Innovative fully biodegradable mulching films & fruit protection bags for sustainable agricultural practices LIFE14 ENV/ES/00048

LIFE MULTIBIOSOL

Multibiosol Life project Introduction: An overview

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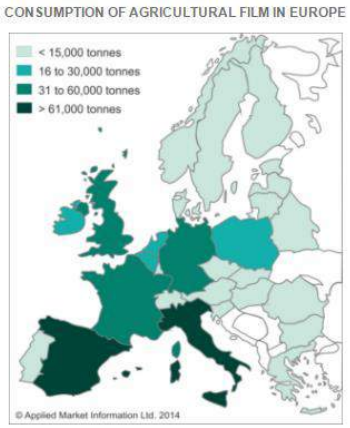
Purpose of LIFE MULTIBIOSOL



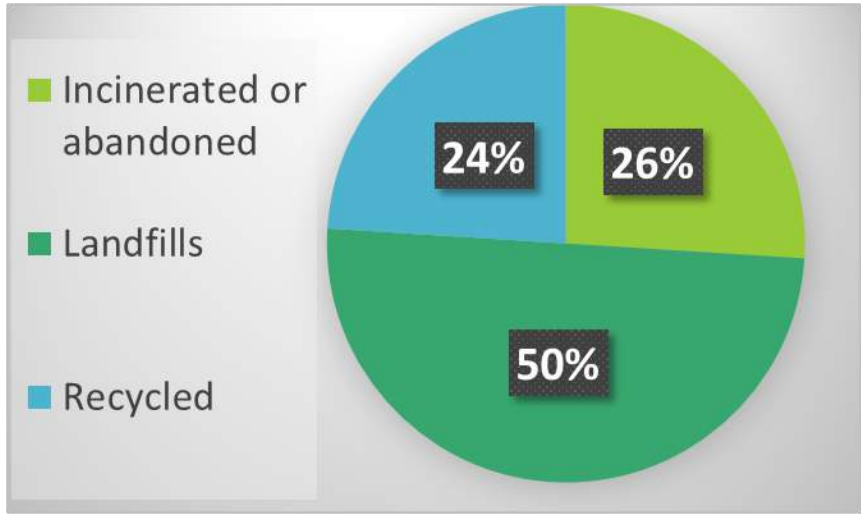
Current semi-intensive and intensive farming practices require the use of large quantities of plastic film and paraffin wax paper.

These practices have a significant environmental impact:

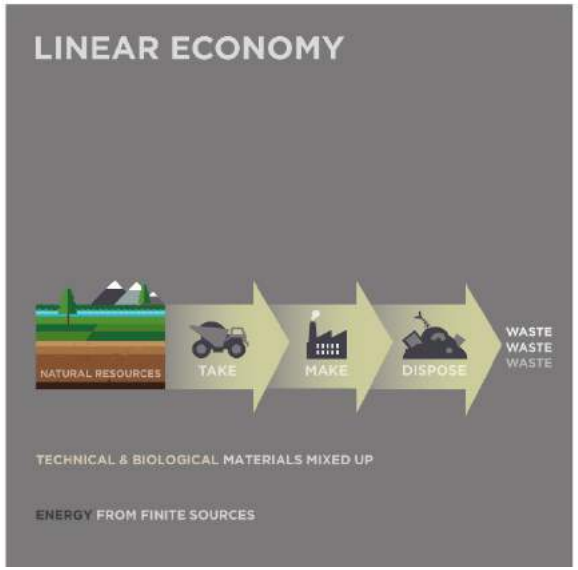
- Single use only
- Elimination involves high costs in terms of time and money

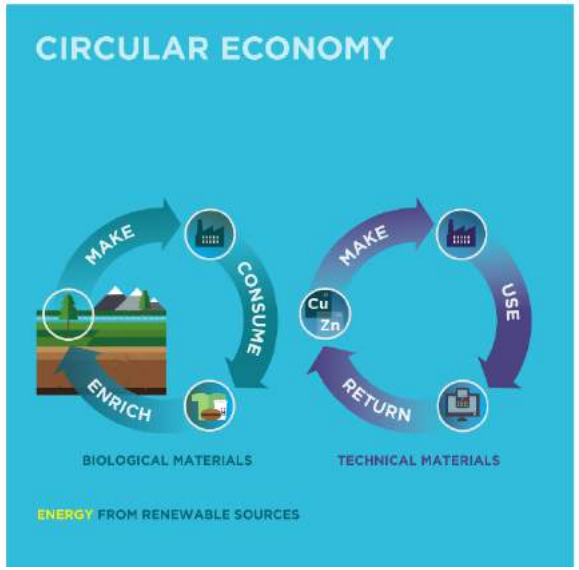
Environmental consequences if not removed correctly

1. High economic and environmental impact in the use of conventional plastics and fossil energy (50% is disposed of in landfill).
2. HDPE and LDPE material abandoned in landfills or open fields may take about 100-500 years to degrade completely.
3. Loss of harvested products due to improper use, soil loses fertility (less nitrogen fixation and nutrients) and lead to erosion as a result of concentrated runoff. Some plastics contains traces of heavy metals, phthalates…



Towards a Circular Economy





<u>Contribution to the specific objectives of the priority areas of the LIFE Subprogramme for Environment.</u>

Towards a circular economy: A zero waste programme for Europe (COM 2014, 398). As a first priority affecting all the phases in a **circular economy**, it should be ensured that **less waste is generated**. Waste Framework Directive EU directive 2008/98/CE required that Waste prevention programmes had to be adopted. Following their assessment, the Commission will develop initiatives promoting good practices in waste prevention in the EU such as:

Directives on the landfill of waste *(COM 397, 2014) aims to "reflect the needs of the circular economy by increasing preparation for re-use and recycling of municipal and packaging waste and eliminating landfilling".*

Our project eliminates the need for **waste management** through **complete biodegradability** directly **leaves out** the necessity of **landfilling** while protecting the soil's integrity.

Towards a Circular Economy

Contribution to the specific objectives of the priority areas of the LIFE Subprogramme for Environment.

Using plastic more sustainably (COM 123, 2013) and **better design of plastics and plastic products**.

This strategy paper is a reflection and consultation paper **"on possible responses to the public policy challenges"** brought by plastic waste. It collects the facts and takes into account the different views of all interested **stakeholders in the challenges of plastic waste**.

Thematic Strategy on the Prevention and Recycling of Waste (COM 211, 2013): "Life-Cycle thinking" introduced in this waste policy focuses on the environmental impact of a product throughout its life cycle. *For both the Commission and our project, Waste prevention remains a key priority which can be achieved through product design and manufacturing.*

-- EU Directive 2008/98/EC, on waste and repealing certain Directives: This Directive is "the legislative framework for the handling of waste". **Key concepts of waste, recovery and disposal are defined as well as requirements/obligations for waste management.**

Contribution to Commission's target of banning recyclable material in landfills by 2025.

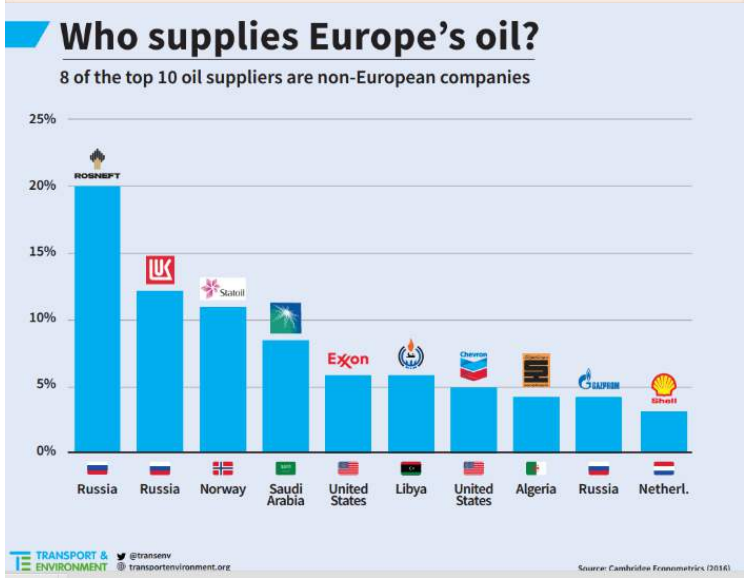
Towards a Circular Economy

MULTIBIOSOL creates synergies with the objectives of other EU policies and contributes to the integration of environmental aspects into other policies:

EU rural development policy in the 2014-2020 period (In line with Europe 2020 and the **Common Agriculture Policy (CAP)** objectives) identifies three long-term strategic objectives: 1) fostering the competitiveness of agriculture (added value), 2) ensuring the sustainable management of natural resources and climate action; and 3) achieving a balanced territorial development of rural economies and communities including the creation and maintenance of employment.

