the organization, costs and finance management induced by the shared governance. Amounts generated by the cost internalization comes from the farmers and must return to them under the form of a service and sustainability.

4.7.12. Operational aspects
Regardless the region of origin, agri-products follow the same flow regarding the operational end of life management. After its useful life, the product needs to be removed, prepared, sometimes cleaned, selectively regrouped, transported, in bulk or bales, to its destination. If costs may be different, the logistic line is alike.
It is recommended to have a dedicated team to manage operations, since it requires expertise and competence in the interest of the scheme and the users.
4.8. Economic and social benefits

4.8.1. Environmental impacts
The implementation of a reliable management tool of used agri-plastics is the best way to tackle agri-plastics pollution.

- Products characteristics should allow a removing and recovering without product destruction on field with polluting consequences.
- Provide farmers and growers with technical recommendation for the use, removal and recovering of agri-plastics.

The objective of “Zero plastic on field, 100% recycled” is shared by all stakeholders and achievable. Plastics correctly managed are not suspected to cause any pollution, soil accumulation, micro-plastics or CO2 releasing.

4.8.2. Social impacts
Agricultural plastics contribute to improve working conditions, especially the efficiency of labour force thanks to the elimination of many operations (weeding, manual irrigation, ridges reshaping) and the increase of yields and quality. Continuous improvement in the use of agricultural plastics is key to maintain such benefits.

Working conditions shall be considered in the design of agri-plastics, especially to avoid any painful maintenance operations and focussing on easing the installation and removal operations, with for example easy unfolding and refolding of silage sheets or greenhouse films, anti-stain greenhouse films...

Such improvement can be achieved in collaboration with agricultural machinists, developing for example bale openers, mulch and drip irrigation cleaning-rolling machines, protective nets rolling machines, etc... It is easier to achieve when such objectives are integrated in the scopes of research and development programs.

4.8.3. Economics impacts
Agri-plastics have several direct and indirect economic impacts. In the direct impacts shall be mentioned:
- Reduction of production costs and losses
- Increase of high-quality fruits and vegetables complying with commercial standards
- Extension of production season and geography
- Increase of farmer incomes
- Savings in supplies (energy, water, fertilizers, pesticides, manpower, infrastructure)

In the indirect impacts shall be mentioned:
- Improvement of environmental footprint (arable land reduction, fertilizers and pesticides leaching reduction, soil artificialization mitigation)
- Contribution to the recycling industry and related energy savings
- Improvement in local food auto sufficiency

4.8.4. Integration of recyclates in new products
Sustainable use of plastics relies on the integration of recyclates in new products. Agri-plastics are precursors in this matter as they are one of the major inputs of recyclers and one the biggest sources...
of consumer of recyclates. This movement shall be developed to ensure that 100% of conventional agri-plastics are collected and recycled. Recyclates may have a higher integration cost that virgin material, considering the cleaning costs and the of specific boosters. Considering that soilage and mechanical degradation are linked to the use phase, they shall be integrated in the end-of-life costs, through the shared responsibility in agricultural EPR systems.

4.8.5. Recycling
As mentioned before, mechanical recycling is the primary means to ensure a second life for the agri-plastics. However, lack of recycling capacity all over the world leads to the following cul-de-sac: to reduce pollution having as an origin agri-plastics, we have identified and underlined the necessity to improve collection system. Collected volume is so subjected to increase significantly.

As stated by the Agri-Working group of the Circular Plastic Alliance of the European Commission, in its “Collection & sorting report”:

| With 700 K tonnes of new plastics placed on the market, the agri sector account for 1.5% of the overall volume put on the market. |
| The present report states that 390 K tonnes (including soilage) of plastic, mainly LDPE, is collected for recycling and recycled. |
| The untapped potential of polymer for recycling is estimated at 300 K tonnes with an additional 150 K tonnes currently diverted to energy recovery (107K Tonnes) and landfill (43 K tonnes) to consider as a reservoir for recycling in the future. |

In agriculture 300 K tonnes of polymer means a minimum of 500K tonnes of agri-plastic waste, considering the soilage content.

4.9. Monitoring
Any new regulation, or even action plan, should be based on a reliable statistics system to implement criteria, identify, and prioritize needs, measure the performance. Monitoring is then a prerequisite to identify progress.

4.10. Raising awareness
If non-packaging agri-plastics products is well known by professional of the sector, there is still a need to for a better sharing of this knowledge among all parties having to deal with plastics in agriculture. If the Plasticulture Magazine is designed for that purpose, there is still a lot to do to see the integrated management totally considered. It is recommended to include in educational program a specific chapter on the matter. As well, it will be valuable to have the academics to include a chapter on this aspect of the usage of plastics (description, characteristics, usage, end of life).
5. Recommendations for the Voluntary Code of Conduct

In the present document, we have tried to summarize all aspects concerning a sustainable end-of-life management, to favor the sustainable use of plastics in agriculture, eradicate the negative impact on the environment. It is recommended for the Voluntary Code of Conduct to underline:

I. Establish a Voluntary Code of Conduct focused non-packaging plastics respondent on specific rule on usage, removing, recovery and recycling.

II. Promote the development of national collection schemes in every country within the EPR's framework and the cost internalisation by:
   ➢ the application of the shared responsibility and governance among economic stakeholders for a sustainable end of life management, a prerequisite to achieve a technical and economic efficiency.
   ➢ Trust industry professionals by negotiating realistic, achievable, and progressive goals.
   ➢ Promote and accelerate implementation through financial support.

III. Promote the transfer of experience, practices, technics, and operational modalities among countries/aera, to ease and accelerate the process toward a sustainable EoL management of agri-plastics.

IV. Promote the usage of standard, norms and international technical recommendations as:
   ➢ Standards and norms for products and usage
   ➢ General guidelines for:
      Waste preparation at farm: product homogeneity, handling, packing when applicable, intermediate storage...
      Grouping centre: area’s configuration, selective storage by products/polymer Collection: selective collection by products/polymer, bulk handling, containers, transport

V. Raising the awareness on agri-plastic’s environmental stakes thru educational programs.

VI. Promoting transparency thru a reliable monitoring system at national, region and international level.

VII. Supporting R&D projects on process, equipment for a better waste reduction at source, as the development of biodegradable products in agriculture.

VIII. Support equipment and increase of recycling capacities focused on agri-plastics.

6. Appendix

6.1. SQUARE project

An increasing proportion of polyethylene agricultural plastic film is made from recycled plastic. Some of this recycled plastic may come from the regeneration of greenhouse films that have been exposed to plant protection products authorised under Annex I of Directive 91/414/EEC.

