

BIODEGRADABLE AND COMPOSTABLE MULCH FILM

USER MANUAL



MATER-BI

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WHAT IS MATER-BI

MULCH FILM MADE FROM MATER-BI

MATER-BI is a range of completely **biodegradable** and **compostable thermoplastic materials**, designed to provide a 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.

By minimising the impact on the environment and saving time and resources in managing the end of life of mulched crops, MATER-BI mulch film provides an agronomically and environmentally efficient alternative to traditional mulch film.

MATER-BI film has similar mechanical properties and usage characteristics to those of traditional plastic films, as proven by over 10 years of research and development and commercial use in the field:

MATER-BI is produced using renewable resources made from plant material such as starches from different crops (e.g. corn, other cereals and potatoes) and vegetable oils. Specific types of MATER-BI have been developed for a range of agricultural applications including mulch film.

- It is laid and perforated with the same machinery used for traditional plastic film and as it can be laid very thin it provides excellent yields [1];
- It eliminates the production of plastic waste requiring disposal at the end of the crop: it does not have to be removed or disposed of at the end of the crop cycle. Thanks to its certified capacity to biodegrade when incorporated into the soil, it transforms into organic substances,

Life cycle of the film in the field



- water and carbon dioxide [2, 3, 4];
- It allows significant reductions in labour costs, eliminating the time required for removal and disposal at the end of the crop cycle [2, 3, 5];
- When biodegrading it does not pollute the soil, which can occur with traditional plastic if it is not correctly removed or disposed of in the field;
- It reduces overall greenhouse gas emissions (“from cradle to grave”)



emissions (“from cradle to grave”) (Figure 1): savings have been estimated at over 500 kg of CO₂ equivalent per hectare of mulch (considering coverage of the land with 6,000 m²/ha of mulch). Moreover, it reduces consumption of non-renewable energy resources by around 80% compared with traditional plastic film. This data was obtained considering

the typical end-of-life scenario for plastic materials in Italy where 10% is recycled, 14% is incinerated and 78% is sent to landfill after use [6].

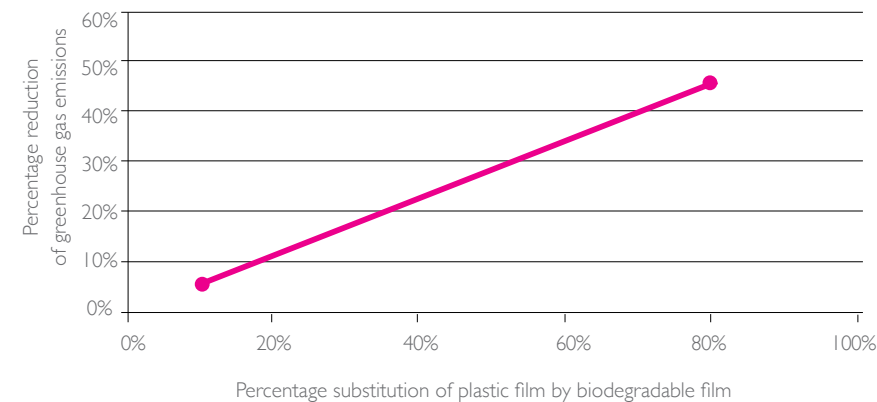


Figure 1
Percentage reduction in greenhouse gases, based on the percentage substitution of traditional plastic film by biodegradable MATER-BI mulch.

Figure 1

CERTIFIED BIODEGRADABILITY AND COMPOSTABILITY

The MATER-BI range for mulching film products comprises materials having the following certifications:

- European standard **UNI EN 13432:2002**, "Requirements for packaging recoverable by composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging" relating to packaging material;
- European standard **UNI EN 14995:2006**, new standard,
- American standard: **ASTM D6400:2004**, "Standard Specification for Compostable Plastics";
- French standard **NF U52-001** "Matériaux biodégradables pour l'agriculture et l'horticulture – Produits de paillage – Exigences et méthodes d'essai" specifically concerning the biodegradability of mulch film.

"Plastic materials. Evaluation of compostability. Test scheme and specifications";

Regarding these standards, the MATER-BI material developed and used to produce mulch film has been awarded the following certifications:

- **"COMPOSTABLE"** issued by DIN CERTCO (Germany) and by BPI (Biodegradable Institute, USA).

- **"OK COMPOST"** and **"OK BIODEGRADABLE SOIL"** issued by the Vinçotte certification organisation (Belgium). MATER-BI mulching film is the only product on the market to have obtained 'OK SOIL' certification for both the raw material and also the finished product;

Table 1

Certifications obtained by the MATER-BI material used to produce mulch film.

