Use of biochar as a soil amendment on *Camelina sativa* (L.Crantz) yield for sustainable oil production

RE·CORD

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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

1-Year Field Trials

1-year 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
- Nitrogen Use Efficiency

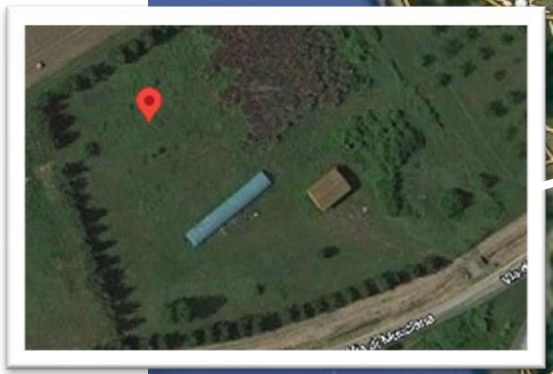
AGRONOMIC AND ENVIRONMENTAL CONDITIONS

- **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

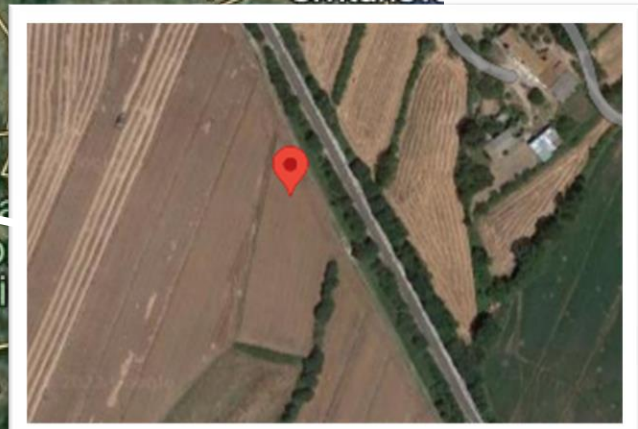
- **CONTROL:** no fertilization or organic amendement
- **NPK FERTILIZATION** (eq. to 133 kg/ha)
- **COMPOST** (eq. to 20 ton/ha) + NPK
- **BIOCHAR** (eq. to 3 ton/ha) + NPK
- **COMPOST** (eq. to 20 ton/ha) + **BIOCHAR** (eq. to 3 ton/ha) + NPK