The project was prompted by questions from users of agricultural films, particularly silage film, containing recycled film from greenhouses. In March 2019, the CPA called on A.D.I.VALOR and its member and recycling partner in the APE sector, Groupe BARBIER, to set up a working group on this subject.

The SQUARE (Serre Qualité Recyclage) project aims to determine the level of concentration of these products or traces of products in recycled plastics. To achieve this,

The main stages of the project involved:
- Drawing up an exhaustive list of plant protection products
- Setting up batches of greenhouse films to be recycled from the APE collection system, from a wide range of sources throughout France,
- Carrying out representative sampling,
- The non-altering transformation of the sample for a complete and optimal analysis of the recycled material (cryo-grinding of the recycled granules).
- The use of a tried and tested protocol for sample preparation, extraction of fungicide, insecticide and herbicide molecules and their quantification, carried out by an independent laboratory.

The analyses carried out confirmed the presence of traces of plant protection products, but at very low concentration levels (of the order of 0.1 ppm). Consequently, in terms of European REACH regulations, the use of recycled plastic materials from the regeneration of greenhouse films does not require any specific provision or mention when manufacturing or marketing the final product.

6.2. Conclusions on CIAP study on banana sleeves recycling in Equator

The Centro de Investigaciones Aplicadas a Polímeros (CIAP) of the Escuela Politécnica Nacional in Quito, Equator conducted a study to check the recyclability of banana sleeves used in the country. Equator is the major banana producer in the world, leading to an intensive use of banana sleeves (8800 Tons per year) to protect the fruits and apply controlled pesticides during the growing season.

The project conducted in 2019 aimed to characterize the waste, measure the pesticides levels and evaluate the recyclates quality and processability.

The characterisation of the waste revealed that the plastic plastic material corresponds to HDPE.

- The determination of the contamination level confirmed the the categorisation of the waste as non-hazardous, and indicate the presence of only 2 pesticides, chlorothalonil and chlorpyrifos.
- The evaluation of the level of degradation showed that the loss of tensile mechanical properties is less than 50 %, which, according to the criteria of the CEN Standard EN 13206, the material is not degraded, and its direct recycling is feasible.
- Six stages of the mechanical recycling process were established, including: sorting and reduction, washing, ambient drying, agglutination and reprocessing by extrusion.
- The processing of recycled matrix mixtures with virgin material showed the best result with the sample MC8 with the addition of 30 % by mass of virgin material, reporting a statistically significant increase in the elongation at break of 33 % compared to the first reprocessing of the material.
- Two types of extrusion profiles were obtained, in the form of a ribbon-shaped and circular cross-section profiles were obtained.
- The evaluation of the tensile mechanical properties under two reprocessing cycles showed that the material loses up to 50 of its elongation at break in the third cycle, which is, according to the criteria of the CEN Standard EN 13206, the material is considered degraded.
6.3. The European Plasticulture Strategy –
A contribution to the European Green Deal

APE Europe brings together companies involved in the production and supply of non-packaging plastics used in agriculture, with the core objective to provide environmentally responsible solutions to farmers for the end-of-life management of agri-plastics waste. APE Europe welcomes the study being conducted by DG Env. and Eunomia on the use of conventional and biodegradable plastics in agriculture.

Agri-plastics are vital to increasing the productivity of agriculture through the efficient control of essential crop and livestock parameters such as temperature, light, hygrometry, irrigation, weeds, pests, crop and fodder protection, whilst also reducing the use of resources such as water and chemicals. Agri-plastics also protect the structure of soils and promote the development of roots, foliage, and fruits. Furthermore, agri-plastics enable an increase in the capacity to store seeds and fodder for livestock, reducing the need for additional farm buildings and thus freeing up arable land. Thus, agri-plastics reduce the environmental impact of agricultural production whilst increasing the quality and quantity of food produced and the health of livestock.

However, a well-organised universal end-of-life management policy is essential to avoid agri-plastics having a negative impact on the environment after their use. If agri-plastics waste is not managed responsibly, it may be left to accumulate in the soil, be buried, burned, or stored in unsuitable areas. Over time, exposure to the sun degrades the plastic waste into small flakes which are carried away on the winds and can end up in our rivers and oceans or micro-plastics.

The principle of Extended Producer Responsibility, being the legal framework adopted by all European countries, can be adopted for the end-of-life management of agri-plastics providing it is tailored to the specific needs of agriculture. For many years now, Plasticultors have been committed to providing environmentally responsible solutions to farmers for the end-of-life management of agri-plastics waste. Indeed, several countries have already implemented national schemes through individual and collective initiatives, involving farmers, distributors, and plastic processors. It has been through industry-led initiatives, within this framework of a shared responsibility and governance, that efficient technical and financial solutions have been developed for agriculture.

This method of agri-plastics waste management has produced remarkable results in every country where it has been adopted. Moreover, these results have been beyond public expectations, such as: increased national collection and recycling rates, widespread communication of good plastic waste management practices, several research and development initiatives to reduce waste at source, improved quality of waste collected thereby enabling recyclers to improve the quality of regenerated pellets so that more PCr can be incorporated into new products.

The Plasticulture community encourages governments to recognise the achievements made by our industry in the end-of-life management of our used agri-plastics. Our success has been achieved through a chain of solidarity of all economic actors within the Plasticulture community. We recommend that this industry-led approach and the governance of it should be encouraged by governments and integrated into policy. Existing national schemes have proven their effectiveness and the positive experience gained should be used to encourage the implementation of similar schemes where none yet exist. As such, any new regulatory legislation should enable farmers, distributors, and processors
to be engaged collectively in the governance of such schemes. It should also promote a technologically neutral approach to the development of new recycling, soil biodegradable and industrial composting solutions.

Through the European Plasticulture Strategy, APE Europe aims to make its contribution to a more ecological and sustainable use of plastics in agriculture and to the implementation of solutions for the environmentally responsible end-of-life management of agri-plastics used by 22 million farmers across Europe. APE Europe stands ready to fully support the Commission in this study.
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The European Plasticulture Strategy

A Contribution to the European Green Deal

The European Plasticulture Strategy aims to make its contribution to tackle environmental issues related to the use of plastics in agriculture. The public’s perception of plastics and their environmental impact has never been so negative. The plasticulture community is committed to addressing these concerns and to improve best practices in the use of plastics in agriculture. Farmers and growers, in partnership with industry and distributors, have taken numerous steps, over many years, to improve the quality and quantity of agricultural production, all the while reducing its impact on the environment.

