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Midas

MARGINAL LANDS, INDUSTRIAL CROPS AND INNOVATIVE BIO-BASED VALUE CHAINS

Deliverable D2.7 Applying MIDAS's products on fields

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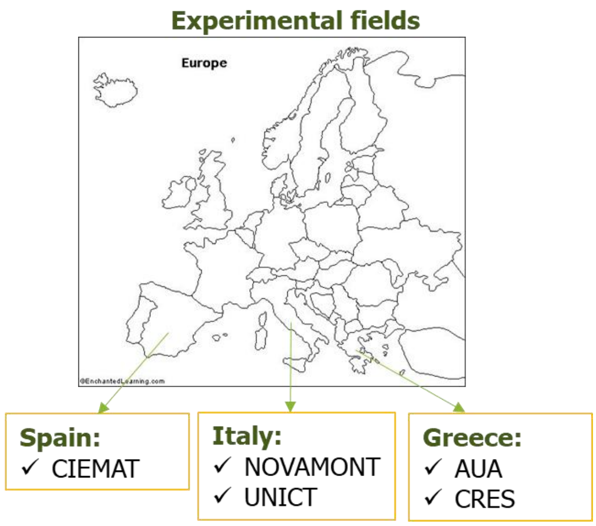
Table of Contents

1 Introduction

D2.7 is going to present the work that have been done within the first 24 months of the project in sub-task 2.2.3. The aim of this subtask was to test and apply part of the bio-based products developed in WP4 (bioherbicide, biostimulant, and soil amendment and soil mulch films) by Novamount and RECORD will be applied on field trials for their sustainable and effective uses. The trials have been established in Italy (Novamont, UNICT), Greece (AUA, CRES), Spain (CIEMAT) with three non-edible crops namely hemp, castor bean and sorghum (Figure 1). Biochar is being applied in a quantity of 5t/ha. In the case of bioherbicide it will also tested on castor bean before the harvesting in order to stop the growth and better scheduled the mechanical harvesting. Wood winegar produced by RECORD will be applied as pre-sowing seed primer. Soil analysis have been conducted at the beginning and at the end of the experiment. Field-scale data on crop response -growth and yield measurements- are being taken and conclusions will be resulted on the best by-product to be used for each crop and location.



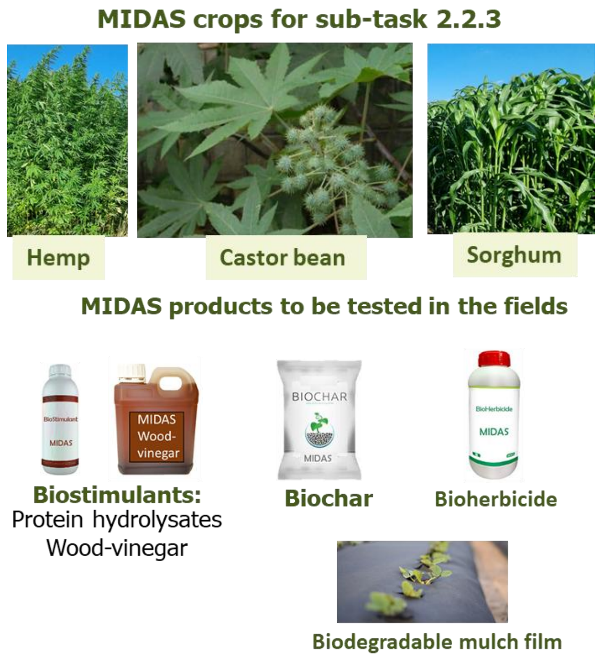


Figure 1: The view of sub-task at a glance (sites of the trials, crops will be included and MIDAS products that will be applied on the fields

2 Activities and results per partner

2.1. Field trials of CIEMAT/Spain

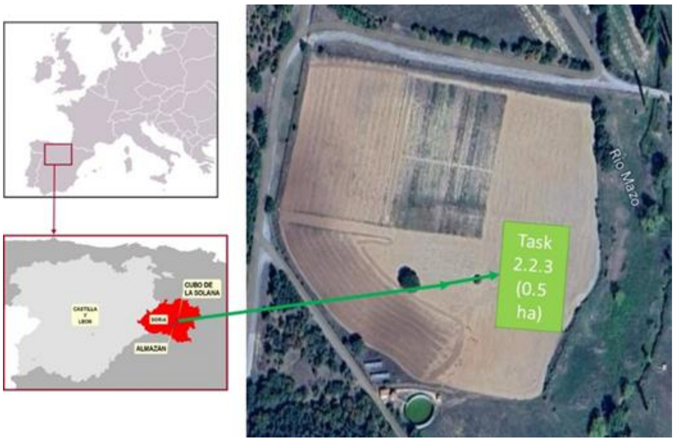


Figure 2: Location of experimental fields of CEDER- CIEMAT in Lubia (Soria)

The experimental site is located in Cubo de la Solana (Castile and León, Spain) and covers an area of 0.5 ha hectares (Figure 2). The soil is characterized by low organic matter ≈1%, as well as high sand content and significant stoniness (>15%), conditions that enhance drainage but may require measures to improve water retention and fertility. Climate conditions were Continental Mediterranean with cold winters, warm summers and low rainfall level.