The table shows the certifications, standards and marks obtained by the MATER-BI material used in the production of mulch film. For additional information on the standards and marks, see the Glossary.





mark	description of the mark	certification organisation
	ENI 3432/ENI 4995 Compostability mark	VINÇOTTE (Belgium)
	ASTM D 6400 Compostability mark	BPI - BioPolymer Institute (USA)
	ENI 3432 Compostability mark	DIN CERTCO (Germany) and ABA (Australia)
	Biodegradable in the soil mark	VINÇOTTE (Belgium)

Table 1

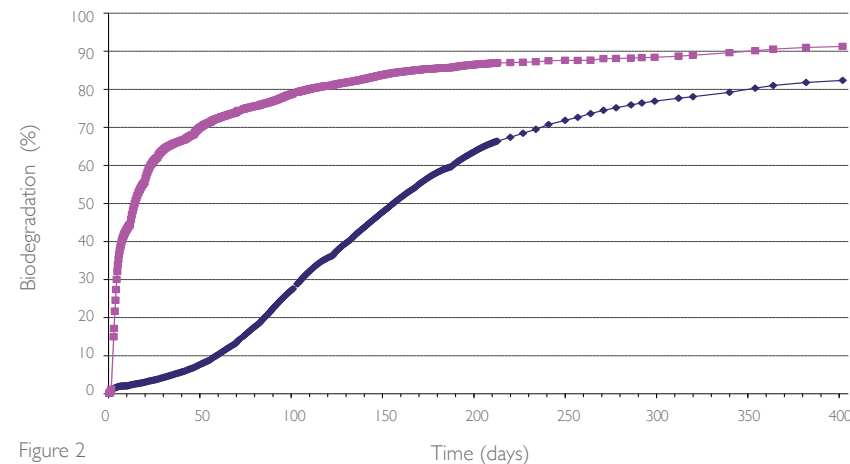


Figure 2

Figure 2

Biodegradation curve of MATER-BI for mulch compared with the positive control normally used in tests (cellulose). Biodegradation is expressed as percentage biodegradation in relation to time (in days).

Key:

- Purple curve = positive control, cellulose
- Dark blue curve = MATER-BI for mulch

TYPES OF MULCH FILM MADE FROM MATER-BI

Thanks to the versatile characteristics of MATER-BI bioplastics used in agricultural applications, mulch film can be used in different environmental conditions, for the cultivation of different species of plants and at different times of the year. Materials are primarily chosen to suit climate, length of production cycle and growing conditions (in the open field or as a protected crop). MATER-BI mulch film has been optimised for the specific characteristics required: duration in the field, mechanisation, thickness and agronomic performance.

As an example, Table 2 shows information on different crops, containing data collected in the field during tests over the course of more than 10 years of experimentation and optimisation of MATER-BI mulch film [2, 3, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 26].

crop	period	agronomic technique	area	duration (months)
Various vegetables (solanaceae, cucurbitaceae)	Spring - summer	Open field/tunnel	Italy, Greece, Spain, Germany, USA, Australia	3 - 8
Courgette	Spring - summer	Open field	Italy	3 - 5
Pumpkin	Spring - summer	Open field	Italy, Germany	4
Lettuce	Spring - autumn	Open field/tunnel	Italy, France, Germany	2 - 3
Solanaceous (tomato, pepper, aubergine)	Spring - summer	Open field/tunnel	Italy, Spain, France, Australia, USA, Canada	4 - 6
Melon	Spring - summer	Tunnel/small tunnel	France, Italy, Greece	3 - 4
Melon, cucumber	Spring - summer	Open field	Italy, Greece	3 - 4
Rooted cuttings	Spring - summer	Open field	Italy	6
Basil, parsley	Spring - summer	Open field	Italy, France	4
Potato	Spring - summer	Open field	Italy	4
Savoy cabbage, cabbage	Autumn - winter	Open field	Italy, Spain, Germany	4 - 5
Onion, garlic	Spring - summer	Open field	Italy, France	6 - 8
Gherkins	Spring - summer	Field/with nonwoven fabric	Germany	6
Corn	Spring - summer	Open field	Italy, Canada	4 - 6
Processing tomatoes	Spring - summer	Open field	Italy, Spain	5
Strawberries	Summer - spring	Open field with small tunnels/in tunnels	Italy, Spain, Belgium, Germany	6 - 12
Vine	From Spring/Autumn	Open field	Italy (North and South)	12 - 18
Berries (raspberries, blueberries)	Autumn/spring	Open field	Italy (North and South)	6 - 12

Table 2
MATER-BI mulch film: crops, usage periods, farming conditions, area of use and duration.



