BIO4A - Advanced sustainable BIOfuels for Aviation BIO4A

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Call: LCE-20-2016-2017 Topic: Aviation Biofuels
Project title: Advanced sustainable BIOfuels for Aviation (BIO4A)

PROJECT CONCEPT

Accelerate the deployment of Aviation Biofuels, enabling commercial production. Supporting the accomplishment of pre-commercial plant(s) for advanced biofuels for aviation based on sustainable biomass feedstock.

PROJECT OBJECTIVES

1) To bring HEFA to full commercial scale in new plant using residual lipids (Used Cooking Oil - UCO);
2) To investigate alternative supply of sustainable feedstocks recovering EU MED marginal land for drought resistant crop production;
3) To test the entire chain and logistic at industrial scale, and assess environmental performances.
4) Positive GHG and energy balance expected

Highlights (technological/non-technological):
New Aviation Biofuel plant producing HEFA
Production and test of HEFA in commercial flights in non-segregated mode
R&D Work on marginal land in Spain and Italy recovered by biochar/compost addition producing non-food sustainable lipids
Dedicated Dissemination, Communication and Exploitation action

Call: LCE-20-2016-2017 Topic: Aviation Biofuels
Project title: Advanced sustainable BIOfuels for Aviation
BIO4A

Industrial Activities M1 – M52

Current Status

- ✓ 1000 metric tons of HEFA produced by ENI in Gela from residual lipids
- ✓ HEFA is ASTM compliant (KPI attained)
- ✓ Internalized distillation step from HVO to HEFA by ENI in Livorno: revamping of unused, former distillation column
- ✓ Value chain demonstrated
- ✓ Flight plan delivered (SKYNRG)

Next steps

- ✓ Blending operations in Amsterdam by SKYNRG/KLM
- ✓ Fuel delivered to Schipol Airport
- ✓ Offtake by KLM for commercial flights

R&D Activities M1 – M52

Current Status

- ✓ Year 3 agronomic field trials in Spain on marginal land completed, biochar protocol identified (CCE, RE-CORD)
- ✓ Year 1 agronomic field trials (larger scale) in Italy completed, biochar protocol confirmed (RE-CORD)
- ✓ Lysimeters Experiment Completed (RE-CORD)
- ✓ Larger climatic chamber for lysimeters experiments completed (RE-CORD)

- ✓ Assessment of potential for drought-resistant oil crop in marginal land of Southern Europe and abroad completed (JRC)
- ✓ Business case completed (SKYNRG)
- ✓ Waste feedstock market analysis completed (SKYNRG)
- ✓ Report on Market Dynamics delivered (SKYNRG)
- ✓ Environmental Assessment completed
- ✓ New drought-resistant Camelina variety patented (CCE)
- ✓ IPR Strategy identified (RE-CORD, CCE, ALL)
- ✓ Environmental and Social LCA to be published in April 2023

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R&D Activities M1 – M52

R&D Activities on biochar production plant from woodchips and agroresidues

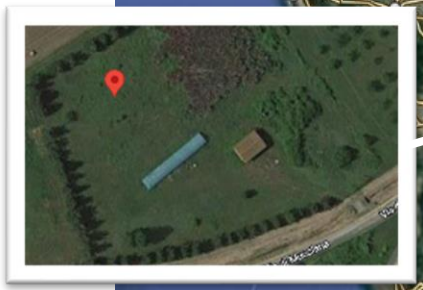
- ✓ Design and test activities on Moving bed pyrolysis reactor model adaptation and innovative concept prototype (SPYRO)
- ✓ Mechanical works on Fixed bed carbonization unit.
- ✓ Moving bed carbonization unit installed, in operation since 2020.

R&D Activities performed on UCO pre-treatment to contribute to and enhance the long-term supply of this feedstock

✓ Hydrolysis and non-catalytic thermochemical conversion tests performed for alternative FFA production pathway

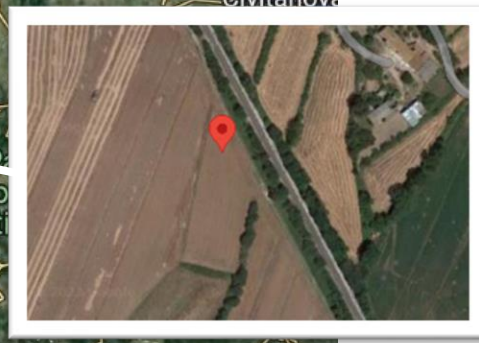
Italian field trials (1 year)

Italian field trials



MONTEPALDI

TERONTOLA



Italian field trials

RESEARCH GOAL

Evaluation of the effect of biochar alone or mixed with compost on:

- Camelina seed yield, biomass and oil yield and quality
- Soil chemical and physical properties
- Agronomic Use Efficiency of nitrogen