1-year field trials



MONTEPALDI

TERONTOLA



Forte dei Marmi
Viareggio
Lucca
Pistoia
Prato
Firenze
San Marino
Pesaro
Senigallia
Ancona
Jesi
Porto Recanati
Macerata
Civitanova
San Gimignano
Arezzo
Gubbio
Siena
Cortona
Perugia
Assisi
Foligno
Piombino
Follonica
Portoferraio
Grosseto
Marina di Campo
Castiglione della Pescaia
Saturnia
Orvieto
Todi
Spoleto
Terni
Viterbo
Rieti
Orbetello
Porto Santo Stefano
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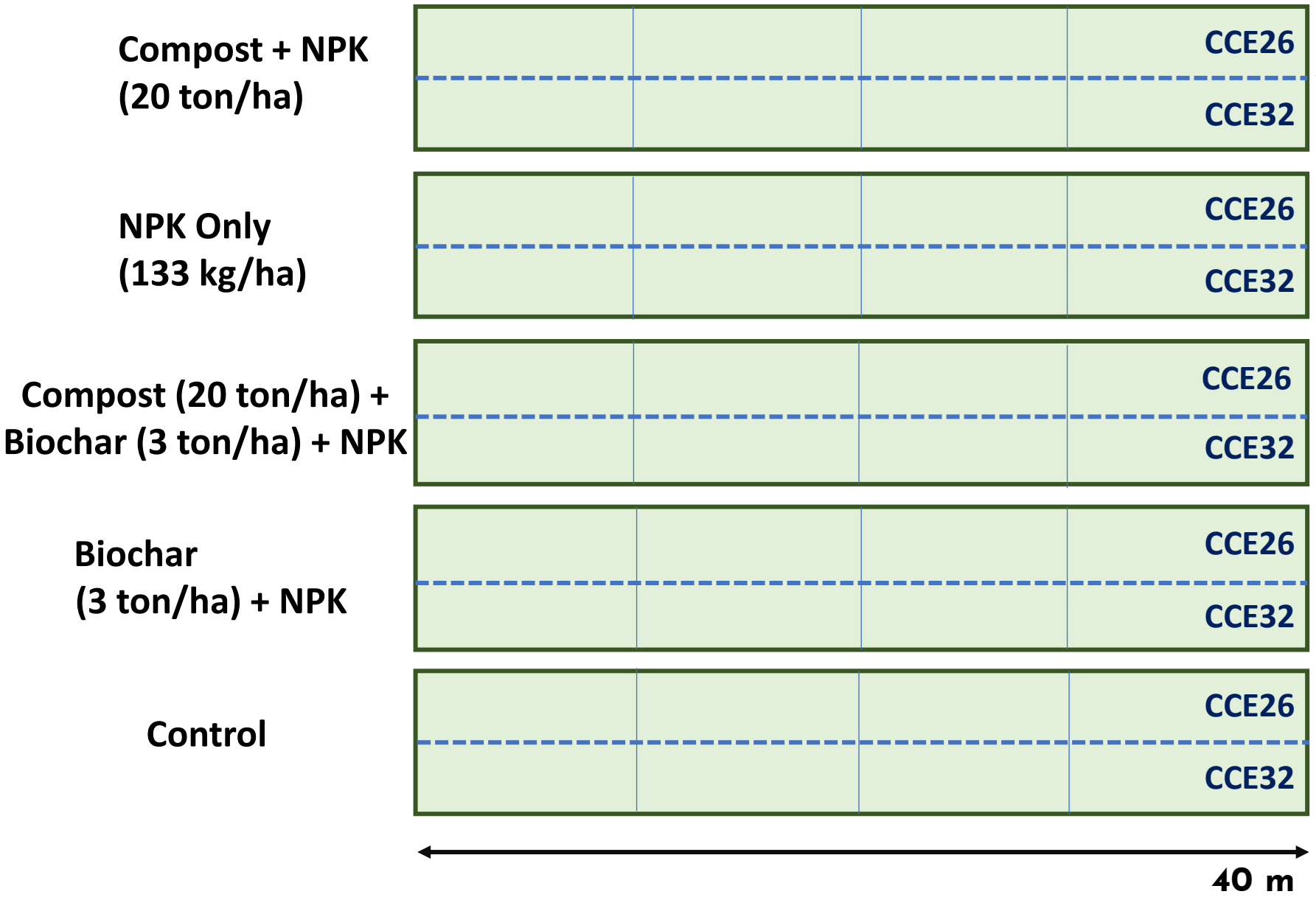
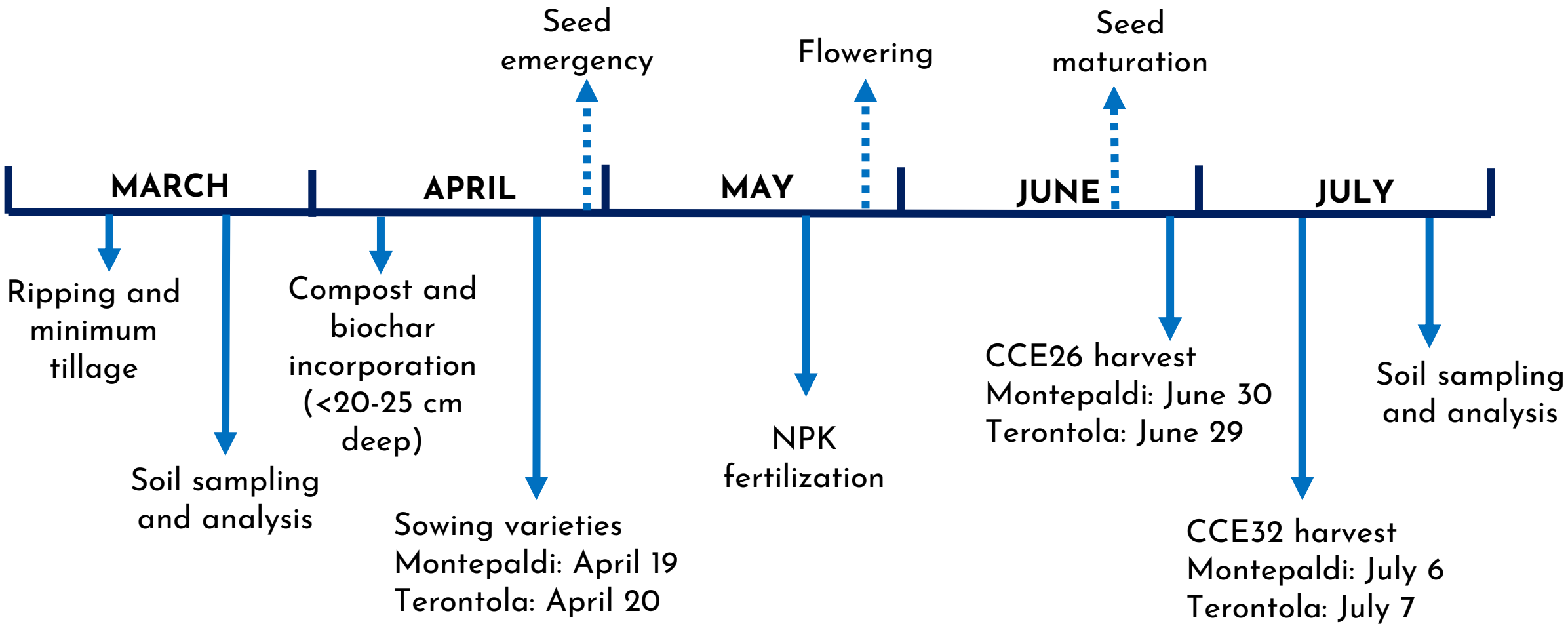
1-year field trial – DESIGN OF THE EXPERIMENT



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

1-year Italian field trial – MAIN AGRONOMICOPERATIONS



Soil field trail in Montepaldi

- Loamy texture (with high clay content)
- No tillage for more than 15 years

Soil field trial in Terontola

- Loamy texture (with high sandy content)
- Soil cultivated annually with conventional agricultural management

Camelina in Montepaldi

- Very dry season
- High temperature from May (> 30°C)
- Plants were stressed

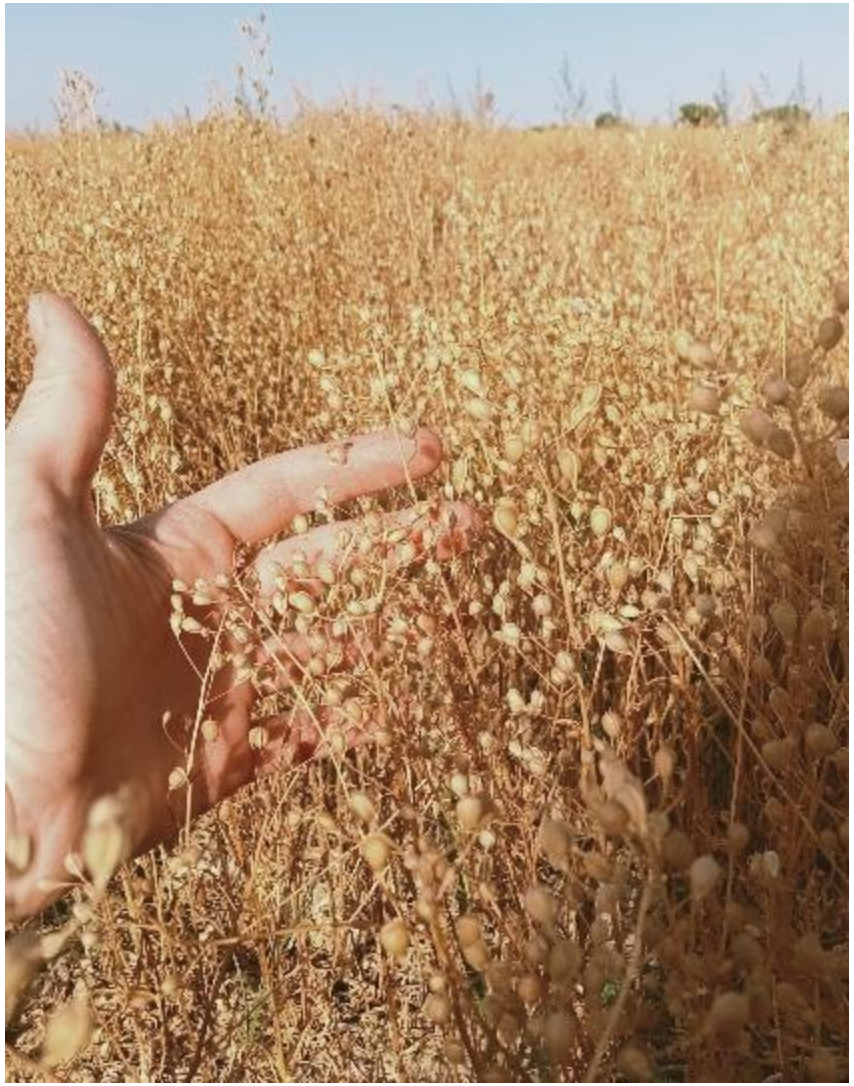
Precipitations (mm)	MONTEPALDI
april	66.0
may	34.6
june	4.6
july	0.2
tot	**105.4**