Multibiosol has identified as one key target "to improve the knowledge base of **biobased products development** within European Region facilitating the Innovation for **Sustainable Growth: a Bioeconomy for Europe (COM 60, 2012)"**. *Multibiosol will contribute to the market for bio-based products.*

Europe 2020 – "Sustainable growth for a resource efficient, greener and more competitive economy": emphasis is being put on building a more competitive low-carbon economy and protecting the environment by **reducing CO_2 emissions**, thus reducing the **resource intensity** of what we **use and consume, since Europe is too dependent on fossil fuels.** *Our project fits right into this strategy by striving to use resources that do not depend on fossil fuels and leave a low carbon footprint.*



EU Regulation

Regulation (EC) No 1069/2009 and (EC) No1107/2009 relating to fertilisers

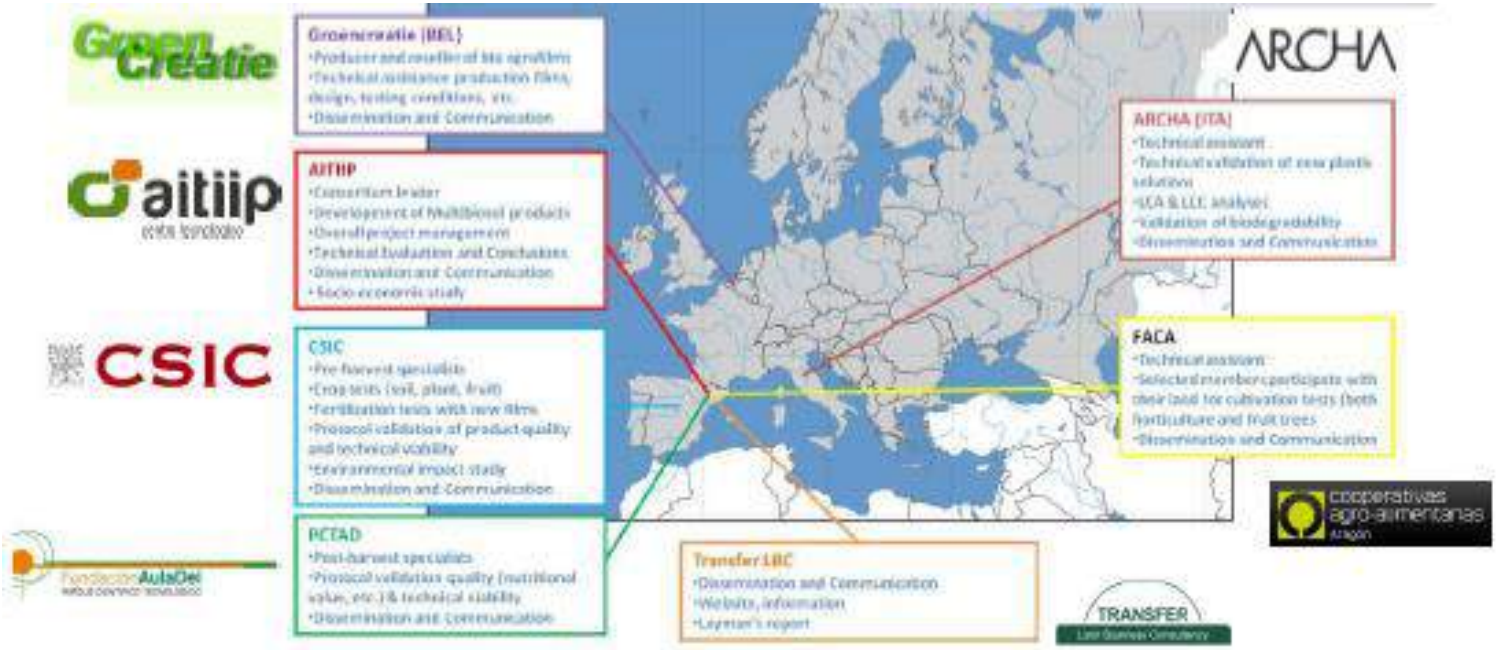
COM(2016) 157

Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL laying down rules on the making available on the market of CE marked fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009

- By including this innovative product in the **Fertilisers Regulation as soil improver** the EU could help tackle several challenges at once including the need to produce more food from less land and to farm more sustainably using less resources.

- According to the Commission, this proposal represents **a step forward towards a circular economy**. However, the proposal fails to recognise the potential role of biodegradable mulch films in modern agriculture *(Position of European Bioplastics & EuropaBio).*

LIFE MULTIBIOSOL (LIFE14 ENV/ES/000486) - Innovative fully biodegradable mulching films & fruit protection bags for sustainable agricultural practices



CONSORTIUM:
7 Partners
3 Countries

BUDGET:
Budget € 2,036,680
Grant € 1,222,002

DURATION:
39 months
(End December 2018)

COORDINATOR:
AITIIP
Carolina Peñalva (Technical coordinator)
carolina.penalva@aitiip.com

Over the project, the key points to be addressed are:

1. **Eliminating waste management.**
2. **Development of new biodegradable plastic films with a very low environmental impact.**
3. **Soil and crop quality improvement.**

The project will take place in Spain (Aragon), France and Belgium.

Demonstration Character

Raw materials
-100% biodegradable
-Polymers based on natural sources

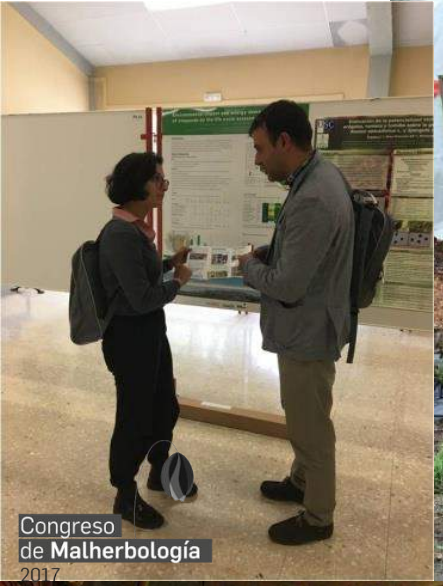
Production processes
-Materials extrusion
-Film blowing
-Injection moulding

Validation of plastics products in fields
-Tomato (Spain and France), pepper and cucumber in Spain and sweet potato in Belgium
-Bags for apple and peach (Spain)

Validation of plastics in laboratory
-Mechanical tests of materials
-Tests for certification OK BIODEGRADABLE SOIL

Validation of quality:
- Soil
-Crop (Pre-harvest)
- Product (Post-harvest)

Expected results
- Reduction of plastic waste
- Less CO_2 emitted during the production of plastics/Non-emissions from disposal
- Improvement of soil quality
- Improvement in crop quality
- Certification OK BIODEGRADABLE SOIL



Technical Seminar

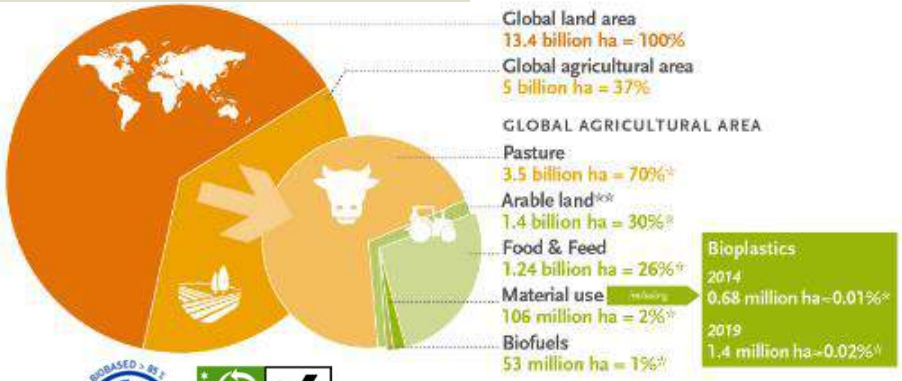
Open Event

TRANSFER
CONSULTANCY

General Dissemination

Innovations of LIFE MULTIBIOSOL

Renewable origin (biobased) refers to the origin of carbon atoms in polymers.



