Food and Agriculture Organization of the United Nations

WORLD BANANA FORUM

FACTSHEET

TOWARDS A BANANA SECTOR FREE OF PLASTIC CONTAMINATION

Sustainable Management of Plastics in the Banana Industry

INTRODUCTION

Climate change, biodiversity loss and pollution of ecosystems are the three main environmental crises of our time (UNEP, 2021). Plastic pollution is a major contributor to these issues, and the banana sector, as a key agricultural industry, is not exempt from its impacts. In fact, global banana supply chains continue to rely heavily on plastics, and while management practices are improving, significant challenges remain.

In this comprehensive factsheet, the World Banana Forum (WBF) through its Working Group 01 on Sustainable Production Systems and Environmental Impact and its Subgroup on Climate Change Mitigation, Adaptation and Biodiversity Conservation, explores the challenges and opportunities related to the use and management of plastic in the banana industry. The goal is to shed light on persistent plastic-related issues affecting the sector and to showcase best practices undertaken by several actors, encouraging all industry stakeholders to follow suit.

Though the prospect of a plastic-free banana industry may seem distant, reducing the risks of plastic pollution in the sector stands as a realistic medium-term goal. Many practical examples demonstrate that this can be accomplished in a cost-effective way.

CONTEXT

In December 2021, the Food and Agriculture Organization of the United Nations (FAO) published the *'Assessment of agricultural plastics and their sustainability: A call for action'*, a comprehensive report on the use and unsustainable management of plastics in agriculture (FAO 2021). The report underscores the exponential increase in the use of plastics in agriculture since the mid-20th century, a trend projected to continue in the future. In 2019, agricultural plastics from various sectors such as crops, livestock, aquaculture and fisheries, accounted for 12.5 million tons, with an additional 37.5 million tons used for food packaging. Together, this represents 14 percent of the total global plastic consumption which amounted to 359 million tons. Notably, most of these products are single-use items with a lifespan of less than 12 months and about 60 percent consist of films (such as plastic bags, mulch sheets or banana bunch bags).

In February 2022, the United Nations Environment Assembly (UNEA-5.2) achieved a landmark agreement to establish an internationally binding treaty within two years aimed at combatting plastic pollution. Negotiations on the draft text are ongoing and are expected to lead to a consensus by the end of 2024. In mid-2022, in line with voluntary approaches encouraged by the United Nations Environment Programme (UNEP), the FAO Council endorsed the decision of the FAO Commission on Agriculture (COAG) to develop a Voluntary Code of Conduct (VCoC) for the use of plastics in agriculture (FAO COAG, 2022). The architecture of this voluntary code of conduct is still under development.

USE OF PLASTICS IN BANANA PRODUCTION

Bananas are the most exported fresh fruit worldwide in both volume and economic value, with exports projected to reach 19.2 million tonnes in 2023 (FAO, 2023), and an estimated import value of USD 15.1 billion (FAOSTAT, 2022).

Banana production and trade rely on the use of plastics for various purposes, including preserving fruit quality during transportation, preventing mechanical damage during production, averting the bending and collapse of banana pseudostems, extending shelf life and providing brand visibility.

In the initial stages of cultivation, nurseries rely on plastic trays, pot trays and plugs for plant propagation. Later in the production process, single-use plastic bunch bags —often impregnated with insecticides and protective foam sheets— are employed to safeguard the fruit as it develops. Additionally, nylon ropes are commonly used to prevent pseudostems from tipping over.

Agricultural inputs used by the banana industry are commonly stored in plastic packaging. Plastic containers store plant protection products, agrochemicals, fuel, disinfectants, detergents and lubricants, while fertilizers, including those coated with plastic films, are kept in plastic bags. Plastic films are sometimes used for soil fumigation, specially in nurseries, as well as for mulching, and irrigation systems frequently depend on plastic tubes and sprinklers.