Camelina in Terontola

- Very dry season
- High temperature from may (> 30°C)

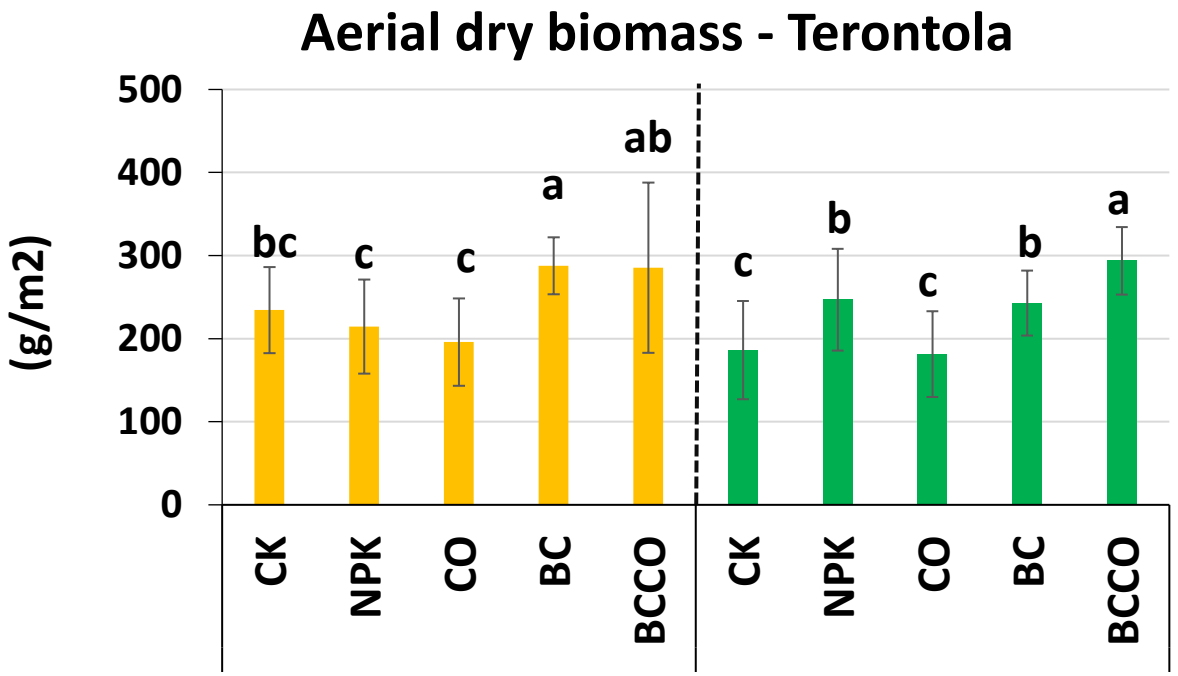
Precipitations (mm)	TERONTOLA
april	101
may	26
june	29
july	5
tot	**160.8**

