Advanced Sustainable BIOfuels for Aviation

Deliverable D2.3: Compost agronomic protocol optimization trial

Consortium:

Acronym	Legal entity	Role
RE-CORD	CONSORZIO PER LA RICERCA E LA DIMOSTRAZIONE SULLE ENERGIE RINNOVABILI	CO
TRC	TOTAL RAFFINAGE CHIMIE SA	BEN
TRF	TOTAL RAFFINAGE FRANCE	BEN
SKYNRG	SKYENERGY BV	BEN
CENER	FUNDACION CENER-CIEMAT	BEN
ETA	ETA – Energia, Trasporti, Agricoltura Srl	BEN
CCE	CAMELINA COMPANY ESPANA S.L.	BEN
JRC	JOINT RESEARCH CENTRE – EUROPEAN COMMISSION	BEN

CO…Coordinator, BEN…Beneficiary

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Document Type		
PRO	Technical/economic progress report (internal work package reports indicating work status)	
DEL	Technical reports identified as deliverables in the Description of Work	**X**
MoM	Minutes of Meeting	
MAN	Procedures and user manuals	
WOR	Working document, issued as preparatory documents to a Technical report	
INF	Information and Notes	

Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	
CON	Confidential, only for members of the Consortium	

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1 Summary

Desertification is a form of land degradation in drylands. In parallel with the changing climate patterns observed in the rest of the world, Europe is registering rising temperatures combined with rainfall reduction, mainly in Mediterranean and Scandinavian regions.
In the framework of Work Package 2, Task 2.1., the Bio4A project has established a serial of trials to corroborate the possibility to reclaim cultivate marginal lands at risk of desertification while increasing the soil carbon content and resilience through the application of biochar and co-composted biochar, produce sustainable oils on underutilized lands and provide sustainable feedstock for the biofuel industry.

Fully characterised biochar from oxidative pyrolisis of wood and organic material e.g. solid fraction of digestate from Anaerobic Digestion) have been tested in various mixturesagainst the business-as-usual mineral fertilization treatment locally used in Spanish agriculture.
This test aims at demonstrating the performances on soil with improved resilience based on biochar alone, traditional compost and co-composted biochar (COMBI) addition.

Camelina sativa (L.), a very high drought tolerant plant, has been selected for cultivation on these tests. Camelina is a hardy crop resistant characterized by its root development that allows high utilization of water and nutrients. In order to accomplish the rotation crop principles, Camelina crop has been alternated with barley crop, establishing a simple rotation two years scheme: Camelina/Barley.
The usual crop rotation practice in these semi-arid areas is to alternate barley with a year of fallow. This practice favours a mineralization process and aggravates the effect of the erosive processes. The introduction of Camelina in rotation schemes, a cruciferous crop with a deeper root, has a number of advantages related to soil fertilization and structure like a reduction of soil erosion and use the leftover nutrients potentially polluting by leaching among others.

The present deliverable D2.3 is based on three years of trials in two agricultural marginal areas from Spain, located in Finca la Canaleja, Alcalá de Henares (Madrid) and Finca Entresierras, Ciudad Real (Castilla La Mancha).

The description of the treatments includes:

- No fertilization: No fertilization product has been applied in this treatment.
- Mineral fertilization: 250 kg/ha of NPK (8:24:8) as background fertilization
- COMBI containing 10% Biochar
- COMBI containing 15% Biochar
- COMBI containing 20% Biochar
- Biochar + 250 kg/ha of NPK (8:24:8) as background fertilization
- 100% Compost

Preliminary results show that biochar and compost produce a positive effect on crop development, achieving yield increases of up to 25%-40% with respect to conventional fertilization practices.

Biochar presented a clear incremental effect ($p<0.05$) compared to the control and business-as-usual NPK fertilization, this effect being more pronounced in very low rainfall conditions (86 mm from seeding to harvest in 2019 in Location L1 – La Canaleja).
The other treatments containing biochar also performed significantly better in lower rainfall conditions. This includes also, for example, the COMBI treatment compared to Compost 100%, which also suggests a clear synergistic effect of co-composting process of biochar with labile C organic material.

After three years, co-composted biochar (COMBI) 15% and 20% percentage levels of biochar w/w resulted in the first and second highest mean yields (cumulating camelina and barley yields) compared to all treatments, including biochar alone and compost alone.
Looking at the dynamic of yields after three years, trends suggest that the effects on yield of co-composted COMBI tend to become predominant, while those of Compost 100% – and also of Biochar 100%, it should be noted - seem to diminish more rapidly over time.
However, the total duration of the experiment is not sufficient to draw conclusions over the long-term effects of these treatments.

At the same time, positive effects have been observed on seed quality: seed weight and camelina oil content tend to increase when cultivated with compost and biochar.
In conclusion, the general recommendation on the agronomic protocol for oleaginous species cultivation, is that biochar can be seen as a promising candidate to increase the resiliency of agrosystems to prolonged dry spells in those regions like EU-MED where agriculture is rainfed and drought periods are more frequent.
However, further research is needed to better refine the optimal quantity of biochar per hectare and per type of soil.
In addition biochar, as a Negative Emissions Technology, offers the capability to permanently sequester C in soil, which provides a precious contribution to offsetting GHG emissions of the entire value chain.
Finally, where organic, nutrient rich material is available (e.g. solid fraction of digestate), the indication is to explore the possibility of co-composting (or, in alternative, of mixing) this material with biochar in order to increase the durability of its synergistic effects as a soil amendment.

2 Introduction

The Bio4A project objectives included in task 2.1 (WP2) are the following ones:

- Define the best biochar+compost agronomic protocol in order to upgrade marginal land with high risk of desertification, based on feedstock production in terms of kg oil per hectare: Deliverable D2.3 and Deliverable D2.5.
- Selection of high yielding camelina variety cultivated under marginal land with high desertification risk in Southern Europe: Deliverable D2.4 and Deliverable D2.6.

These activities have been performed in different trials during the two first years. In the third year, both objectives have converged in the same trial located in two locations.