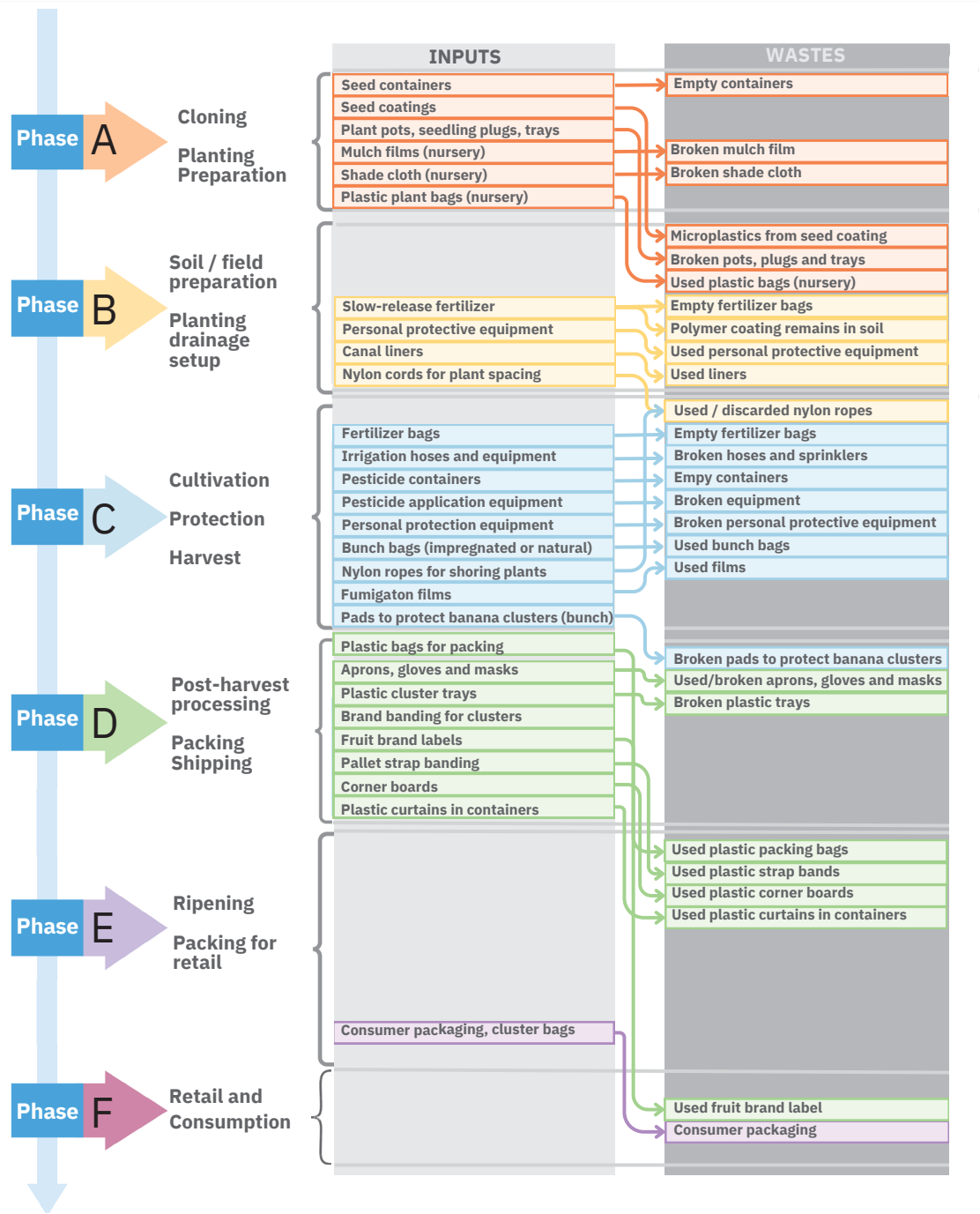
Plastic mulch on banana seedlings. Source: iStock/Nadiya Senko.

During packing house operations, plastic trays are extensively used to transport the recently selected banana hands into boxes, typically lined with plastic bags to control maturation. The

use of knapsack sprayers and personal protective equipment made of plastic, such as coveralls, gloves, aprons and boots, reaffirms the reliance on plastic for different purposes.

For the transportation of bananas, straps and corner boards are utilized to ensure the stability and protection of banana boxes on the pallets; polyvinyl chloride (PVC) plastic curtains are also often used behind the containers' doors to maintain temperature and hygiene. At the point of sale, plastic is used in various ways, including branding bands, labeling stickers for product identification, as well as plastic bags and trays designed to present bananas attractively to consumers (Figure 1).

