INNOVATIVE SOLUTION FOR THE MANAGEMENT OF THE AGRICULTURAL PLASTIC WASTE

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Introduction

Plastic materials are widely used in agriculture and they contribute to the qualitative and quantitative increase of the horticultural production. The strategic role of plastics is testified by a constant research of new polymers and blends by the chemical industry (Picuno et al., 2004). In agriculture, plastic materials are used for protected cultivations, such as greenhouses and low tunnels, for soil mulching and seasonal covering of orchards, for irrigation and drainage pipes, for soil solarization, for silage and for packaging, for harvest, transport, storage and sale of agricultural products. Besides, many other plastic manufacts are used in agriculture, as pots for ornamental plants and flower, nursery containers, soilles culture substrate, bags and containers, agrochemical containers and tools.

At the end of their useful life, these plastic materials produce a large amount of plastic waste that cause severe damages for the environment in all its components (water, atmosphere, earth) because, at present, only a part of agricultural plastic wastes is collected and recovered. The most remaining quantity is abandoned in the countryside, or is burnt in an uncontrolled way or it is disposed in unauthorized dumping sites near cultivated areas or in drainage channel, producing negative effects on the landscape and on the whole ecosystem (Scarascia Mugnozza et al., 1994; Sica, 2000; Scarascia Mugnozza et al., 2005).

On the contrary, agricultural plastic wastes must be considered a "source" to recovery; they can be recycled through mechanical or chemical recycling, or used to produce energy through direct combustion of the waste or Package Derived Fuel (PDF) (Mecarelli et al., 1997).

Aim of this research is the individuation of the key parameters able to characterise agricultural plastic waste and, consequently, the identification of guidelines for environmentally friendly waste treatment able to enhance disposal techniques of the agricultural plastic waste by standardised procedures and integrated methodologies to label the agricultural plastic waste streams, in order to facilitate their management to the best alternative processing and final disposal for a sustainable agriculture.

Agricultural plastic materials

Plastic materials are widely used in agriculture with a total amount of about 2,000,000 tons/year in the World (1,3% of the global plastic consumption), 744.000 tons/year in Western Europe (2% of the total consumption) and 350,000 tons/year in Italy (5% of the national plastic consumption) (tab.1).

Table 1: Plastic consumption (tons/year) - *APME (2003); **Pacini (2002)

	WORLD (*)	**WESTERN EUROPE (*)**	**ITALY (**)**
Total plastic consumption	169,000,000	39,706,000	6,800,000
Total agricultural plastic consumption	2,200,000	744,000	345,275

At present, in Italian agriculture about 160,000 tons/year (46% of the total agricultural consumption) are used for protected cultivations (tab. 2).

Table 2: Main agricultural uses and consumption of plastics in Italy (Pacini 2000-03)

Uses	**Polymer**	**Consumption (tons) 2002 year**
Greenhouse films	LDPE	37,600
	PE.IR	5,625
	EVA	11,450
	PVC	0
	Sub -total	**54,675**
Greenhouse semirigid sheets	PMMA, PVC, PC, PRFV	2,000
Low tunnels	LDPE, PE.IR, EVA	29,350
	PVC	650
	Sub -total	**30,000**
Mulching films	LDPE, LLDPE	43,200
Floating covers	LDPE	2,400
Nets (wind breaks, anti-hail, shading, thermal screens, anti-birds, anti-insect, harvesting, etc.)	HDPE, PP	5,300
Vineyard coverings	LDPE, EVA	25,000
Silage and protective coverings	LDPE	8,500
Irrigation and drainage pipes	LDPE	56,000
	PVC	25,700
	PRFV	5,000
	Sub -total	**86,700**
Other (pots, agrochemical containers, packaging of fresh products, etc.)	HDPE, PVC, PS, PP, LDPE, PRFV	87,500
	TOTAL	**345,275**

Agricultural plastic waste and recovery methods

The large amount of agricultural plastic materials consumption in Western Europe produces, consequently, a rapid growth of the quantity of post-consume material in terms of more than 300,000 tons/year (tab. 3).

The most part of agricultural plastic waste is constituted from covering and soil mulching plastic films; due to the degradation of physical and mechanical characteristics of plastic films they need to be replaced every few years or seasons.

A non suitable agricultural plastic waste disposal system could be an economical damages, due to the loss of material or energy. On the contrary, agricultural plastic waste must be considered a "secondary raw material". Several methods aim at disposing of plastic waste: mechanical recycling, chemical recycling, thermo-destruction with energy recovery or landfill. But when plastic waste are disposed in landfills, the incineration is without energy recovery (fig.1).