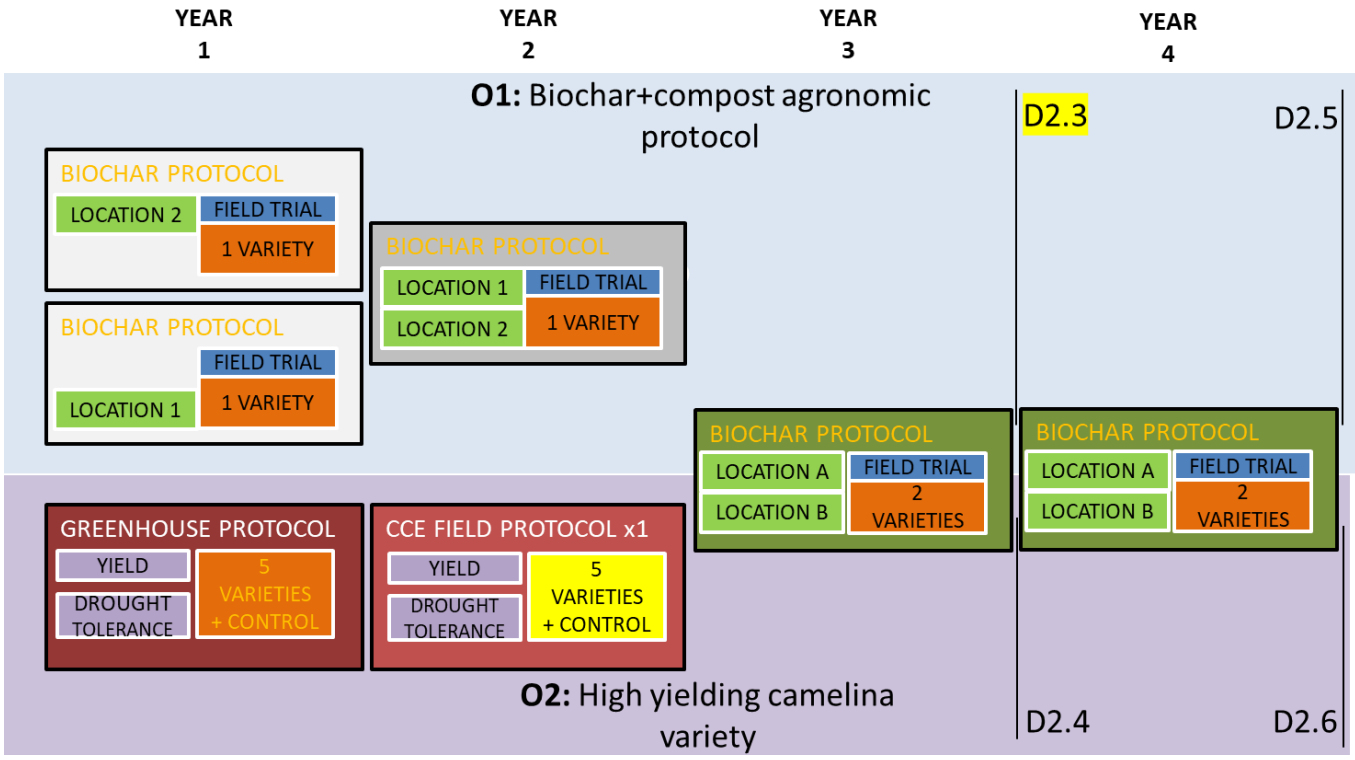

Figure 1. Bio4A objectives of the Task 2.1

3 Trial definition

Camelina Company España has developed this study in Spain in marginal land with high risk of desertification. The selected locations have been Alcalá de Henares (Madrid) and Ciudad Real (Castilla La Mancha).

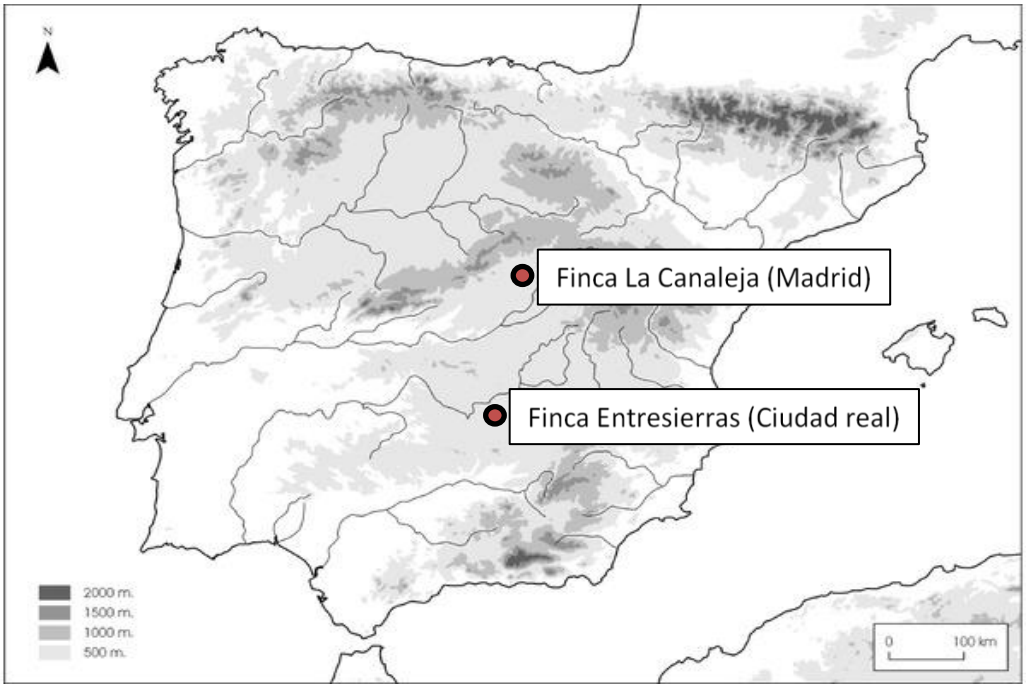

Figure 2. Trial locations

Trials have been designed in micro-plots with 4 replications on arid lands with no irrigation. The placement of the treatments was designed in lines in order to facilitate the management and avoid a possible contamination of the biochar and COMBI addition during soil preparation.

The description of the treatments includes:

- No fertilization: No fertilization product has been applied in this treatment.
- Mineral fertilization: 250 kg/ha of NPK (8:24:8) as background fertilization
- COMBI containing 10% Biochar
- COMBI containing 15% Biochar
- COMBI containing 20% Biochar
- Biochar supplied by RECORD + 250 kg/ha of NPK (8:24:8) as background fertilization
- 100% Compost supplied by RECORD

Biochar and compost mixes have been applied only once, previous to the first-year experiment. Background fertilization (NPK), has been applied every year before sowing, but only to Mineral fertilization treatment and Biochar+NPK treatment. Dressing fertilization has been applied in all treatments during spring with the exception of “No fertilization treatment”.

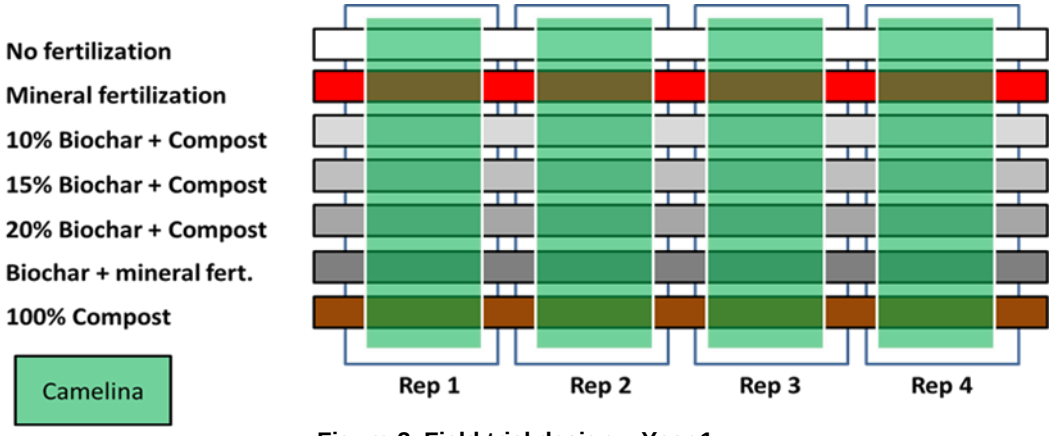

Figure 3. Field trial design – Year 1.