Figure 1. Plastics used throughout the banana value chain.



Source: Adapted from **FAO.** 2021. *Assessment of agricultural plastics and their sustainability: A call for action*. Rome, Italy, Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/ cb7856en

Despite the high reliance of the banana industry on plastic, there is limited information available on the types and volumes of plastic products used throughout the sector, both as input and packing material. Furthermore, clear data regarding how plastic waste is managed within the industry remain largely unknown.

It is important to highlight that much larger volumes of plastic products and packaging are used for internationally traded bananas (mainly Cavendish), in contrast to bananas produced in domestic markets and consumed locally.

Industry stakeholders and agricultural plastics experts have identified banana bunch bags, protective foam sheets, nylon ropes and packaging bags as the main plastic materials used in the banana value chain. These materials demand prioritized interventions due to their short lifespan, substantial volume and annual waste generation. Moreover, they pose risks of environmental leakage at the point of use, potentially impacting both terrestrial and aquatic ecosystems and posing threats to plants, animals and human health. Additionally, their degradation presents a high risk of microplastic formation, underscoring the urgency for effective management strategies.

Plastic bunch bags, Peru. Source: @Agrofair.

Banana bunch bags and protective foam sheets are increasingly used in the banana export sector due to their positive impact on fruit quality and appearance[1]. These bags act as a physical barrier, safeguarding bananas from temperature fluctuations, pests and diseases that target banana bunches. They also prevent mechanical injuries caused by birds and friction, as well as fruit contamination from pesticide drift.

One notable advantage of banana bunch bags is their ability to expedite the maturation process. By creating a favorable microclimate within the bags, they reduce the time between flowering and harvest. This results in longer and higher-quality fruits, with increased overall weight, shorter intervals between subsequent harvests, leading to higher yields and economic returns per hectare.

1 International markets prioritize blemish-free bananas and have low or zero tolerance for minor 'cosmetic damage,' such as small scars and spots on the skin caused by insects (Staver *et al.*, 2024). These quality criteria are also encompassed in the market regulations of the European Union (European Commission, 2011).

Bunch bags are typically made of polyethylene and come in different thicknesses (between 12 and 25 µm) and tensile and flexibility characteristics (High Density Polyethylene [HDPE], Low Density Polyethylene [LDPE], Linear Low-Density Polyethylene [LLDPE]). These bags have perforations of varying sizes, ranging from micro-perforations to 12.7 mm, which enables airflow and prevents fungal growth. The standard dimensions of a bag are 72–90 cm in width and 120–155 cm in length, with a weight ranging from 20–25 g per bag. Various colors are used globally, with blue, transparent and silver covers being particularly common. To protect the fruit from insects, insecticide-impregnated bags are commonly used in conventional banana production. Different concentrations of insecticide, such as 0.5 percent, 1 percent, and 2 percent, are used to control aphids, thrips, moths and beetles. In organic production, pesticide-free bags are typically used, although at times, bags treated with formulations based on pepper and garlic are employed for pest control.

Banana bunches wrapped in bunch bags and protected by foam sheets, being transported to the packing station, Peru. Source: @Agrofair.

Protective foam sheets, also known as separators, are widely used in the production and packaging of bananas as a flexible protective material. These sheets are typically made of Expandable Polyethylene (EPE) and have a thickness ranging from 1–3 mm. Their weight ranges from approximately 10–15 g and they are placed between banana hands on the bunch during production, harvesting, transport to the packing station and packaging to prevent mechanical damage to the banana peel caused by friction. The soft texture and shock absorption properties of the foam sheets contribute to their effectiveness in protecting bananas.

Worker carrying protective foam sheets, Peru. Source: @Agrofair.