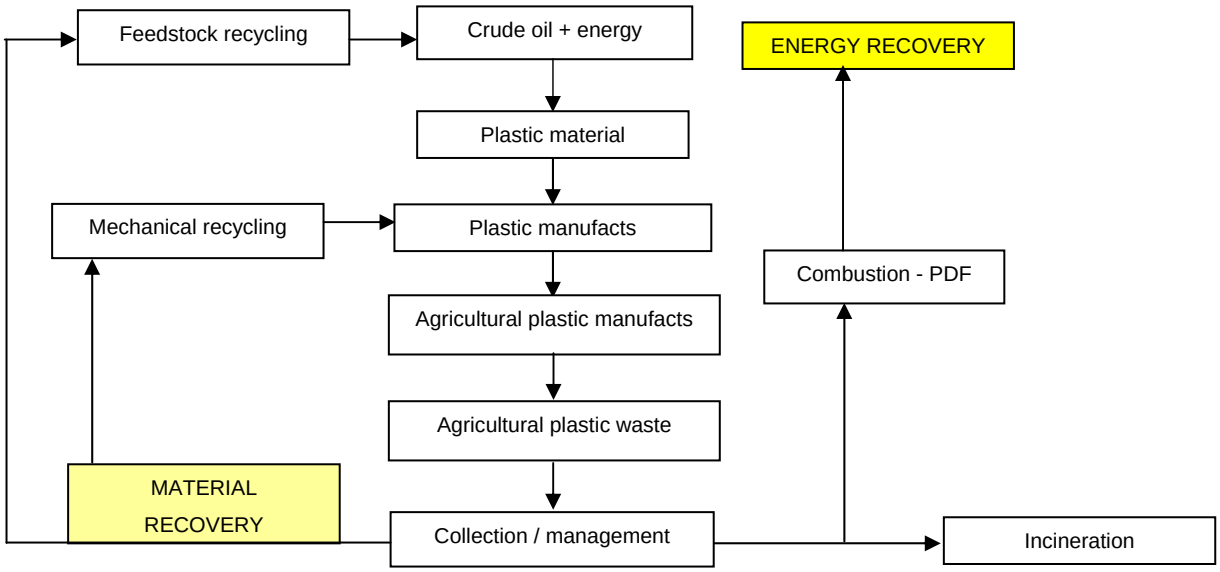

Figure 1: Scheme of recovery methodologies

Mechanical recycling consists in the material reprocessing of plastic waste by physical means into new plastic products. This method is the preferred recovery system for homogeneous and relatively clean plastic waste streams. In Western Europe the mechanical recycling is the second largest recovery technique after energy recovery, with 14.8% of total plastic waste recovered in 2003.

Feedstock recycling is the material reprocessing of plastic waste by conversion into basic chemicals, monomers for plastics or hydrocarbon feedstock. Feedstock recycling in theory has great potential to boost plastic waste recovery levels.

Energy recovery is the recovery of plastics waste into energy. This method offers a valuable alternative that contributes to the preservation of fossil fuel because the calorific value of the plastics is similar to that of the crude oil. 4,750,000 tonnes of post-consumer plastic waste collected in Western Europe, was reclaimed through energy recovery in 2003.

Table 3: Recovery route and by end-use in Western Europe, 2002 (APME, 2004)

	Agriculture	**Total**
Total available plastic waste collectable	311,000	20,607,000
Landfill and incineration (without energy recovery)	145,000	12,817,000
energy recovery	1,000	4,678,000
Feedstock recycling	0	330,000
Mechanical recycling within Europe	149,000	2,466,000
Mechanical recycling for export	16,000	341,000

The choice of the best method for the management and disposal of these waste lies within a number of factors, that characterize several kind of waste, such as the polymers, the level of purity of waste to be disposed of, the energetic consumption of the process, the prime costs of the regenerated materials (selection, washing, etc.), the characteristics of the new materials and the environmental performance of each recycling method.

Proposals of management of the agricultural plastic waste

At present, in Western Europe, many farmers, plastic industry members and legislators are looking to the recycled plastics more diligently, both to exploit the resources of the plastic waste stream and to make recycled products competitive on the market.

In order to improve the management of the agricultural plastic waste, minimizing the loss of valuable resources, it is necessary to foresee a possible recovery of the plastic waste.

The knowledge of the plastic material characteristics (different initial formulations, use of additives, etc.) is very important to favour the post-consumer waste management operations. Identification and labelling of the plastic materials are two necessary tools to define the characteristics of the product, the best recycling practice and the exact amount of the used and disused plastic materials so as to stop illegal disposal.

Plastic manufacts traceability would allow to find information on the product and to reconstruct immediately its history; it would become the mean to give to the producers the possibility to certify their products and to the consumers the certainty of the quality. Finally,

the traceability would give, to the plastics recyclers, the chance to select homogeneous material in the collection phase.

An identification system, to trace out the cycle of plastic materials used in the agricultural sector, could consist in the imprinting on each plastic manufact an optically-reading code, by which it is possible to individuate, with a different code, the material quantity (e.g., 100 metres of PE film, or 50 metres of irrigation hose, etc.). The seller, during the sale, by means of an optical reader, can register the first and last code on the sold material. These codes should be associated to the fiscal code or VAT number of the buyer, this information being easily obtained by the invoicing data. The optical reader could therefore print two barcodes that will be reported on the two copies of the invoice (one for the seller, the other for the customer).

Finally, the optical identification system could be supported by a procedure for the individuation of the plastic material. The code should be printed on a magnetic band, like that one used for anti-shoplifting purposes, in order to detect the presence of plastic material (with a specific detector) even in the case of burying or burning of the plastic material. This system may be obtained at low costs, because in the market very cheap anti-shoplifting magnetic bands are available. The code bar should describe the polymer (PE, EVA, GRP, etc.), additives, useful life, recycling methods or recommended post-consume use, with the aim to manage properly the recycling systems and, consequently, to foresee their activities. Both plastic producers and recyclers consortium must be involved. All these information are necessary for the implementation of the Life Cycle Assessment of agricultural plastic materials, for a sustainable management of the post-consume agricultural plastic and for a future European Legislation.

Conclusion

The agricultural sector offers a good potential for mechanical recycling, due to the fact that in agriculture it is possible to collect great volumes of plastic material, relatively clean and homogeneous. Besides they should be easily collected, because their consumption is concentrated in a well-defined number of specialized farms, located in well-known restricted geographic areas and produced during specific periods of the year, depending on the cropping activities.

In this paper a proposal of labelling the agricultural plastic waste is shown, with the aim to develop schemes and policy recommendations for an appropriate disposal and/or utilisation of the post-consumption plastics, increasing and improving, consequently, the environmental sustainability of the agricultural production.

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