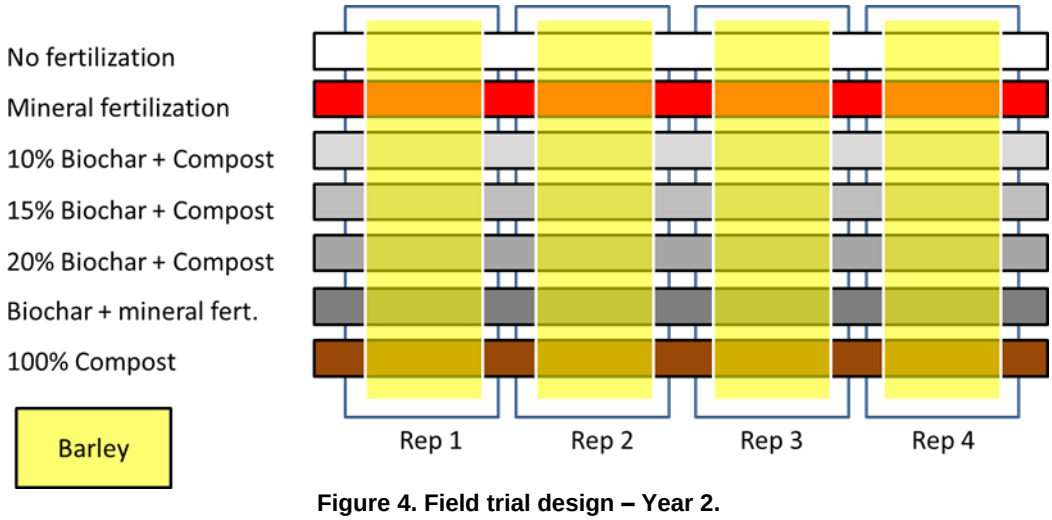

Figure 4. Field trial design – Year 2.

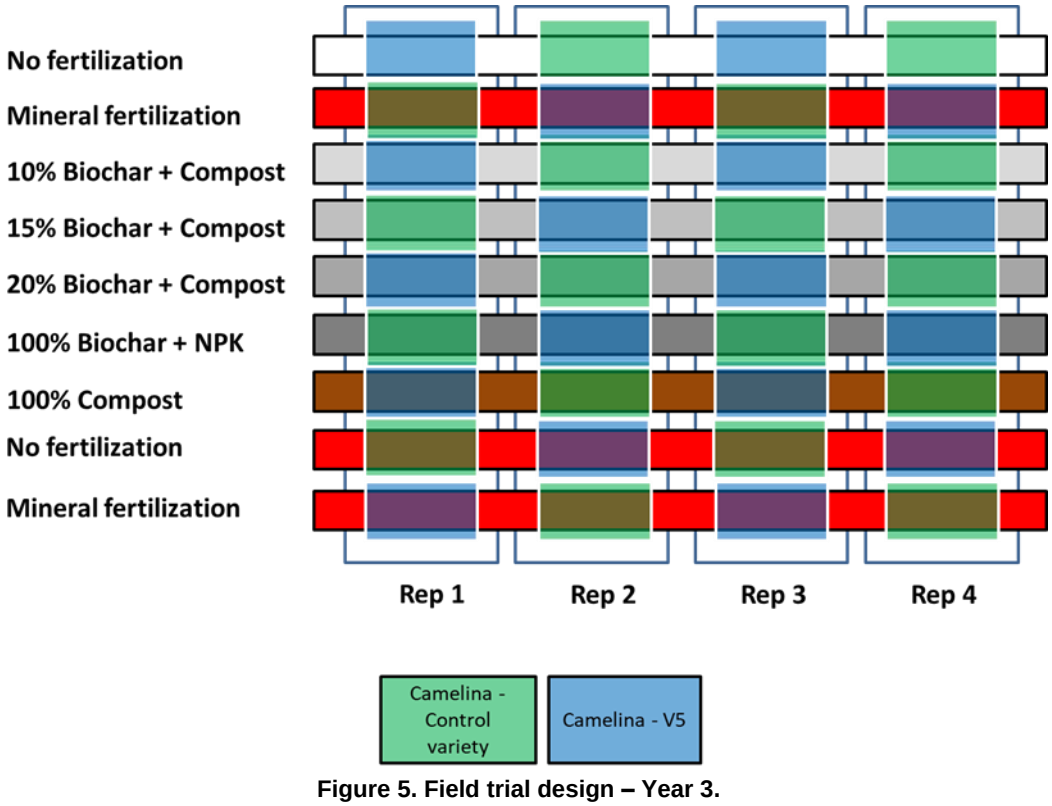

Figure 5. Field trial design – Year 3.

4 Materials and Methods

4.1 Methodology

4.1.1 Location 1 (L1) – Finca La Canaleja (Alcalá de Henares, Madrid)

CCE has developed this trial in collaboration with the INIA (Instituto Nacional de Investigación y Tecnología Agraria). The trial has been performed following the design previously indicated with four replicates in 4 m x 3 m, plus 3 m corridor for the access needed for equipment and data collection by technicians.

Year 1

The agricultural labours performed in this trial include:

- *20th of January 2019*: First plow pass.
- *15th of February 2019*: Plot stacking.
- *27th of February 2019*: Application of the fertilization treatments.
- *28th of February 2019*: Treatments were incorporated with a pass of cultivator.
- *14th of March 2019*: Trial was planted in rows of 12.5 cm of separation at a density of 8 kg/ha. As a consequence of the seeding date, a short cycle camelina variety was selected for the development of this trial (CCE26).
- *15th of February 2019 – 22th of February 2019*: In order to assure an adequate germination, this trial was irrigated using an irrigation cannon during the first two weeks (5 times,10 mm/irrigation).
- *5th of April 2019*: An application of 200 kg/ha of calcium ammonium nitrate was performed.
- *21th of June 2019*: Trial was harvested. Due to the poor development of the plants, treatments were harvested by hand, using a ring of 0.28 m^2. The first replicate of all treatments was discarded due to the absence of camelina plants.

Figure 6. Pictures of L1 trial (La Canaleja, Madrid). Year 1: 14th March 2019 – Seeding (Top-left), 4th April 2019 - Seedlings (Top-right), 10th May 2019 - Elongation (Middle-left), 22th May 2019 – Irrigation Cannon (Middle-right), 22th May 2019 –Flowering (Bottom-left), 21th June 2019 – Harvest (Bottom-Right).