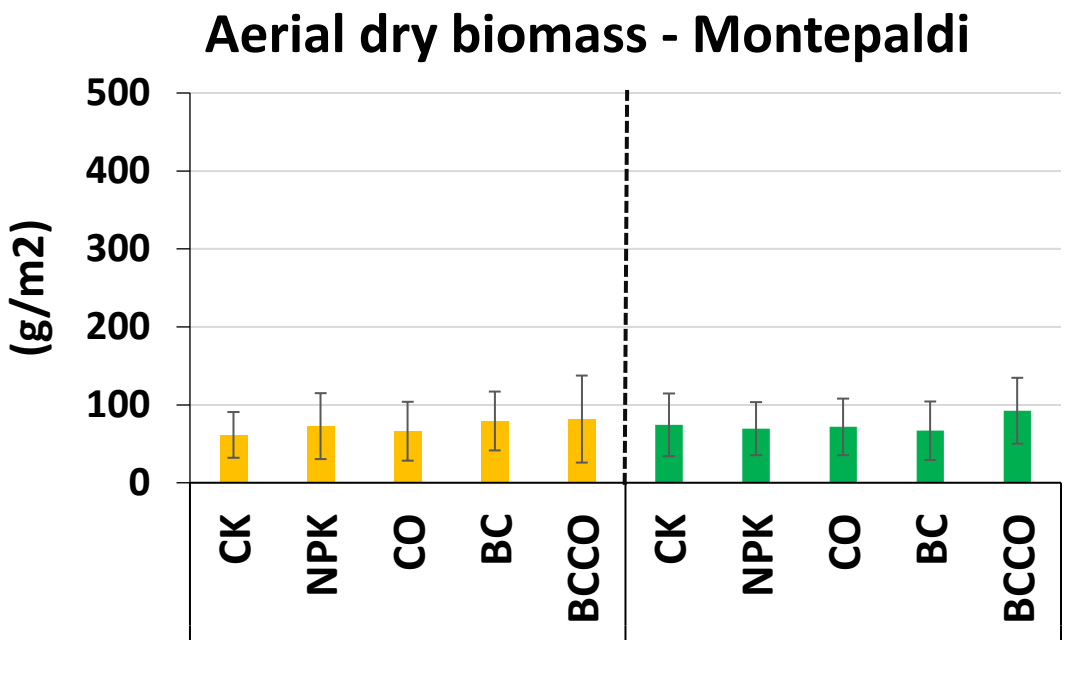
Camelina seed processing



1-Year Results
Yield

1-year field trial – CAMELINA BIOMASS AT HARVEST

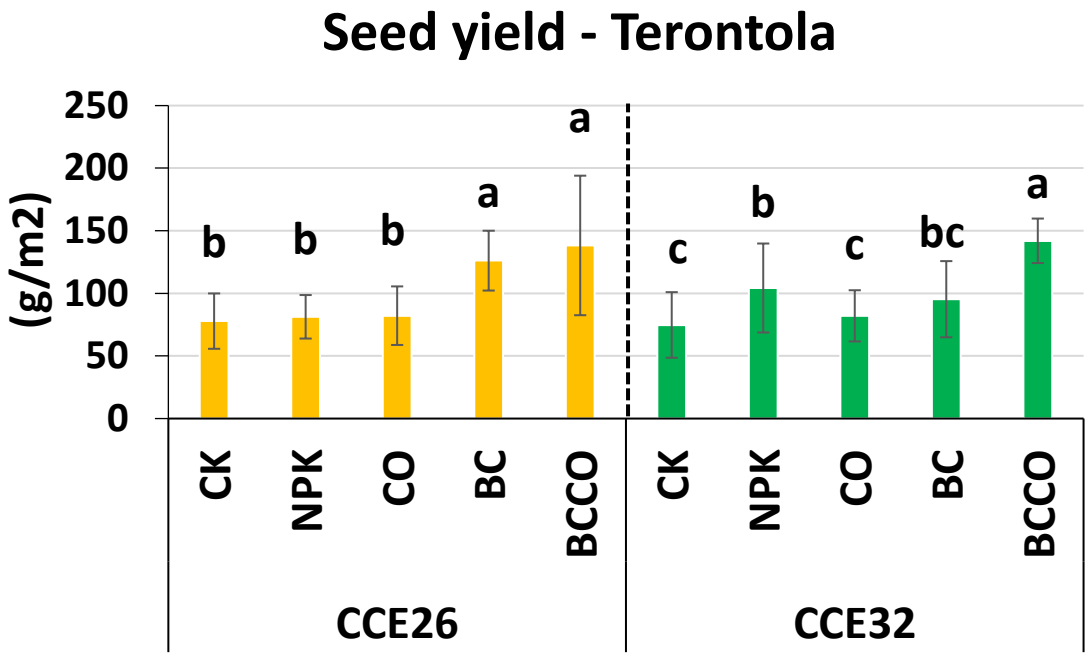


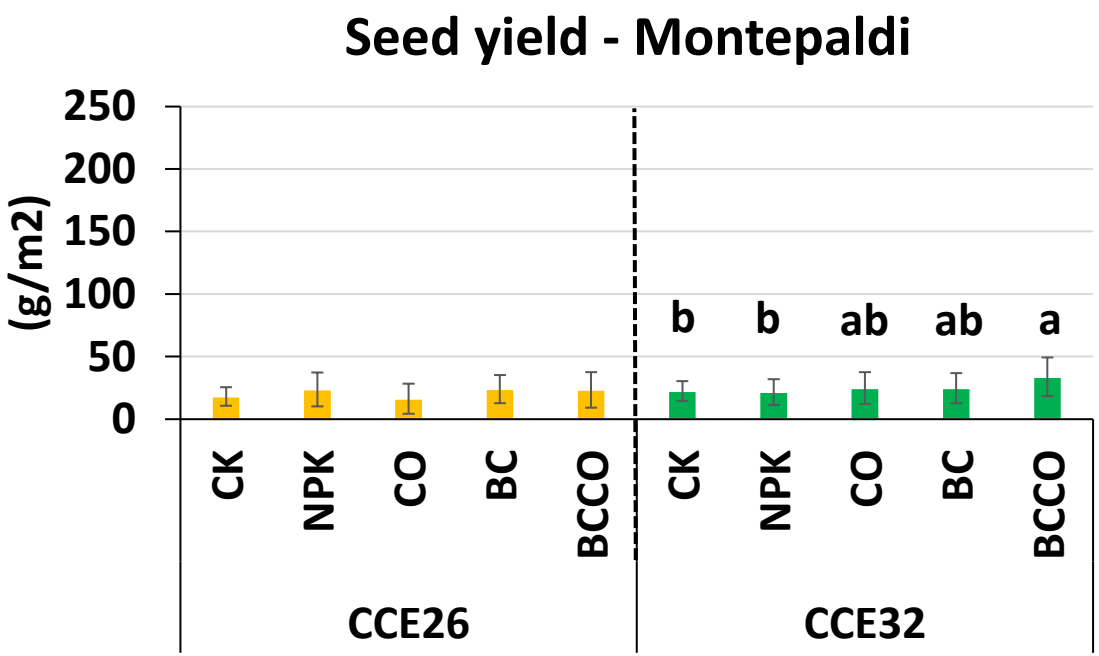


- Aerial dry biomass includes all plant organs with the exception of seed and root system
- Camelina plants performed better in Terontola location => probably better agro-environmental conditions