Are biobased — Biobased

Are biobased and biodegradable

Not biodegradable

Bioplastics
Eg biobased PE, PET, PTT

Bioplastics
Eg PLA, PHA, PBS

Biodegradable

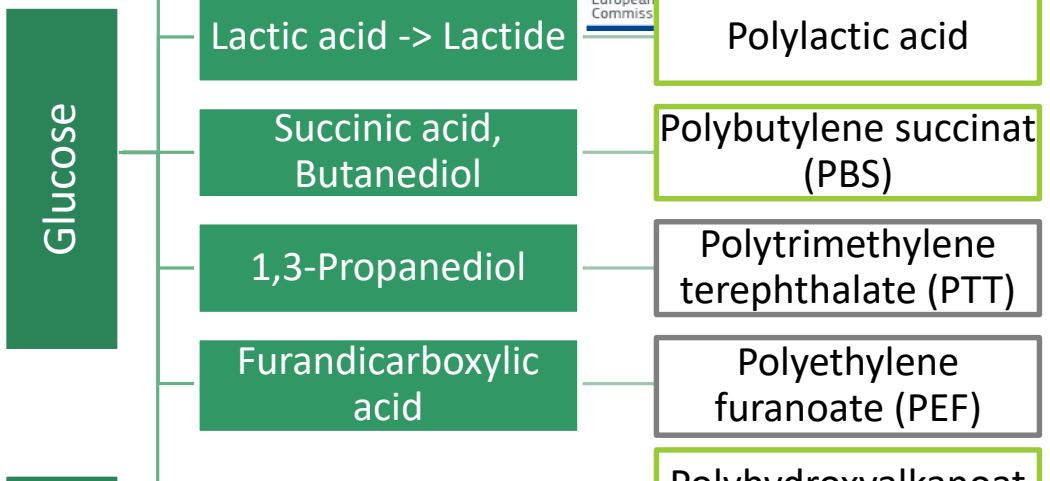
Conventional plastics
Nearly all conventional plastics eg PE, PP, PET

Bioplastics
Eg PBAT, PCL

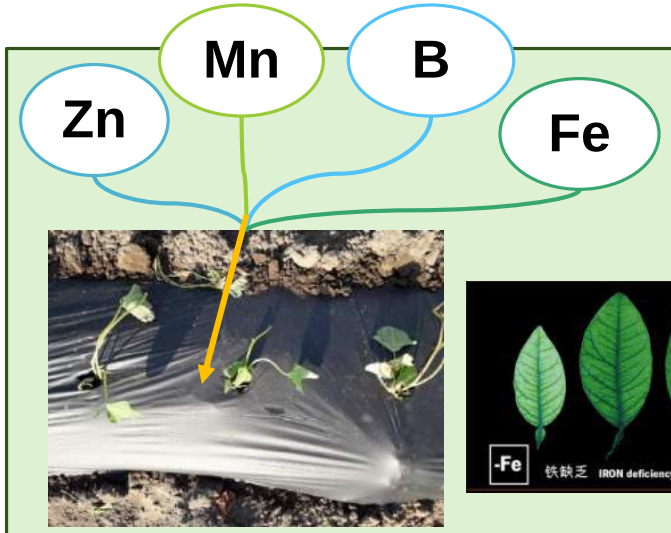
Are biodegradable

Not biobased

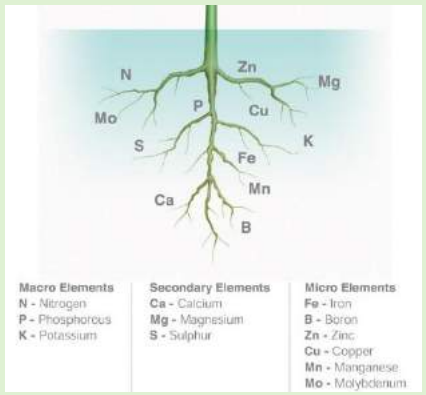
Source: European Bioplastics



Biodegradation by microorganisms is a matter of polymer structure, not of carbon origin. Not oxo-biodegradable (Chemical degradation).



Mulching Innovations

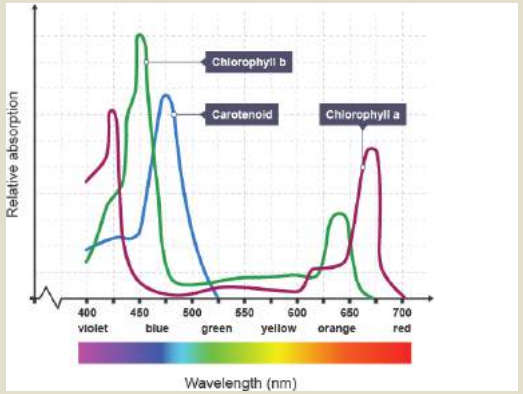


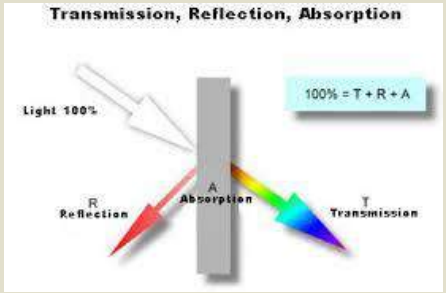
Plastic Legislation

Fertilizer value

- **Iron** deficiency is the main lack in crops under plastic (chlorosis)
- **Boron** deficiency appears in dry climates (important for plant metabolism)
- **Zinc** is required by many enzymes (hormone auxin, little leaf)
- **Manganese** is necessary for photosynthesis (coloration)

Fruit protection bags innovations





Photosynthetically Active Radiation (RFA) *amount of integrated radiation in the range of wavelengths that are capable of producing photosynthetic activity in plants.*

Perforations *to prevent rotting due to the concentration of water vapour inside the bag.*

Innovations of LIFE MULTIBIOSOL

Protected Designation Origin

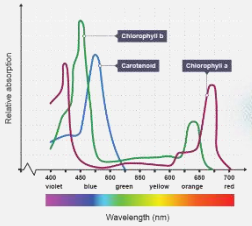
Agroplastics are needed:

Innovations **Sustainable**

- Conserve water and nutrients
- Prevent weed growth
- Permit adequate temperature in the rhizosphere

Trace elements

- Protection against pests and infestations
- Isolate fruit from plant protection products
- Fruit with uniform skin colour



Macro-perforations
Coloring bags

Biodegradable films deliver the same positive agronomical effects as conventional ones, additionally, they offer additional advantages at the end of the crop cycle because they can simply be left on the field and ploughed under.

The overall objective of the project is to demonstrate that the **sustainability and efficiency of agricultural practices** can be achieved by introducing an **innovative**, economically viable and soil biodegradable plastic that **eliminates waste** completely.

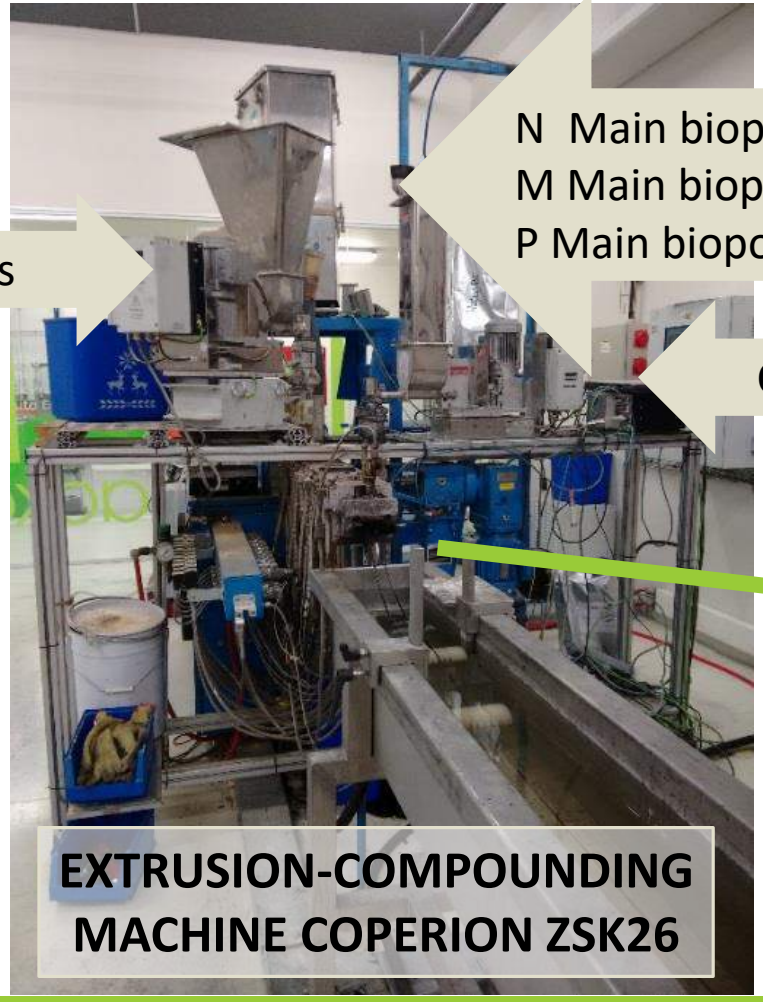
Transformation processes

1 Extrusion compounding

Twin-screw extruder equipped with one gravimetric dosing for pellets, two for powder and one for liquids (1 to 100 Kg/h)