Below is a graph with the meteorological data recorded during the field trial:

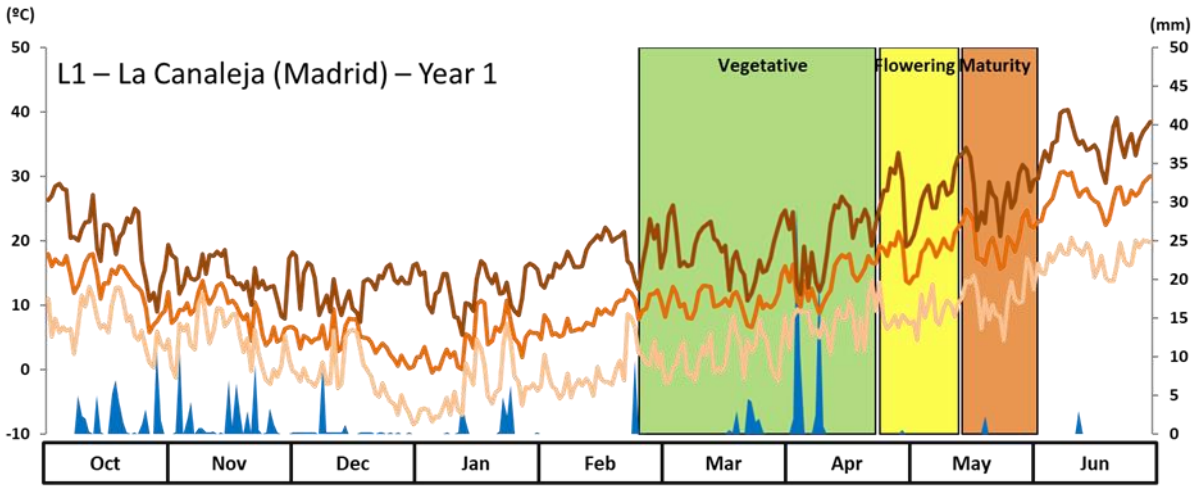

Figure 7. Meteorological data during L1 trial – Year 1 (La Canaleja, Madrid):

- Temperatures (ºC): Maximum temperature (dark brown), Average temperature (brown), Minimum temperature (light brown).
- Precipitation (mm) (Blue).
- Phenological stages: Vegetative (Green area), Flowering (Yellow area) and Maturity (Brown area).

Year 2

The agricultural labours performed in this trial include:

- *17th of October 2019*: Cultivator pass.
- *7th of November 2019:* Plot stacking and background fertilization (250 kg/ha "8-24-8) was developed.
- *8th of November 2019:* Barley (Variety vinagrosa) was planted in rows of 12.5 cm of separation at a density of 180 sem/m^2.
- *5th of March 2020:* An application of 180 kg/ha of calcium ammonium nitrate was performed in the corresponding treatments. No herbicide was applied in this trial.
- *28th of May 2020:* "No fertilization" treatment was harvested by hand, using a ring of 0.28 m^2.
- *11th of June 2020:* Rest of treatments were harvested by hand, using the same methodology previously described.

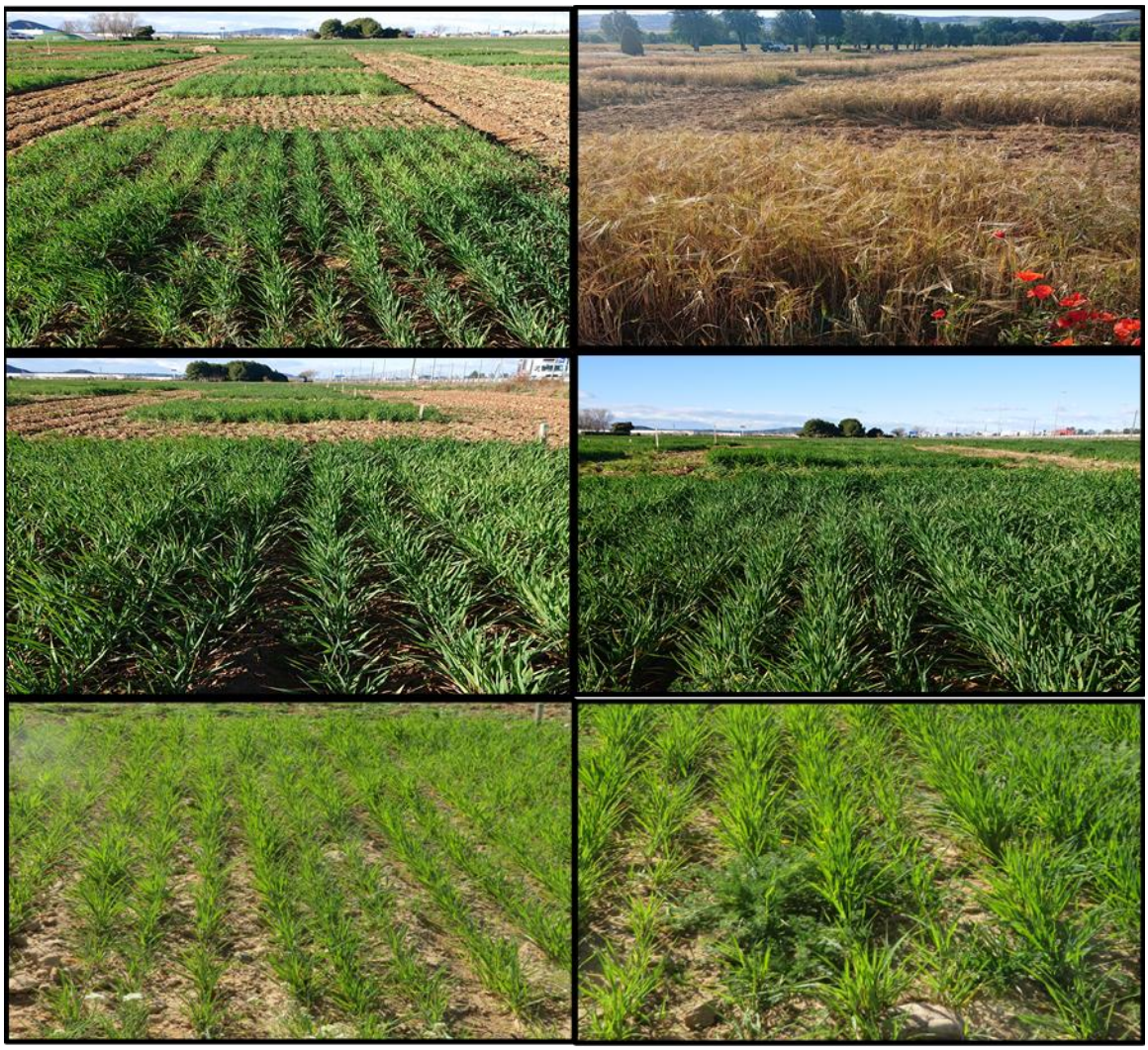

Figure 8. Pictures of L1 trial (La Canaleja, Madrid) - Year 2: 2nd March 2020 – General view (Top-left), 26th May 2020 – General view (Top-right), 2nd March 2020 -No fertilization treatment (Middle-left), 2nd March 2020 -20% biochar+compost treatment (Middle-right), 26th March 2020 – -No fertilization treatment (Bottom-leftt), 26th March 2020 - 20% biochar+compost treatment (Bottom-right).