Fisher's test p<0.001

1-year field trial – CAMELINA GRAIN YIELD

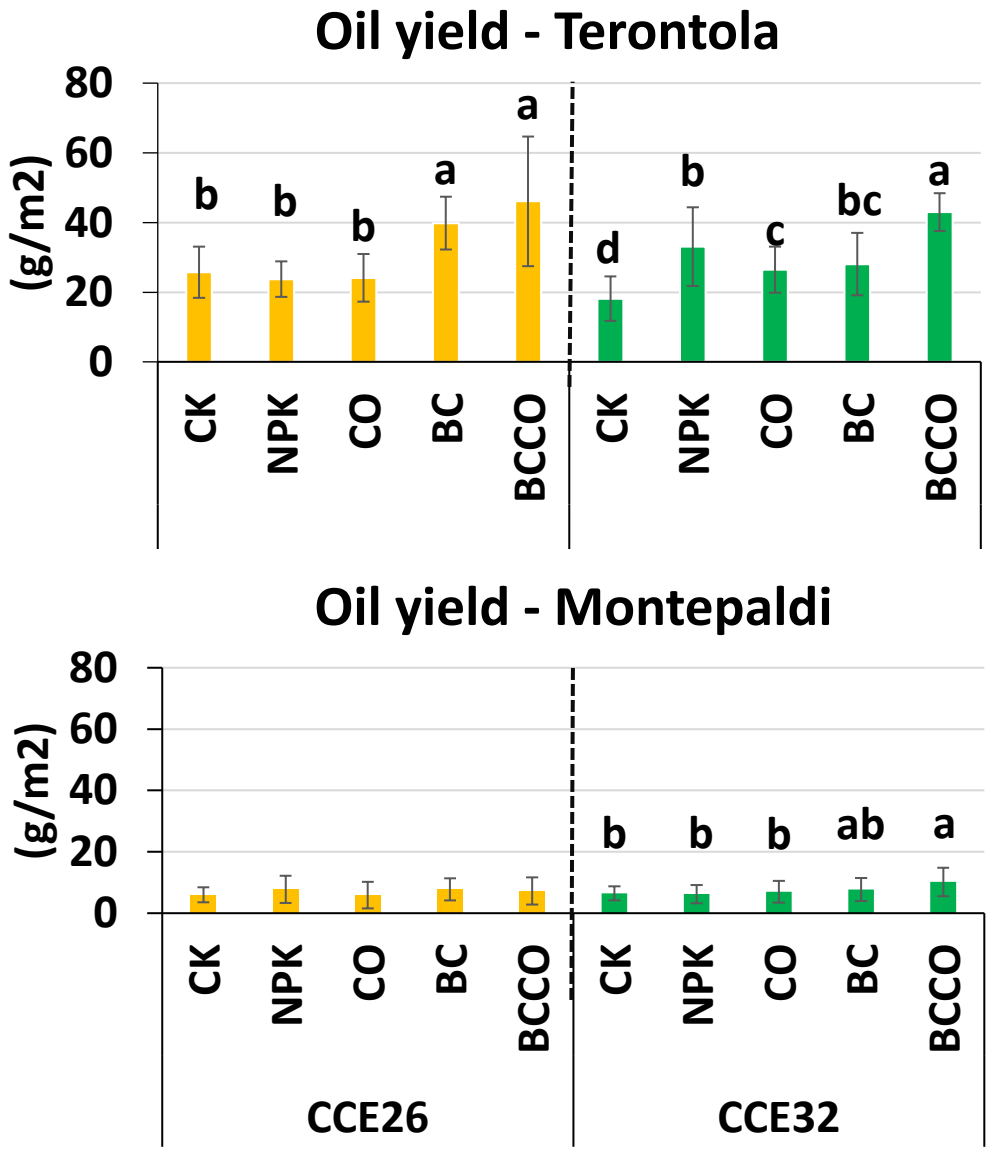




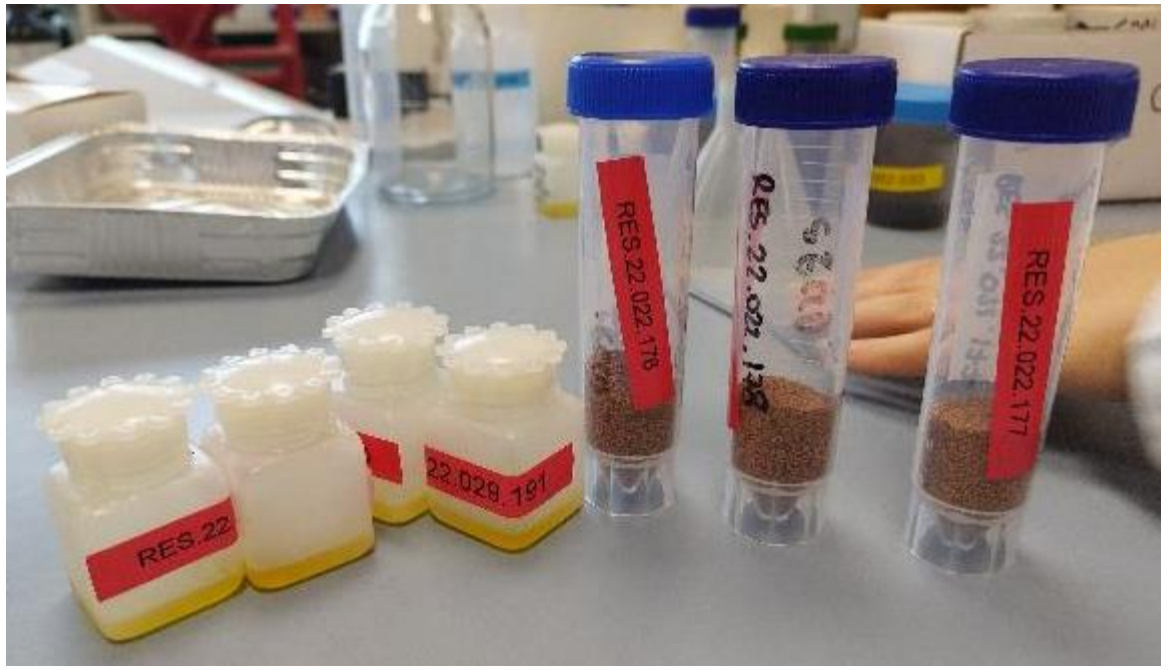
- Statistical differences were detected except for CCE26 in Montepaldi
- The highest yield were collected with BCCO in both locations
- Different genotype effect
- Terontola CCE26 – with BC and BCCO increment of about 65%
- Terontola CCE32 – with BCCO increment of about 57%
- Montepaldi CCE32 – with BCCO increment of about 47%

