Training course packages targeting food operators on the adoption and management of the technological innovations

BIODEGRADABLE MULCHING

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1. FoodLAND technical innovation for local food supply chains: concepts and approaches

The FoodLAND project has the ambition to impact on a large number of supply chains and communities, hence the process of food operators' capacity development has to be tailored and as much participative as possible. Accordingly, one of the assumptions of FoodLAND is that sustainable and nutrition-responsive farming systems can be achieved basically by strengthening the capacity development, and specifically by **a)** empowering farmers and processors through the implementation of capacity building processes and concrete opportunities; **b)** creating or consolidating cooperation and shared knowledge to overcome the lack of coordination among food operators; **c)** addressing the inefficient use of resources; **d)** trying to address and build resiliency to the high vulnerability of food systems to climate change; **e)** enhancing the integration of supply chains by creating commercial and stakeholders' networks; **f)** improving the responsiveness of the production sector to the market demand.

To implement these elements of capacity development, FoodLAND proposed the adoption of specific innovations, among which the organizational ones, to create strong and responsive links between producers and encompassing all the intermediate actors along the food value chain, such as researchers, SMEs, NGOs, local and national authorities. In order to ease the creation of those links and guarantee the sustainability over time of the results, 14 Food Hubs will be created in 6 countries as part of the organizational innovations. Food Hubs are conceived as multi-actors centers of innovation where to develop or enhance the organizational and operational conditions enabling local food supply chains (D3.6).

Functional to the implementation of the Food Hubs and of the innovations, the training courses were designed – in form of capacity development activities – as a two-phase process. Firstly, a training session focused on general, preparatory topics was provided to farmers as described and reported in D3.5 ("Group Introductory Training", GIT). According to the project GA, GIT broad set of goals

were: to enhance the knowledge of consumers' nutritional needs and market opportunities, and to boost the notions about climate change, sustainability, resilience, and food culture. Secondly, a specific training session were organized to provide food operators with practical information on the adoption and management of the innovations tested at lab / small scale level and to contribute to validating them at appropriate scale.

However, as the whole approach has been designed by FoodLAND to ensure the inclusion of the local actors from the first moment, both the training sessions were set up accordingly. Indeed, yet in the inception phase of the project, an assessment on participatory methods has been run and Participatory Learning and Action (PLA) approach has been eventually assessed as the best one to ensure the inclusion of multiple perspectives. The main purpose of PLA is to support people within communities to analyze their own situation, rather than have it analyzed by outsiders, and to ensure that any learning is then translated into action (Gosling and Edwards 2003). In addition, a gender-sensitive approach has been applied to the trainings that have been designed considering gender roles and power relations; they have provided equal opportunities to participate in the process by caring to times, venues and use of local languages.

The GITs have been conceived as the first step towards the innovation validation and aim at involving the producers, yet from the inception phase. They are just the first step in a sequence of 6, summed up in **Table 1**. After the GITs, where farmers and processors meet and share their vision and goals for the Food Hubs and exchange information about specific topics, the Food Hubs were created and the innovation tested (first in pre-test, then in pilot phase). The constant iteration between researchers and local actors is a key feature of the project: specifically, the practical trainings focused the single innovations (step 5) are aimed at validating the innovations at adequate scale and planned to trigger feedback loops of control and improvement involving developers and adopters.

Table 1. Activities with farmers and food processors (SMEs) and participatory approach

Step	1	2	3	4	5	6
Task	**T3.3**	**T3.3**	**T3.4**	**T4.1¸T4.5**	**T5.1¸T5.5**	**T5.1¸T5.5**
Activity	Group introductory training	Food Hubs creation	Innovation undertaking	Innovation tests	Individual and group practical training	Innovation pilot and validation

2. FoodLAND practical training: aims and scope

According to the project bottom-up and participatory approaches, following the courses on introductory topics GIT organized in the early project phase (T3.3), and as component creating / strengthening the Food Hubs as local innovation centres, FoodLAND has organized a second set of training activities with food operators based on active learning methods and gender equality principle (Task 5.1-5.9). In this regard, specific mechanisms (being aware of the gender roles and power relations; providing equal opportunities to participate in the process by putting attention to the times, venues, use of local languages, etc.) will be lifted to ensure women's participation. These training packages are aimed at providing the local farmers and food processors with operational instructions on the adoption and management of the validated innovations.

This second set of training activities has been organised – triggering PLA approach – as individual and group practical (demonstration/capacity building) activities to be conducted in parallel to the implementation of the technological research (where relevant) and of the innovation pilots and validation. These technology-centred trainings aim at strengthening the participants' understanding of novel production and post-harvest techniques, innovative tools and systems (e.g., climate smart/precision agriculture, hydroponics, and integrated aquaculture), new technologies for primary and secondary processing, and supply chain management. Thus they aim at fostering knowledge and operational capacity to deploy, manage, and maintain the validated technological innovations – documented by the released guidelines D4.1 ÷ D4.11 (e.g., training pamphlets, user manuals, flow diagrams, and operational recommendations) and practice abstracts D6.5 – validated jointly at appropriate scale.