The crop used for the field test were Hemp cultivar Futura 83 (Figure I). The plots were established following a randomized strip design with three repetitions of 10 m2 per bioproduct. For the establishment of the crops 260 kg/ha of an N-P-K: 22-8-10 fertilizer was applied the 21th of May of 2024 in pre-sowing. After the fertilization, a tillage operation with a cultivator was performed the 23rd of May of 2024. Finally, the sowing was done manually at a dose of 125 plants/m2. Two products were applied this season: biochar at a dose of 5 t/ha before fertilization and biodegradable mulch film (1 layer) before sowing.

The growing season was characterized by no rainfall in July and high temperatures (See Figure II), this situation together with the late sowing led to not harvesting hemp. Biodegradable mulch film was received 11th of June and installation was done 1st July and immediately after this hemp was sowed in mulch film plots as well as in the biochar ones. This variety of hemp was successfully grown (>1 Mg DM/ha) in the same soil for the breeding material tests of Task 2.2.1, the main difference was that in T2.2.1 the crop was established ≈40 days before. Figures 4-7 show photos of the establishment of the plots at its final development that was insufficient to allow its harvest.

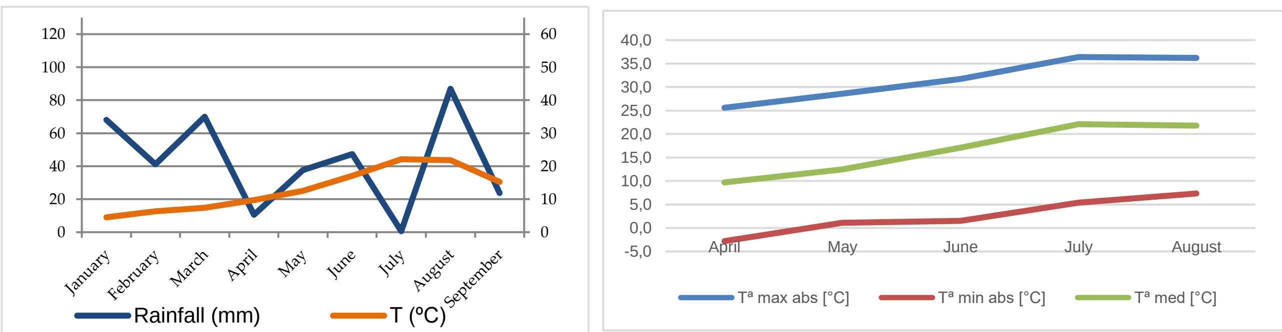


Figure 3: Ombrothermic diagram and temperatures in 2024

Figure 4: General view bioproduct trials (Biochar and Biodegradable mulch film) (July 2024)

Figure 5: Detail of Biochar and Biodegradable mulch film plots (01/07/24)

Figure 6: Detail of the manual sowing in the mulch film (01/07/24).

Figure 7: Maximum development of hemp for both experiments (27/08/24)

In the next growing season, we will establishment hemp with biochar and mulch film again at least 1.5 months earlier. At least one additional bioproduct is expected to be tested next season together with the mulch film and the biochar.

2.2. Field trials of UNICT/Italy

The biochar trial conducted by UNICT will assess the response of castor (*Ricinus communis* L. variety C1012), sorghum (*Sorghum bicolor* (L.) Moench variety Sweet Betty) and hemp (*Cannabis sativa* L. variety Futura 83) to the soil conditioning with biochar under non-limiting soil water availability. The trial has been set at the Experimental Farm of the University of Catania (10 m a.s.l., 7°24′ N, 15° 03′ E) in a soil with the following conditions: 11.8% silt, 55.9% sand, 32.3% clay, 1.4% organic matter.

Figure 8: Soil amended with biochar before tillage.

Biochar was applied in a quantity of 5t/ha on 3 plots of 19.8 m^2 (5.5 m x 3.6 m) on 7/05/2024 (Figure 8) and the soil was subsequently tilled with a disk harrow.

The plots were fertilized with 80 kg/ha of N provided as ammonium sulphate and 100 kg/ha provided as monocalcium phosphate. A control plot was treated with the same amount of fertilizer without the biochar soil amendment.