- Pelletizer and dryer on the same line.
- Adapted screws for several materials and additives
- Ultrasonic system of dispersion available

Oligo elements, additives



N Main biopolymers AAPE
M Main biopolymer PHA-PLA
P Main biopolymer PBS

Carbon Black, colourants

- ✓ Tª control
- ✓ Material flow control
- ✓ % components

EXTRUSION-COMPOUNDING MACHINE COPERION ZSK26

Moretto X DRY AIR T Minidryers

2 Film blowing

Film blowing unit LABTECH LF 400 for film production

- ✓ Air speed control
- ✓ BUR control
- ✓ Height of the equipment
- ✓ Roll speed

- Different layer configurations 3-layer (bi material: ABA), 2-layer (AB or BA) and monolayer
- Max film width output: 800 mm
- Blow ratio up to 3,5
- Thickness from 10 µm depending on material

Technical measurements

Thickness

Width

Dispersion

Mulching

Film for fruit bags

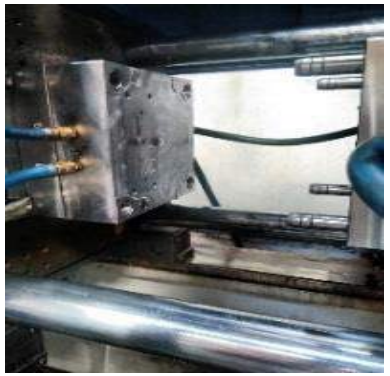
Samples (materials) 2016			Thickness
MULCHING 3% oligoel.	M	M1-M3	2 thickness
	N	N1-N3	3 thickness
	P	P1-P3	1 thickness
FRUIT BAGS 2% and 2 different colour	M	M4-M7	40 µm
	N	N4-N6	35 µm
	O	O1-O3	50 µm

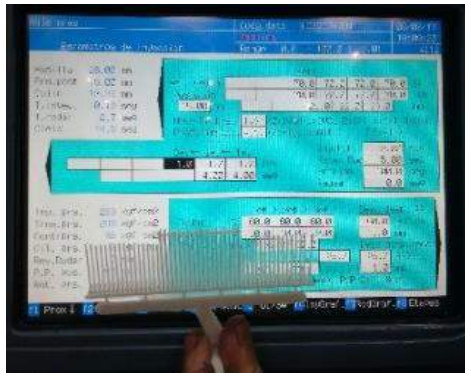
3 Injection moulding

INJECTION MACHINE JSW 85 JELII

- Injection Volume 97 cm^3
- Maximum injection pressure 1960 bar
- Screw diameter 32 mm
- Injection rate 188 cm^3/seg
- Clamping force 85 Ton
- Mould thickness 180-350 mm

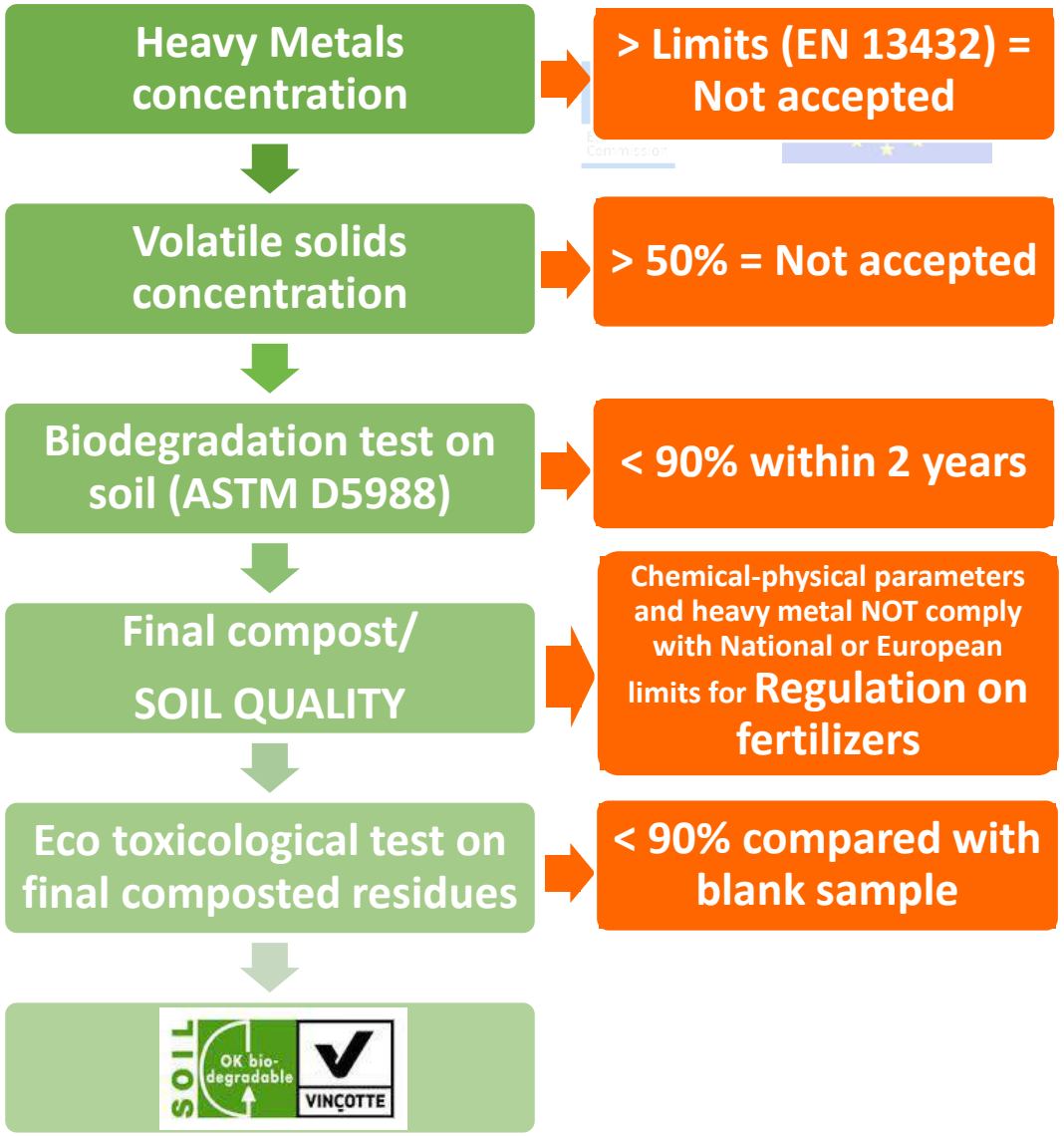
2 samples with different biopolymer composition
S1: based on PBS, S2: based on AAPE.
1 Final prototype to be tested (S2 based on AAPE)