Below is a graph with the meteorological data recorded during the field trial:

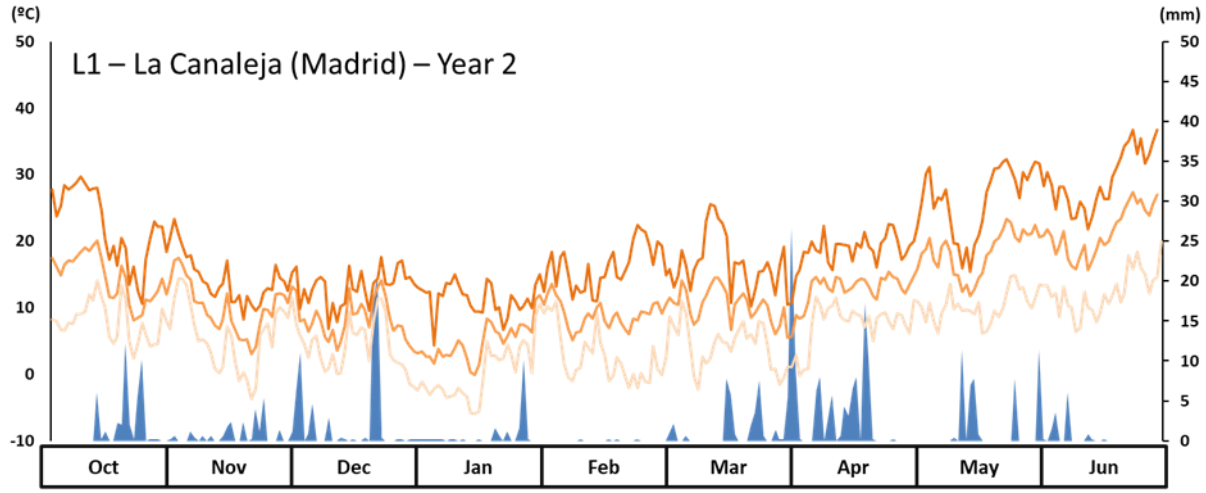

Figure 9. Meteorological data during L1 trial - Year 2 (La Canaleja, Madrid):

- Temperatures (ºC): Maximum temperature (dark brown), Average temperature (brown), Minimum temperature (light brown).
- Precipitation (mm) (Blue).

Year 3

The agricultural labours performed in this trial include:

- *28th of October 2020*: First plow pass.
- *11th of November 2020*: Cultivator pass.
- *19th of November 2020*: Application of 250 kg/ha of an NPK:8-24-8 as background fertilization (only in "mineral fertilization" and "biochar+mineral fertilization" treatments).
- *3th of December 2020*: The trial was planted in rows of 12.5 cm of separation at a density of 8 kg/ha. Two varieties (Control, V5) were planted in order to evaluate their performance (Activity described in D2.4).
- *17th of March 2021*: An application of 180 kg/ha of calcium ammonium nitrate was performed in all treatments with the exception of "No fertilization treatment".
- *9th of June 2021*: The trial was harvested by hand, using a ring of 0.28 m^2. Two samples per plot were collected.

Figure 10. Pictures of L1 trial (La Canaleja, Madrid). Year 3: 14th December 2020 – Sowing (Top-left), 2th March 2021 – Cotyledon stage (Top-right), 1th June 2021 - Maturity (Bottom-left), 9th June 2021 – Harvest (Bottom-Right).

Below is a graph with the meteorological data recorded during the field trial:

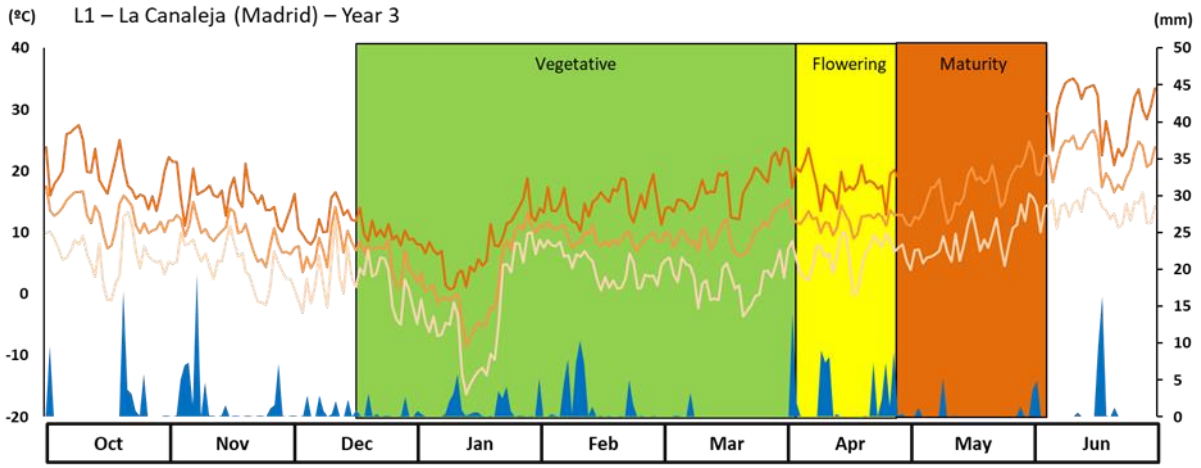

Figure 11. Meteorological data during L1 trial – Year 3 (La Canaleja, Madrid):

- Temperatures (ºC): Maximum temperature (dark brown), Average temperature (brown), Minimum temperature (light brown).
- Precipitation (mm) (Blue).
- Phenological stages: Vegetative (Green area), Flowering (Yellow area) and Maturity (Brown area).

4.1.2 Location 2 (L2) – Finca Entresierras (Ciudad Real, Ciudad Real)

CCE has developed this trial in collaboration with the JCCM (Junta Castilla La Mancha). The trial has been performed following the design previously indicated with four replicates in 12.5 m x 1.2 m, plus 0.2 m corridor for the access needed for equipment and data collection by technicians.

Year 1

The agricultural labours performed in this trial include:

- *7th to 10th of January 2019*: The land preparation consisted in a pass of cultivator and a pass of barbed harrow.
- *11th of January 2019*: Application of the fertilization treatments.
- *12th of January 2019*: Treatments were incorporated with a pass of rotovator.
- *14th of January 2019*: Trial was planted in rows separated by 12.5 cm at a density of 8 kg/ha. The variety selected for this trial was a medium cycle camelina variety (CCE32).
- *30th of January 2019*: A roller harrow pass was performed when camelina seedlings reached the rosette stage.
- *22th March of 2019*: Dressing fertilization consisted in an application of 230 kg/ha of BONO D-CODER TOP (20N-6P-6K-2Mg-20S).
- *22th May of 2019*: The height of each treatment was measured in the flowering stage (Peak height).
- *15th of June 2019*: Harvest was performed with a microplot harvester.

Figure 12. Pictures of L2 trial – Year 1 (Entresierras, Ciudad Real): 11th January 2019 – Seeding (Top-left), 21th February 2019 -Cotyledons (Top-right), 18th March 2019 – Root development (Middle-left), 18th March 2019 – Rosette (Middle-right), 17th April 2019 –Flowering (Bottom-left), 22th May 2019 – Maturity (Bottom-Right).