3. Second training packages on the adoption and management of the tested innovations: an overview

The second training course aimed at consolidating the food operators' knowledge and practical skills to adopt, manage and validate the project innovations and complement the related guidelines. Specifically, the realized training materials provide local farmers and food operators with a set of notions and concrete information on a series of innovative tools and systems as per the following **Table 2**. It is clear that both the contents and formats of the learning packages widely differ across technologies as well as Food Hubs (when the same type of innovation must be validated in different contexts). The diversity that emerges from the proposed solutions reflects the different needs highlighted by farmers and stakeholders as well as the conditions and opportunities characterizing the local communities. Nevertheless, in order to take into due account the existing heterogeneity inside the local communities, the developed learning materials have been let available on the project intranet so as to be used for further training initiatives across the network of Food Hubs.

4. Second training packages on practical information on the adoption and management of the tested innovations

Biodegradable mulching

Biodegradable Mulching

Novamont spa

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THE BIODEGRADABLE MULCH FILMS DEVELOPED BY NOVAMONT

MAIN CHARACTERISTICS

Introduction:

Mulching is an agricultural technique which was developed in semi-arid regions in order to preserve and save water use and reduce competition with weeds for nutrients and light.
Plastic Mulching has helped the intensification of agriculture, but the end-of-life management of traditional plastic mulch films can lead to different environmental issues.
Within the FOODLAND project, to boost a sustainable intensification of agriculture through the introduction of combined agro-ecological practices, Novamont is developing biodegradable in soil mulch films according to EN17033 standard, so that they can be left in the soil without environmental negative effects while avoiding the production of agricultural plastic waste.

MAIN CHARACTERISTICS OF MULCH FILM

- **Available color**: black, white / black, green (with based biodegradable master)
- **Standard thickness**: 15 microns; it is also possible to make films starting from 10 microns according to the needs of the crop cycle.
- **Average shelf life**: from 2 to 6 months for 15 microns films, it is possible to increase the duration up to 10 months with a thickness of 20 microns, and beyond 10 months by increasing the thickness up to 30- 40 microns
- **Widths**: available in different sizes

Typical characteristics of mulching materials	Value	Method
Tensile strength (MPa)	20÷40	ISO 527-3
Elongation at break (%)	250÷500	ISO 527-3
Young modulus (MPa)	100÷300	ISO 527-3
Density (g/cm³)	from 1,23 to 1,29	ASTM D792
MFR (g/10')	from 3 to 7	ASTM D1238

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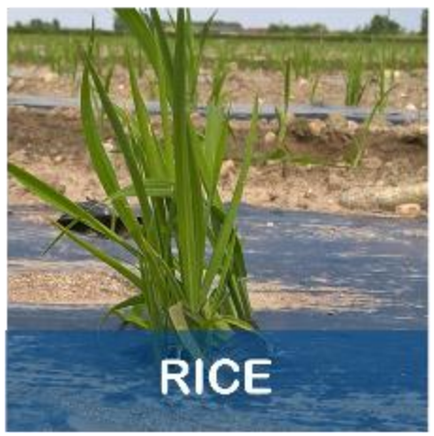
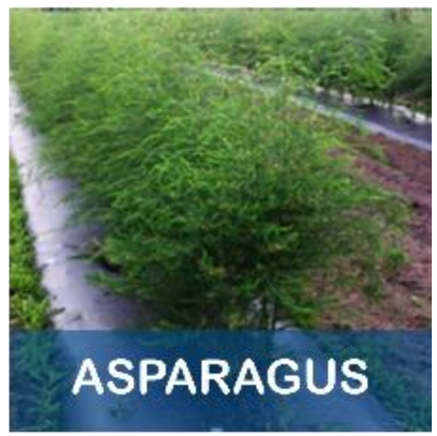
USAGE OF BIODEGRADABLE MULCH FILM

EXAMPLES OF CROPS





Cycle	Duration (months)	Crops	Thickness
SHORT CYCLE	1-3	lettuce	15µm (possible also 12 µm)
MEDIUM CYCLE	4-6	Zucchini, Pumpkin, Solanaceae (tomato, bell pepper, eggplant), Melon, Watermelon, Aromatics (Basil, Parsley,...), Potato, Cabbage, Corn, Industrial tomato, Green bean, Rice, Asparagus, propagating material	15µm
MEDIUM-LONG CYCLE	6-12	Strawberry, Onion, Garlic, Gherkin	from 15 to 18µm
LONG CYCLE	>12	Vine, Small fruit (blueberry, raspberry)	30-40 µm