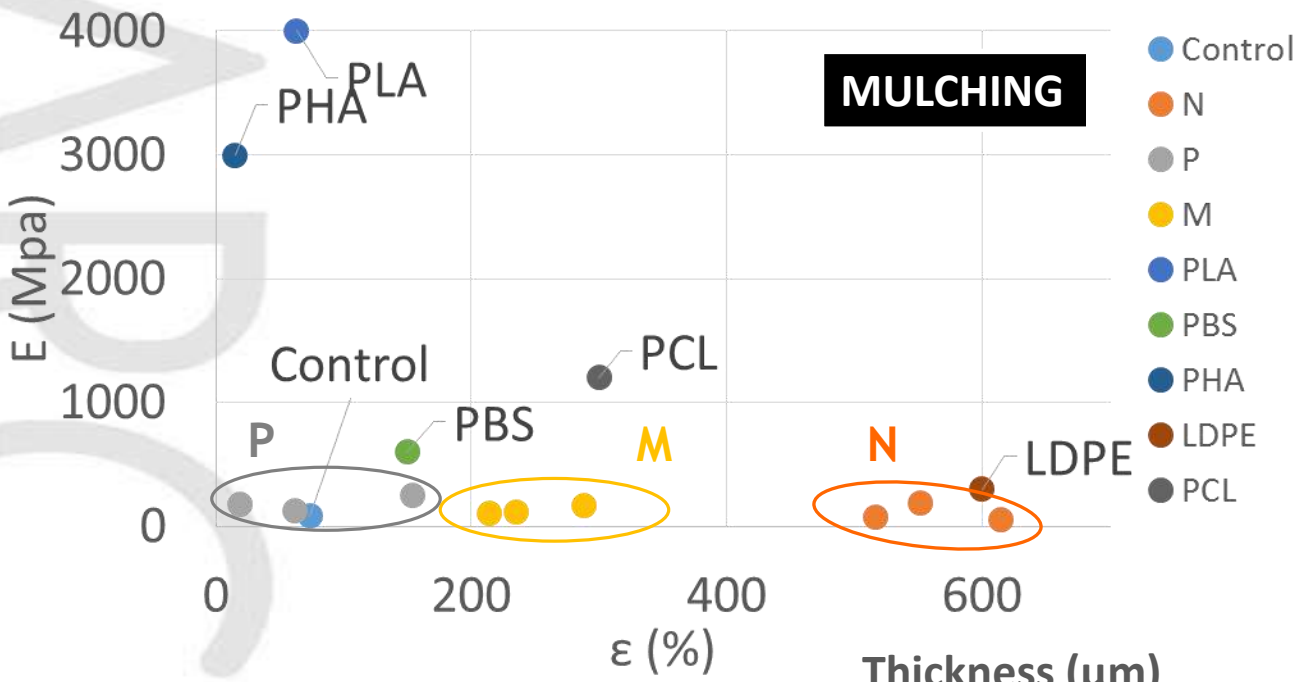


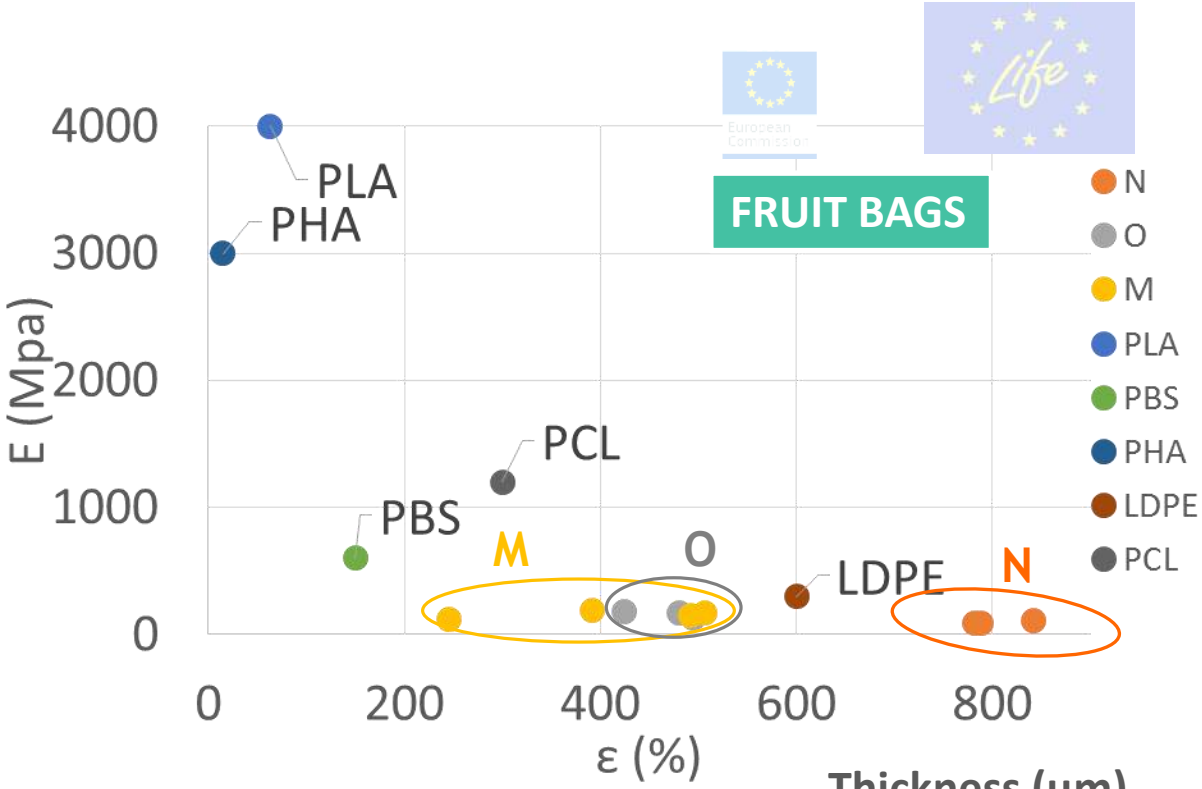
Laboratory plastics validation

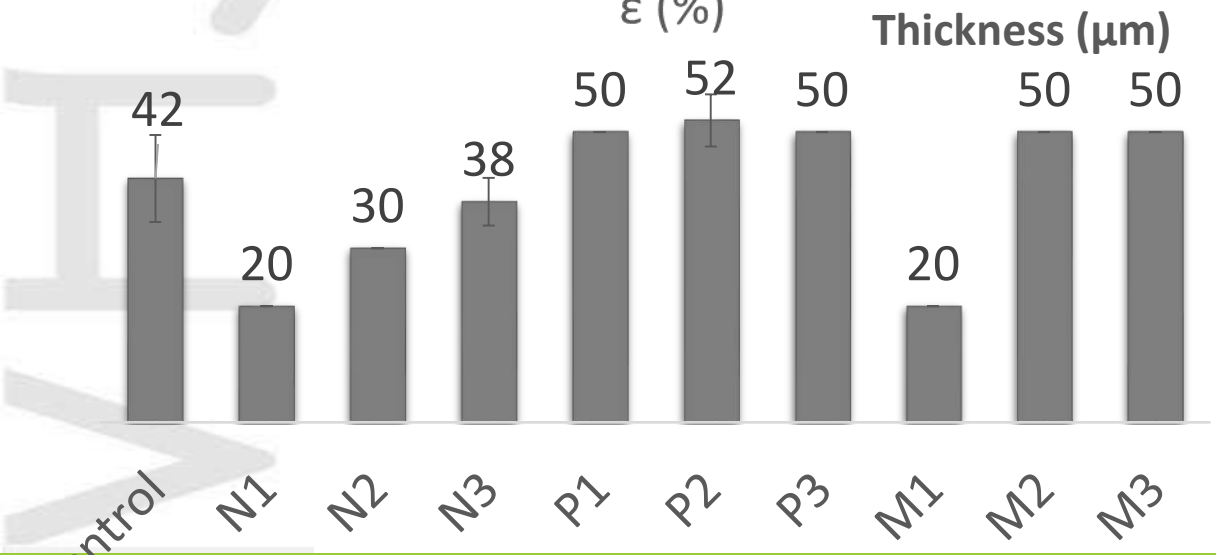
BIOPLASTICS CHARACTERIZATION	Method
Tensile Properties of Thin Plastic Sheeting	ASTM D 882 – 12
Tear-Propagation Resistance of Plastic Film and Thin Sheeting by a Single-Tear Method	ASTM D 1938 –14
Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials	ASTM D 790 – 15
Plastics – Methods of exposure to laboratory light sources	EN:ISO 4892-3
Standard Test Method for Oxidative-Induction Time of Polyolefin by Differential Scanning Calorimetry	ASTM D3985 - 10
Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor	ASTM F1249 - 13
"OK Biodegradable Soil"	EN13432:2000