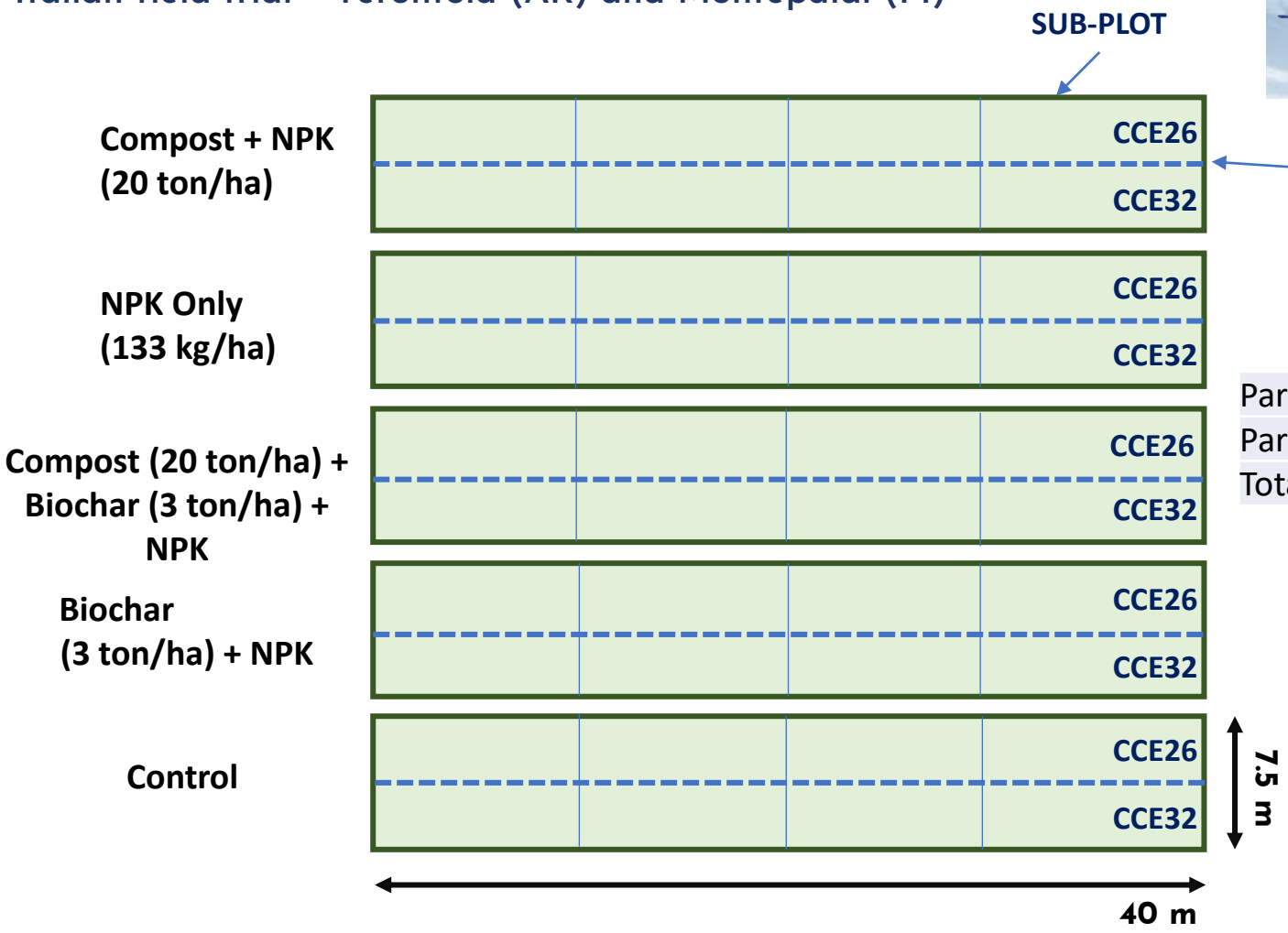
AGRONOMIC AND ENVIRONMENTAL CONDITIONS

- **Field experiment**
- **2 locations**: **Terontola (Arezzo) and Montepaldi (Florence)**
- No artificial irrigation
- **Biochar** from poplar (550°C, slow pirolysis)
- 2 Camelina varieties: short cycle (**CCE26**) and medium cycle (**CCE32**)

TREATMENTS

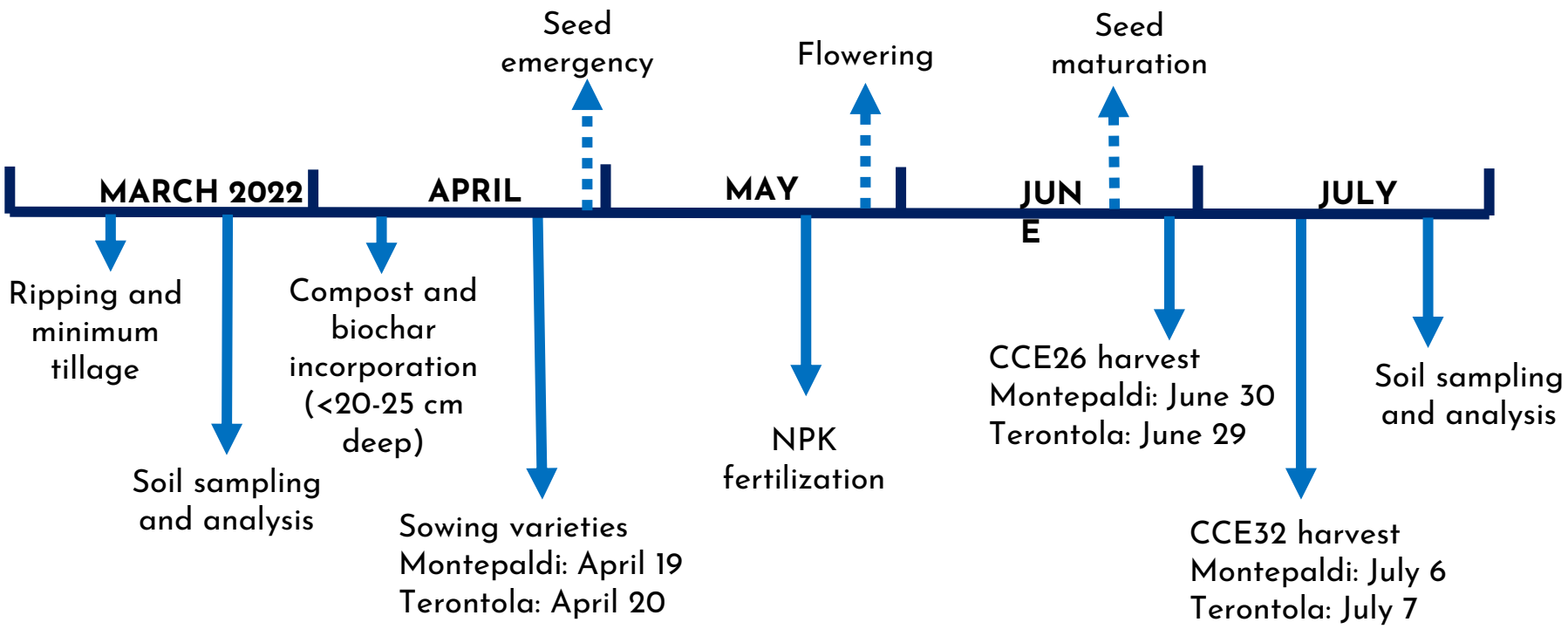
- **CONTROL:** no fertilization or organic amendement
- **NPK FERTILIZATION** (eq. to 133 kg/ha)
- **COMPOST** (eq. to 20 ton/ha) + NPK
- **BIOCHAR** (eq. to 3 ton/ha) + NPK
- **COMPOST** (eq. to 20 ton/ha) + **BIOCHAR** (eq. to 3 ton/ha) + NPK

Italian field trial – Terontola (AR) and Montepaldi (FI)