Estimations suggest an approximated generation of 45 kg of plastic waste per hectare annually, deriving from the use of banana bunch bags. Consultations conducted under the plastic-free initiative of Byodynamic Federation Demeter International e.V. indicated that this figure could reach up to 75 kg. Additionally, Dominique Farms estimates that between 196 kg to 548 kg of plastic waste per hectare are generated annually due to the use of plastic protective sheets (Dominique Farms, personal communication, June 2023). This variation depends on the thickness of the material and the number of bunches produced by the farm. According to AgroFair (2019), approximately 40 kg of plastic waste from bunch bags alone is generated per container of exported fruit. Furthermore, estimations from the banana sector in Peru suggest that 20 million bunch bags (equivalent to 400 tonnes) are used annually, while this value reaches 60 million bunch bags (equivalent to 1 200 tonnes) in the Dominican Republic (AgroFair, 2021).

Nylon ropes are widely used for shoring banana plants in areas with high productivity, particularly in regions prone to strong winds. Shoring prevents bending, breaking, and collapsing of banana plants due to their rapid growth and the weight of fruit bunches. It also provides protection against storms and intense weather events, minimizing damage to pseudostems and bunches. The vertical orientation of banana plants achieved through shoring improves nutrient absorption and airflow, resulting in larger and better-shaped bananas. Additionally, it facilitates access for pest and disease management interventions, such as pesticide application and removal of affected plant parts.

Packaging plastics are used in post-harvest operations with the objective of preserving fruit quality and extending the shelf-life of bananas. These plastics support uniform ripening, prolong the green life of the fruit during shipping, and enhance overall fruit quality.

For instance, BANAVAC® vacuum bags are polyethylene bags (HDPE) without perforations. They are primarily used when extending the green life of bananas is necessary, especially on vessels without controlled atmosphere capabilities. These bags are specially designed to restrict oxygen exposure and effectively preserve the bananas' freshness.

On the other hand, POLYPACK® bags are 0.7 mm thick polyethylene bags that feature small perforations. These bags play an important role in facilitating uniform ripening by allowing controlled airflow around the bananas during the ripening process.

Additionally, a range of other plastic materials is employed during banana packaging. These include plastic bands/tapes, pallet straps, films and brand stickers. Expanded polystyrene trays and various plastic-based packages are also used in supermarkets to ensure safe transportation and attractive presentation of bananas to consumers.

Packaging of bananas into plastic bags within cardboard boxes, Peru. Source: @Agrofair.

IMPACTS CAUSED BY THE USE OF PLASTICS IN THE BANANA INDUSTRY

Plastic products can significantly impact the environment by persisting in ecosystems and adversely affecting wildlife and generating microplastics that pose serious health risks to marine, terrestrial and human life. Moreover, plastic production and disposal release greenhouse gases (GHG), contributing to climate change. Despite the lack of precise data regarding the amount of plastic waste produced by the banana industry and leaked to the environment, empirical data indicate that significant amounts of these materials are inadequately managed at the end of their lifecycle. They are often buried, abandoned, illegally dumped, or burned, which generates toxic gases harmful to humans, animals and the environment. In the scenario where plastics are collected and deposited in a landfill, their decomposition produces GHG and represents a significant waste of potentially valuable raw material that could be recycled.

Improper management of plastic waste generated by the banana industry can deeply affect terrestrial and aquatic ecosystems. Inadequate disposal and mishandling of these products can lead to soil contamination, water pollution, habitat destruction, ecological imbalances, adverse effects on human health and ultimately losses in crop productivity (FAO, 2021). In coastal and offshore areas, plastic pollution from wind dispersal poses a greater risk to both terrestrial and marine ecosystems compared to inland regions. In many countries, banana plantations for export are located in lowlands, in close proximity to ports and with drainage systems connected to rivers.

Plastic pollution in banana plantation. Source: @Agrofair.

Soil Contamination: When plastic wastes accumulate in the soil, they can release harmful chemicals and additives. These substances can leach into the soil and alter its composition, affecting the metabolism of different microorganisms such as bacteria, fungi, nematodes, protozoa and macro-organisms as insects, other arthropods and earthworms (Shahnawaz *et al.*, 2024). This can lead to disruptions in nutrient cycling, organic matter decomposition, and overall ecosystem functioning. Moreover, plastic particles can also physically harm organisms by blocking their digestive systems and creating barriers that restrict their movement, feeding activities, and reproductive success, ultimately leading to biodiversity losses (Shahnawaz *et al.,* 2024).