The sowing took place on 3/06/2024 using a manual single-row seeder (Terradonis) at 3.3 m-2, 11 m-2 and 125 m-2 germinable seeds density for castor, sorghum and hemp respectively. Irrigation is provided by a drip irrigation system providing 100% of maximum crop evapotranspiration (ETm) restoration. Daily ETm is calculated according to: ETm = ET0 × Kc where ETm is the maximum daily evapotranspiration (mm) and Kc is the crop coefficients (Kc) according to (Allen et al., 1998, p. 56).

The total aboveground biomass has been harvested at the end of the growing cycle (4 November for hemp and 21 November for castor and sorghum) from 1 m2 plots replicated 3 times. The seeds, stems and threshing residue have been separated manually from the biomass to determine the yields of the components. The analysis of the data for castor and sorghum is ongoing.

The addition of biochar had a non-significant effect on aboveground biomass (AGB) yield (Table 1), while the effect was more pronounced on the biomass composition, leading to lower stem yield, while achieving higher seed yield and threshing residue production (Figure 9).

Soil mulch will be tested by UNICT at the Experimental Farm of the University of Catania under non-limiting soil water availability on sorghum, castor and on hemp (spring 2025). Direct sowing will be performed at 3.3 m^{-2} and 11 m^{-2} germinable seeds density for castor and sorghum respectively, keeping a distance of 0.6 m between the lines.

Table 1: T-test

Variable	p value
AGB yields	0.50
Stem yields	0.06
Threshing residues	5.58×10^{-05}
Seed yields	0.029

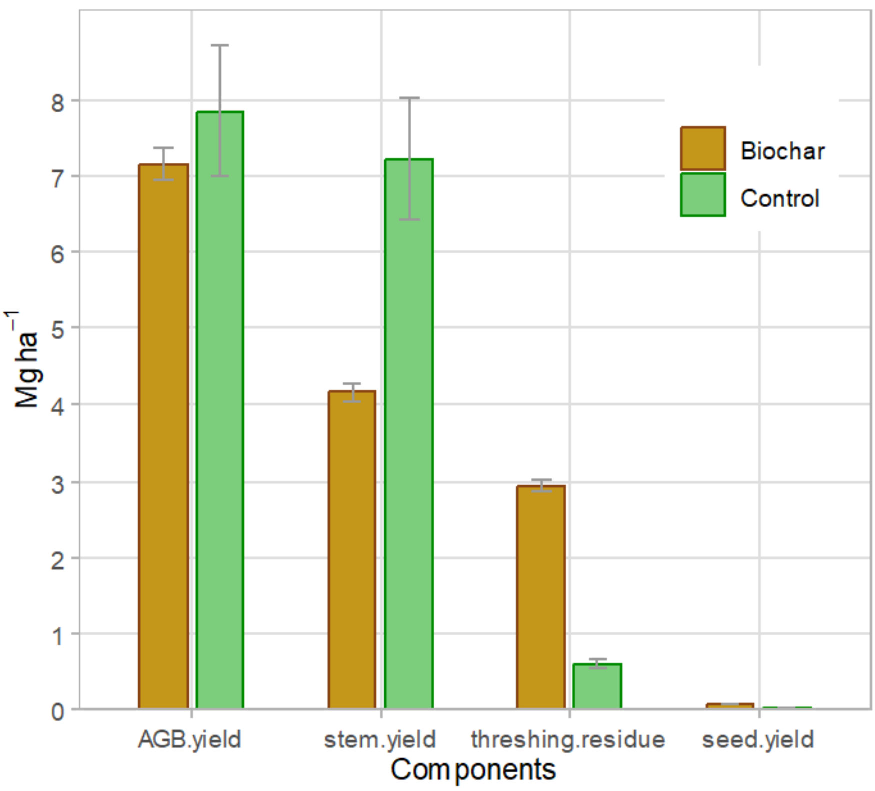


Figure 9: AGB yield, stem yield, threshing residue and seed yield of hemp variety Futura 83 amended with biochar in comparison with the not amended control.

2.3. Field trials of AUA & CRES / Greece

During the first growing period of sub-task 2.2.2 a field trial was set up in Greece where biochar provided by RECORD was applied on the soil before the sowing of three industrial crops (sorghum, castor bean and hemp) had been compared. The total size of the field trial was 60 m^2 and it was split in three plots, 20 m^2 each. The trial was set up on 22nd of April 2024.

Castor bean and hemp were harvested on 27th of September 2024, while sorghum was harvested a month later. The seed yields of castor bean were quite good (3.8 t/ha), while the yields of hemp were too poor. Hemp growth and yields were affected by the extreme heat between mid-June till end of July and as it is presented in Figure 10 the plot of hemp had very poor density and the hemp plants were very short, almost without leaves. On the contrary the growth and yields of sorghum was very good with dry yields of 22 t/ha.