Parcel area	300 mq
Parcel area for variety	150 mq
Total area	1500 mq

Italian field trial – AGRONOMIC PRACTICES AND MAIN OPERATIONS



Italian field trial – PARAMETERS AND ANALYSIS

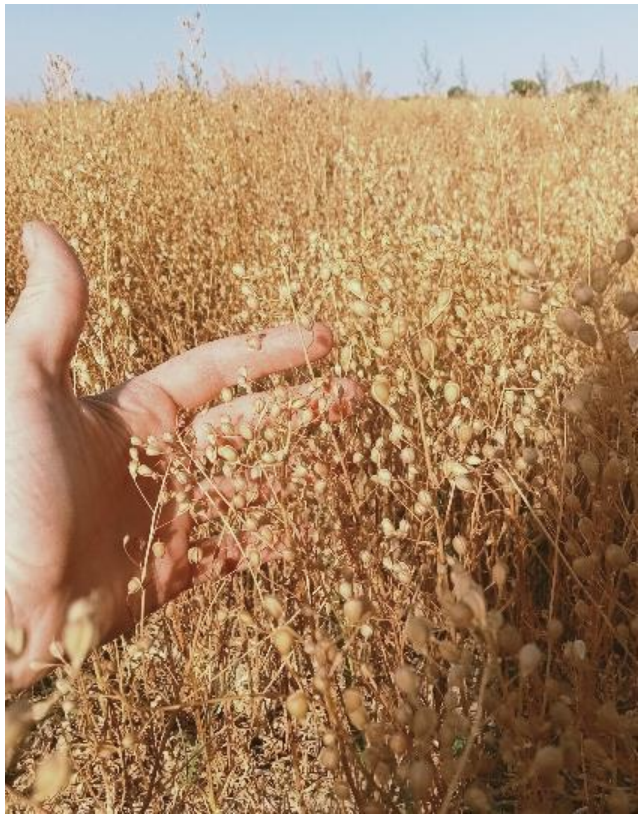
ANALYSIS	PARAMETERS
Camelina plant	Biomass
	Yield
Camelina oil	yield + some quality parameters
Biochar	Full characterization
Compost	Full characterization
Soil	Chemical analysis (Before cultivation and at the end of the plant cycle)
	pH, EC, CEC
	Water holding capacity, bulk density
	Total carbon
	Organic carbon
	P available, P organic, P total
	N forms
	Macro and micro-nutrient available and total concentration