Below is a graph with the meteorological data recorded during the field trial:

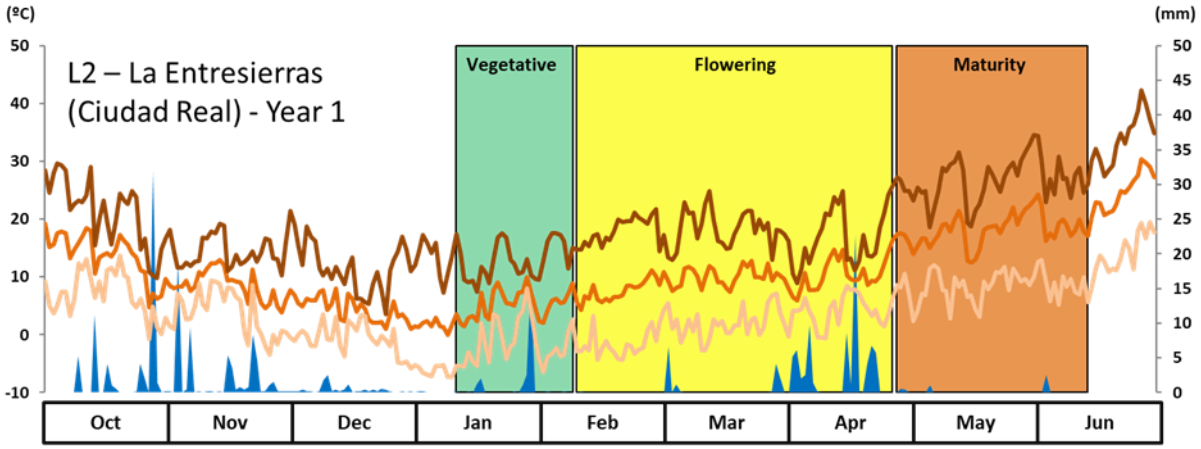

Figure 13. Meteorological data registered during L2 trial (Entresierras, Ciudad Real):

- Temperatures (ºC): Maximum temperature (dark brown), Average temperature (brown), Minimum temperature (light brown).
- Precipitation (mm) (Blue).
- Phenological stages: Vegetative (Green area), Flowering (Yellow area) and Maturity (Brown area)

Year 2

The agricultural labours performed in this trial include:

- *25th of October 2019 and 28th November 2019*: The land preparation consisted in two passes of cultivator, developed in the same direction of the treatments in order to avoid a possible mix.
- *29th of November 2019*: Application of the background fertilization (only in the corresponding treatments). It consisted in a dose of 150 kg/ha of an NPK "10-12-20" fertilizer.
- *29th of November 2019*: The trial was planted in rows separated by 12.5 cm at a density of 375 sem/m^2. The barley variety selected for this trial was Sfera.
- *14th February of 2020*: Dressing fertilization consisted in an application of 230 kg/ha of BONO D-CODER TOP (20N-6P-6K-2Mg-20S).
- *18th February 2020*. A broadleaf herbicide (Granstar super 50 sx, dose: 45 g/ha) was applied in order to control the weeds.
- *17th of June 2020:* Harvest was performed with a microplot harvester.

Figure 14. Pictures of L2 trial – Year 2 (Entresierras, Ciudad Real): 26th March 2020 – Barley in true leaves (Top-left), 17th April 2020 – Barley bolting (Top-right), 30th April 2020 – Barley fructification (Bottom-left), 5th June 2020 – Barley in harvest point (Bottom-Right).

Below is a graph with the meteorological data recorded during the field trial:

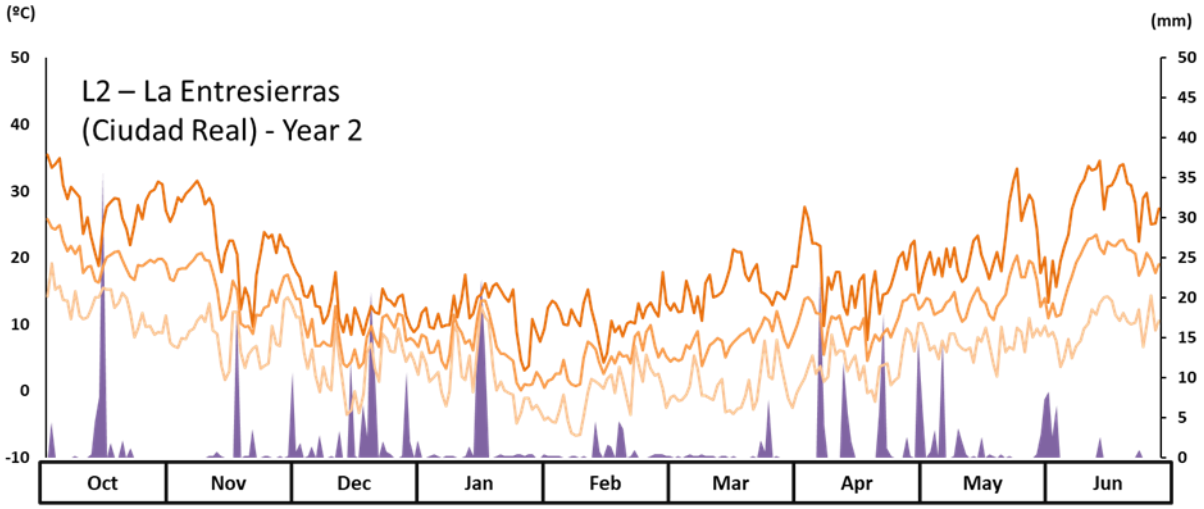

Figure 15. Meteorological data registered during L2 trial – Year 2 (Entresierras, Ciudad Real):

- Temperatures (ºC): Maximum temperature (dark brown), Average temperature (brown), Minimum temperature (light brown).
- Precipitation (mm) (Blue).

Year 3

The agricultural labours performed in this trial include:

- *4th to 24th of November 2020*: The land preparation consisted of a pass of the cultivator and a pass of barbed harrow. A roller harrow pass was performed before sowing in order to facilitate the sowing depth setting.
- *25th of November 2020*: The background fertilization (only in "mineral fertilization" and "biochar+mineral fertilization" treatments) consisted in 200 kg/ha D-CODER TOP8 (7N-10P-20K) incorporated during sowing (localized fertilizer).
- *25th of November 2020*: Trial was planted in rows separated by 12.5 cm at a density of 650 seeds/m^2. Two varieties (Control, V5) were planted in order to evaluate their performance (Activity described in D2.4).
- *15th February of 2021*: Dressing fertilization consisted in an application of 400 kg/ha of BONO D-CODER TOP (20N-6P-6K-2Mg-20S). This application was performed in all treatments with the exception of "No fertilization treatment".
- *13th March of 2021 to 16th April of 2020*: The height of each treatment was measured during the flowering stage (Peak height).
- *15th of July 2021*: Harvest was performed with a microplot harvester. A problem during this task was detected. Yield results have been affected by a malfunctioning of the combine, suspecting that there have been considerable losses and also, possible mixtures between the treatments.

Figure 16. Pictures of L2 trial – Year 1 (Entresierras, Ciudad Real): 23th December 2020 – Cotyledons (Top-left), 24th February 2021 - Rosette (Top-right), 20th March 2020 – Flowering (Bottom-left), 22th May 2019 – Maturity (Bottom-Right).