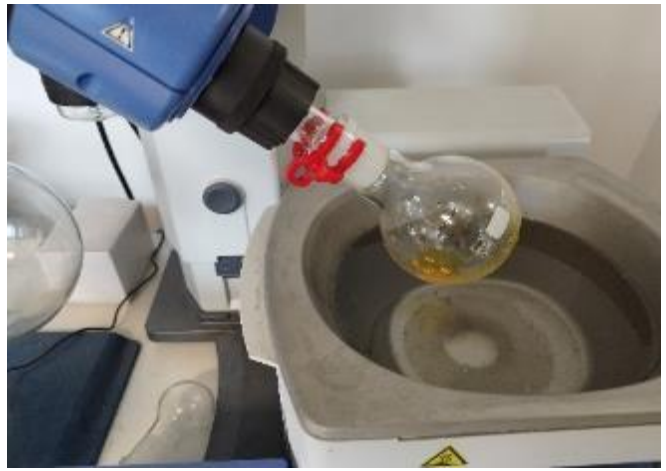
Fisher's test p<0.001

1-year field trial – CAMELINA OIL YIELD



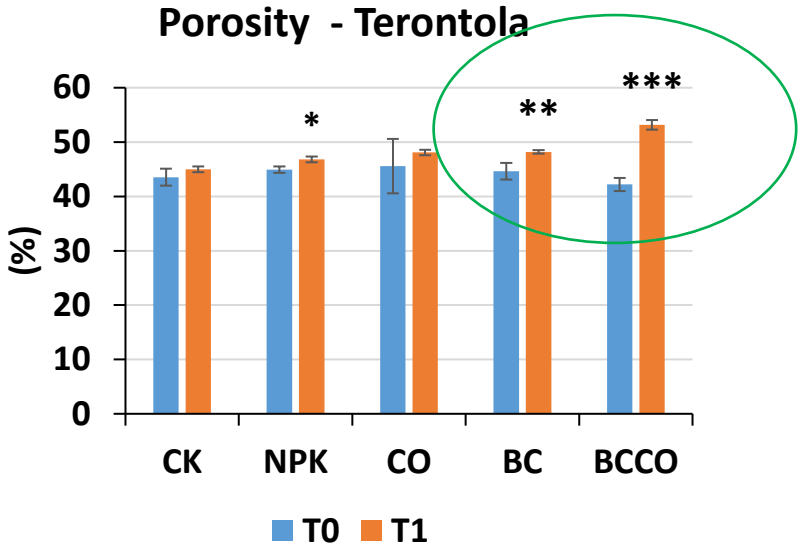
Fisher's test p<0.001

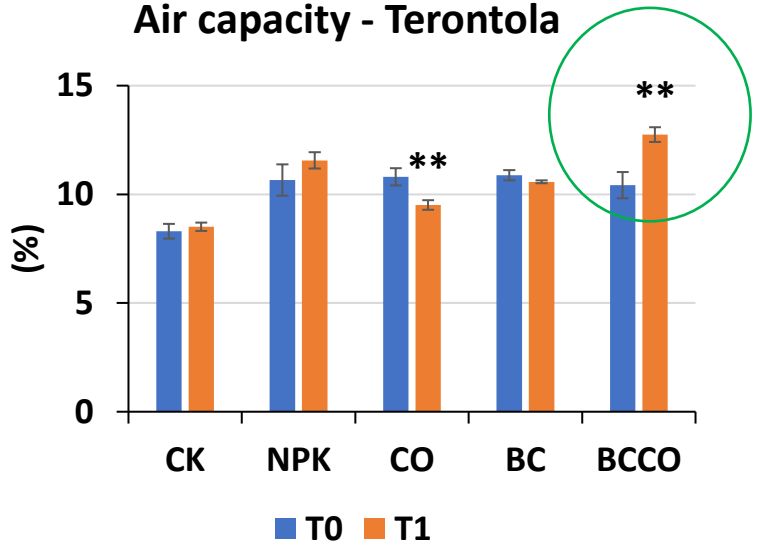




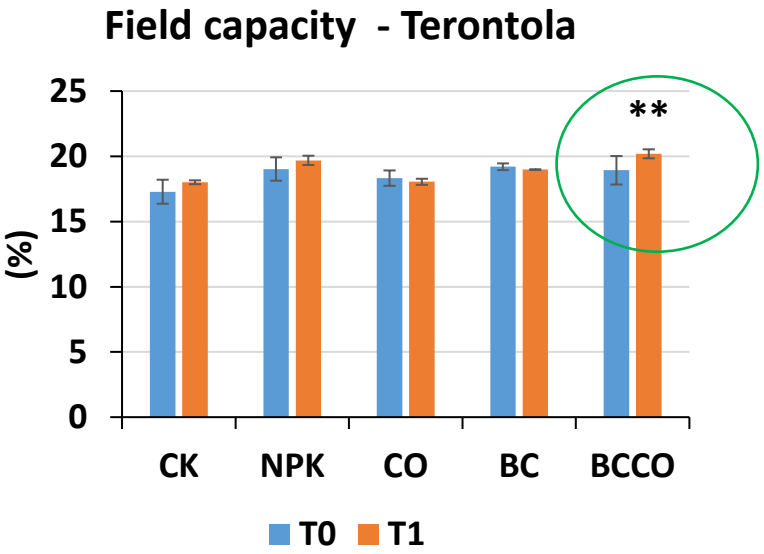
Effects on soil properties

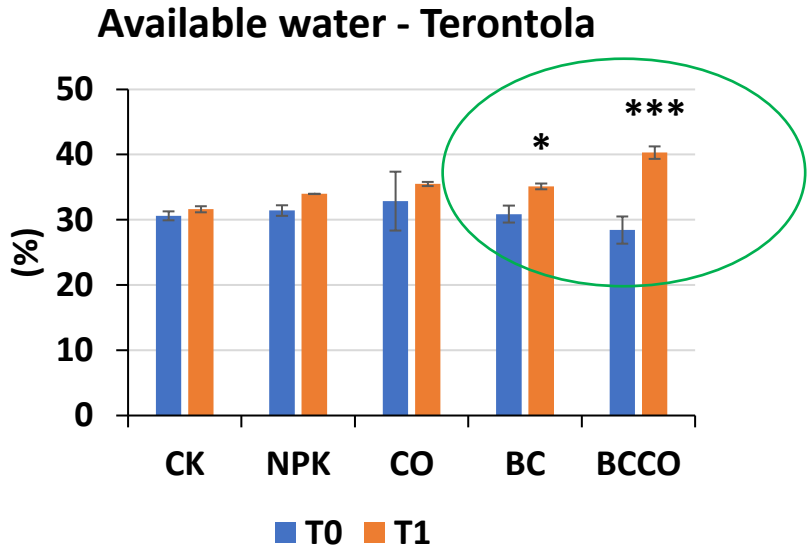
1-year field trial - Effect on soil properties