Italian field trial – Terontola

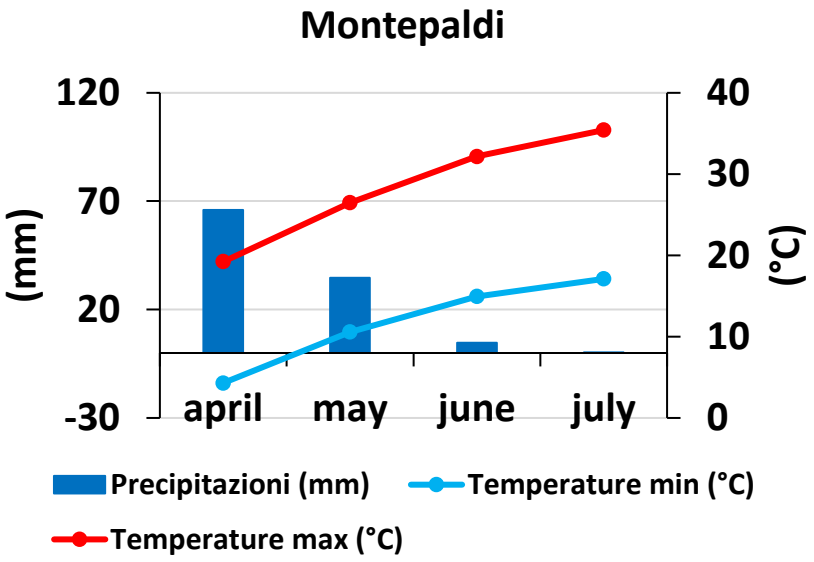
Italian field trial – Montepaldi

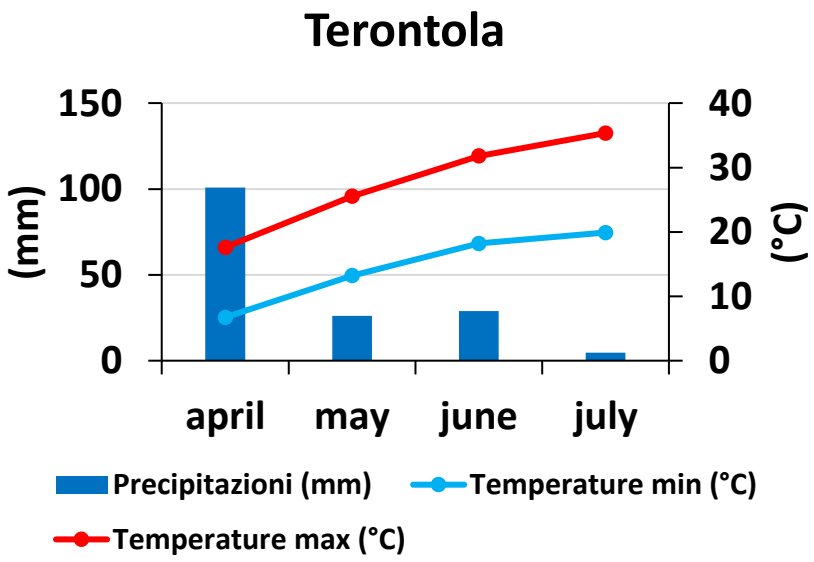
Italian field trial – Terontola

Italian field trial – CAMELINA SEED PROCESSING



Italian field trial – CLIMATIC PARAMETERS



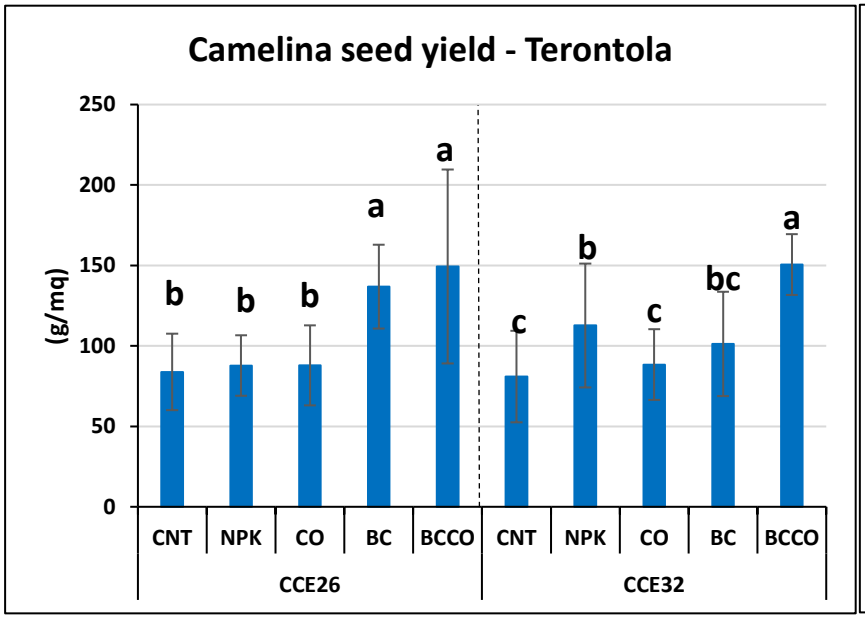


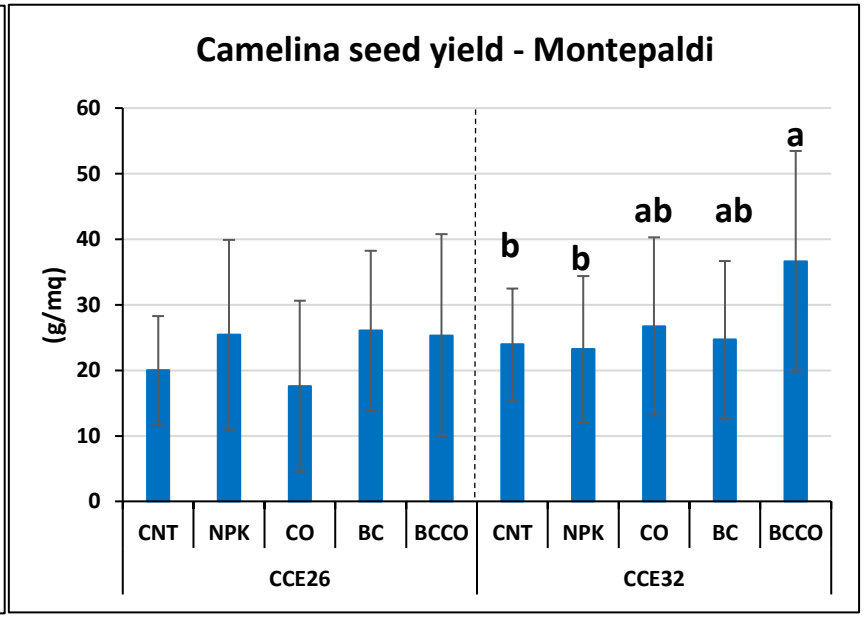
	Precipitations (mm)	
	MONTEPALDI	**TERONTOLA**
april	66.0	101
may	34.6	26
june	4.6	29
july	0.2	5
tot	**105.4**	**160.8**

https://www.sir.toscana.it/consistenza-rete

Italian field trial – CAMELINA SEED YIELD

Fisher's test p<0.001

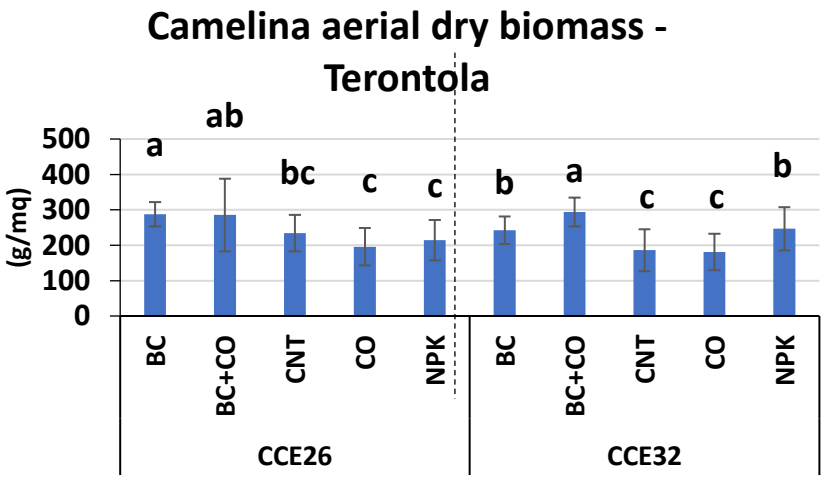


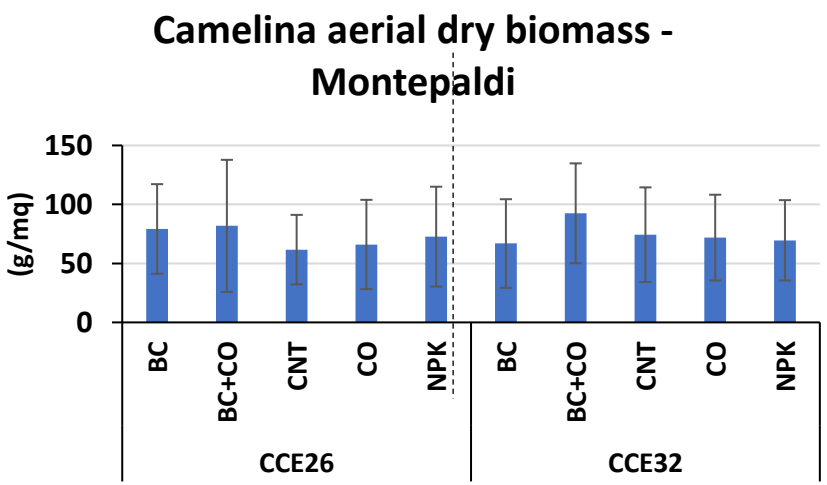


- 12 samples harvested manually for each variety using circular frames
- Camelina plants performed better in Terontola location => probably better agro-environmental condi
- Statistical differences were detected except for CCE26 in Montepaldi
- The highest yield were collected with biochar + compost

Italian field trial – CAMELINA DRY BIOMASS AT HARVEST

Fisher's test p<0.001





- Aerial dry biomass includes all plant organs with the exception of seed and root
- Statistical differences were dectected only for Terontola location (high variability in Montepaldi)
- CCE26 highest biomass with biochar; CCE32 highest biomass with biochar + compost

Spanish field trials (3 years) RED II Esca factor

Biochar and Combi production (REC)

Products preparation and characterization

COMBI production in field condition	Delivery	Locations	Field trials

Batch 1	Summer season (Aug-Oct 2018)	CD1 CB1 CB2 CB3	L1: La Canaleja Madrid, Spain	Started in November 2018
Batch 2	Winter season (Dec-Feb 2018/19)	CD2 CB4 CB5 CB6	L2: Entresierras Ciudad Real, Spain	Started in February 2019

Feedstock and product characterization

Woodchips
Biochar
Solid fraction of digestate
COMBI products

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No *[789562]*

Spanish field trials

RESEARCH GOAL

Evaluation of the effect of different biochar-based amendments on:

- Soil Corg and soil health
- Camelina / Barley rotation and yield

AGRONOMIC AND ENVIRONMENTAL CONDITIONS

- **Field experiment**
- **2 locations**: **Madrid and Ciudad Real**
- No artificial irrigation
- **Biochar** from poplar (550°C, slow pirolysis)

TREATMENTS

- **CONTROL**: no fertilization or organic amendement
- **MINERAL FERTILIZATION**
- **ONLY BIOCHAR**
- **COMBI 10%**
- **COMBI 15%**
- **COMBI 20%**
- **ONLY COMPOST**