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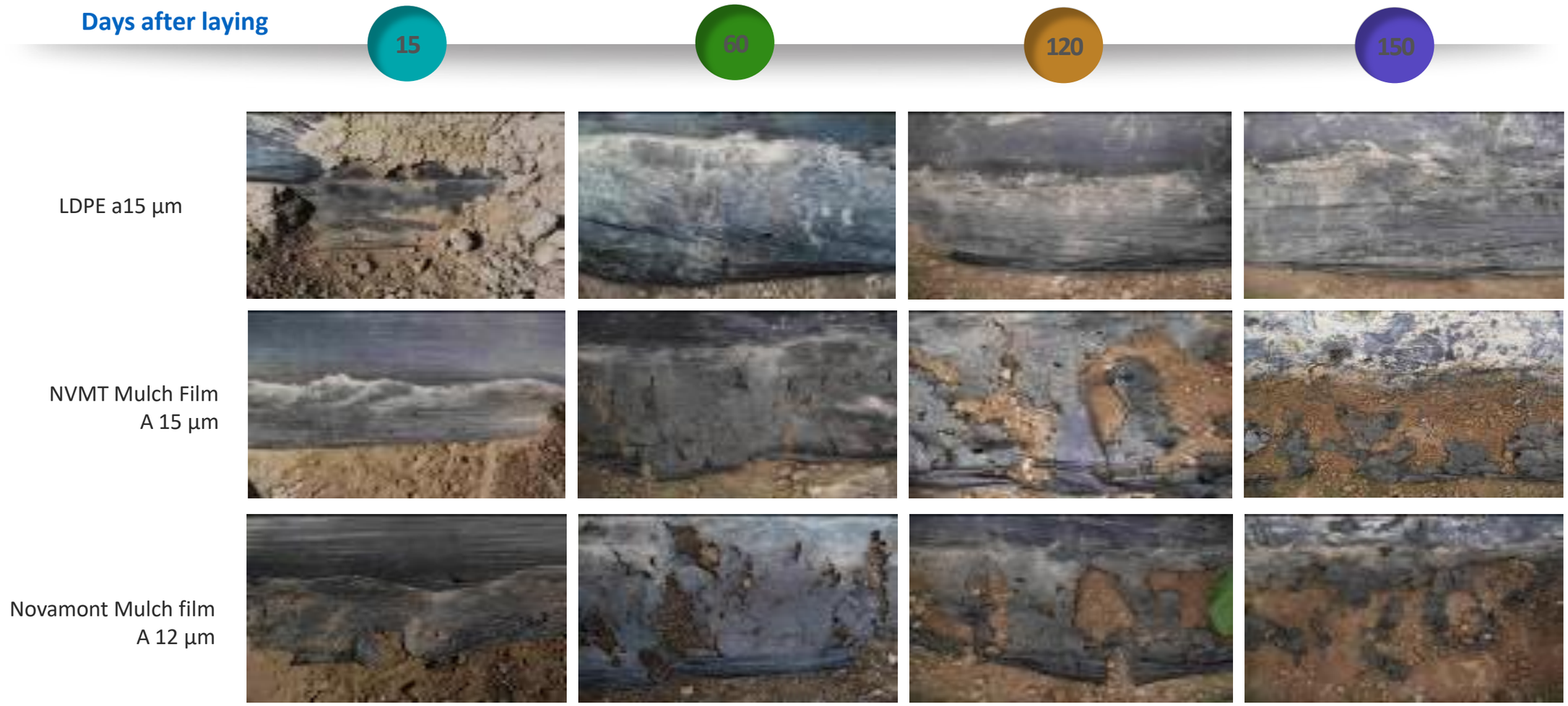
BIODEGRADATION OF BIODEGRADABLE MULCHING

BIODEGRADATION STAGES

Biodegradability: is the ability of a substance or material to decompose into simpler substances through the action of microorganisms. In fact, this characteristic depends on the intrinsic chemical structure of the materials/substances.

Here below an example of biodegradation of Novamont Mulch film vs Classic LDPE mulch film.