Protecting the environment is a top priority and urgent action must be taken. We must ensure that such action is based on scientific rather than emotional grounds. It must also be achievable and environmentally, socially, and economically sustainable. Agriculture is the cornerstone of our fundamental economic activities, which helps to feed a growing and ever more demanding population. Short-term decisions require a long-term vision to avoid unintended or irreversible negative consequences in the future.

Plasticultors are fully aware of the challenges ahead and are dedicated to developing and providing solutions for agriculture. They aim is to contribute to a more sustainable production of crops, vegetables, and meat within the “From Farm to Fork” Strategy. They consider that their responsibility is to improve the knowledge of the public and of decision makers by providing better information about the use of plastics in agriculture and about their consequences in the environment when not properly managed at the end of their life.

The European Plasticulture Strategy is to recommend programs and actions that tackle these environmental challenges in a collaborative way with farmers and growers, industry, and public authorities at a local, national, and European level.

1. Plastics in agriculture

1.1. A limited market

The European Plastics Strategy for Plastics in a Circular Economy, issued by the European Commission in January 2018, refers to a global plastics demand in 2015 of 49 million tonnes establishing that “In
the EU, the potential for recycling plastic waste remains largely unexploited. By comparison, non-packaging plastics for agriculture accounts for 721K tonnes per year or 1.4%. In Europe, 10 countries represent 80% of this volume. Made mainly of low-density polyethylene (81%), polypropylene and high-density polyethylene accounting respectively for 11% and 8% of the total. Subject to important constraints during their useful life, specific additives can be introduced to improve certain characteristics and optimise product performance. Should biodegradable products become an alternative, their use is specific only to mulch films or horticulture twines. Soil biodegradable products account for less than 1% of the global agricultural market, but their use will develop very quickly. They reduce waste at source and not produce microplastics.

**1.2. A key role in the production**

Agri-plastics are vital to increasing the productivity of agriculture through the efficient control of essential crop and livestock parameters such as temperature, light, hygrometry, irrigation, weeds, pests, crop and fodder protection, whilst also reducing the use of resources such as water and chemicals, reducing usage of fertilizers and pesticides due to limited evaporation. Agri-plastics also protect the structure of soils and by increasing the temperature and moisture of soils they promote the development of roots, foliage, and fruits, resulting in better harvests and higher yields.

Agri-plastics form a clean physical barrier to protect crops from rotting and from being contaminated, thus improving their quality and appearance. They also protect the storage of forage for livestock efficiently throughout the seasons and save Added to this, it also saves cultural land, avoiding the building of more barns, protecting the harvest, soil, and the water table. In so many ways, the benefits of plastics used in agriculture are tremendous. Production without plastics is unimaginable. In practical terms, limiting the use of plastics in agriculture would lead to a significant drop in production, or even the disappearance of some crops!

**1.3. Agri-plastics waste**

After use, agri-plastics keep most of their original characteristics. For most of them, their useful life can be measured in weeks or months. Only a few of them, such as greenhouse films or anti-hail nets, may have a durability of a few years. Being made of good quality polymers they are fully recyclable. However, depending on their application, use and thereafter the method of their removal, agri-plastics waste is sometimes heavily contaminated by exogenous materials, such as minerals, sand, organic matter, and water. Hence, the weight of the agri-plastics waste can be the equivalent of 3 or 4 times the weight of the original plastics especially mulch films. In such cases even a fully recyclable product may become difficult to recycle or at least at a very high cost. Since the Chinese National Sword or “Green Wall” started in January 2018, many agri-plastics wastes are no longer accepted by the recycling industry in the EU, especially those with such a high soilage content.
though they were being recycled before. This has led to an increase in agri-plastics waste being diverted to landfill.

Table 1: European Market for Agricultural Plastics: New vs Used

<table>
<thead>
<tr>
<th>Products</th>
<th>New Tonnes</th>
<th>%</th>
<th>Used Tonnes</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Films</td>
<td>547,000</td>
<td>75%</td>
<td>927,500</td>
<td>78%</td>
</tr>
<tr>
<td>Flexibles irrigation pipes</td>
<td>40,000</td>
<td>6%</td>
<td>48,000</td>
<td>4%</td>
</tr>
<tr>
<td>Nets</td>
<td>54,500</td>
<td>8%</td>
<td>80,500</td>
<td>7%</td>
</tr>
<tr>
<td>Twines</td>
<td>80,000</td>
<td>11%</td>
<td>104,000</td>
<td>9%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>710,500</strong></td>
<td></td>
<td><strong>1,151,450</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Polymers</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LDPE</td>
<td>587,000</td>
<td>81%</td>
<td>975,500</td>
<td>83%</td>
</tr>
<tr>
<td>HDPE</td>
<td>54,500</td>
<td>8%</td>
<td>79,950</td>
<td>7%</td>
</tr>
<tr>
<td>PP</td>
<td>80,000</td>
<td>11%</td>
<td>116,000</td>
<td>10%</td>
</tr>
<tr>
<td><strong>General</strong></td>
<td><strong>721,500</strong></td>
<td>100%</td>
<td><strong>1,175,450</strong></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Except o xo</strong></td>
<td><strong>713,500</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The average soilage content across all products is estimated to have a coefficient of 1.63, resulting in 721K tonnes of new agri-plastics becoming 1,175K tonnes of used agri-plastics waste. One third of this additional volume comes from products dedicated for animal production and two thirds for vegetable production.

In the absence of a relevant waste management system, agri-plastics may have a negative impact on the environment. Farmers and growers can often find it difficult to manage their agri-plastics waste in an environmentally responsible way as it is bulky, cumbersome, and usually soiled. There can also be technical, geographical, or financial reasons why they do not always manage their agri-plastics waste properly. Furthermore, for some crops it is technically not possible to remove 100% of the plastics once used. Nonetheless, unprofessional bad practices, such as dumping, burying, or burning agri-plastics waste damage the environment and should not be an option. Farmers and growers need another option and deserve to be provided with solutions to these issues, now more than ever. It is encouraging to see the positive reaction from farmers and growers when a collection scheme is offered to them. In countries where national collection schemes have been introduced, such bad practices have been eradicated.