PREPARATION OF THE SOIL

The methods used for working and preparing the land (ploughing, milling, etc.) are largely the same as those used with traditional plastics for vegetable crops.

However, in order to obtain the best results, both for controlling weeds and for the mechanical performance of the product, it is essential to prepare the soil correctly before laying out MATER-BI mulch film.

The soil should be refined and prepared to ensure that stones and any crop remains, particularly harder items (e.g. corn or sorghum stalks, etc.), do not damage the film whilst it is being laid.

Greater care must be taken when laying mulch film over soil with a high percentage of rock fragments or stones, and if possible the surface must be prepared using a bed former capable of burying the crop remains and rock fragments in the soil.

Laying the film correctly guarantees it will last longer in the field.

MATER-BI mulch film should not be laid immediately after surface application of manure (even if it is mature), in order to prevent the organic fertiliser from causing early biodegradation owing to its high micro-organism content.

However, if fertilisation is conducted one or two months in advance, as usually occurs in normal farming practices, then the film will not be affected in any way.



LIFE CYCLE OF THE FILM

LAYING OUT THE FILM

The laying out of MATER-BI mulch film and the preparation of the soil are the most important operations to guarantee successful results in the field.

The film can be laid mechanically using the same machinery as for traditional plastic film and at similar speed and in the same gear.

It is essential to ensure the correct calibration of the mulch laying machine to ensure the MATER-BI film is laid properly; the film tension must be reduced to a minimum to prevent



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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 laying machine so to avoid applying excessive stress to the film during this operation [1, 23, 24].

It is also advisable to avoid using any rollers which pass over the film once it has been laid out in order to improve its adherence to the soil. Since it is very thin MATER-BI mulch film will stick to the ground perfectly after a number of days.

The main producers of mulch laying machines can now provide information about the ideal configurations for laying MATER-BI mulch film. In addition, some mulch laying machines on the market have been optimised for the application of thin film made from MATER-BI.

Finally, care should be taken when using rollers for micro-perforations in the field (or to create perforations



that allow irrigation waters to penetrate the soil more easily). If not adequately performed, these perforations may allow too much light to penetrate the film, stimulating weed growth which could prematurely damage the film. In order to avoid the problems associated with the improper application of micro-perforations, perforated films are also available. However, if carried out carefully, the micro-perforation

of laid film is well tolerated, especially for shorter crop cycles (e.g. spring-summer lettuce). In particularly windy areas, it is advisable to anchor the mulch film to the ground with small quantities of soil (a shovelful is sufficient) every 2-3 metres on exposed areas.

It is advisable to lay the film and transplant cuttings at the same time (using a mulch laying and transplanting machine), or to minimise the time between these operations. This will make it possible to take full advantage of MATER-BI mulch film.



PERFORATION

Perforation is generally carried out when the film is laid and is therefore completely mechanised.

It is conducted using the same machines and procedures used for traditional plastics, bearing in mind that MATER-BI film is more elastic.

Ideally the systems used should perforate the film when it is already positioned on the ground.

For manual perforation, equipment should not be used that could

produce holes with irregular edges (e.g. cut tin cans) because these cuts can damage the film prematurely.

One of the best ways to make perforations 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.

Holes made using cylindrical implements (including hot cylinders) make it possible to create holes with "clean" edges suitable for MATER-BI mulch film.



CULTIVATION TECHNIQUES

The use of MATER-BI mulch film does not require any change in normal cultivation techniques.

Irrigation

MATER-BI is compatible with the same irrigation systems used with traditional plastic mulch materials: drip irrigation, spray irrigation and surface irrigation (less commonly used with vegetable crops).

The use of MATER-BI mulch film does not lead to changes in the quantity of water used, capacity or irrigation intervals compared with traditional materials [20, 25].

Use of fertilisers

and agricultural inputs

No research agencies, universities or end users have reported any damage or negative interactions between MATER-BI mulch film and fertilisers and agricultural inputs, at the same doses and in the same periods used normally during cultivation with traditional plastic film.



CONTROLLING WEEDS

Test results and data from the widespread use of black MATER-BI mulch film in the field have shown it is as effective at controlling weeds as traditional materials of the same colour.

However, particular attention should be paid to certain species of weeds: field tests have shown that major infestations of horsetail (*Equisetum* sp.) and sedge (*Cyperus* sp.) can damage MATER-BI mulch film, which also occurs with thinner varieties of traditional plastic materials [21, 22].