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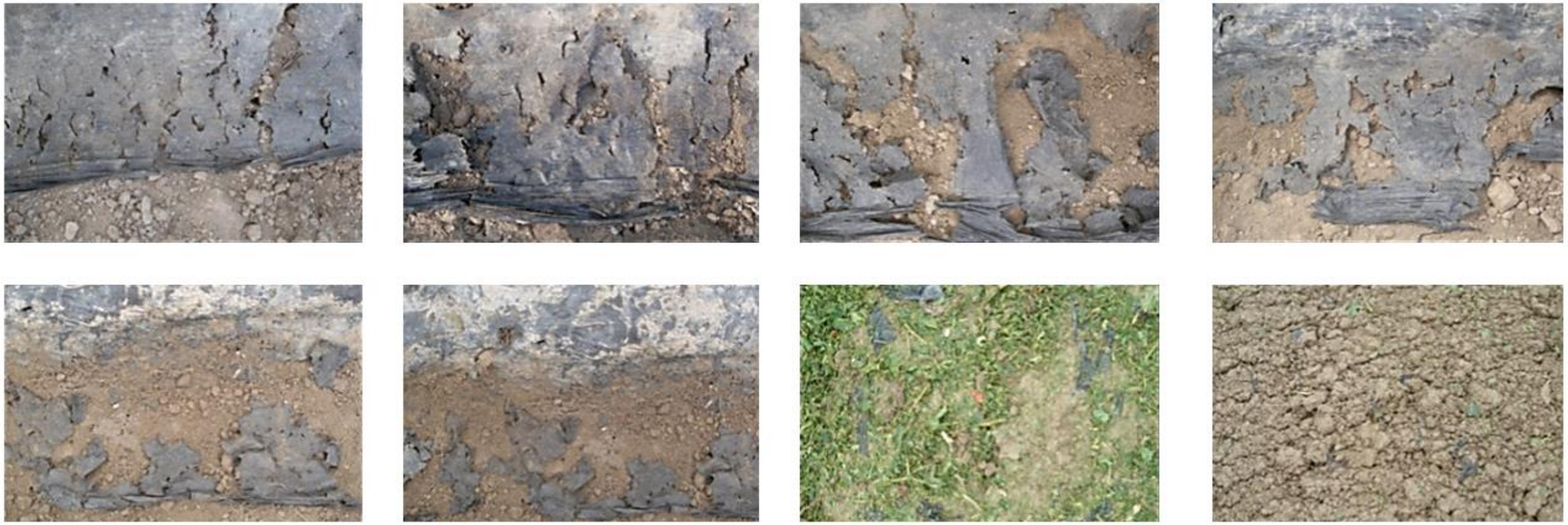
BIODEGRADABILITY IN SOIL

COMPLETE BIODEGRADATION IN SOIL

EN 17033:2018 – European standard which defines the characteristics of biodegradable film in terms of complete **biodegradability in soil without negative effects** (toxicity) **on the biodegradation substrate** (soil), characteristics of the finished product (initial and optical tensile properties):

- **Biodegradation (conversion to CO_2): > = 90% in 24 months compared to a reference material, measured in soil at room temperature (according to ISO 17056)**
- **Ecotoxicology: growth test on plants (according to OECD 208 method)**
- **Heavy metal values lower than the thresholds established by standards**

OK bio-degradable SOIL is a certificate for those materials that are **completely biodegradable in soil without negative effects (toxicity)** on the soil substrate - **Certificate issued by TŪV Austria**



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BIODEGRADABLE IN SOIL MULCH FILM

NO REMOVAL, NO LANDFILL, MANPOWER REDUCTION

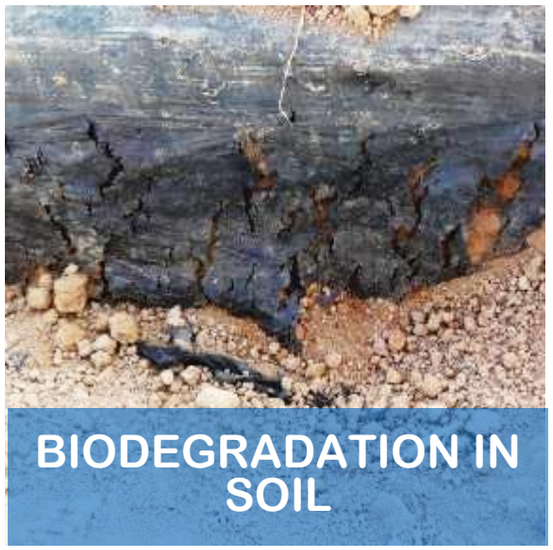
- END OF LIFE OF AGRICULTURAL PLASTICS: An enviromental issue

- **Agriculture plastic waste: 5% of total plastic waste**
- **Thin mulch films are not easy to recycle and the raw materials obtained are not high in quality**
- **Every year 15,000 tons of microplastics are released in European soils reducing crops yield up to 15%***

solution

BIODEGRADABLE MULCH FILM

At the end of the crop cycle biodegradable mulch film must not be removed, but should be worked into the soil, in order to properly biodegrade (through the mineralizing action of soil microorganisms) into CO_2, water and organic matter.