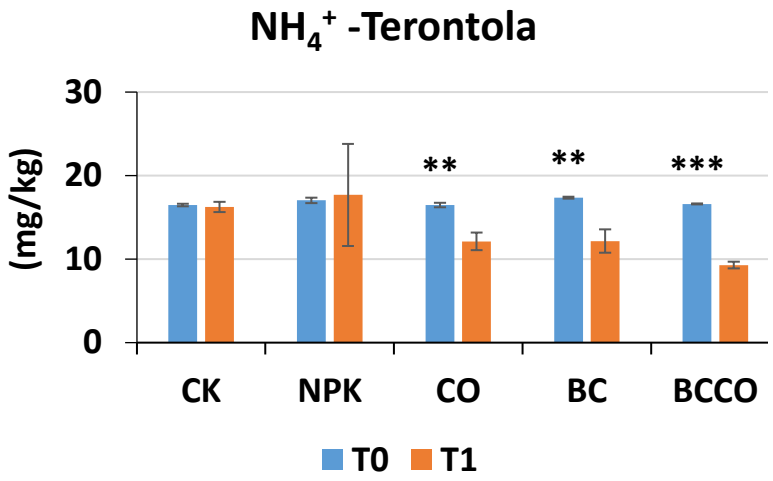


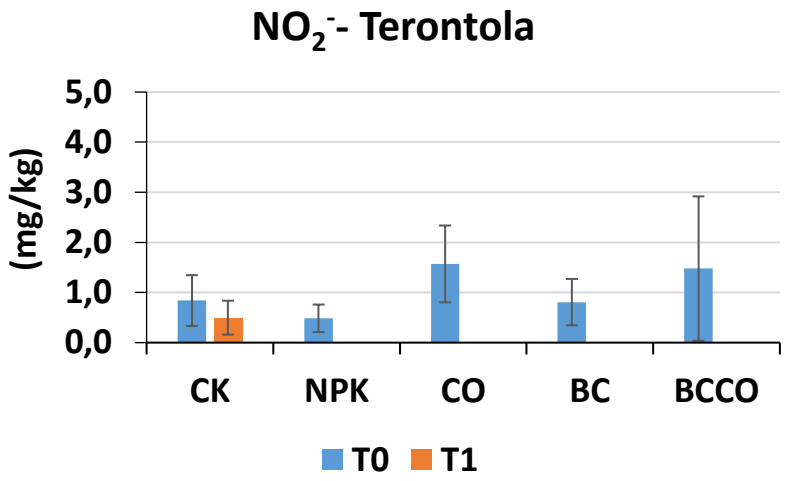
In Montepaldi, no significant variations were observed, probably due to the high clay content

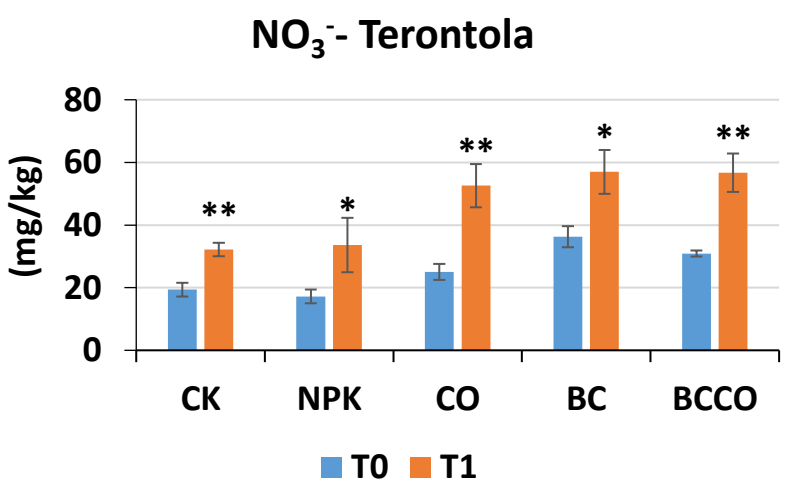




1-year field trial - Effect on soil properties

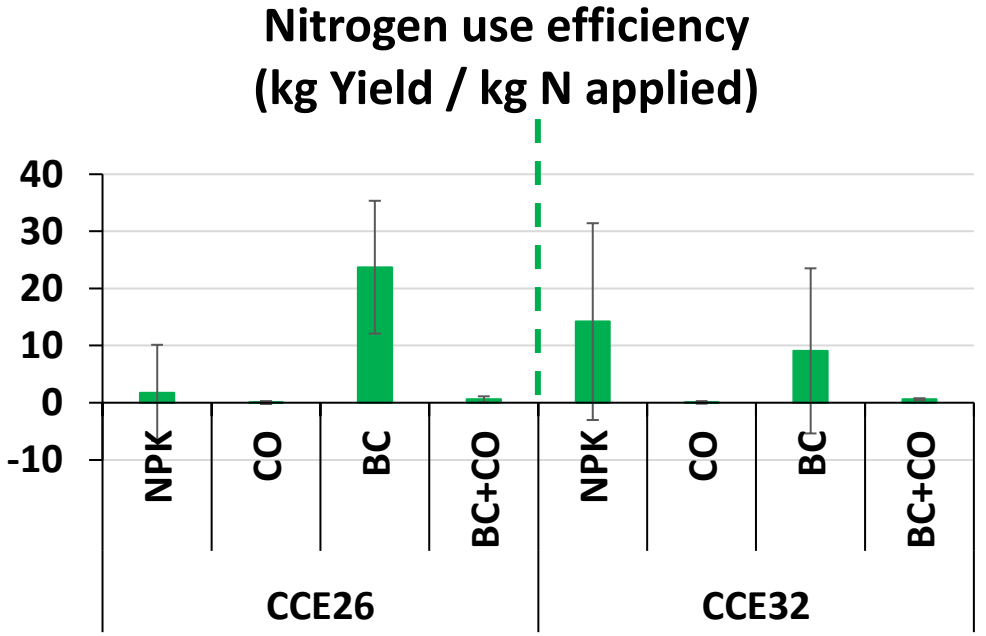






Treatments	Nitrogen (kg) applied in each plot
CK	0
NPK	0.44
CO	21.52
BC	0.44
BCCO	21.52