Figure 10: View of the trial where biochar was applied before the sowing of three annual industrial crops

This trial is going to be carried out in 2025 and the tested crops will be rotated in the area of 60m2. Additional trials will set up to test additional MIDAS's products on the fields (Figure 11). In summer 2025 mulch films from Novamont was sent to CRES. The time that arrived didn't give the possibility to be applied on a field trial and thus this activity is being postponed for 2025. Moreover, in 2025 a castor bean field trial will set up in Greece in order pelargonic acid to be applied two weeks before the final mechanical harvesting of the plantation. Novamont will visit the field trial and will be present during the pelargonic acid application. The wood-vinegar produced by RECORD in 2024 is expected to be arrived at CRES in the beginning of 2025 is going to be used on seeds before sowing following the application protocol that will be provided by RECORD.

Figure 11: View of the MIDAS's products that will be applied in 2025 field trials

2.4. Bio-based products developed by RECORD

Biochar production and characterization

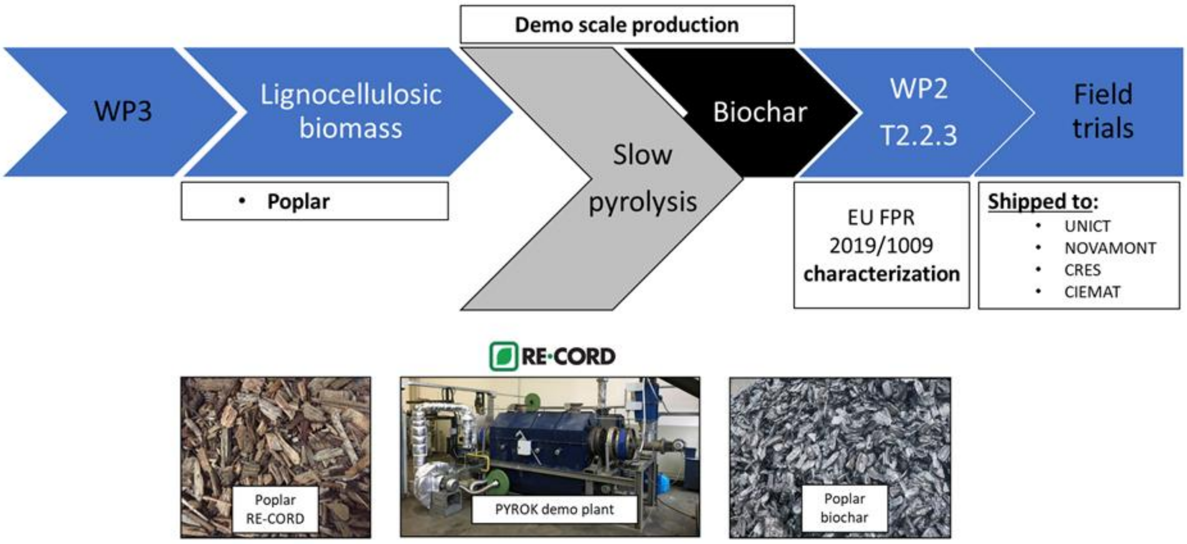


Figure 12: Biochar production scheme

Figure 13: Poplar biochar produced in RE-CORD demo-plant

Main physico-chemical characteristics, metals and organic contaminants concentrations of the poplar biochar (Figures 12, 13) produced in the RE-CORD Pyrok plant through slow pyrolysis process (TMAX= 550°C), are shown in Table 2. The production process description will be presented in D4.11 (M36).

The material characterization was done following the European Fertilizing Product Regulation (EU Reg. 1009/2019, considering the parameters related to CMC14 (biochar) and PFC3(A) (soil improver). Specific requirements for CMC 14 (biochar) refer to organic pollutants content, such as PAH-16 (polycyclic aromatic hydrocarbons), PCDD/F (dioxins and furans) and PCB (polychlorinated biphenyls. CMC 14 can be used alone or combined with other CMCs to constitute a PFC. The Product Function Categories n.3A and n.4, for example, permit to characterise a product as soil improver (PFC 3A) or growing medium (PFC 4). These classifications included thresholds for heavy metals content, such as Cd (Cadmium), Cr VI (Hexavalent Chromium), Hg (Mercury), Ni (Nickel), Pb (Lead), As (Inorganic Arsenic), Cu (Copper) and Zn (Zinc). In conclusion, biochar that complies the EU FPR requirements, is a very clean and safe vegetable carbon to be used for agronomic purposes.