REDII Esca factor – Carbon Stock calculation

ANNEX V

METHODOLOGY FOR DETERMINING THE EMISSION SAVINGS FROM SOIL CARBON ACCUMULATION VIA IMPROVED AGRICULTURAL MANAGEMENT

Economic operators seeking to claim emission savings from soil carbon accumulation via improved agricultural management (e_{sca}) in terms of g CO_2eq/MJ should use the following formula to calculate their actual values:

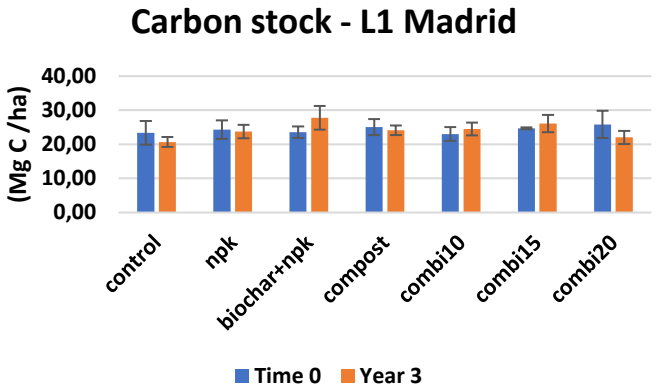
$$e_{sca} = (CS_A - CS_R) \times 3{,}664 \times 10^6 \times \frac{1}{n} \times \frac{1}{P} \text{-} e_f$$

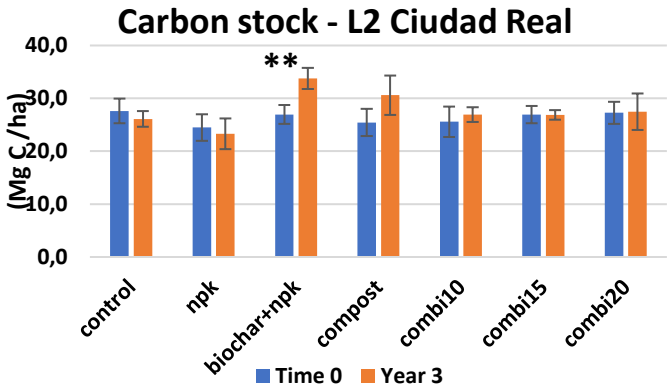
Where:

CS_R	is the mass of soil carbon stock per unit area associated with the reference crop management practice in Mg of C per ha.
CS_A	is the mass of soil estimated carbon stock per unit area associated with the actual crop management practices after at least 10 years of application in Mg of C per ha.
3,664	is the quotient obtained by dividing the molecular weight of CO_2 (44,010 g/mol) by the molecular weight of carbon (12,011 g/mol) in g CO_{2eq}/g C.
n	is the period (in years) of the cultivation of the crop considered.
P	is the productivity of the crop (measured as MJ biofuel or bioliquid energy per ha per year).
ef	emissions from the increased fertilisers or herbicide use

Biochar is included as an improved agricultural practice for Soil Carbon Accumulation

REDII Esca factor – Carbon Stock calculation





$$CS_R = \frac{\left(C_{ORG}\ x\ BD\ x\ T\ x(1-F)\right)}{100}$$

$$CS_{Adjusted} = \left(\frac{BD_O}{BD_N}\right) x\ CS_n$$

Where:

CS_R is the carbon stock at the initial measurement expressed as Mg of C/ha;

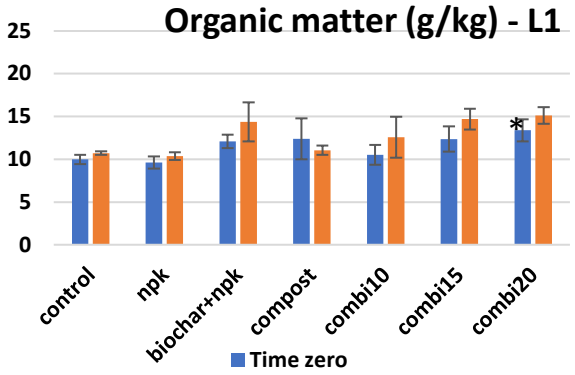
C_{org} is the organic carbon content (g C/ha);

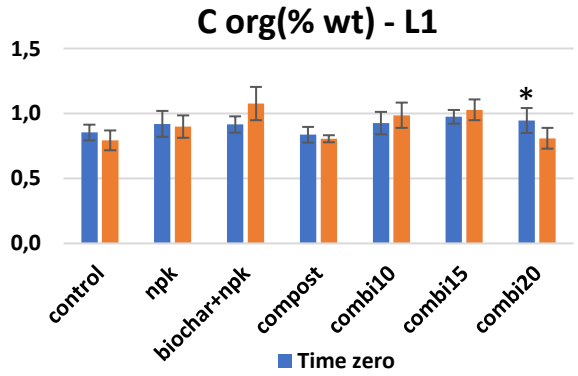
BD is the soil bulk density (kg/m^3);

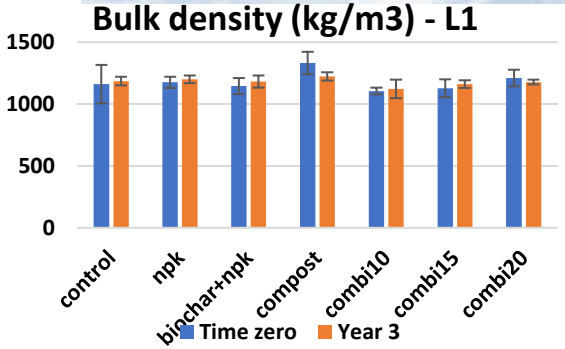
T is the thickness (depth, m);

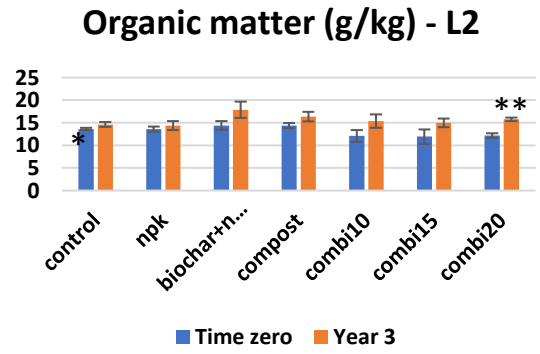
F is the volume of coarse mineral fraction in % by mass (m^3/m^3 x 100).