1.4. A professional value-chain
Plasticulture covers the economic activity surrounding products produced from plastic and intended for use in agriculture. This does not include plastics used for packaging phytopharmaceutical products or fertilisers, nor protective clothing made from plastics, but solely plastic products used for cultivation or storage, and which have a direct impact on the quantity or quality of production. The plasticulture community is defined as any activity related to plastic in agriculture: farmers & growers, distributors, and converters, as well as researchers when their projects are related to plastics, or collectors and recyclers. The plasticulture community can be considered as a value chain as soon as an actor or decision maker influences or changes the attitude of the next actor down the line. Thus, from design to recycling, through usage and collection, the link is close in these business-to-business relationships. This chain has been clear in the design stage and in the use of new product, but it is only more recently that this concept has been applied to the end-of-life management. The emergence of national collection schemes (NCS) has highlighted that the level of preparation of the waste after use determines down the line the process that the plastic will go through and where it will end up. A recyclable product may ultimately not be recycled simply because of the practices and processes used. So, the plasticulture community plays an important role in sharing best practices to improve the end-of-life management of agri-plastics, but the end result depends upon the attitude of each individual.

2. Plastics and the environment

The recent “Green Deal” published by the European Commission underlines its political determination in terms of agriculture and the environment: "The Commission will ensure that these strategic plans are assessed against sound climate and environmental criteria. These plans should lead to sustainable practices, such as precision farming, organic farming, agroecology, agroforestry, as well as stricter animal welfare standards."\(^{14}\) For plastics, if the “Green Deal” is seen as the global answer to the challenges facing the environment and climate change, it has to be considered also under the scope of the European Plastics Strategy and the SUP directive published in 2018, followed by the Circular Plastics Alliance launched in 2019\(^{15}\). The Green Deal: "Strategic plans will need to be more ambitious to significantly reduce the use and risks associated with chemical pesticides, as well as the use of fertilizers and antibiotics." “Precision farming, organic farming, agroecology...” cannot be achieved without plastics.

Plastic provides numerous services to farmers and to agriculture. With a modest investment the farmer can improve his income with a yield that is superior in quality and quantity. However, at a very early stage the plasticulture community saw the negative externalities of agricultural plastics and the need to reduce their environmental impact. But in the absence of a well-functioning system to manage the end of their lifecycle, these negative externalities have led to used plastics being left in the field, whereby a cumulating effect has seen them change the soil and micro-organism structure, thus affecting the development of plant roots and fruits and, as a consequence, leading to a dip in


\(^{15}\) Circular Plastics Alliance – CPA - for the integration of 10 million tonnes of post-consumer recyclate into new products.
yields\textsuperscript{16}. Furthermore, if left uncollected, these plastics can deteriorate into small plastic flakes which are then blown away by the wind, or carried away by rivers and streams, ending up as marine litter.

For sure, the absence of a commercial value of the waste hinders the free market from being able to solve the end-of-life management of agri-plastics by itself. When there is a commercial value to the waste, the market can recover the collection, recovery and treatment costs, allowing companies to make a living out of it. Without any value, the waste remains a burden for the farmer and the environment. Furthermore, for several decades now, poor economic conditions have not allowed the recycling industry to develop sufficient resources to invest in technology and capacity for the plasticulture sector. These are some of the reasons why, quite apart from the market condition, additional financial resources must be mobilized, and R&D projects encouraged to improve technical and economic performances.

Tackling the environmental challenges of plastics used in agriculture is possible and indeed has already been achieved in some countries even before the downturn due to the Chinese National Sword. Therefore, the plasticulture community has already gained significant experience and is well advanced in identifying the areas to focus on.

3. To tackle pollution from plastic in agriculture

Whilst some of the technical and financial solutions may already be known by some plasticultors, it should be admitted that they have not always been applied. The Circular Plastics Alliance has identified 5 thematic groups\textsuperscript{17} for this chapter:

➢ **Design for recycling** means new product conception considers the entire lifecycle of the product both technically and economically along the whole value chain. This is the new paradigm for our industry: products should be easy to use, remove, collect, clean, recycle and to integrate them into new products. In this context, we must also consider soil biodegradable products as offering a significant reduction in the environmental impact of agricultural production. Notwithstanding this, our industry now considers a product’s end-of-life during its design.

➢ **Collection and Sorting** begins with the preparation of agri-plastics waste on the farm. The quality of agri-plastics waste is a key factor for its recycling and its eventual integration into new products. The dissemination of good practices greatly improves the quality of waste at no additional cost and ultimately determines the product’s end-of-life: recycling or landfilling. If waste reduction at source begins with farmers and growers, in many cases, the growth in the use of soil biodegradable mulch films can make a large contribution to it\textsuperscript{18}. Once plastics are removed after their useful life, farmers and growers still need a solution for their collection. By sorting the waste, both by product category and by polymer, an organized collection system can increase the quantity and quality of the waste collected and enable an improvement in its recycling. The soilage content of the waste can also be reduced at source and thereby increase its capacity to be recycled.

➢ **R&D** has been made in some countries with the aim to give value back to the waste, for example by improving its quality by pre-treatment cleaning processes. Projects made in France, such as

\textsuperscript{16} Plasticulture Magazine N°136 "The benefits and challenge of plastic film mulching in China. Prof. Changrong, CAAS".

\textsuperscript{17} See the Circular Plastics Alliance

\textsuperscript{18} 500 tonnes soil biodegradable mulch film can reduce plastic waste by 2,100 tonnes
RAFU or CleanFlex, will be duplicated in Europe wherever possible. Another option will be to develop films that reduce the amount of soilage content retained on the film after its use. Research and development also include the search for recycling solutions for all orphan products, such as for round bale nets.

➢ **Recycling** can include different processes:
  • Mechanical recycling has been the best solution. However, the present lack of recycling capacity, the huge volume of waste available since the Chinese National Sword, and the low PCr value of it, has created great difficulties for the recycling industry and has led to limited options for the agri-plastics waste that is collected\(^\text{19}\). Furthermore, the integration of PCr into new products is dependent on the quality of the granulate coming from the used plastics.
  • Energy recovery is not currently widely used and is not seen as a full alternative when plastic waste can be properly prepared\(^\text{20}\).
  • Chemical recycling is probably the most interesting opportunity in the future, in complement of mechanical recycling, once the quality of agri-plastics waste is suitable for it.

Whilst in some countries the value chain is taken seriously, over the years we have seen many projects to tackle pollution with limited results because they have not been followed universally. As stated before, farmers & growers the environment: burning, burying, accumulation, wild stockpiling, and contributing to marine pollution and micro-plastics. To address this situation, a global vision (Think global) with specific actions (Act local) are needed.

\(^{19}\) Collected mulch films have few recycling solutions in Europe, although they were being recycled until 2017

\(^{20}\) Washing and shredding is a prerequisite
4. Towards a second life for used agri-plastics.