Table 2: Biochar characterization

Parameter	U.M.	Value	Analytic method
Moisture	% w/w a.r.	2.33	UNI EN ISO 18134-2
Ashes 550°C	% w/w d.b.	7.98	UNI EN ISO 18122
Volatiles	% w/w d.b.	11.66	UNI EN ISO 18123
Fixed Carbon	% w/w d.b.	80.36	Calculated
Total C	% w/w d.b.	86.92	UNI EN ISO 16948
Total H	% w/w d.b.	2.07	UNI EN ISO 16948
Total N	% w/w d.b.	0.29	UNI EN ISO 16948
Inorganic C	% w/w d.b.	0.48	D.M. 13/09/99 Met. V.1
Organic C	% w/w d.b.	86.44	Calculated
H:C_{ORG}	mol/mol	0.28	Calculated
Bulk density	Kg/m^3 a.d.	263.00	UNI EN ISO 17828
pH	-	8.00	ISO 10390
EC (1:10)	mS/m	4.35	ISO 11265
WHC (% m/m)	% w/w	143	DM 01/08/1997 Met. 5
Granulometry			UNI EN ISO 17827-1
< 0,5 mm	% w/w	21.37	
> 0,5 mm	% w/w	6.19	
> 1 mm	% w/w	7.52	
> 2 mm	% w/w	16.85	
> 5 mm	% w/w	48.07	
d50	% w/w	1.89	
Specific surface area (BET)	m^2/g	88.00	ASTM D6556-10
Elements and metals			UNI EN ISO 16967 + UNI EN ISO 16968
Al	mg/kg d.b.	667.70	
B	mg/kg d.b.	b.d.l.	
Ba	mg/kg d.b.	45.27	
Ca	mg/kg d.b.	23141.55	
Cd	mg/kg d.b.	<0.20	
Co	mg/kg d.b.	b.d.l.	
Cr	mg/kg d.b.	6.46	
Cu	mg/kg d.b.	b.d.l.	
Fe	mg/kg d.b.	893.48	
K	mg/kg d.b.	4964.79	
Li	mg/kg d.b.	0.90	
Mg	mg/kg d.b.	2570.89	
Mn	mg/kg d.b.	73.98	
Mo	mg/kg d.b.	b.d.l.	
Na	mg/kg d.b.	321.15	
Ni	mg/kg d.b.	b.d.l.	
P	mg/kg d.b.	b.d.l.	
Pb	mg/kg d.b.	b.d.l.	
Si	mg/kg d.b.	1129.32	
Ti	mg/kg d.b.	32.62	
V	mg/kg d.b.	b.d.l.	
Zn	mg/kg d.b.	92.23	
As	mg/kg d.b.	<2	UNI EN 13657:2004 + UNI EN ISO 11885:2009

Tl	mg/kg d.b.	<1	
Hg	mg/kg d.b.	<1	
Cr VI	mg/kg d.b.	<0.5	DM 08/05/2003
Germination index	%	57	UNI 10780:1998 App.K
PAHs	mg/kg d.b.	<4	UNI EN 16181
Sum PCDDs+PCDFs	ngTE/kg d.b.	0.65	EPA 31613B 1994
PCBs	mg/kg d.b.	0.0151	EPA 1668 C 2010

a.r.= as received
d.b.= dry basis
b.d.l.= below detection limit

All the parameters confirm the compliance of the material as an organic soil improver for agronomic applications.

Wood vinegar production and characterization

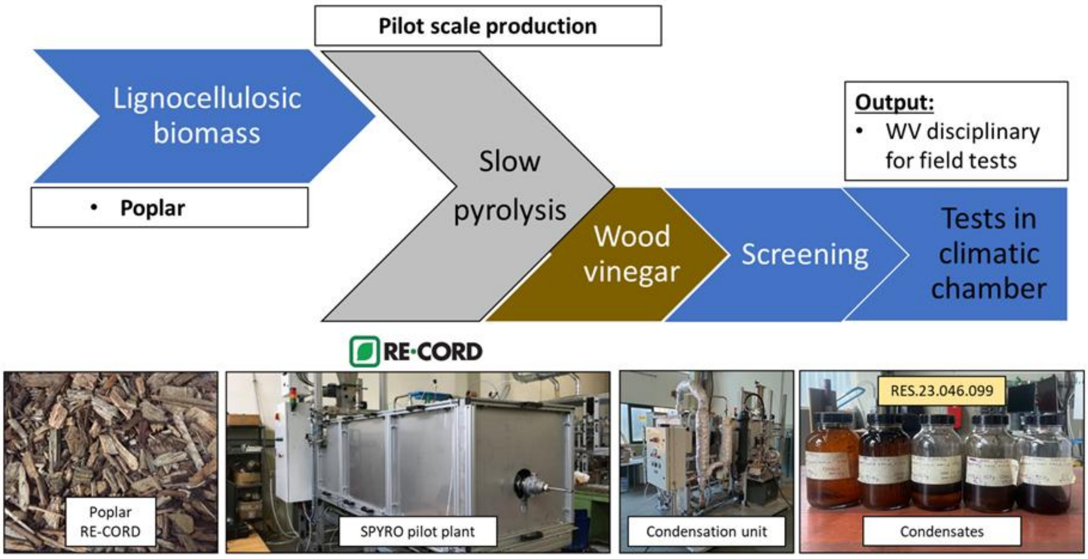


Figure 14: Wood vinegar RE-CORD production scheme in WP4 – T4.2.4

The wood vinegar production scheme is presented in Figure 14. Condensates were collected by the slow pyrolysis test performed in RE-CORD SPYRO pilot-plant. Wood vinegar was separated by gravimetric method and then characterized as shown in Table 3. Process description will be presented in D4.11 (M36).