Losses in Productivity: Plastic contamination in banana plantations can have detrimental effects on productivity through various mechanisms. Disruption of nutrient cycling can lead to imbalances and deficiencies in essential nutrients crucial for the correct development of banana plants. Accumulation of plastic waste can compact the soil and impair drainage, inhibiting root development and water uptake (Shahnawaz *et al.,* 2024). This can hinder the delivery of water and nutrients, causing water stress and inadequate hydration for banana plants. Additionally, the absorption of microplastics by banana roots can potentially impact plant physiology and decrease crop productivity (Shahnawaz *et al.,* 2024).

Water Pollution: According to the same authors, improper disposal of plastic products in agricultural areas near water bodies often leads to water contamination as these materials are transported by wind, runoff from the land or floods. Macro and microplastics that end up in aquatic ecosystems can persist for extended periods, posing significant threat and harm to various organisms, including fish, seabirds and marine mammals, causing internal injuries, malnutrition and even death. Consequently, the populations of these organisms may decline, disrupting the natural balance of aquatic ecosystems. Moreover, the accumulation of these materials on the water surface can create physical barriers that prevent sunlight penetration and reduce gas exchange with the atmosphere, thereby reducing the photosynthesis of aquatic plants and triggering impacts at different levels of the aquatic habitat. While the banana sector contributes to this issue, it is important to recognize that a wide range of industrial and agricultural activities also significantly contribute to ocean pollution.

Microplastics, Food Chains and Human Health: Microplastics are garnering more attention in food safety discussions due to their potential to transfer along the food chain, potentially impacting human health. Concern arises from the toxicity of certain plastic polymer components and the presence of residues from other potentially harmful chemicals used in manufacturing (Shahnawaz *et al.,* 2024). Additionally, microplastics have been shown to sorb and potentially concentrate contaminants from the environment (FAO, 2022). The scientific understanding of the exposure and health risks associated with microplastics in food supply chains is still developing.

SUSTAINABLE MANAGEMENT OF PLASTICS – GOOD PRACTICES

To address the environmental impacts caused by agricultural plastic wastes, particularly within the banana industry, an integrated strategy is needed. The 6R approach (Refuse, Redesign, Reduce, *Reuse, Recycle and Recover)* outlined in FAO's Assessment of Agricultural Plastics, presents a series of hierarchical options that can be applied to the design, manufacture, supply, mode of use, and end-of-life management of products in order to promote circularity and bioeconomy. In addition to the 6Rs, remediation has been added as a separate complementary component, which often supports plastic reduction, reuse and recycling efforts.

1. **Refuse:** Intentionally avoid the use of certain products. For instance, this could mean not using plastic labels and stickers on single bananas that are packaged in a larger retail box.
2. **Redesign:** Prioritize the redesign of materials, especially single-use plastics, by replacing them with recyclable alternatives, transitioning to bio-based and biodegradable plastics, or adopting less harmful options. This will contribute to increase circularity and reduce the associated environmental impact.
3. **Reduction:** Analyse production and supply chain processes to identify opportunities for minimizing plastic use, optimizing packaging, and exploring alternatives such as bulk packaging.

4. **Reuse:** Encourage the collection, cleaning, and reuse of plastic packaging, such as bunch bags, to extend their utility and reduce the need for new plastic items.
5. **Recycle:** Establish efficient logistics for collecting and recycling plastic materials used in the banana industry, ensuring they are easily recyclable and implementing appropriate recycling infrastructure and logistics to divert plastic waste from landfills and decrease the demand for new plastic production.
6. **Remediation:** Launch programmes aimed at collecting plastic residues present in the soil and waterways adjacent to banana cropping areas.
7. **Recover:** In case the previous 6Rs cannot be implemented due to technical or economic constraints, and/or life assessments indicate that recovery is more sustainable than landfilling, extracting energy from used plastics can be pursued.

Furthermore, it is essential to raise awareness among farmers, agricultural businesses, producers, distributors of plastic products, and consumers about the detrimental effects of inadequate plastic waste management within the banana value chain. It is key to critically assess and consider existing business practices, while implementing financial mechanisms that support the industry's shift towards more a sustainable plastic-free supply chain. For instance, **Extended Producer Responsibility (EPR) programs** assign product manufacturers financial and operational responsibility for the end-of-life of products. By transferring the cost of collection, transport, recycling, and disposal to product manufacturers and considering that they have the most direct influence on whether their products and packaging can be recycled, these programs can contribute towards more environmentally sustainable products and packaging.