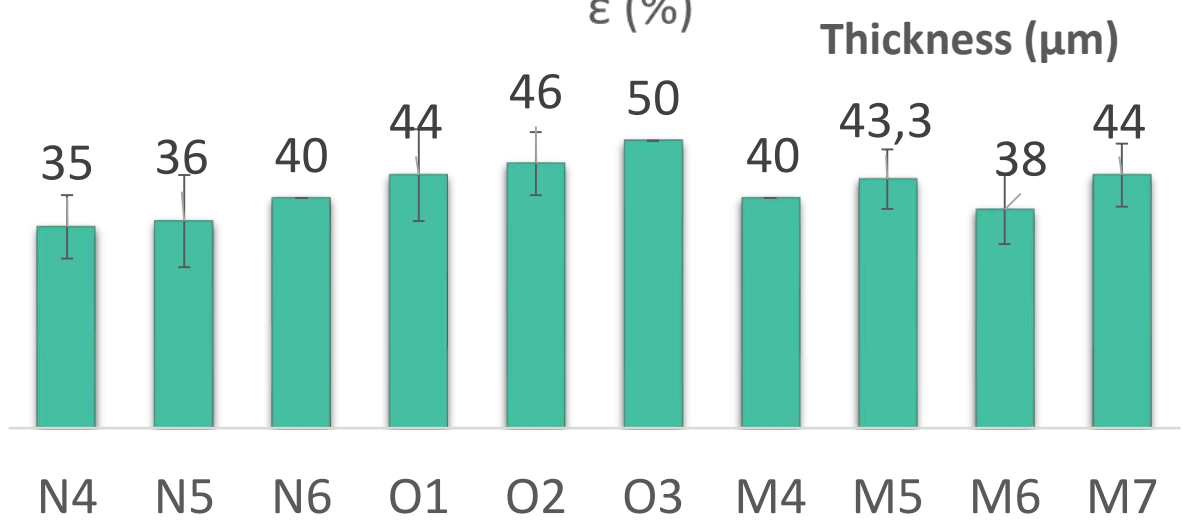


Laboratory plastics validation









Laboratory plastics validation

Heavy metals content in plastic samples

Heavy Metals concentration → > Limits (EN 13432) = Not accepted

- **EN 13432:2000: Packaging - Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging.**
- ***UNE-EN 14995:2007*** *Plastics. Evaluation of Compostability. Test scheme and specifications.*
- ***prEN 17033:2016 Plastics - Biodegradable mulch films for use in agriculture and horticulture - Requirements and test methods.***

Plastic Legislation

Fertilizers values

	As	Cd	Cr	Hg	Mo	Ni	Pb	Cu	Se	Zn
LDPE	<DL	<DL	<DL	<DL	<DL	1,15	<DL	6,73	<DL	<DL
N1	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	5,88
N2 ✖	<DL	<DL	0,751	<DL	<DL	<DL	<DL	1,24	<DL	**766**
M1	<DL	<DL	1,33	<DL	<DL	<DL	<DL	<DL	<DL	7,18
P1	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	10,5
M7 ✖	<DL	<DL	1,81	<DL	<DL	<DL	<DL	**581**	<DL	<DL
DL (mg/kg dm)	2,5	0,19	0,5	0,3	0,5	1	2	1	0,5	5
EN 13432 (mg/kg dm)	5	0,5	50	0,5	1	25	50	50	0,75	150

Visual field assessment and soil analysis

Polymer characteristics

Microorganisms
Extracellular enzymes

Abiotic factors (Humidity, Oxygen, UV / vis irradiation)

H_2O CO_2 CH_4

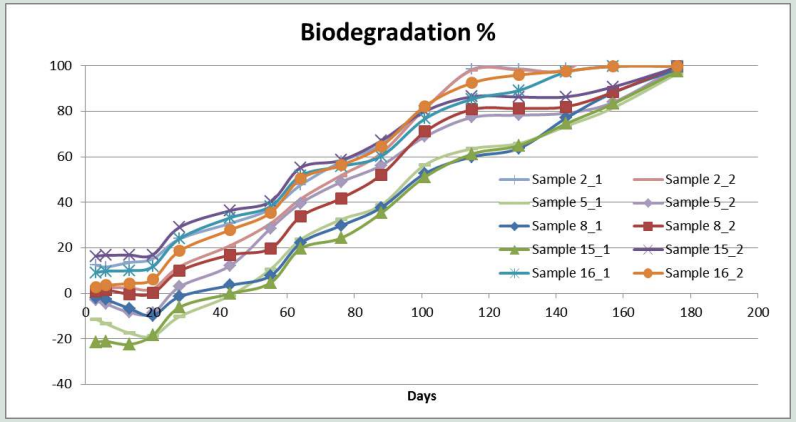
Soil analysis

- Conductivity, pH
- Organic material, C / N
- Microelements and anions
- Weeds

Visual assessment

OK Soil Biodegradable

1. Heavy Metals
2. **Biodegradation: Plastic in soil samples (ASTM D5988)**



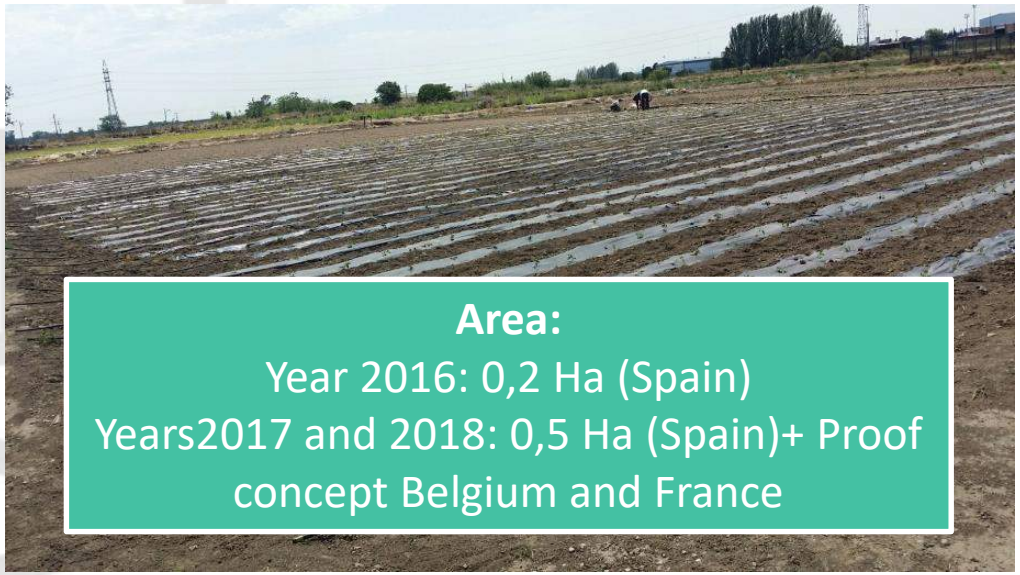
	Biodegradation (mean and standard deviation)			
	After 143 days		After 176 days	
N1	98,6	0,28	99,9	0,00
M1	79,6	3,54	99,2	0,85
P1	76,4	4,10	97,9	1,84
O2	80,55	8,27	98,5	1,27
O3	97,55	0,35	99,9	0,00

Validation of products in field

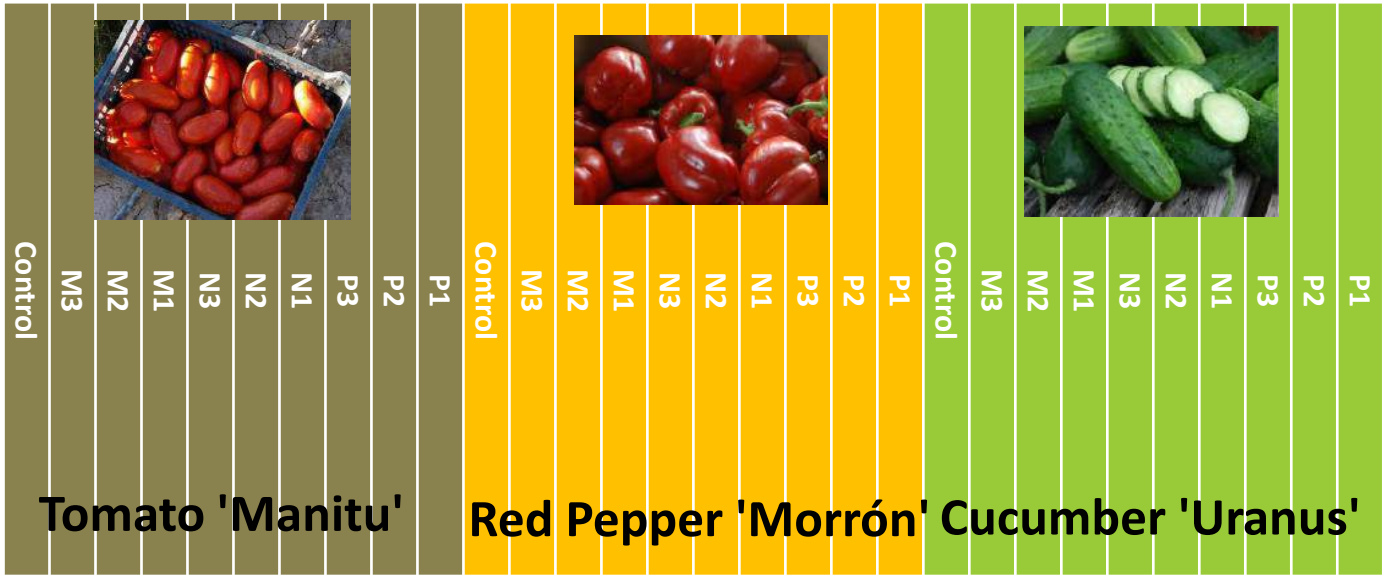
M1-M3: Sample based on PLA-PHA + MnZn (%)
N1-N3: Sample based on AAPE + MnZn (%)
P1-P3: Sample based on PBS + MnZn (%)