Table 3: Wood vinegar - Aqueous phase (RES.023.046.099) characterization.

Code	U.o.M.	Value	method
Water content	wt%$_{wb}$	74.8	ASTM E203-24
TOC	mg/L	65719	APHA 5310
pH	-	2.77	ASTM E70-24
C	wt%$_{wb}$	13.7	ASTM D5291-21
H	wt%$_{wb}$	10.4	ASTM D5291-21
N	wt%$_{wb}$	0.2	ASTM D5291-21
O (calculated)	wt%$_{wb}$	75.7	-
HHV (measured)	MJ/kg wb	6.04	DIN 51900-1:2000 /3:2005
LHV (calculated)	MJ/kg wb	3.9	DIN 51900-1:2000 /3:2005
C (calculated)	wt%$_{db}$	54.6	ASTM D5291-21

H (calculated)	$wt\%_{db}$	7.9	ASTM D5291-21
N (calculated)	$wt\%_{db}$	0.8	ASTM D5291-21
O (calculated)	$wt\%_{db}$	36.7	-
HHV (calculated)	MJ/kg_{db}	24.0	DIN 51900-1:2000 /3:2005
LHV (calculated)	MJ/kg_{db}	22.4	DIN 51900-1:2000 /3:2005

The organic compounds characterization of the wood vinegar was performed by HPLC according to an internal standard method (RE-CORD 001) and following the NREL 42623 guidelines. The HPLC apparatus (LC-20 AT Prominence Shimadzu) is equipped with a refractive index detector, a Hi-Plex H column 300 x 7.7 mm (Agilent) and a guard column PL Hi-Plex H 50 x 7.7 mm (Agilent), operating at 55 °C with a flow of 0.6 mL min^{-1} with 0.005 M sulfuric acid as mobile phase. Twenty-five microliters of the wood vinegar sample were injected after a 0.2 µm syringe filtration. The quantitative analysis was accomplished after a 5-point calibration with pure standards following the NREL 42623 guidelines. Table 4 shows the composition of the wood vinegar. Acetic acid content resulted of 9.6% by weight on a wet basis.

Table 4: Wood vinegar - Aqueous phase (RES.023.046.099) composition.

		g_i/l_{H2O}	kg_i/kg_{H2O} *100
Carboxylic acids	Acetic acid	96,0	9,6%
Alcohols	Methanol	31,20	3,1%
Alcohols	Glycerol	12,12	1,2%
Aromatics	HMF	2,37	0,2%
Aromatics	Furfural	4,99	0,5%
Aromatics	Catechol	5,45	0,5%
Aromatics	Benzoic acid	0,88	0,1%
Aromatics	Phenol	4,46	0,4%
Aromatics	3-methoxycatech	0,00	0,0%
Aromatics	Guaiacol	0,00	0,0%
Ketones	3-methyl-1,2-cycl	2,55	0,3%

Wood vinegar was diluted with distilled water to obtain a final acetic acid (AA) concentration of 1 mM. A picture of the diluted wood vinegar is shown in Figure 15.

Figure 15: Wood vinegar dilutions at 1 mM (right), distilled water (left)

2.5. Bio-based products developed by NOVAMONT

The MIDAS project aims to develop and optimize low-ILUC (Indirect Land Use Change) cropping systems on marginal agricultural lands in Europe, promoting climate resilience and biodiversity. Through an integrated approach, the project seeks to deliver innovative bio-based products by following the biorefinery concept and the cascading use of biomass.

Within the framework of the project activities, Novamont has undertaken studies aimed at implementing innovative cropping strategies to enhance crops such as cardoon, safflower, and castor bean. These efforts are intended to supply raw materials to biorefineries and produce innovative bio-based products. Novamont, actively involved in both field trials (WP3) and in the valorization of crops for applications in the agricultural sector (WP4), has focused on oilseed crops used as feedstock. For these feedstocks, rich in compounds of interest for the applications envisioned in the project, the first 24 months of activities have demonstrated their convertibility into active ingredients and molecules through Novamont's proprietary chemical and biotechnological processes. These compounds can be incorporated into formulations to develop the bio-based products targeted by Task 2.2.3 and the project as a whole.

Specifically, WP2, and in particular Sub-task T2.2.3, “Circular use of MIDAS products on marginal lands”, aims to directly test in the field some of the bio-based products developed within the WP4 “Innovative bio-based products”. For Novamont, this sub-task has involved the field application of bio-based bioherbicides, biostimulants, and soil mulch films in Italy, focusing on non-food crops such as hemp and castor bean. The objective is to assess the sustainability and effectiveness of these products. The outcomes of these activities are expected to identify the most suitable bio-based products for each crop and location, thereby enhancing the circular and sustainable value of the project.