If the legal framework of the Extended Producer Responsibility (EPR) is well adapted in business to consumers relationships, in agriculture it is recommended that the “producer” should be considered as being all economic actors involved together in the scheme. We have seen that the method of preparing the waste can determine the product’s end of life. When the waste is considered as purely garbage it will be more difficult to recycle but when the waste is considered as a used product to be prepared for a second life\textsuperscript{21}, then sustainability can become a reality. In a business-to-business relationship, professionals - farmers/distributors/converters - share 100% of the responsibility for a sustainable end-of-life management since individual attitudes influence the actor further down the line. Farmers & growers, waste owners, share their responsibility with other stakeholders and are keen to use best practices, according to minimum technical requirements, in waste preparation and in the deliveries to the grouping centres. Distributors play a significant role in communicating information about collection sites and schedules. They may also offer space for a grouping centre as well as for quality control. Converters can ensure the collections up until the destination of the used product.

This shared responsibility has shown its efficiency both technically and economically when it is put into action. When good practices are embraced, we have seen an improvement in the quality of the waste collected year on year along with an increase in the quantity collected. This is thanks mostly to the voluntary actions of the actors involved. By increasing the volumes of agri-plastics waste being collected and sorted, logistics costs\textsuperscript{22} to and from grouping centres can be optimised.

The financing of such a system is secured by internalising the costs, as with any other EPR scheme. It must be noted that each product category has its own costs in the management of its end-of-life. The shared responsibility offers the additional advantage of cost transparency when, previously, hidden costs were the norm. It is possible, therefore, to identify individual costs for each product and to then establish an adapted eco-modulation on the fee applied on each product.

5. A strategy for plasticulture

5.1. Transforming challenges into opportunities

With its declared objective of Zero plastics to Nature and 100% to be recycled, the plasticulture community understood the importance of managing agricultural plastics at a very early point. However, it can take several years to ensure the sustainable management of agri-plastics waste.

\begin{table}
\centering
\begin{tabular}{|l|}
\hline
Over 10 years of existence the APE France scheme has dedicated €44 million to financing the collection by ADIVALOR of 460,000t of plastic. For films alone, 410,000t of used films were turned into material recycling, representing 275,000t of regenerated granules finding a new life in new products. Until 2017 98% of plastic films collected were effectively turned into recycled material, showing that the goal of zero waste sent to landfill can be achieved. \\
\hline
\end{tabular}
\end{table}

\textsuperscript{21} See Adivalor communication campaign: “1.1 recycle” in Annex I

\textsuperscript{22} 30m3 container is the reference size for loading
The plasticulture community is dedicated to:

- No more conventional plastic left on the fields thereby stopping the accumulation in soils and the contribution to marine pollution.
- Zero agri-plastics waste at landfill.
- Additional activities in collecting, recovering, recycling allowing investment and job creation.
- To increase the recycled content in new products.

However, there are still many challenges to face:

- Agricultural practices on farm must evolve to improve the management of plastics after their useful life, to increase both the quality and quantity of the waste, thereby easing their recycling.
- Progress must be made regarding solutions brought to farmers to increase the volumes collected, particularly for products with the lowest collection rates.
- The range of items collected must be extended to cover all plastic products used in agriculture.
- To improve the quality of highly soiled plastic waste and make them eligible for recycling again. The reduction of soilage content will also reduce the carbon footprint.
- For plastics with no recycling solution, R&D investments will be made to develop new industrial and recycling opportunities.
- The integration of post-consumer recyclates (PCr) into new products. Integration gives back value to the environment.

For the plasticulture community, zero plastic in landfill is achievable. To get there, it is necessary to encourage efforts related to waste management at farm, collection, research and development, and recycling. The integration of PCr into new products is a challenge but is first a matter of the quality of the waste determining the quality of the recyclates produced from it. Quality matters all along the whole value chain: from the farm to the incorporation of PCr into new products. Not everything can be achieved at once, but progress can be made progressively.

### 5.2. A plasticulture strategy for everyone

Whist a product’s recyclability depends initially on its design, after use in agriculture, the conditions for removing and collecting the products determine their true recyclability. Therefore, by the mobilization of the plasticulture value chain, favourable conditions can be created to manage properly the end-of-life of agri-plastics by optimizing the technical and economic methods and procedures.

**Zero plastics to nature and 100% recycled** is achievable because of the experience we have gained already. Within the shared responsibility, all actors are involved to give back value to the environment.

### 5.2.1. Plastic neutral farming

Farmers and growers are dedicated to environmentally friendly agriculture production. Plastic use on farm should have no impact on the environment so all weight going in must go out at the end of the process. Increasingly, farmers and growers are integrating agricultural production as a system with a
social responsibility. The decisions of farmers about how to use and to remove agri-plastics play a vital role in the end-of-life of the product.

- **Design, a buying criterion**: Farmers check if a product is recyclable and eligible to a collection scheme. They can consider whether the PCr from the used product can be incorporated into new products.
- **Usage**: Farmers use plastics that have the lowest impact to the environment and those that may be used in reduced amounts.
- **Waste reduction at source**: Farmers use best practices known to reduce soilage and improve waste quality. They use alternatives such as soil biodegradables where applicable.
- **Optimizing waste collection**: Farmers are open to better information and training about waste management on farm, both operationally and technically. Farmers prefer technology that helps with preparation of waste on farm to improve the quality of waste for removal, storage, and transport.
- **Collection scheme**: Farmers are dedicated to collaborating with collection schemes and to their improvement.

### 5.2.2. Distribution as a key

Because of its close relationship with farmers and their concerns, the distribution network plays a key role in advising the user on the use and elimination of the products they supply. The socially responsible company can use its expertise, competencies, and services to their clients to help improve the end-of-life management of the products they supply.

- **Design, a buying criterion**: Distributors check if a product is recyclable and eligible to a collection scheme. They can consider whether the PCr from the used product can be incorporated into new products.
- **Select suppliers on environmental criteria**: Distributors consider a company's environmental policy and strategy, their incorporation of PCr into new products and their participation in collection schemes.
- **Advice to farmers on product use, waste reduction at source and waste management**: Distributors promote good practices, best techniques and equipment and propose alternative products, such as soil biodegradables.
- **Information to farmers**: Distributors inform farmers about a relevant collection scheme, its operating conditions, timing, and any relevant technical requirements.
- **Provide full service to farmers**: Distributors support farmers operationally in the waste collection scheme when applicable.