- COST REDUCTION
in terms of manpower (removal, dispose of, transport)

- NET REDUCTION OF PLASTIC WASTE

- REDUCTION OF POTENTIALLY NEGATIVE IMPACTS
on the environment when the plastic films are not properly removed and disposed

*** EUNOMIA (2021)**

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COLLECTION OF BASELINE INFO AND DESIGNING OF MULCH FILMS

ISACM and SUA MULCHING TRIALS design

	ISACM – Tunisian food hub	SUA – Tanzanian food hub
Selected crops	Tomato	Beans
Agronomic technique	Open field, conventional practices	Open field, conventional practices
Previous use of mulching	N	N
Mulching laying	Manual	Manual
Irrigation	Drip irrigation	Hoses irrigation
Season test	mid- February and mid-June Temp. min: 9 - 21°C Temp. max: 17 - 30°C	Mid- February Temp. min: 16 - 22°C Temp. max: 28 - 32°C
Test surface	2 mulched rows (25 m) for 2 fields	0,5 acres

SELECTED FILM	
Colour	BLACK
Thickness	15 microns
Width	1000 mm

Novamont's biodegradable films are suitable, for mechanical and manual lying.

The film can be laid mechanically using the same machinery as for traditional plastic film and at similar speed and gear, requiring no additional cost for farmers.

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GUIDELINES ON IMPLEMENTATION OF BIODEGRADABLE MULCHING IN FILM

Mechanical laying best practices, handling and management of films in field

1

Preparation of the soil

Soil shall be prepared using methods adopted for the specific crop (ploughing, milling, etc.). However, soil shall be refined removing from the ground surface hard elements such as stones, rocks fragments, crop residues such as corn stalks.

Biodegradable mulch film should not be laid immediately after surface application of manure, in order to prevent the early biodegradation due to the presence of high micro-organism content.

2

Laying out the film

The film can be laid mechanically using the same machinery as for traditional plastic film and at similar speed and gear. It is essential to ensure the correct calibration of the mulch unroller machine: the film tension must be reduced to a minimum to prevent it from being weakened during application, which could make it less effective. It is therefore advisable to adjust the brakes and clutch of the mulch unroller machine to avoid applying excessive stress to the film during this operation.

3

Crops setup

Mulching machines can lay the film and transplant cuttings at the same time for taking full properties of biodegradable mulch film. Cylindrical implements make it possible to create holes with “clear” edges.

4

End of the crop cycle

Biodegradable mulch film should not be removed or disposed of at the end of the crop cycle (an obligatory process for traditional plastic film); instead, it is worked into the soil.

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Guidelines on implementation of biodegradable mulching in film

Manual laying best practices, handling and management of films in field

1

Preparation of the soil

Soil shall be prepared using methods adopted for the specific crop (ploughing, milling, etc.). However, soil shall be refined removing from the ground surface hard elements such as stones, rocks fragments, crop residues such as corn stalks. After this operation elevated soil plots, (about 10 cm) should be prepared, with a width based on the mulch film.

The use of wires and stakes can support plots sizing and preparation.

2

Laying out the film

For manually laying, is more simple to avoid applying excessive stress to the film, but it is advisable don't step on laid mulch film and avoiding mechanical damages (breaks, punctures...) during the hilling the land around the film. Avoid using any roller that pass over the film once it has been laid out in order to improve its adherence to the soil.

3

Crops setup

Perforation is generally carried out when the film is laid. One of the best ways to make perforations for film laid manually is to use a knife to make a cut in a cross shape or in a T or Y shape. This technique reduces the amount of uncovered land around the transplanted cutting.

Regarding irrigation and fertilization, no changes are needed.

4

End of the crop cycle

Biodegradable mulch film should not be removed or disposed of at the end of the crop cycle (an obligatory process for traditional plastic film); instead, it is worked into the soil, and end its life cycle through the mineralising action of microorganisms, transforming it into water, carbon dioxide and biomass.

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Production of biodegradable in soil mulch films within the FOODLAND project

OBJECTIVES AND INNOVATION

Novamont is a Benefit Company, B-Corp certified, international leader in the bioplastic sector, and in the development of biochemical and bioproducts obtained through the integration of chemistry, environment and agriculture.

As Novamont we promote a circular bioeconomy model to promote territorial regeneration.

Novamont has designed a range of completely biodegradable and compostable thermoplastic materials to provide low impact environmental solution and solve specific problems in different sectors, such as the separate collection of organic waste, packaging, catering, hygiene, agriculture and many other areas.

Novamont's bioplastics are produced using renewable resources made from plant material such as starches from different crops (e.g. corn, other cereals and potatoes) and vegetable oils.