Product	Phase 1	Phase 2	Phase 3
Biomulching	**648 m²**	**2,664 m²**	2,016 m²
Biobags	900	3,700	2,800
Bioclips	900	3,700	2,800

- Lines 35 m
- 0,8 m with Drip irrigation
- Separation between plants: 0,5- 0,7 m
- Separation between lines: 1- 1,5 m
- Planting date: 24/05/2016
- Date of collection:
  - Tomato: 25/08/2016
  - Pepper: 13/10/2016
  - Cucumber: 07/07/2016



Area:
Year 2016: 0,2 Ha (Spain)
Years2017 and 2018: 0,5 Ha (Spain)+ Proof concept Belgium and France



Validation of products in field

M4-M7: Sample based on PLA-PHA + colour (%)
N4-N6: Sample based on AAPE + colour (%)
O1-O3: Sample based on AAPE + colour (%)

Product	Phase1	Phase2	Phase3
Biomulching	648 m^2	2,664 m^2	2,016 m^2
Biobags	**900**	**3,700**	2,800
Bioclips	900	3,700	2,800

September Peach

Fuji Apple

Peach field
1 ha
5×4 m
Drip irrigation

Apple field
1 ha
5×4 m
Drip irrigation

N4 N5 O1 O2 M4 M5

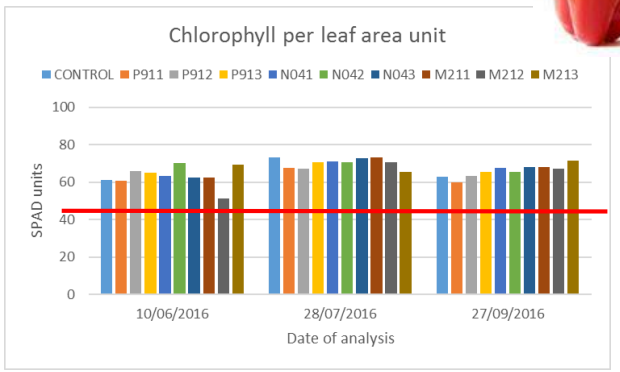
N5 N6 O2 O3 M7 M6 M5

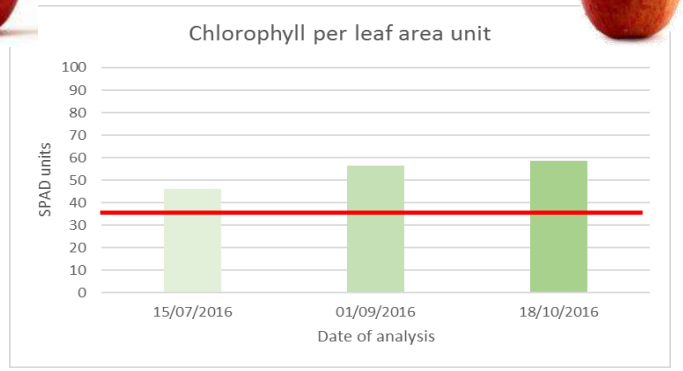
- ✓ Two months of bagging
- ✓ Biobags are easy to put at the tree

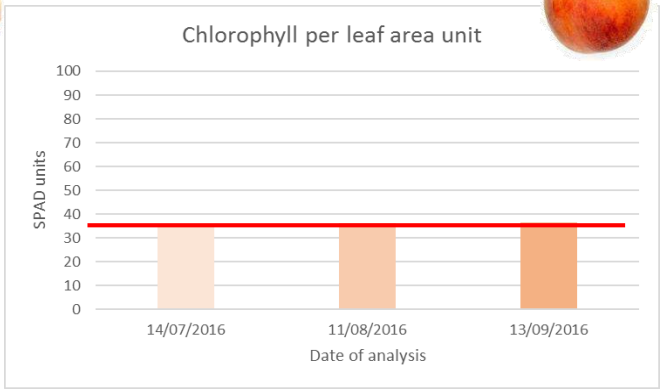
Preharvest quality measurements

The nutritional state of the crops was adequate throughout growing cycle.

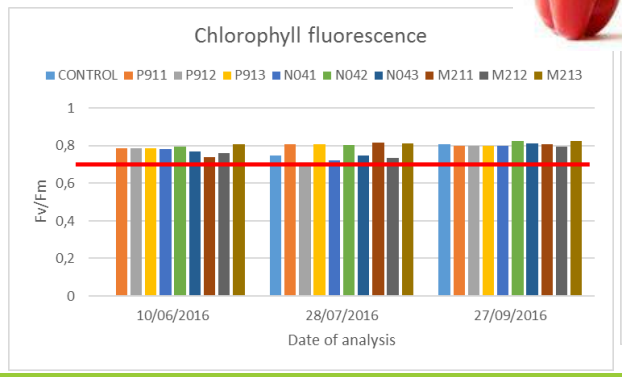
Chlorophyll per leaf area unit
(40 units)

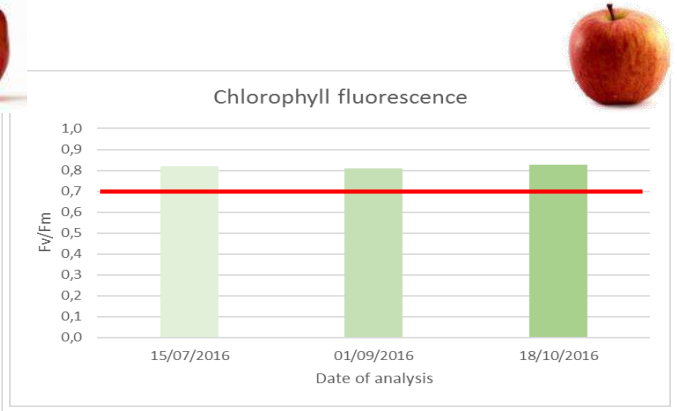


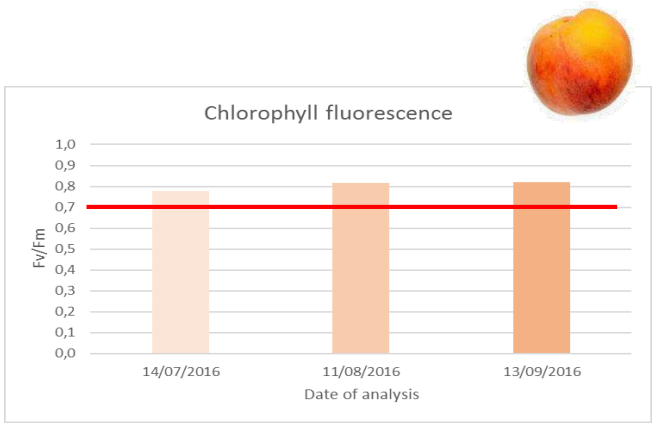




Chlorophyll fluorescence
(Fv/Fm = 0,7)





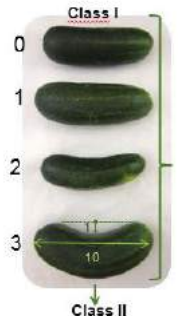


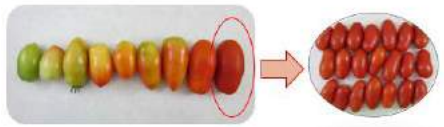
Post-harvest quality measurements

Classification → **Disorders and diseases** → **Quality analysis (Commercial class)**