Regarding biostimulants, a pilot-scale process was developed for obtaining and purifying protein hydrolysates from cardoon oilseed cakes, which can be used as a base for biostimulant formulations. Current activities are focused on producing new protein hydrolysates from safflower oilseed cakes and evaluating their biostimulant activity, with the goal of developing formulations to be employed in Task 2.2.3 field activities.

For soil mulch films, a reference biopolymer with optimized chemical-physical and mechanical properties for blown film applications was produced using Novamont’s proprietary process. Within Task 2.2.3, this material was converted into black mulch films, which were shipped to partners for field tests, and black-and-white mulch films, which were tested on hemp by Novamont during the agricultural seasons 2023 and 2024.

Finally, regarding the bioherbicide, the potential for obtaining pelargonic acid was analyzed through chromatographic characterization of oils extracted from the crops implemented by Novamont in the project. In particular, cardoon and especially safflower demonstrated significant potential for the production of pelargonic acid through Novamont’s proprietary process. Once this potential was confirmed, a pelargonic acid-based reference bioherbicide was produced and tested by Novamont as desiccant pre-harvest on castor bean in the growing season 2024.

The next chapters provide a detailed overview of the field activities carried out as part of Task 2.2.3.

The reference biomaterial produced in Task 4.1.3, “Biodegradable in soil mulch films”, was used to produce black and white (B&W) mulch film samples tested on hemp during the 2023 and 2024 growing season. The aim of these trials was to evaluate the performance of the bio-product and its effect on hemp growth and productivity.

B&W films are generally used for summer crops and/or in hot areas to reduce surface and soil temperatures, thereby improving water use efficiency while simultaneously controlling weeds. The high albedo effect of the white top layer minimizes overheating of underlying fertile soil, while the black bottom layer filters residual UV and photoactive radiation (PAR) to prevent weeds growth.

In the 2023 growing season, a trial was conducted on 1 hectare at specialized hemp cultivation farm located in Empoli (FI), central Italy (Figure 16). The main objective was to assess the agronomic performance of mulched hemp compared to a non-mulched control (thesis). In addition, the durability of the film under specific soil, climatic and agricultural conditions was monitored using Novamont’s field monitor protocol.

Figure 16: Location of mulch film trial (Red point) - Empoli (FI), Italy

The film was laid in summer in order to evaluate their performance in open filed conditions on hemp. In Table 5 the characteristics of the trials are reported.

Table 5: B&W mulch film tests in Empoli, 2023.

Location	Materials	Thesis	Crop	Period	Assessment
Empoli (Tuscany, Italy)	B&W biodegradable mulch film	18 micron	Hemp	Summer (June)	Visual assessment, agronomical assessment

The Novamont B&W biodegradable in soil mulch film (120 cm wide and 18 µm thick) was manually laid in June 2023 over the experimental area (Figure 17), leaving 12 uncovered plots (marked in red in Figure X) for agronomic data collection. The same field management was applied to the covered and uncovered plots as well as water supplies and fertilisers.

Figure 17: Experimental layout of the field trial in Empoli, 2023, where the reference Novamont biodegradable mulch film was applied showing the 12 uncovered plots (red areas in Figure 14).

From transplanting (June 2023) to the harvest (October 2023) the mulch film and the crop were regularly monitored using Novamont's field monitor protocol. The main parameters assessed were:

- **Plant growth:** monitored monthly using biometric parameters according to standard BBCH scale.
- **Yield at harvest:** measured in grams per plant (g/plant).

Figure 18: Hemp plants with biodegradable mulch film applied for the field trial.

Results obtained showed a very good performance in terms of plant vigour and development in the mulched hemp plots. In addition, the biomass production was slightly higher in the mulched areas (Table 6), due to improved weed control and enhanced water availability for the crop.

The B&W biodegradable mulch film showed satisfactory field durability (over 100 days), effectively meeting the crop's needs for weed suppression.

Table 6: Comparison of hemp growth parameters between mulched and non-mulched plots during the 2023 growing season.

THESIS	Fresh weight of the flowers (g)	Fresh weight of the stems and leaves (g)	Stem diameter (mm) *
NO MULCH	435,3 ± 53,4	62,3 ± 31,1	14,8 ± 3,1
MULCH	690,2 ± 86,4	94,7 ± 11,2	18,3 ± 2,2

Figure 19: Experimental field in Empoli during the 2024 growing season, showcasing the application of Novamont's reference biodegradable mulch film.

The B&W biodegradable mulch film was tested again during the 2024 growing season to validate the results obtained the previous year. The trial was implemented in the same location following the same experimental design, but the mulch film was mechanically laid at the end of May (31/05/2024) and the transplant was performed on 8th June 2024.