### 5.2.3. Converters

Committed to a sustainable industry, and as the first actors of Extended Producer Responsibility, converters are keen to fulfil their company’s social responsibility. Involved in many ways, in several initiatives and actions to reduce the environmental footprint of their activities, they contribute to the establishment of national collection schemes to provide farmers with solutions for the end-of-life management of their used plastics.

- **Converters apply the incorporation of PCr into their new product** whenever applicable. To underline their involvement, they support the Circular Plastics Alliance by signing the declaration directly or through their professional organizations and unions.
- **Converters inform employees and clients about initiatives and actions** their company undertakes
for a sustainable agriculture: decisions made, debates, messages, educational materials.

- **Converters support and contribute to implementing and joining a collection scheme** ensuring farmers with sustainable solutions to the end-of-life management of the plastics they put on the market.
- **To commit to a comprehensive certification scheme** allowing traceability on recycled content into new products.

6. **Agri-plastics waste management: A European model**

In several countries, farmers, distributors, and converters are already involved in a national collection scheme and have experienced different methodologies to improve the management of agri-plastics waste. Over time, and as experience has been gained, a **European national collection scheme** model, has been developed, considering the specifics of the end-of-life management of agri-plastics.

**As its first objective, the NCS must bring solutions to farmers.** As the owner of the waste, the farmer is legally responsible for the end-of-life management of the plastic after use. When deprived of practical solutions to the management of used plastics, farmers may resort to unprofessional bad practices. It is therefore necessary to provide farmers and growers with coherent and effective solutions, both technically and economically, so that they can concentrate on their core business: agricultural production.

- **Extended Producer Responsibility (EPR):** The OECD, Europe and each country within Europe have incorporated the principle of extended producer responsibility. This states that, where waste is not able to be managed in an appropriate manner, it is up to the product manufacturer (producer) to contribute to its end-of-life management. Agricultural plastics fall into this category.
- **A collective and shared responsibility between economic actors:** The responsibility is considered collectively between all economic actors who accompany, advise and supply the farmer: distributors and converters. The scheme’s performance begins on farm and the entire value chain is focused on best practices and operations to improve technical and economic efficiency. Therefore, the scheme governance is shared among economics actors in order to establish the scheme’s modality that is suitable for all.
- **Cost internalization:** The new product finances its own end-of-life management, through a contribution applied on the sales price of the product.
- **The role of system operator** is a key factor and an important part of EPR schemes as RIGK (Germany), IFFPG (Ireland), A.D.I.Valor (France), SvepRetur (Sweden), Green Dot (Norway).

A scheme, built on collective initiatives, can register progress year after year on both the range of new products included in the scheme and the quality of used products for recycling. Data monitoring can provide reliable information on the scheme’s performance and can be shared with all stakeholders and public authorities. Transparency, especially on costs, is an advantage too, removing any hidden costs, improving best practices, and bringing sustainability. The implementation of such a new system requires time and pedagogy, in order to obtain the commitment of all the stakeholders involved. It is done gradually before full coverage of products or geographical areas can be ensured.
7. Plasticulture Alliance

It is a tremendous challenge to tackle the environment related issues from plastics used in agriculture in a sustainable way. The plasticulture community intends to meet it. Seen as a value chain, every link has an important role to play and a strong alliance is needed.

7.1. Research and Innovation

The reduction of waste at source is the first step that should be considered, to improve the efficiency of the scheme and to reduce the costs of operating it. Several directions can be taken to do this.

7.1.1. Soil Biodegradable and Compostable Products

Soil biodegradable products, such as mulch films, and compostable like twines, and clips for horticulture, are an alternative to traditional plastic products. Very thin polyethylene mulch film cannot be fully collected from the field or be efficiently recycled due to the soil contamination attached to the film. Soil biodegradable mulch film can be simply ploughed into the soil after harvest and biodegrade through contact with soil microbes. Thus, they leave behind no long-term persistent plastic residues. During crop production, soil biodegradable mulch film offers the same benefits as conventional (non-biodegradable) mulch film.

➢ Soil biodegradable plastics are produced using soil biodegradable polymers, either fossil fuel based or biobased. These materials act as a source of food for naturally occurring soil microorganisms. Therefore, when the material is ploughed into the soil and is in contact with soil microorganisms, the material biodegrades. The polymer is converted into CO2, CH4 (in the absence of oxygen), H2O and microbial biomass (i.e. all organic constituents of microbial cells). This process is the same as for natural polymers, such as for cellulose or cutin.

➢ The incomplete removal of conventional plastics from the field can be a source of macro and microplastics in agriculture. As soil biodegradable products are consumed by microbes in the soil as food, polymer residues will not remain in the soil after some time. Therefore, soil biodegradable mulch films are an effective means to avoid the accumulation of plastics in soil. These certified (EN17033, ISO23517) soil biodegradable materials are good alternatives for the conventional mulch films when removal difficulties occurs. Nets, threads, clips and shelters are difficult to recover from the field and green waste streams. In these cases application of compostable (EN13431) and soil biodegradable (EN17033, ISO23517)) materials will help to reduce persistent microplastics in soil and in compost.

➢ To ensure that soil biodegradable mulch films will fully biodegrade in soil, a standardized measurement and certification of the biodegradation process is essential. Published in 2018, the European standard EN 17033 puts together a set of mandatory requirements that ensure the safety and functionality of the product. A stringent control of constituents, ecotoxicological testing, mineralization testing and physical characterization is mandatory. Certification is granted by independent bodies such as TÜV Austria, Belgium or TÜV Rhineland, Berlin.

➢ Researchers around the world are investigating the biodegradability of soil-biodegradable materials even further. A broad variety of studies have been published in recent years. Some of the most recent publications prove unequivocally that carbon from synthetic polyester is utilized by microbes for the formation of biomass24. Other studies have focused on the impact of soil

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24 On 3,000 tonnes of agronomic soil per hectare, with a biodegradable film in the soil of 150kg/ha, according to EN 17033, only 15kg/ha of film remains in the soil, contributing to a new biomass.
biodegradable mulch films on the health of soil over several years but without finding any negative effects.

In summary, **soil biodegradable mulch film** is a highly innovative product helping to solve environmental challenges connected to plasticulture and a **valuable alternative to PE film in cases where the film cannot be properly removed from the field.**

Compostable products allow a simplification of the management of horticultural crops remain at the end of the growing season as twines and clips are always difficult to sort. The crop remains can then simply be send to industrial compost station and reuse as plant nutrient after the treatment. **500t** of biodegradable mulch film avoids the use of 700t of plastics and the management **2,100t** of waste. Therefore, biodegradable products may be seen in agriculture as part of the overall solution.