Below is a graph with the meteorological data recorded during the field trial:

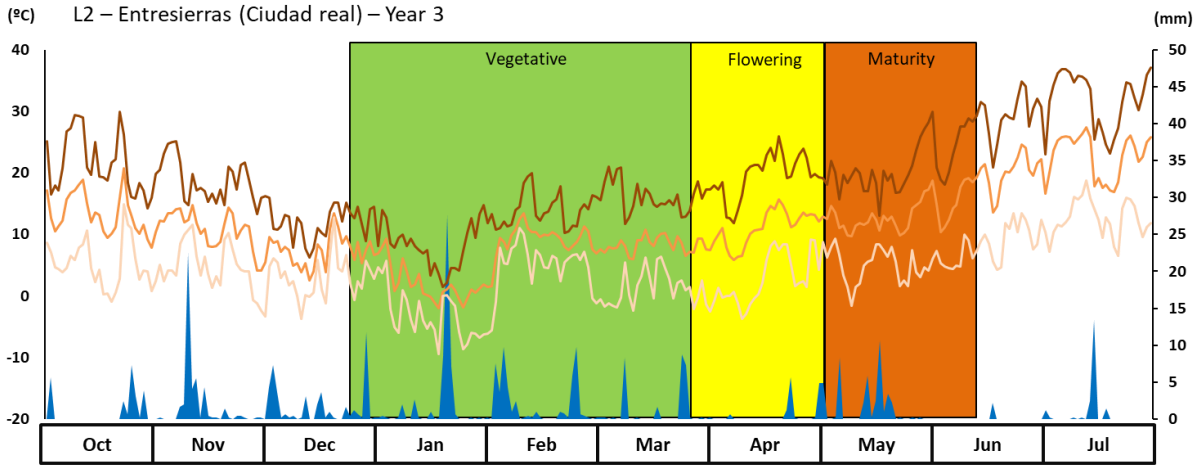

Figure 17. Meteorological data registered during L2 trial (Entresierras, Ciudad Real):

- Temperatures (ºC): Maximum temperature (dark brown), Average temperature (brown), Minimum temperature (light brown).
- Precipitation (mm) (Blue).
- Phenological stages: Vegetative (Green area), Flowering (Yellow area) and Maturity (Brown area)

4.2 Laboratory analyses

Each replicate has been analyzed after harvest to determine the performance of each treatment regarding the project objectives.

Camelina samples (Year 1 and Year 3)

After harvest, a seed cleaning process was performed - employing a SLN cleaner (Pfeuffer)- removing impurities and preventing their interaction in future analysis.

Figure 18. SLN cleaner-PFEUFFER.

Once the harvest sample of each variety has been cleaned, the one thousand grain weight (TGW) has been measured with a precision scale and a seed counter (Contador, Pfeuffer).

Figure 19. Seed counter (Pfeuffer)

Finally, samples have been analyzed by a Near Infrared Spectroscopy (NIRs) device. Measurements of humidity, fat content (total oil) and crude protein are obtained for each sample.

Figure 20. Near Infrared Spectroscopy device (FOSS DS2500).

Barley samples (Year 2)

Barley samples have been analyzed by the research centre which has developed the trial:

- L1 – Instituto Nacional de Investigación y Tecnología Agraria
- L2 - JCCM (Junta Castilla La Mancha)

In both cases, the analysis has consisted of conditioning the harvested sample and measuring yield.

5 Results

CCE has measured the following agronomic traits in camelina trials (year 1 and year 3):

- Cycle duration (days)
- Yield (kg seed/ha)
- Weight of 1,000 seeds
- Seed quality characteristics – oil content (%), moisture (%), oleic acid (%).

In addition, differences between treatments were observed in the plant development during the performance of the trial.

In the case of barley trials (year 2), in both locations the following parameters have been determined:

- Cycle duration (days)
- Yield (kg seed/ha)

5.1.1 L1 – Finca La Canaleja (Alcalá de Henares, Madrid)

Year 1 (Camelina cultivation)

Cycle duration (days)
The cycle duration in this trial was 99 days distributed in 60 days of vegetative stage (Cotyledons and rosette), 20 days of flowering and 20 days of maturity.

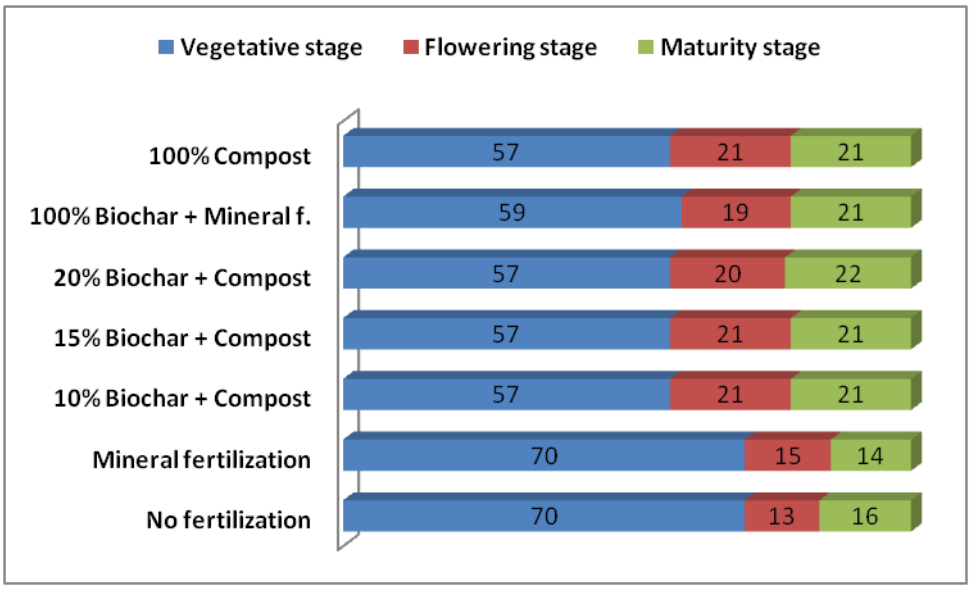

Figure 21. Cycle duration in days. L1 trial – Year 1.

Yield (kg seed/ha)
Seed yield in this trial has been very poor due to the late seeding date and the extremely difficult climatologic conditions. However, the treatments with an input of Biochar have shown a better performance.