Bananas packaged in plastic and displayed on retail shelves. Source: iStock.

Banana industry actors, crop protection organizations and other stakeholders have implemented concrete initiatives to address the challenges posed by inadequate plastic management. These initiatives have been classified into seven categories, and a non-exhaustive list is provided below:

1. Development and implementation of bio-based plastic alternatives (Redesign)

Dominique Bananas, a Demeter certified banana producing company based in Colombia uses biodegradable paper bags, separators, and natural fique ropes in their plastic-free banana farms, thereby cutting down on around 700 kg of plastic waste annually. Moreover, the company's adoption of plastic-free packaging methods helps prevent the use of about 120 kg of plastic per hectare each year (Dominique Bananas, 2023).

PATI, an Italian manufacturer, has developed FILMFLEX, a banana bunch bag made from MaterBi® bioplastic, which can be left on the ground or totally composted. Trials are currently being implemented in South Africa to evaluate the agronomic results, bag durability, and biodegradation rate at the end of its lifecycle (FreshPlaza, 2020).

Smurfit Kappa has developed a paper-based biodegradable bag designed to cover banana bunches. Made from cellulose, BanaBag® acts as a natural insulator and aims to protect the fruit from insects and prevent overheating (Smurfit Kappa, 2023).

AgroFair conducted two trials with biodegradable plastic bunch bags in Peru, although they were not 100 percent biobased (AgroFair, 2023). Initial findings suggest that while technically feasible, this approach is more costly compared to the plastic bunch bags.

In 2019, **Fyffes** launched recyclable paper bands made from 100 percent Kraft pulp for its organic Fairtrade bananas at the point of sale. In Ireland alone, this initiative is expected to yield a reduction of over 5.5 tons of plastics (Fyffes, 2019).

In that same year, the Thai supermarket **Rimping** introduced banana leaves as a substitute for plastic in packaging vegetables. Using banana leaves offers several benefits: they are biodegradable, readily available in tropical locations and cost-effective (The Economic Times, 2019).

2. Reduction or elimination of plastic packaging

Aldi Global made a public commitment to reduce plastic packaging by 25 percent by the end of 2025. In an effort to achieve this target, **Aldi Australia** eliminated plastic packaging for bananas in 2021 and encouraged consumers to avoid using single-use plastic bags for thick-skinned fruits such as bananas and pineapple (Aldi Australia, 2021). In June 2024, **Aldi UK** announced a trial in selected stores across the United Kingdom of Great Britain and Northern Ireland to replace plastic bags with paper bands, potentially saving 234 tons of plastic packaging annually (Fresh Fruit Portal, 2024).

Since 2017, **REWE Group** and its discount store Penny have exclusively sold bananas without packaging, saving more than 210 tons of plastic per year. The retail group aims to make 100 percent of its private-label packaging more environmentally friendly by the end of 2030 (Rewe Group, n.d.).

In Ireland, **Lidl** took the initiative to eliminate all plastic packaging from Fairtrade, organic bananas, resulting in a reduction of packaging for over 2.5 million bananas annually, leading to a reduction of 10 tons of plastic per year (Lidl Ireland, 2018).

Following a successful 12-weeks trial, the supermarket **Morrisons** also decided to eliminate plastic bags from all bananas sold in its stores, leading to an estimated reduction of 45 million single-use plastic bags (180 tons of plastic) per year. The plastic bags will be replaced by strengthened paper bands, made from FSC certified paper (Morrisons Corporate, 2021).

Carrefour also launched an initiative aimed at reducing unnecessary packaging on organic fruits and vegetables, with bananas being among the fruits benefiting from this effort, along with cucumber and eggplant. The replacement of single-use plastic bags for paper bands is estimated to result into a 32 tons reduction of plastic per year (Carrefour, n.d.).

3. Reuse of Plastics Programmes

In 2023, **Del Monte** announced a strategic partnership with Arena Packaging to introduce Reusable Plastic Containers (RPCs) for bananas. Each container is expected to be reused five times each year, and if damaged, individual parts will be collected, replaced and repurposed.