### 7.1.2. Leave the soilage content in the field.

With only 250 kg of plastic per hectare, it is not unusual to remove over 1,000 kg of plastic waste per hectare after use, such is the very high level of soil contamination. An average collection cost of 150€ per tonne of such waste equates to a management cost of 600€ per tonne of the actual plastic content in that waste. 1,000 tonnes of plastics soiled at 70% requires 150 containers to transport it. If the soilage rate is reduced to 30%, only 50 containers are needed. **It is a serious strategic and environmental priority to reduce the soilage content** after the plastics are used and to leave the soil in the field. The dissemination of good practices on farm must be the first step for reducing waste at source. To date, the equipment used by farmers to mechanically remove the film from the field after use are not yet designed to clean or reduce the soilage content. However, recent developments with equipment used for harvesting carrots, shallots, melons, and salad have proven to be more efficient in this regard. These technical developments will be over time be shared throughout Europe and eventually be accessible for all farmers and growers.

### 7.2. Collection

Sustainability can be achieved by a national collection scheme through the maintenance and development of the whole collection sector, regardless of the general waste market conditions. The recurrent, regular and increasing volumes being collected by a scheme provide the security of long-term sustainable supply of good quality feedstock. Collection and recovering companies can grow through cost efficiency, improved financial results and the flow of financial investment based on a reliable and sustainable business model. Experience shows that increased professionalism brings additional efficiency when sustainability is introduced. Best practices on farm, added to an optimized logistics structure, with the grouping of minimum quantities (30m3) for onward delivery to recyclers, by a selective collection process ensures the best condition for the waste to be recyclable.

### 7.3. Pre-treatment

Pre-treatment is defined as the transformation of waste upon collection in order to improve logistics, storage and recycling conditions. Baling of the waste is considered as the first step in pre-treatment but the need for improving the quality of the pre-treated waste is becoming increasingly important so as to enable the subsequent pre-treatments, such as washing and shredding. This will help to ensure
that a clean product is delivered to recyclers. National collection schemes do now consider pre-treatment operations as a necessity to guaranteeing the recyclability of the used plastic collected.

### 7.4. Recycling

The recycling of flexible films has been growing steadily in Europe. In 2018 the total installed capacity reached 2.3mil tonnes compared to 1.5K tonnes in 2015 and the recycling rate in the EU is approximately 20%. The main sources of flexible PE waste originate from commercial/retailers (43%), production (23%), agriculture (17%) and household packaging (13%). Plastic waste coming from the agricultural sector continues to be an important resource. Agricultural plastic film is one of the plastic waste streams for recycling in Europe that does not have any EU-wide legislation in place. There are several challenges that the sector is facing and so further growth in the recycling of this plastic waste stream will depend on overcoming these challenges.

- **Better quality.** The major challenge for recycling agricultural film in Europe being faced today is the quality of the waste being collected. Ever since the Chinese ban on the imports of plastic waste came into effect there has been a huge increase in the availability of high-quality plastic waste material coming from post-consumer streams. This material became the preferred stream for recyclers since the contamination of material coming from agriculture is so much higher and therefore more expensive to recycle. Agricultural film recyclers are struggling today with low quality inputs which contain on average around 50% of contamination, such as soil, moisture, and other organic materials. This in turn, has had a negative impact on the efficiency of the recycling process as at least half of the input material is lost as contamination or cannot be used and is rejected. This has led to ever increasing high maintenance and disposal costs to the recyclers. Additionally, output material from this stream are of lower quality and so offer recyclers lower margins.

- **An increase in the quality of the material being collected should result in a reduction in the overall costs of recycling agri-plastics waste.** Increasing the efficiency of recycling agri-plastics waste should drive more investment into recycling.

- **Higher collection rates.** Collection rates and the quality of plastic waste go hand in hand. Collection is the first step in ensuring that the material will be recycled. Europe lacks dedicated collection points for agricultural plastics and increasing the tonnages of collected waste is a must to safeguard the regular flow of materials for recyclers and to guarantee their well-functioning. Additionally, the collected waste must be sorted and pre-cleaned so that the input material that recyclers receive is of the best possible quality.

- **Harmonization of practices and standards.** The EU waste market is fragmented and malfunctioning. Common standards and practices must be introduced across Europe to create a level playing field. These will need to cover best practices and standards in the collection, sorting, and quality of recyclates, amongst others.

- **Investments.** State of the art collection and sorting recycling technologies must be applied and further investments in new technologies made to improve the quality of the recycled material so that it can be used in high end applications. Additionally, pre-treatment (e.g. cleaning) steps will also need to be introduced to increase the quality of waste and to minimize the contamination of the recyclers’ input material.

- **Value chain collaboration.** The success of agricultural plastics recycling is a matter of the whole value chain starting with agricultural plastic producers, collectors, farmers, and recyclers, among

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25 Source: Plastics Recyclers Europe
others. Only through collaborative action can the recycling rate be improved.

- **Future of agricultural plastics.** With a growing population worldwide, there will be an urgent need to produce extra food supplies, and therefore the quantity of plastics produced for this sector will need to increase. The quality and quantity of used plastic collected from agriculture must drastically improve along with investment in new recycling capacity. It is therefore unavoidable to advance the collection, sorting and overall rates for this stream in Europe to make plastics genuinely circular.

8. The plasticulture commitments

Europe, governments, and companies can accelerate the transition to a circular economy by making sustainable choices in the products purchased and used. A conscious choice to prioritise sustainable and circular options creates more demand for sustainable, recycled, and renewable plastics. The European model of a national collection scheme ensures a growing collection rate as well as an improvement in the quality of the waste collected, both pre-requisites for better recyclability and the consequential incorporation of PCR into new products.

The proposed methodology, developed from good experience, meet the expectations of everyone:

- Farmers, better management of their production processes for the environment.
- Distribution networks, the assurance of a long-term service provided to their customers and their members.
- Converters, the guarantee that they meet the social responsibility of the company and the requirements of the regulations.
- Legal requirements and public authorities. the guarantee of a responsible and involved professional sector, bringing technical and financial solutions for any national collection scheme.

The plasticulture community has identified its responsibility and traced the route for the permanent sustainable end-of-life management for agri-plastic products so essential for agriculture production. These are the reasons why the plasticulture community is committed to it:

- **Individual initiative** through the inclusion in a company’s strategic plan for a sustainable end-of-life management of plastics used in agriculture.
- **Collective initiative**, in a shared responsibility of all economics actors dealing with plastics in agriculture, considering the specific issues relating to the agricultural sector.
- **In association with** the operational waste sector bringing knowledge, competencies and additional efficiency and quality to the process.