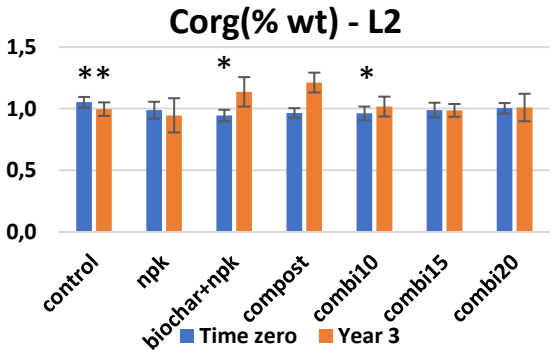
Spanish Field Trials
Soil organic matter, organic carbon and bulk density

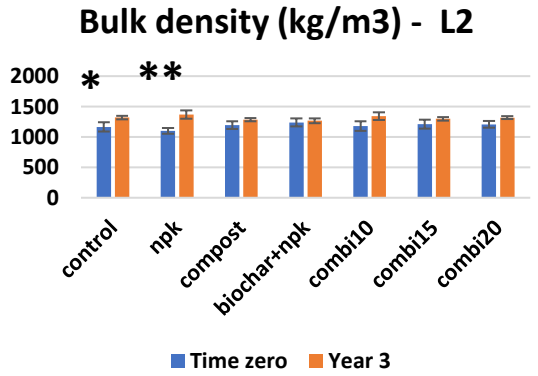












REDII Esca factor calculation

LOCATION 1			
Madrid	**Stock (Mg of C /ha)**		
Treatment	**Time 0**	**Year 3**	**C stock increment (%)**
control	23.33	20.69	-11.3
npk	24.3	23.8	-2.2
biochar+npk	23.6	27.8	17.8
Compost + npk	25.0	24.1	-3.7
Combi10 + npk	23.0	24.4	6.3
Combi15 + npk	24.7	26.1	5.8
Combi20 + npk	25.8	22.0	-14.8

LOCATION 2			
Ciudad Real	**Stock (Mg of C /ha)**		
Treatment	**Time 0**	**Year 3**	**C stock increment (%)**
control	27.6	26.1	-5.4
npk	24.5	23.3	-4.8
biochar+npk	26.9	33.7	25.3
Compost + npk	25.4	30.6	20.3
Combi10 + npk	25.6	26.9	5.3
Combi15 + npk	26.9	26.9	-0.2
Combi20 + npk	27.3	27.4	0.7

1) BAU Agriculture depletes soil Carbon Stock
2) Carbon Stock is a product of Corg and Bulk Density
3) Labile Corg is subject to oxidation

→ Improved management practices should be accompanied by minimum / no disturbance of soil structure.

Italian field trials (1 year) with co-composted manure

Italian trial with COMBI

RESEARCH GOAL

Evaluation of the effect of biochar on:
- Barley yield
- Manure management through co-composting

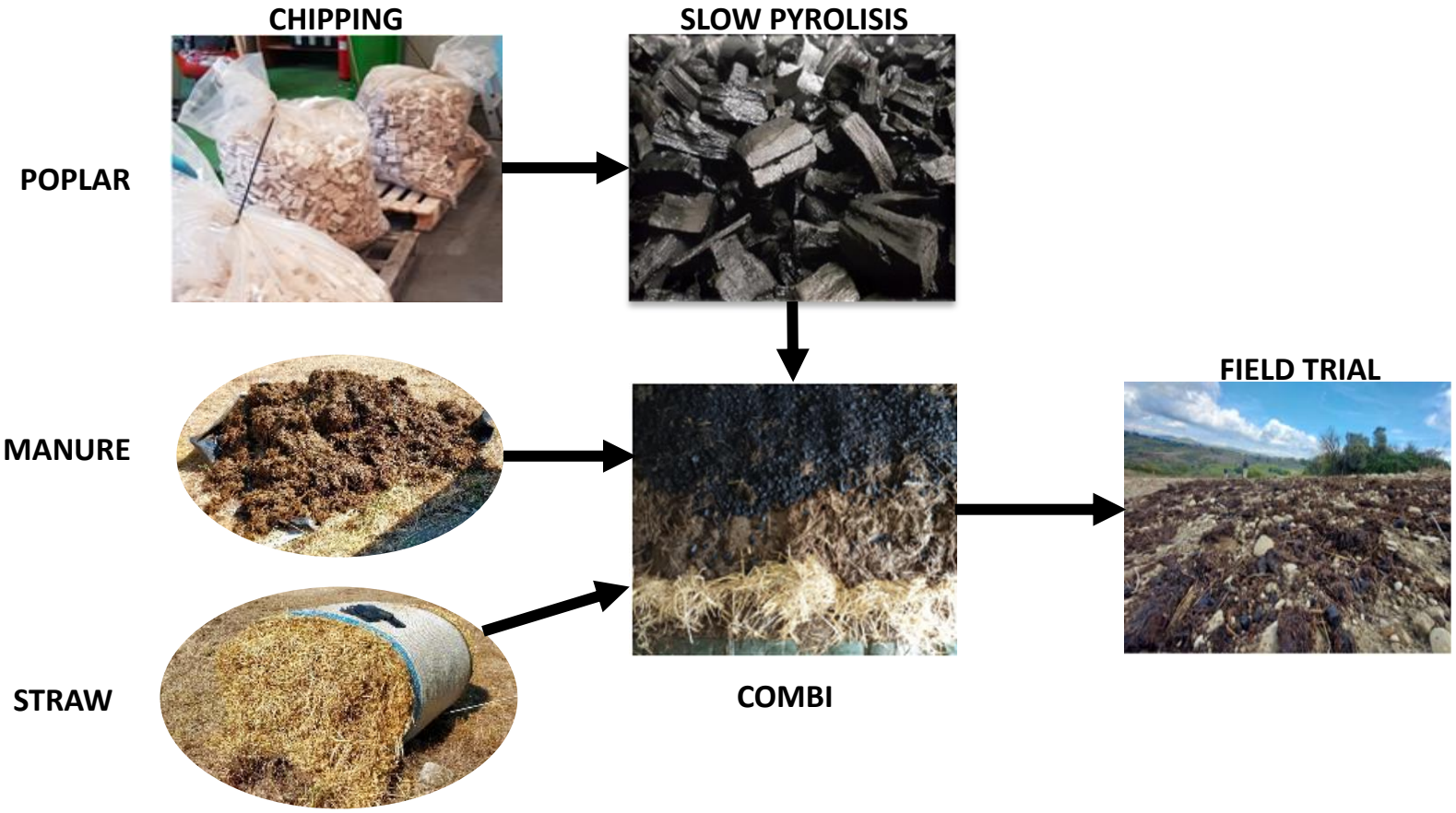
AGRONOMIC AND ENVIRONMENTAL CONDITIONS

- **Abandoned land** (>10 years)
- **Organic** agricultural practices
- **Biochar** from poplar (550°C, slow pyrolysis)
- **Low rainfall** conditions (2022 lowest spring/summer precipitation in 10 years series)