This innovation is set to reduce GHG emissions, food waste, and operational costs, while preserving the fruit's health through improved airflow and extended shelf life (Del Monte, 2023).

In early 2023, **Penny**, the brand discount store of **REWE**, also announced the replacement of disposable single-use packaging with specially designed RPCs known as Banana Lift Lock. Based on import volumes from South America to Europe, this initiative is estimated to save around 150 000 MT CO_2eq (DRC, 2023). Additionally, RPCs are managed, matched, and delivered to producers and retailers through the closed pooling system IFCO Smartcycle. This pooling circular system operates through sharing and reuse, cleaning and sanitizing and the recollection and inspection of RPCs, with each container being reused up to 120 times (IFCO Systems, 2023).

4. Recycling and Recovery programs

ECOBAN SRL, is a start-up established in 2022 by Solidaridad, AgroFair, the Banana Cluster of Peru, along with several banana cooperatives as shareholders (Clercx *et al.,* 2023). It is dedicated to reducing the environmental impact caused by plastic wastes by manufacturing corner boards used in banana production and recycling plastic bunch bags. By December 2023, ECOBAN had collected over 186 tons of plastic and 8.1 million bunch bags, producing 324 000 corner boards. The coordination of this work involves small producers, emphasizing inclusivity and collaboration, and promotes a circular economy within the organic banana value chain (Solidaridad, 2022; AgroFair, 2020; AgroFair, 2022; AgroFair, 2023).

Recycling facility ECOBAN transforming bunch bags into corner boards, Peru. Source:@Agrofair

DOLE and **Del Monte** founded the joint venture **RECYPLAST** in Costa Rica in 1993 with the objective of making all tropical fruit packaging materials recyclable or compostable by 2025. Currently, 14 000 tons of plastic waste are recycled in the banana industry in the country, from which 7 000 tons of corner boards for pallets used in transportation are made annually. In this process, RECYPLAST collaborates with educational institutions to raise awareness on recycling and waste separation (Dole, 2023).

Reybanpac is an Ecuadorian banana supplier that recycles all plastic waste generated in their plantations to make a positive environmental and social impact in the region. In cooperation with Plasticforts company, they have transformed all plastic residues generated from their banana farms into over 300 000 plastic posts and playground equipment (Eurofruit, 2023; Reybanpac, 2023).

KATA is an innovative green chemistry company based in Costa Rica and Guatemala focused on building mini-refineries to process agri-plastics generated by the melon and banana industries. The process employed by KATA not only generates energy from the plastic waste, but also produces biodegradable iso-paraffinic oils, which are used in aerial applications as an adjuvant and protective agent against Black Sigatoka (*Mycosphaerella fijiensis*), demonstrating a unique circular economy model (KATA, 2024).

5. Reverse Logistic Programs

CropLife International's plan is an initiative to implement a classification and collection program for empty pesticide containers, fence posts, plastic bags and drainage pipes. The goal is to repurpose these materials into corner protectors for pallets or re-use them as pesticide containers, following a classification into hazardous and non-hazardous containers. The CropLife Network container management program has successfully collected 867 491 metric tons of plastic across 59 countries (CropLife International, 2015; CropLife International, 2019; FAO and WHO, 2008).

ADIVALOR represents the French national scheme for the management of plant protection waste. This initiative brings together product manufacturers, packers, importers, cooperatives, traders and farmers in a collective effort to improve the efficiency of collection, recycling and disposal services of agricultural supplies in the country. ADIVALOR is an example of an Extended Producer Responsibility (EPR) scheme, based on shared responsibility among value chain actors. Farmers are asked to store and return products that reached the end of their lifecycle to specific sites, while distributors, cooperatives and dealers are responsible for waste collection, classification and storage operations. Market players, namely manufacturers and traders, finance the recovery and treatment of wastes by paying an "eco-contribution". Currently, virtually all types of agricultural plastics are collected from over 300 000 farmers, with a recycling rate ranging between 80 percent and 99 percent. Today, 1 300 distributors are involved in collection logistics, while 350 marketers are involved in the financing of this scheme (Adivalor, 2023).