The duration of MATER-BI mulch film in the field depends greatly on environmental factors (rain, thermal regimes, solar irradiation, etc.) and therefore it does not depend solely on the action of micro-organisms in the soil.

MATER-BI mulch film with a thickness of 15 μm is used to grow a wide range of vegetable species with crop cycles of between 2 and 6 months: from lettuce or leaf crops transplanted in the spring or summer to solanaceae grown in the open field [2, 3, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 20, 25, 26]. Crops with a longer crop cycle e.g. the cultivation of strawberries with an annual cycle (or which remain in the field for between 9 and 12 months and which are transplanted in summer-autumn), MATER-BI mulch film has shown good performance in typical conditions in Mediterranean areas (Spain and Italy), with thickness of 18-20 μm [5, 11]. MATER-BI film maintains its mulching capacity for longer in autumnal crop cycles than in the spring or summer, owing to the reduced impact

of temperature and solar irradiation, and due to the reduced activity of micro-organism populations in the soil. Finally, for crops for which the soil must be covered for periods of over a year, MATER-BI film with a thickness of 40 μm and above is recommended. Applications include small fruits (raspberries) and new vine plantations [19].

In Table 2 (page. 10)

Shows the main crops on which black MATER-BI mulch film is used, in different climatic and geographic conditions and with film of different thickness.

DURATION OF THE FILM

LIFE CYCLE OF THE FILM

AT THE END OF THE CROP CYCLE



MATER-BI 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. This operation provides MATER-BI mulch film with the ideal environment to end

its life cycle through the mineralising action of soil micro-organisms, transforming it into water, carbon dioxide and biomass.

Mulch film made from MATER-BI which is left on the surface rather than being worked into the soil will take longer to biodegrade.

A range of different operations can be used to work MATER-BI mulch film into the soil depending on the type of soil and its state at the time of the operation.

Soil conditions and environmental factors are therefore the fundamental elements in determining the biodegradation of the material. For example during the winter, with low soil temperatures, or in lands that remain saturated with water for long periods of time, the biodegradation processes will naturally take longer.



Biodegradation of the film in the soil

At the end of the growing cycle the biodegradable film is milled into the land together with crop remains.

LIFE CYCLE OF THE FILM

STORAGE

The processes used for storing MATER-BI mulch film are different from those used for the storage of traditional plastics film.

When not being used, bobbins of MATER-BI mulch film must always be stored inside the farm store in their original packaging, protected from water, light and sources of direct heat. Bobbins stored correctly may be used in subsequent seasons.

If the bobbin is not replaced in its original packaging after use, it is advisable to keep them upright to avoid flattening, deformation or breakage. Various tests have shown that when MATER-BI mulch film is properly stored it can be used

in subsequent seasons, with satisfactory performance and agronomic behaviour:

Accidental breakages caused by improper storage of materials or damage during transport may have a negative impact on the life of the film in the field. If possible, any damaged parts of the film should be removed before use.



GLOSSARY

Biodegradation

Degradation caused by biological activity, especially through the action of enzymes, leading to a significant change in the chemical structure of a material.

Biodegradable

An organic substance which can be broken down by the action of living organisms. Complete biodegradation leads to a total conversion of the organic substance into inorganic molecules, such as carbon dioxide (CO₂), water and methane (depending on the environment). It is important to note that the definition of biodegradable should include the biodegradation environment and the time frame. In other words, it is necessary to define the conditions under which biodegradation is expected to occur and how long it will take. Without defining these elements the term 'biodegradable' becomes vague and useless, since virtually any organic substance is biodegradable over an unlimited period.

Compostability

Property of a biodegradable organic material (kitchen scraps, garden waste, manure, etc.) to be converted into compost in a compost site.

Compost

Humus or soil improver; it is the result of the decomposition and humification of a mixture of organic material (e.g. material from the pruning of plants, kitchen scraps, manure, effluent or gardening waste) by macro and micro-organisms under specific conditions: the presence of oxygen and a balance between the chemical elements of the material being transformed.

Degradation

Molecular breakdown of materials caused by the action of microbes (biodegradation), water (hydrogenation) or light (photodegradation) or by any other action that can cause this breakdown.

Abiotic disintegration

Fragmentation of plastic materials due to physical and/or chemical environmental factors, such as oxidative embrittlement (heat ageing) or photolytic embrittlement (ageing caused by light or UV rays), without involving biological processes.