Within the Foodland project Novamont is producing and testing newly developed materials in order to validate the shelf life, mechanical and disintegration cynetic performances of Biodegradable in soil mulch films in different climate condition and soil characteristics.

Involved partners and universities were provided with **Guidelines for the performance assessment** in the project trials. The collected results will be an important starting point for future material development for agricultural applications suitable also for North African countries.

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DEFINITION OF GUIDELINES FOR FIELD RESULTS ASSESSMENT

FIELD ASSESMENT PROTOCOL

Description	Survey modality	Timing for check
Degradation exposed side of film	SCORING (1-9)	Every 15 days
Degradation of the underground side of film	SCORING (1-9)	Every 15 days
Damages	SCORING (1-9)	Every 15 days
Tear resistance	SCORING (1-9)	Every 15 days
Laying damages	SCORING (1-9)	At beginning of test
Easy to lay	SCORING (1-9)	During laying
Weather conditions	Climatic station	Season of trials
Photographic survey		Every 15 days
Soil temperature	Temperature probe	daily

SCORING CRITERIA

- **Damages at laying**: 1 = very high number of damages & hard to lay - 9 = no damages & easy laying
- **Film degradation of the exposed side**: 1 = 0% uncovered soil - 9 = 100% covered soil
- **Film degradation of the underground side**: 1 = film totally disappeared - 9 = film as new
- **Damages** (referring only to the exposed part of the sheet): any break, tear, hole, tear that appears on the sheet, reducing its functionality: 1 = very high number of damages - 9 = no damages
- **Tear resistance of film exposed side**: 1 = extremely fragile - 9 = very strong, elastic like new one

ADDITIONAL SUGGESTIONS

- **Collection of field digital photos:** general field view, film status, crops status
- **Monitoring weather conditions during trials**: Trends temperature (minimum, average, maximum ° C) and relative humidity (%), rainfall (mm), wind (m/s), soil temperature at 10 cm deep.

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DEFINITION OF GUIDELINES FOR FIELD RESULTS ASSESSMENT

FIELD ASSESSMENT CASES

DEGRADATION: 9

LESIONS: 9

STRENGTH: 9

DEGRADATION: 8

LESIONS: 6

STRENGTH: 8

DEGRADATION: 6

LESIONS: 4

STRENGTH: 3

DEGRADATION: 1

LESIONS: 1

STRENGTH: 1

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BIODEGRADABLE MULCH FILMS SUPPLIED FOR THE EXPERIMENTAL VALIDATION IN THE FOODHUBS

Food Hub	Food Product	Prototype supplied
Enfidha / Chebika (TN)	Fresh vegetables (tomatoes)	30 Kg of roll film (2022) 20 Kg of roll film (2023)
Mvomero / Morogoro (TZ)	Legumes (beans)	30 Kg of roll film (2022) 10 Kg of roll film (2024)

Typical characteristics of mulching materials	Value	Method
Tensile strength (MPa)	20÷40	ISO 527-3
Elongation at break (%)	250÷500	ISO 527-3
Young modulus (MPa)	100÷300	ISO 527-3
Density (g/cm³)	from 1,23 to 1,29	ASTM D792
MFR (g/10')	from 3 to 7	ASTM D1238

Sample	Transmittance	Tensile properties				Tear Resistance	
	%	σb	εb	E	En	Direction	Strength
		(Mpa)	(%)	(Mpa)	(KJ/m²)		(N/mm)
Reference	100%	100%	100%	100%	100%	MD	100%
						TD	100%
FD22_PC01	100%	91%	89%	120%	90%	MD	83%
						TD	78%
PC23N1	100%	90%	89%	119%	89%	MD	110%
						TD	95%
PC24N1	100%	105%	95%	95%	102%	MD	105%
						TD	94%

Novamont developed a suitable biopolymeric formulation (FD22_PC01) finalized to the mulching use in African conditions. The biopolymeric formulation has been replicated and manufactured into film rolls in 2022, 2023 and 2024 to provide mulch prototypes to be tested in the field in the different test seasons.

The experimental validation of the biodegradable mulch film demonstrated:

- **Good replicability on the properties of the film**
- **Suitable field shelf life for selected crops**
- **Storage shelf life of film: Observed max 1 year**