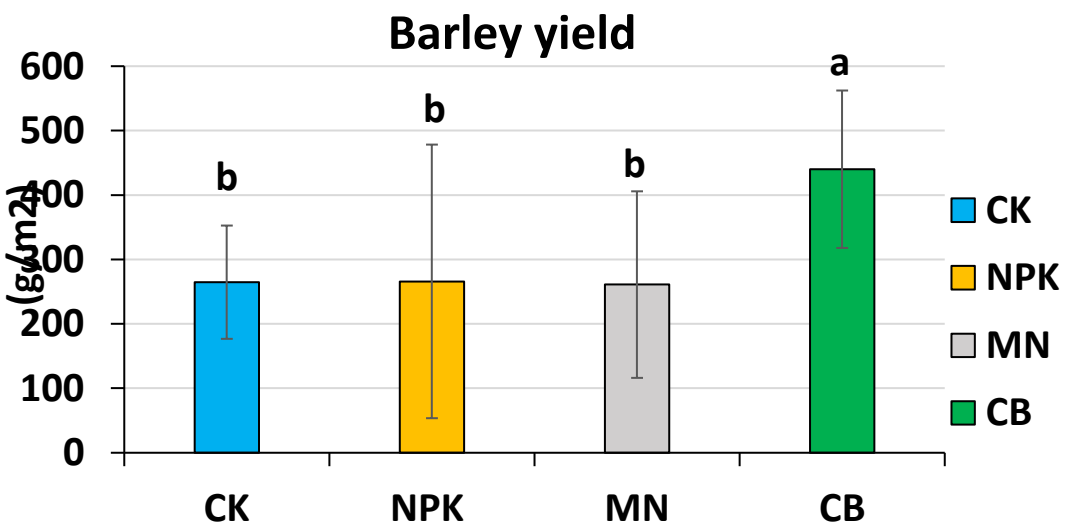
TREATMENTS

- **CONTROL TREATMENT**: no fertilization or amendement
- **NPK** (0.5 +0.5 ton/ha)
- **AGED MANURE** (20 t/ha)
- **COMBI** (20 ton/ha)

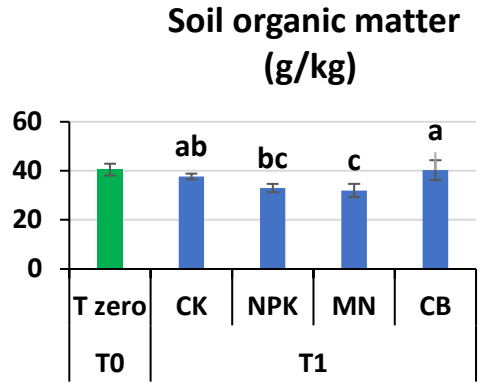
Material & Methods

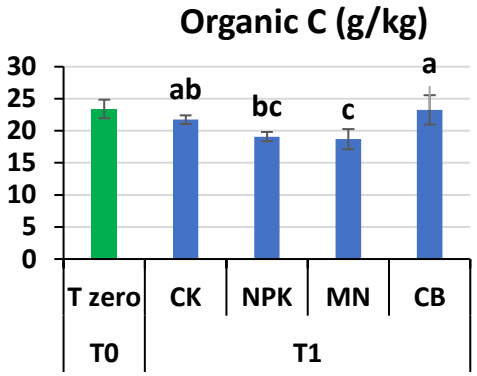


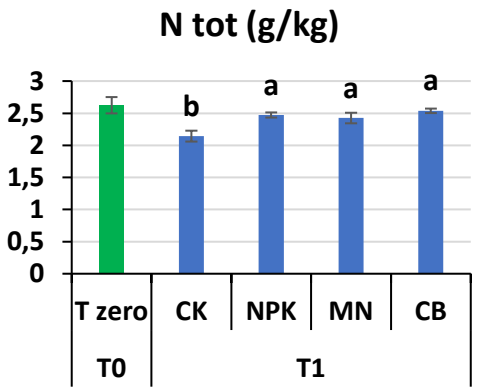
RESULTS - YIELD

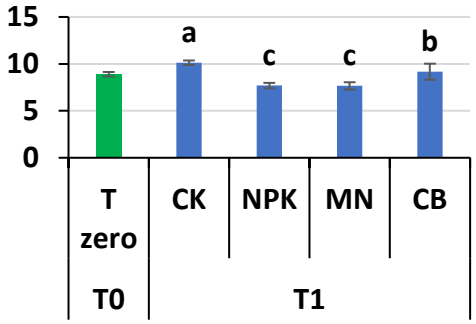


RESULTS - SOIL









Lysimeters Trials in Italy

RESEARCH GOAL

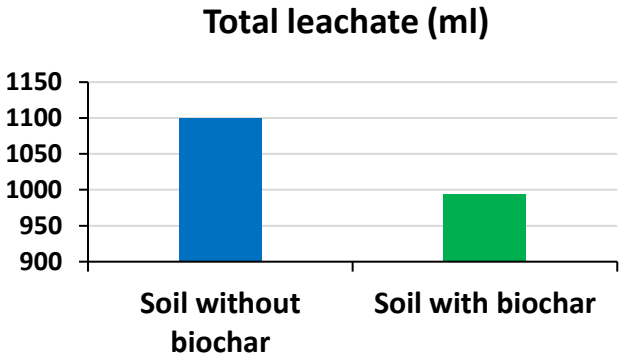
- Evaluate effect of biochar addition on soil humidity pattern and water holding capacity
- Evaluate effect of biochar addition on N dynamics in soil leachate
- Evaluate effect of biochar addition on soil GHG emissions

MATERIALS & METHODS

- Climatic chamber where field trials meteorology, soil and variety (Spain) are reproduced
- Comparation NPK vs Biochar (3 t/ha equivalent) + NPK
- 2 lysimeters for Humidity continuous monitoring
- 2 lysimeters for irrigation followed by leachate weighing (continuous) and analysis.
- Continous monitoring of ambient CO2
- Barley cultivation: variety Vinagrosa, seeding rate 250 kg/ha equivalent.
- Irrigation = Rainfall equivalent in field trial
- 3 replicates of 12 weeks experiment