During this season, particular attention was placed on evaluating the durability of the mulch film. The film's disintegration was monitored through visual observations at specific time intervals (18, 46, 79, and 105 days). Assessments were made using an empirical scale developed by Novamont:

Disintegration Grade (DG):

- DG=0: Film with no lesions.
- DG=1: Film with very scarse lesions (e.g.,1 or 2)
- DG=2: Film with lesion but structure still ok.
- DG=3: Film with many degraded areas and many lesions. No structural integrity.
- DG=4: Sparse pieces of film, difficult to retrieve.
- DG=5: Film completely degraded.

In Table 7 the observations during the entire testing period (105 days) are reported.

Table 7: Disintegration progress of B&W mulch film over 105 days, evaluated using Novamont's empirical scale (DG = Disintegration Grade).

Time (days)	Observations B&W mulch film
18	Intact with some white moulds – **DG 0**
46	Some degraded areas and some lesions – **DG 2**
79	Degraded areas, medium shape - **DG 2.5**
105	Slight increase in fragmentation **– DG 3**

By the end of the 105-day trial, the film reached a condition categorized as "Film with many degraded areas and many lesions," demonstrating its satisfactory field durability over 100 days (Table 7, Figure 20). This performance effectively met the crop's requirements for weed suppression, consistent with results from the 2023 growing season. The durability and efficacy confirmed the reliability of the B&W biodegradable mulch film under the specific soil and climatic conditions of the trial.

Figure 20: Disintegration stages of the B&W biodegradable mulch film over time: 18 days (1), 46 days (2), 79 days (3), and 105 days (4).

Due the high rainfall in November 2024, the hemp crop was not harvested, and as a result, no agronomic data (such as plant growth and yield at harvest) were collected.

Bioherbicide

A preliminary trial with a reference Novamont bioherbicide based on pelargonic acid was carried out in Fiumicino (RM), Italy, to evaluate the efficacy and selectively of the formulation as a pre-harvest desiccant for castor bean (*Ricinus communis* L) to accelerate biomass maturity (Figure 21). The performance of selected formulations was compared to an untreated control.

Figure 21: Castor bean field three days after the application of pelargonic acid.

The treatments were manually applied in an open-field trial by an operator equipped with a portable battery-powered sprayer. The application doses ranged from 14,5 to 20 l/ha of the pelargonic acid-based formulation, with water volumes of 300-400 l/ha (Table 8). The study followed a fully randomized design with two replicates for each treatment.

Table 8: Protocol of the trial using pelargonic acid formulation as a pre-harvest desiccant for castor bean.

Thesis No.	Treatment Name	Concentration (l/ha)	Water volume (l/ha)	Description
1	Untreated	-	-	not treated
2	Pelargonic acid	14,5	300	treated
3	Pelargonic acid	20	300	treated
4	Pelargonic acid	14,5	400	treated
5	Pelargonic acid	20	400	treated

The treatments were applied on 27th September 2024, when castor bean capsules were ready for harvest. Crop samples and efficacy data were collected 3 days after application (DAA).

Figure 22: Evaluation of treatments efficacy 3 days after application (from left to right: Thesis 1 control, thesis 2, thesis 3, thesis 4, thesis 5).

The analysis of the collected data showed the best performance of pelargonic acid formulation applied at 20 l/ha with 400 l/ha of water, achieving the most effective desiccation (Table 9).

Table 9: Humidity percentage in different plant components 3 days after application (DAA).

Trt No.	Treatment Name	Concentration (l/ha)	Water volume (l/ha)	Description	Humidity (%)		
					Biomass	Capsule	Seeds
1	Untreated	-	-	not treated	81,2	74,6	64,8
2	Pelargonic acid formulation	14,5	300	treated	69,2	68	60,1
3	Pelargonic acid formulation	20	300	treated	68,0	37,1	34,7
4	Pelargonic acid formulation	14,5	400	treated	73,9	31,9	36,5
5	Pelargonic acid formulation	20	400	treated	67,0	21,4	29,9

The results indicate that the combination of higher concentration (20 l/ha) and increased water volume (400 l/ha) significantly enhances the desiccation effect. The greater wettability achieved with the higher water volume likely improved the uniform distribution of the bioherbicide on the plant surfaces, maximizing the contact area. This increased coverage is crucial for efficient action of the pelargonic acid, which disrupts plant cell membranes.

Moreover, the higher concentration of pelargonic acid provides a stronger desiccant action, effectively accelerating the desiccation of capsules and seeds. At 3 DAA, the untreated plants retained significantly higher humidity levels in all components, whereas the treated plants showed notable reductions in biomass and seed

In conclusion, the findings demonstrate statistically significant desiccant activity for the pelargonic acid formulation compared to untreated plants.

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