The biodegradable mulch film prototype could be considered as validated

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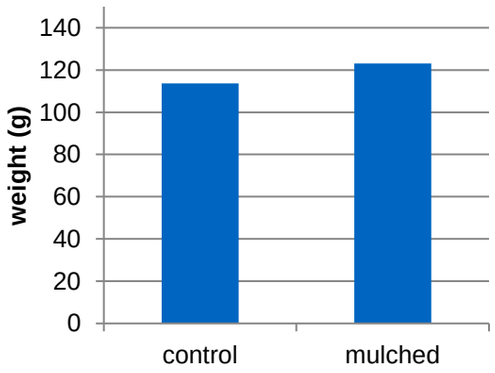
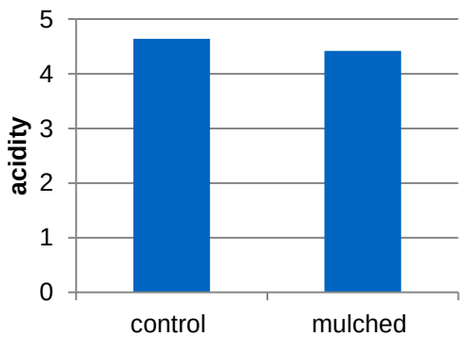
THE BIODEGRADABLE MULCH FILMS TRIALS IN TUNISIAN FOODHUB

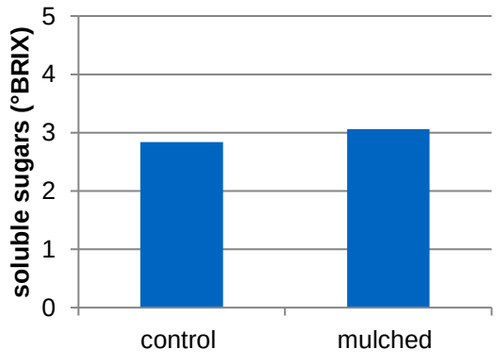
RESULTS – TUNISIA - Institut supèrieur agronomique de Chott Mariem (ISA CM)

ISACM conducted in two Tunisian food hubs (Enfidha and Chebika) mulching test on tomato crops. Objectives: To estimate the effects of biodegradable mulch films on tomato performance – To create awareness among Tunisian farmers of innovative agronomical practices such as the use of biodegradable mulch films.

The biodegradable mulch film based on the biopolymer FD22_PC01 resulted suitable for the mulching of tomatoes in Tunisian Food Hubs and their related conditions (crop selected, weather). Guidelines and protocols of adoption for biodegradable mulch film resulted well implementable towards the actual agronomics practices in use.







Food Hub	Innovation	KPIs measuring the achievements
Chebika (TN)	Biodegradable mulching	At least 20% reduction of input use (herbicides for weed control; water)
		About 30% increase of tomato yield

Biodegradable mulching was resulted efficient in improving tomato performance, specially considering the ameliorating of yield, fruit weight and reduction of input use on the culture. Tests showed some discrepancies on performance of mulching but related to the fluctuation in the daily weather conditions among the seasons of trials. However, the farmers recognized the efficiency of biodegradable mulching use in improving the open field tomato quality and yield and showing his willingness to use it and to encourage the neighbours to do the same.

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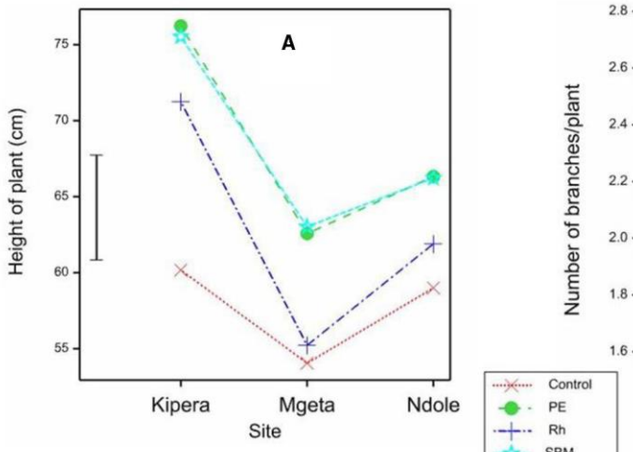
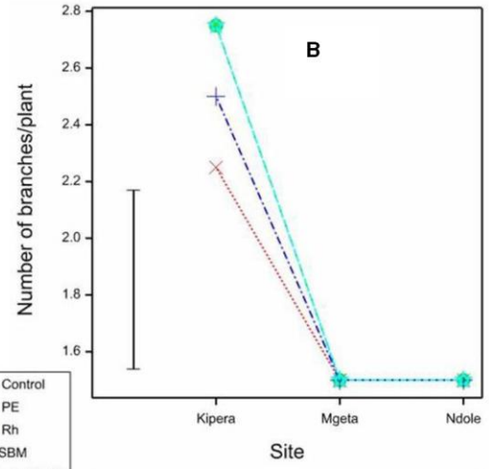
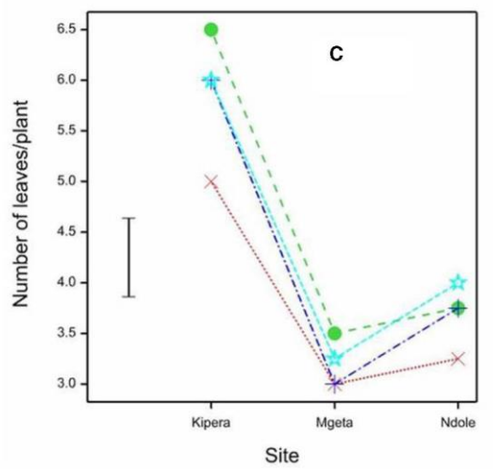
THE BIODEGRADABLE MULCH FILMS TRIALS IN TANZANIAN FOODHUB