BIO4A – Lysimeter experiment: Results from 1° Italy trial on N fate in water

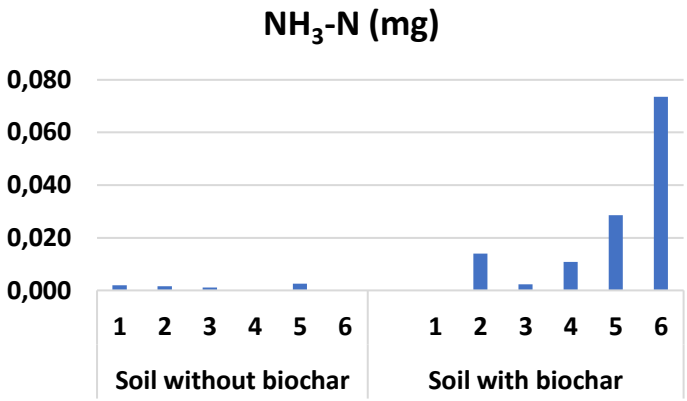
Treatments	pH	Leachate collected (ml)	Irrigation (ml)
Soil without biochar			
sample 1	7.9	59	290
sample 2	7.9	258	290
sample 3	7.9	38	90
sample 4	7.6	144	220
sample 5	7.9	190	220
sample 6	7.9	412	530
total		1100	1640
Soil with biochar			
sample 1	na	5	290
sample 2	7.8	234	290
sample 3	8.1	31	90
sample 4	7.8	123	220
sample 5	7.6	190	220
sample 6	7.7	410	530
total		*994*	*1640*

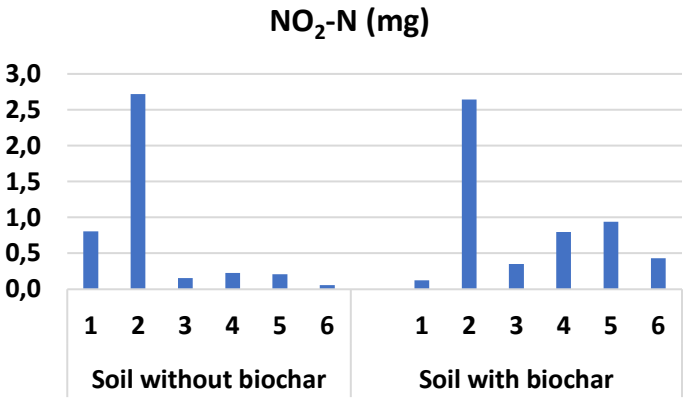


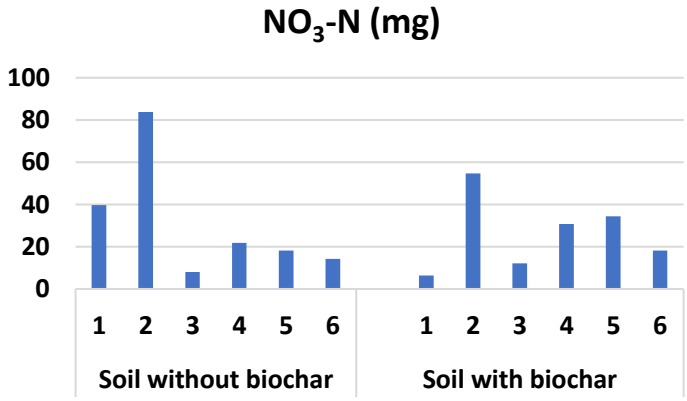
Biochar influences positively water retention and the emissions of nitrates: less N pollution in water

BIO4A – Total amount (mg) of N leached

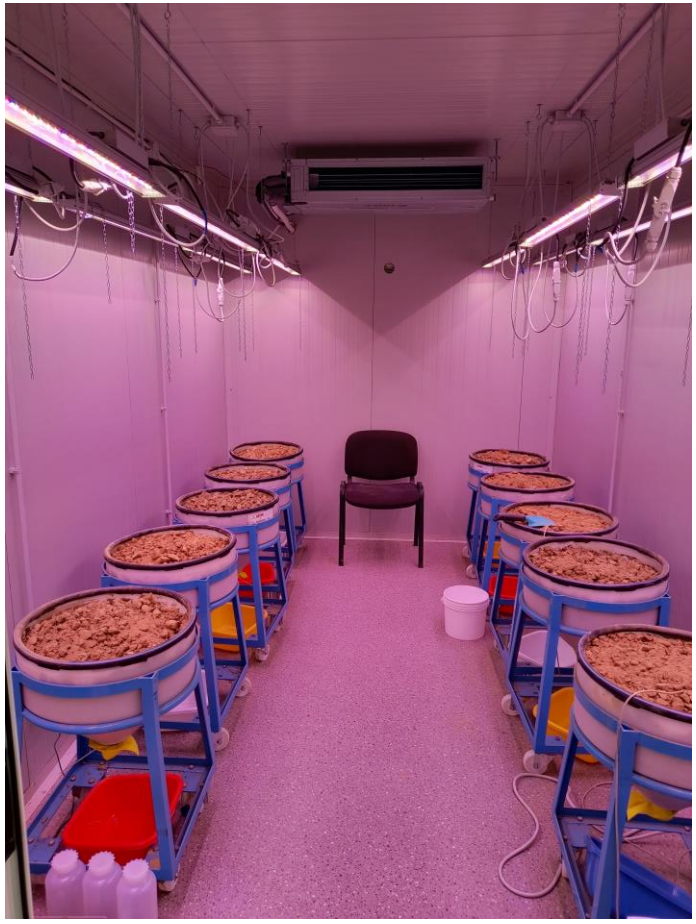
	NH_3-N (mg)	NO_2-N (mg)	NO_3-N (mg)	Total N (mg)
Soil without biochar				
sample 1	0.002	0.8	39.6	40.4
sample 2	0.002	2.7	83.7	86.5
sample 3	0.001	0.2	8.1	8.3
sample 4	0.000	0.2	21.9	22.1
sample 5	0.003	0.2	18.1	18.4
sample 6	0.000	0.1	14.4	14.4
total	*0.007*	*4.2*	*185.9*	*190.1*
Soil with biochar				
sample 1	na	0.1	6.5	6.6
sample 2	0.01	2.6	54.6	57.3
sample 3	0.00	0.4	12.2	12.5
sample 4	0.01	0.8	30.8	31.6
sample 5	0.03	0.9	34.4	35.4
sample 6	0.07	0.4	18.3	18.8
total	*0.129*	*5.3*	*156.8*	*162.2*







Lysimeters Trials in Italy
New RE-CORD climatic chamber prototype installed



Lysimeters Trials in Italy
RE-CORD climatic chamber prototype

RESEARCH GOAL

- Evaluate effect of growing biochar rates (up to 20 t/ha) on drought resistance of barley
- Water Use Efficiency with biochar

MATERIALS & METHODS

- 9 replicates (3 treatments * 3 replicates) for statistical consolidation
- Simulation of drought conditions
- 30% Field capacity after true leaves stage
- Humidity monitoring
- Evaporation measurement
- Yield analysis

- Results in June 2023

Bio4A

Advanced Sustainable Biofuels for Aviation

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Thanks for your attention!

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