In Montepaldi, no significant variations regarding the main chemical properties were observed



3-year Spanish field trial – Effect on soil properties

RESEARCH GOAL

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

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

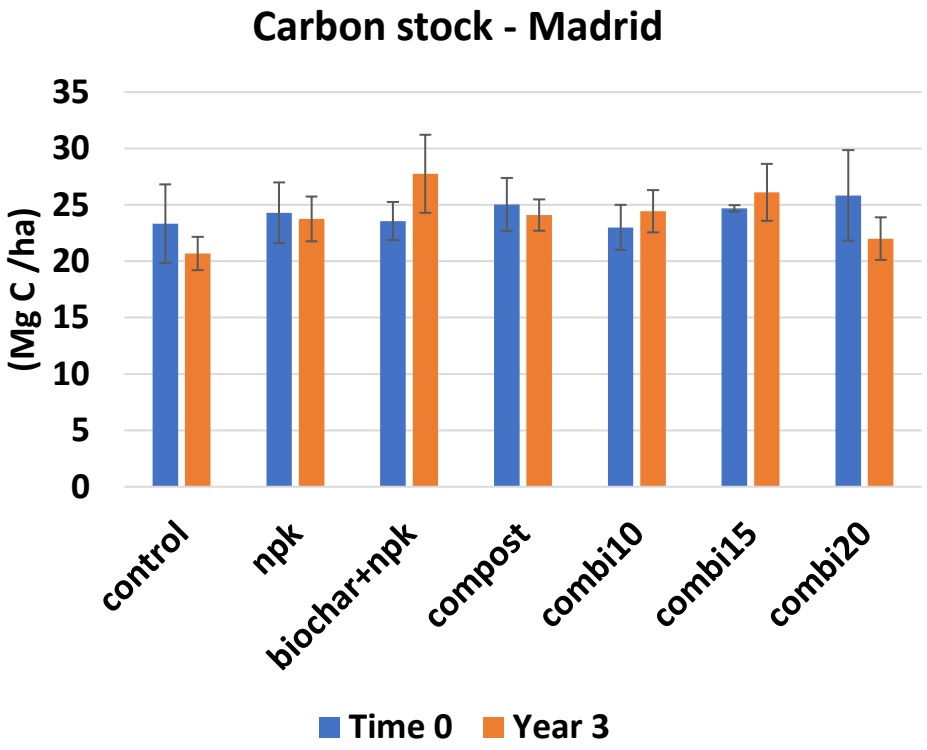
AGRONOMIC AND ENVIRONMENTAL CONDITIONS

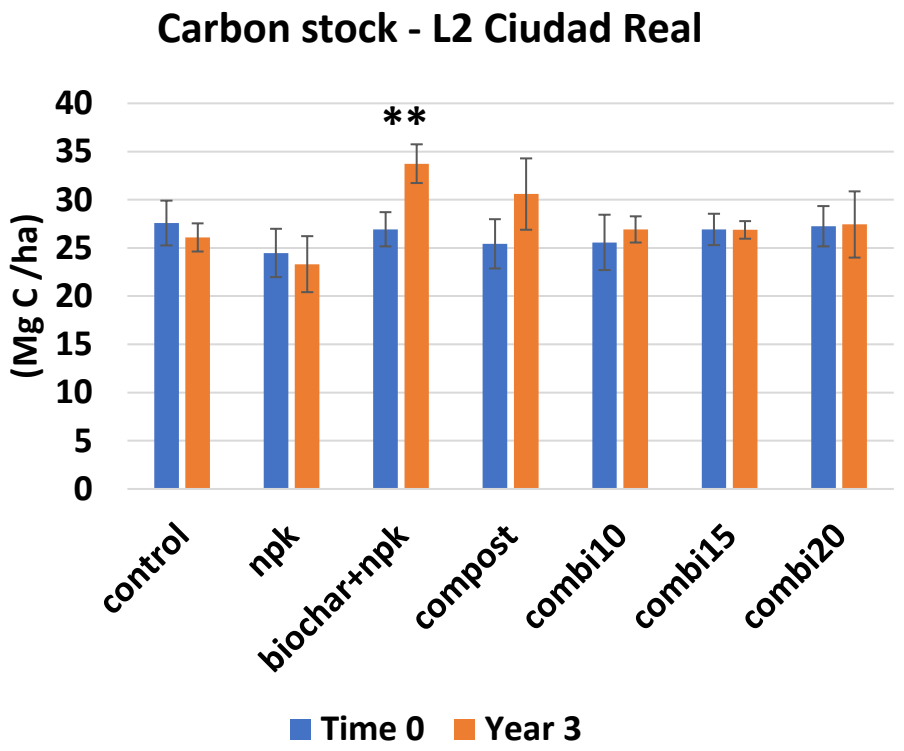
- **Field experiment**
- **2 locations**: **Madrid and Ciudad Real**
- No artificial irrigation
- **Biochar** from poplar (550°C, slow pirolysis)

TREATMENTS

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

3-year Spanish field trial – Effect on carbon stock





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

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

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).

3-year Spanish field trial – Effect on soil properties

Madrid	Stock (Mg of C /ha)		
Treatment	Time 0	Year 3	C stock increment (%)
control	23.3	20.7	-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

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.

Conclusions

- In Terontola, Camelina performed very well in the presence of biochar mixed with compost alone, but also with biochar alone
- An improvement of the soil physical characteristics was observed in the biochar-mixed plots
- With only biochar, higher nitrogen use efficiency
- Biochar increases organic carbon stock – long term experiment
- Bulk density is equally key for Carbon Stock as Corg! Attention should be paid to combination of sustainable agricultural practices

Bio4A

Advanced Sustainable Biofuels for Aviation

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Thanks for your attention!

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