The implementation of National Collection Schemes (NCS) throughout Europe is a pre-requisite to achieve the goals already seen in some European countries. NCS allow the research into the performance of an agricultural process considering its environmental impact. On farm practices

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26 The European market leaders have already successfully included this dimension in their organization and are also running recycling facilities to provide regenerated granules in their new products.

27 Norway, Iceland, Ireland, Sweden, Germany, UK, France, Spain... with NCS achieve high (>75%) collection rate whereas for other countries the identified rate is 25% to 35%.
determine the end of the products’ lifecycle and a reduction in pollution is linked to reducing waste at source.

During the development of new products, the plasticulture industry commits itself to integrate all the aspects of the product’s lifecycle, not only for the duration of its useful life, and to a complete integration of the value chain. Today the environmental design is not solely based on the development of a recyclable product, but goes further, analysing all the parameters of the lifecycle for it to be recycled effectively.

All existing National Collection Schemes have been developed in collaboration with national public authorities. The 2020 French bill “against waste and for the circular economy” states that: "An organism that fulfilling the obligations of expanded producer responsibility in the agribusiness according to the agreement concluded with the Minister in charge of the environment before December 31, 2019 is not subject to approval as long as this agreement is renewed." The French scheme ADIVALOR\textsuperscript{28} has for many years signed such an agreement with the ministry of Environment and with the ministry of Agriculture. It has ensured a universal understanding of the issues at stake and the sharing of objectives.

The logical end of this methodology is the integration of the recycled material into new products. The plasticulture industry has always integrated regenerated plastic into new products whenever technically possible\textsuperscript{29}. Whilst the cost of base material may represent 60% to 70% of the production cost of a product, the search for competitiveness means there cannot be any reduction in the quality of the product. The technical characteristics required in the finished product need to be maintained, so the inconsistent quality of regenerated plastic materials mean they can only be used in basic applications which do not demand high technical performance.

8.1. Plasticulture Goal 2030

8.1.1. The environmental engagement of plasticulture players: The European Plasticulture Alliance

With the European Plasticulture Alliance, the plasticiculture community (manufacturers, distributors, users, and researchers) is engaged in seeking better adapted solutions for the use of plastics in agriculture and the improved end-of-life management of used agricultural plastics. It aims for zero waste to nature or landfill. The objectives of the Alliance are to reduce waste at source, to improve quantities collected and recycled, and to develop alternative solutions, such as soil biodegradable mulch film, increase integration of PCR into new products.

8.1.2. Continuous engagement for the Circular Economy

The oldest concept of the circular economy comes from agriculture. Plasticulture has for a long time been engaged in a move towards a circular economy, long before the concept was formalised as it is today. However, there is still some way to go for the objectives of this transition to be achieved. By learning from our experience, the plasticulture industry recommends and is resolutely engaged in

\textsuperscript{28} Agriculteurs, Distributeurs, Industriels VALORisation: French eco-organism specialized in plastic wastes from agriculture.

\textsuperscript{29} Silage sheets and stretch films, flexible irrigation pipes, small tunnels and mulch films for horticulture already includes from 10 to 40% of recycled material and converters are engaged in R&D programs to increase this proportion.
actions aimed to accelerate this transition. In France, the converters committed in 2018 to increase the percentage of recycled material from 19 to 25 % by 2025\textsuperscript{30}.

8.1.3. A value chain co-operation in operations

From product design through to recycling, the lifecycle is seen as a global system dedicated to lowering the impact on the environment from agricultural production. A shared responsibility implies that each actor contributes to the overall functioning of operations:

➢ Farmers buy NCS contributing products, prepare the plastics after use according to minimum technical requirements (TPM) and make them available to the organization managing their recovery.
➢ Distributors ensure the communication of information about the operations: collections (PTM), modalities, dates, etc. They can also, whenever possible, manage grouping sites and control operations.
➢ Manufacturers, through service providers, ensure the recovery and processing of products.

9. Recommendations for Public Policy

The plasticulture community encourages governments to recognize the achievements made by our industry in the end-of-life management of our used agri-plastics. Our success has been achieved through a chain of solidarity of all economic actors within the Plasticulture community. We recommend that this industry-led approach and the governance of it should be encouraged by governments and integrated into policy.

Existing national schemes have proven their effectiveness and the positive experience gained should be used to encourage the implementation of similar schemes where none yet exist, whilst considering any individual national differences. It will be necessary to support financially and technically, through a transfer of knowledge, any new scheme, to accelerate its implementation. A transition phase will be needed to give time for all players in the value chain to implement the best national collection schemes and so that Member States that do not yet have a coherent and efficient scheme can get organized.

Any new regulatory legislation should enable farmers, distributors, and processors to be engaged collectively in the governance of it. This will ensure European farmers protected on the international stage so that competition rules are equal to their counterparts in the rest of the world, to stimulate investment in more innovative and sustainable solutions. It should promote the provision of resources at the local level (grouping sites, transport, and storage permits, etc.) It must also promote a technologically neutral approach to various mechanical, chemical, or organic recycling solutions as well as biodegradable solutions in the soil for specific applications.

\textsuperscript{30} Engagement de la Plasticulture dans la Feuille de Route de l’Economie Circulaire (FREC)
7. ANNEXES

7.1. ANNEX I - Sorting
# 7.2. ANNEX II - Existing European National Collection Schemes

<table>
<thead>
<tr>
<th>Scheme Operators</th>
<th>Country</th>
<th>Financing</th>
<th>Date of Creation</th>
<th>Governance</th>
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<tr>
<td><strong>Spain</strong></td>
<td></td>
<td>Industry Association</td>
<td>2020</td>
<td>Non-Profit</td>
</tr>
<tr>
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<td>Industry Association</td>
<td>2020</td>
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<td><strong>Germany</strong></td>
<td></td>
<td>Industry Association</td>
<td>2015</td>
<td>Non-Profit</td>
</tr>
<tr>
<td><strong>Ireland</strong></td>
<td></td>
<td>Industry Association</td>
<td>2015</td>
<td>Producers, Co-ops, Importers, Agents, Associations, Distributors and private sales organisations</td>
</tr>
<tr>
<td><strong>France</strong></td>
<td></td>
<td>Industry Association</td>
<td>2001</td>
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<tr>
<td>Iceland</td>
<td>Icelandic Recycling Fund (collecting recycling fees)</td>
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