Colour Calibre & weight






External damages





Internal damages


Acidity Soluble solids

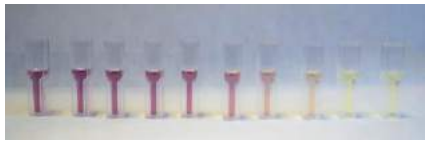

Firmness


Sensory and olfactory analysis

150 VEGETABLES/BATCH and **75** FRUITS/BATCH are analysed (per year)

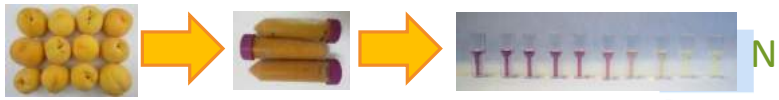
Nutritional compounds





VEGETABLES: No significate differences were found

Post-harvest quality measurements



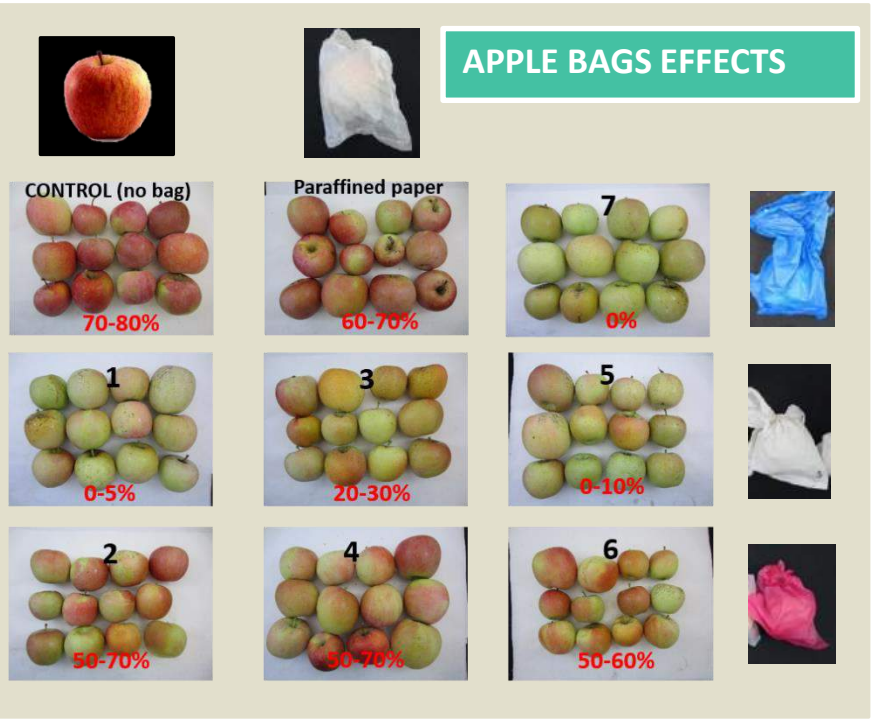
Nutritional compounds

SAMPLE			PHENOLS (mg/100g)		Xanthophyll +Carotenoids (µg/g)	
nº	material	external	mean	d.s.	mean	d.s.
1	N	opaque	46,62 ab	6,21	12,94 a	4,58
2		translucent	***53,63 b***	13,34	***19,87 ab***	4,55
3	O	opaque	31,36 a	11,52	16,51 ab	4,24
4		translucent	***58,43 b***	4,79	***22,41 b***	2,09
5	M	opaque	29,38 ab	6,83	13,52 a	0,14
6		translucent	***39,14 a***	11,95	***14,45 a***	2,79
c	CONTROL	WP	49,78 ab	14,53	14,30 a	4,56
sign.			0,029		0,048	

- Fruits in **translucent** biodegradable bags (N &O) have **higher polyphenols and carotenoids+xantophils concentration** than control and lower in the opaque ones.
- Developed biodegradable bags reduce the amount of red colour zone in peaches. **ºBrix are even higher** than those in control ones.
- M samples have more rots and internal and external damages (34-52%).
- N and O biodegradable samples presents **similar disorders and diseases** (16-31%) than control (26%).

SAMPLE			ºBrix		a*	
nº	material	external	mean	s.d.	mean	d.s.
1	N	opaque	**14,58 c**	0,53	**14,49 ab**	1,68
2		translucent	**14,03 c**	0,25	**14,88 bc**	1,54
3	O	opaque	13,08 b	0,43	**13,16 a**	2,17
4		translucent	**14,70 c**	0,37	16,05 cd	1,67
5	M	opaque	12,35 a	0,62	**13,34 a**	1,79
6		translucent	12,93 ab	0,13	15,76 bcd	2,83
c	CONTROL	WP	12,78 ab	0,29	16,4 d	2,66
sign.			0,00		0,00	

Post-harvest quality measurements



SAMPLE			ºBrix		Coordinate a*	
nº	material	color	mean	s.d.	mean	s.d.
1	N	White	*16,23abc*	0,93	***0,67ab***	3,23
2		Red	***16,83bc***	0,75	***5,27cd***	5,17
3	O	White	*16,13abc*	1,42	***2,95bc***	2,88
4		Red	***17,37c***	0,81	***7,66de***	4,78
5	M	White	*16,47abc*	0,12	***-0,27a***	3,71
6		Red	*15,77abc*	1,24	***4,37c***	4,11
7		Blue	14,70a	1,23	***-2,12a***	2,17
P	WP	White	15,33ab	0,80	9,36e	5,81
C	CONTROL	no bag	14,83a	0,51	12,27f	5,09
	sign.		0,04		0,00	

Nutritional compounds

SAMPLE			ANTOCIANS (mg eq C3Glucosido/100g)	
nº	material	color	mean	s.d.
1	N	White	***4,59 b***	*0,50*
2		Red	***6,9 c***	*0,39*
3	O	White	***4,43 b***	*0,25*
4		Red	***6,97 c***	*0,31*
5	M	White	***4,75 b***	*0,25*
6		Red	***6,74 c***	*0,30*
7		Blue	***1,41 a***	*0,25*
P	WP	White	*8,58 d*	*0,26*
C	CONTROL	no bag	*8,66 d*	*0,31*
	sign.		0,025	

- Biodegradable **red bags** allows reaching the **typical red colour** of this variety while white and blue bags don´t.
- Biodegradable **red bags** allows to reach **similar Antocians content** than waxed paper or without bag while white and blue bags don´t.
- Biodegradable samples presents similar disorders and diseases (24-42%) than waxed paper (37%) but both are higher than without bag (6% red points no rots).

Post-harvest quality measurements

Reduction of number of pesticides treatments following the completion of bagging technique in the **peach crop.** **That means a reduction of a 50% in pesticide treatments.**

Ceratitis capitata

Grafolita molesta / Anarsia lineatella

PLAGUE/Nº TREATMENTS	CONTROL	BAGGED
G. MOLESTA Y A. LINEATA	8	4
C. CAPITATA	6	2
TOTAL	14 (12)	6

Pesticide Residues

In the analysis of **pesticide residues**, some traces of **Difenoconazole** (lower MRL) have been detected in apples grown **without bags**, with **waxed paper** bags and with biodegradable plastic O2 and O3. It is worth noting the **absence of pesticide residues** in apples covered with **N** and **M** bioplastics.

MRL: 0,8

Batch	Colour	Sample	Pesticide
1	White	N5	NO
2	Red	N6	NO
3	White	O2	0,011
4	Red	O3	0,012
5	White	M5	NO
6	Red	M6	NO
7	Blue	M7	NO
Control bag	WP (White)		0,011
CONTROL	no bag		0,012

Conclusions

- **New formulations for Biomulching have been developed.**
  - ✓ Certain % of oligoelements can be added in the mulching providing an innovative characteristic.
  - ✓ Reduction of plastic waste has been achieved (98-99,9% biodegradation in 176 days).
  - ✓ Mechanical properties of bioplastics are similar to those of LDPE.
  - ✓ Plant health were adequate during crop cycle.
  - ✓ Crop quality and nutritional content were similar to that obtained with conventional mulching.
  - ✓ Lower thickness make plastics breakable in fields.

- **New formulations for Biobags and bioclips have been developed.**
  - ✓ Reduction of plastic waste will be achieved (98,5 -99,9% biodegradation in 176 days).
  - ✓ Reduction of pesticides treatments -> better crop quality.
  - ✓ Mechanical properties of bioplastics are similar to those of LDPE.
  - ✓ Colour can be used providing an innovative characteristic: Affects to fruit coloration but not to maturation.
  - ✓ Macroperforations eliminate water inside bags, producing similar rots than with other type of bagging.

Thank you for your attention

Innovative fully biodegradable mulching films & fruit protection bags for sustainable agricultural practices LIFE14 ENV/ES/00048

LIFE MULTIBIOSOL

Multibiosol Life project Introduction: An overview

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Project co-financed by the European Union through the LIFE Programme

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