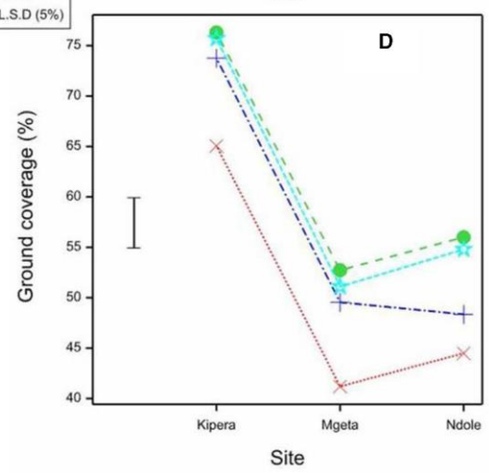
RESULTS – TANZANIA - Sokoine University of Agriculture, Morogoro

Sokoine University of Agriculture in Morogoro has performed first field mulching trials with common bean seeds in three agro-ecological zones around Morogoro. **Objectives**: to compare the effectiveness of different mulching materials (biodegradable mulch film, pimento grass mulch and maize straw mulch) on performance of common beans crop, traditionally not mulched.





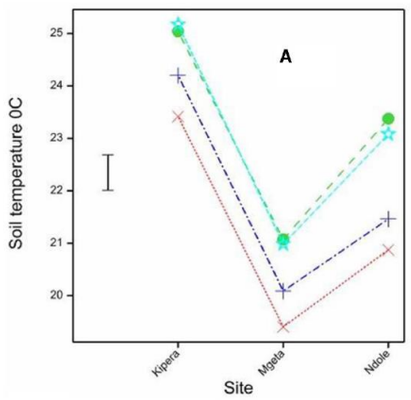


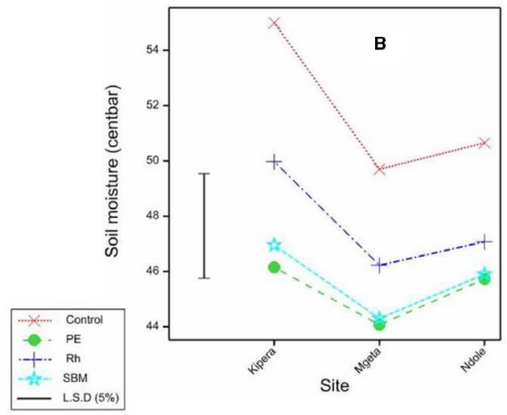


A good functionality of biodegradable mulch film FD22_PC01 has been observed during the whole crop cycle confirming the mulch use feasibility on such new crop. Specially, also the supplied guidelines and protocols resulted also reliable for the beans crop.

Food Hub	Innovation	KPIs measuring the achievements
Mvomero TZ	Biodegradable mulching	6% increase in yield compared to rice husk mulching 49% increase compared to no mulch use

Biodegradable mulch films (SBM) outperformed the other treatments resulting in a substantial increase in biomass production. SBM has demonstrated its efficacy in opening new agronomical practices on beans crop, while concurrently saving the environment and promoting sustainable production.





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CONCLUSIONS

BIODEGRABLE MULCHING APPLICATIONS

- A proper disposal of the mulch films in waste management plants at the end of its life, resulting in higher cost for farmers and for the municipalities;
- Environmental pollution due to accidental dispersion of non-biodegradable plastic fragments in the arable fields (white pollution).

- **Certified biodegradable in soil mulch films offers an agronomically and environmentally efficient alternative to traditional plastic films**, minimizing environmental impact and saving time and resources in managing the end-of-life of mulched crops.

- Novamont's biodegradable films are suitable, for mechanical and manual lying. In the case of mechanical lying, NVMT film can be lye using the same machinery as for traditional plastic film and at similar speed and gear, requiring no additional cost for farmers.

- The results of biodegradable mulching film revelated the high potential of biodegradable materials for agricultural applications, demonstrating suitable both for the conditions of African countries and on the local strategic crops.

- **Biodegradable mulch film has demonstrated its efficacy in enhancing crop productivity** while concurrently saving crop inputs and promoting a sustainable production

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Thank you !

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