Life cycle assessment (LCA)

An objective method for evaluating and quantifying the energy and environmental consequences and impacts associated with a product/process/activity throughout its entire life

cycle, from the acquisition of raw materials until its end of life ('from cradle to grave'). The importance of this technique lies principally in its innovative approach, in which all phases of a production process are considered related and interdependent, making it possible to evaluate the cumulative environmental impacts.

Standard

UNI EN 13432, "Requirements for packaging recoverable by composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging": defines the compostability characteristics and requirements of a material. According to this standard, compostable materials must have the following characteristics:

- Biodegradability, meaning the capacity of a material to be converted into CO₂ by the action of micro-organisms. In order to present complete biodegradability, the material must be at least 90% biodegraded in less than 6 months;
- Disintegrability, namely fragmentation and invisibility in the final compost. After 3 months in compost the fragments of the compostable material must have disappeared, leaving no more than 10% of the substance with a diameter of over 2 mm;
- Absence of negative effects on the composting process;

- Low levels of heavy metals (in relation to pre-defined maximum amounts) and the absence of negative effects on the final compost (e.g. reduction in the agronomic value and presence of phytotoxic effects on plant growth). Standard UNI EN 13432 is a harmonised standard, meaning it has been published in the Official Gazette of the European Community and has been implemented in Europe at a national level. Moreover, it grants presumption of conformity with European Directive 94/62 EC on packaging and packaging waste.

UNI EN 14995:2006, "Plastics – evaluation of compostability – test scheme and specifications": extends the scope of UNI EN 13432 to plastic materials not used in packaging, such as plastics used in agriculture and bags for the collection of waste. The requirements and test scheme are identical to those of UNI EN 13432.

ASTM D6400:2004, "Standard Specification for Compostable Plastics" - relating to specific techniques employed in order to define a plastic material as compostable. Very similar to the methods

GLOSSARY

used in UNI EN 13432:2002 and UNI EN 14995:2006.

NF U52-001, "Matériaux biodégradables pour l'agriculture et l'horticulture - Produits de paillage - Exigences et méthodes d'essai": a French standard relating to mulch film. Alongside methods and tests to determine the biodegradation of the material, it also defines the duration of mulch films in the field in different environments (average life of the product). Based on their duration, biodegradable mulch films are divided into different classes.

UNI 11183:2006, "Plastic materials biodegradable at ambient temperature - Requirements and test methods"; this standard defines the biodegradability requirements that must be met by plastics used to make items that can be disposed of through aerobic biodegradation at ambient temperature. Ambient temperature means the temperature range of temperate regions excluding the high temperatures typical of industrial composting. As a rule the ecotoxicity requirements of the plastic materials are also taken into consideration (Source: UNI).

OK Biodegradable Soil: a conformity mark issued by the Belgian certification organisation Vinçotte

for products and materials which are specifically biodegradable in a typical soil. This mark guarantees the product/material is completely biodegradable in the soil, without the need for additional treatments, during a period determined by international criteria, and also guarantees it will not have any negative effect on the soil. For further information on Vinçotte's certification systems visit:

www.okcompost.be/en/home

"Compostable DIN CERTCO" certification: DIN CERTCO is the German certification organisation which issues a range of certificates, including those for biodegradable materials. DIN CERTCO has prepared a certification scheme for compostable products made from biodegradable materials.

The certification process is conducted in accordance with the principal international standards: DIN EN 13432 and ASTM D6400. For further information visit the DIN CERTCO website: www.dincertco.de/en



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Electronic or hard copies of this manual, together with articles of particular interest, may be requested from:
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Disclaimer

The data contained in this manual is based on the current knowledge and experience of NOVAMONT in the area of biodegradable and compostable materials and on information from manufacturers which use NOVAMONT materials to produce mulch film. As the producer of the materials, NOVAMONT, warrants exclusively that such materials meet the characteristics indicated in the technical specifications and in the safety data sheets provided to manufacturers which use NOVAMONT materials to produce mulch film.



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NOVAMONT has long been convinced of the possibility of truly sustainable development. Since 1989 NOVAMONT researchers have been working on an ambitious project combining chemistry, agriculture and the environment: "Living Chemistry for Quality of Life".

Objective: the creation of low environmental impact products.

NOVAMONT's research resulted in MATER-BI, a range of completely biodegradable and compostable thermoplastic materials. MATER-BI performs to the same standards as traditional plastic but creates energy savings, helps reduce the greenhouse effect and is transformed into fertile humus at the end of its life cycle, ready to start the process over again. **The dream is becoming a reality.**