Similar to ADIVALOR, **ERDE** (Crop Plastics Recycling Germany) is the nationwide recovery and recycling system for agricultural plastics in Germany. This initiative brings together a wide array of stakeholders including plastic manufacturers and distributors, farmers, traders and disposal companies. Managed by the system operator RIGK, the network of collection points allows farmers and contractors to deposit various cleaned and sorted used crop plastics like silage sheets, underlayer films and mulching films. These materials are then mechanically recycled within the European Union (EU), mainly in Germany, into granulates for new agricultural

products. This program has successfully collected 39 912 tons of agricultural plastics, with an estimated annual savings of 36 188 tons of CO_2eq (ERDE, 2023).

InpEV – Sistema Campo Limpo is a reverse logistics program in Brazil that focuses on the responsible management of empty crop protection product packaging. The program operates on the principle of shared responsibility, involving farmers, the manufacturing industry, distribution channels, and public authorities, with specific roles and responsibilities defined by law. The program currently ensures the environmentally sound disposal of approximately 94 percent of primary plastic packaging (which directly contacts the product) and 80 percent of all empty packaging associated with marketed agricultural pesticides. In 2022, Sistema Campo Limpo processed 52.5 thousand tons through its system, achieving a 92 percent recycling rate for total plastic waste (inpEV, 2023).

Pesticide containers waiting to be cleaned and recycled, InpEV – Sistema Campo Limpo. Source: @InpEV/Divulgação.

6. Remediation programmes

Chiquita's remediation and reengineering programme aims to clean-up historic litter in plantations under the company's direct control. Through this initiative, they have successfully removed plastic residues up to 1 ton per hectare, contributing to soil regeneration and quality (Chiquita Brands LLC., 2019).

7. Plastic credits programmes

The Far North Queensland Farm Plastics Project, launched by **GreenCollar**, the Australian Banana Growers Council, and the waste company Mams Group, incentivizes businesses to responsibly discard, collect and recycle, and manage plastics generated by the banana industry in the country. The project focuses on recovering and recycling (where possible) plastic banana covers, removing them from the environment and tackling plastic pollution. This initiative helps reduce the impact of plastic waste entering the Great Barrier Reef and the surrounding waterways and ecosystems of Far North Queensland. Since 2021, GreenCollar has been working

with farmers in the region to manage the recovery of banana bunch covers for secure disposal or recycling. This project relies on the Plastic Credit Program, approved by Verra in 2021, which converts accredited plastic-reduction projects into plastic credits. These credits can then be sold as a plastic offset to businesses seeking to reduce the plastic waste within their supply chains and drive investment towards the effective management of agricultural waste in Far North Queensland (Greencollar, 2021; Verra, 2023).

CONCLUSIONS AND PERSPECTIVES

The effective and sustainable management of plastics generated by the banana industry presents complex challenges. One major hurdle is the collection process, particularly the careful retrieval of plastic residues from soil. Improper handling can inadvertently exacerbate the issue of microplastics due to potential material damage, leading to increased fragmentation and environmental contamination. Moreover, pesticide-impregnated bunch bags and other plastic materials pose a health risk to farm workers who handle them in farms and recycling facilities. The inherent low value of unprocessed plastic waste and the distance between farms and the recycling facilities are critical factors that can strongly influence the feasibility of sustainable plastic waste management schemes (FAO, 2021).

Urgent actions are needed. It is crucial to tackle all plastic usage in the industry to mitigate its widespread impact on the environment and human health. In the short term, it is advised to focus on products that pose a significant risk to human health and the environment, such as pesticide containers and pesticide-impregnated bunch bags. Addressing plastic items with a high potential to create microplastics is also crucial, as they can harm ecosystems and organisms. Implementing effective policies, conducting research, and creating legislative frameworks and incentives can support the shift toward more sustainable banana production and trade.

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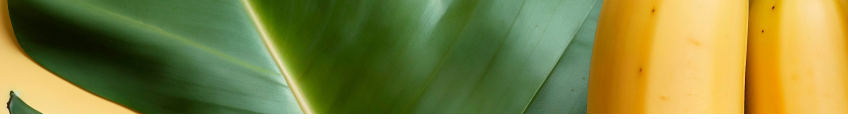

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