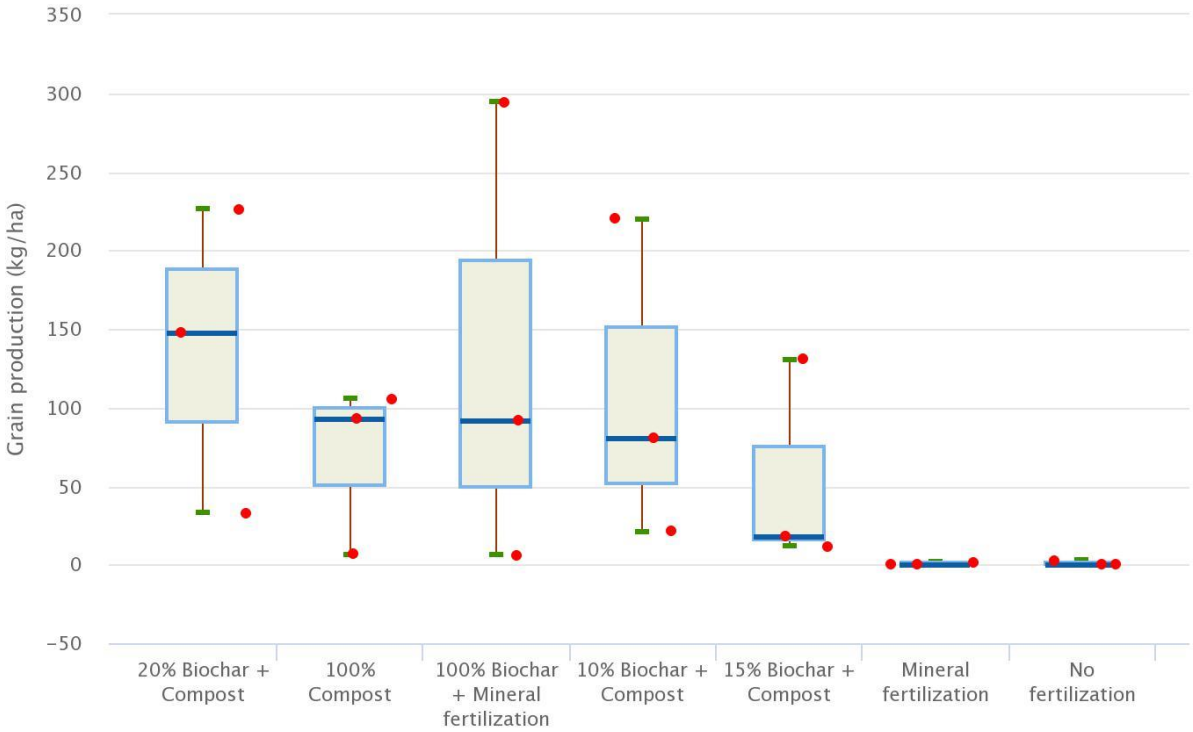

Figure 22. Seed yield in kg/ha. L1 trial – Year 1.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Biomass yield (kg biomass/ha)

Given the poor seed yield harvest, CCE decided to include an additional measure for this camelina trial. The biomass yield, measured in kg of biomass per hectare has been measured in Year 1.

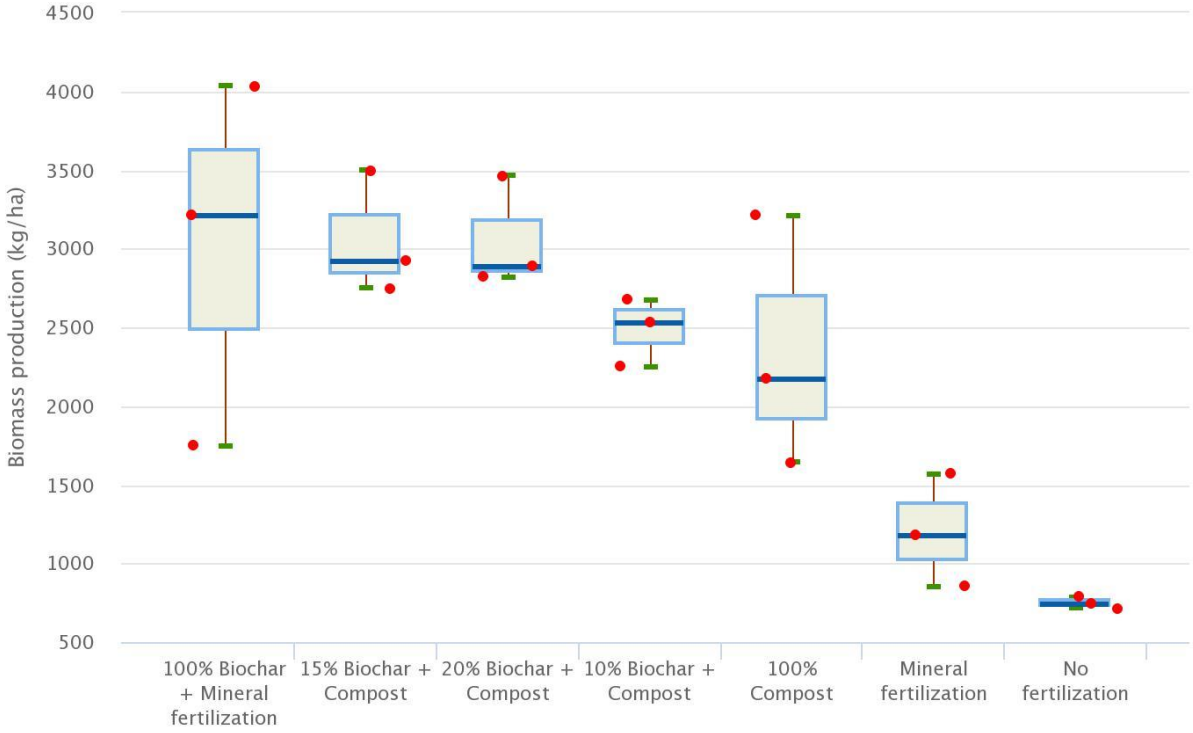

Figure 23. Biomass yield in kg/ha. L1 trial – Year 1:

-
- Replication values (Red spots)

- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

The addition of Biochar has shown a positive effect on increased biomass production. The mineral fertilization + Biochar treatment has registered an increment of almost a 250% comparing the Mineral fertilization treatment (treatments where biochar effect can be isolated). Also, the rest of the treatments with biochar have shown higher biomass production than the treatments without this compound.

Weight of 1,000 seeds (TSW)

The variety used for this trial has been a short cycle camelina variety (CCE26), which is characterized by a low seed size (0.7-1.0 g per 1000 seeds). “No fertilization” and “mineral fertilization” treatments have no data in this feature due to the low amount of seed harvested (lower than 1000 seeds). However, significant differences in this trait have not been observed between the different treatments.

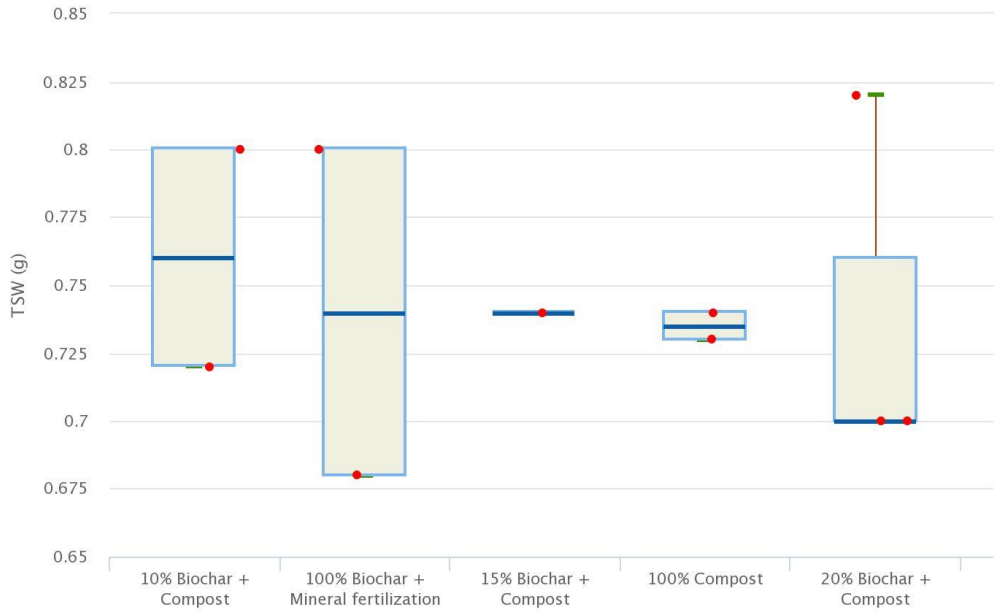

Figure 24. Thousand seed weight in grams. L1 trial – Year 1.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Seed quality characteristics

Significant differences in moisture and oil content have not been observed between the different treatments.

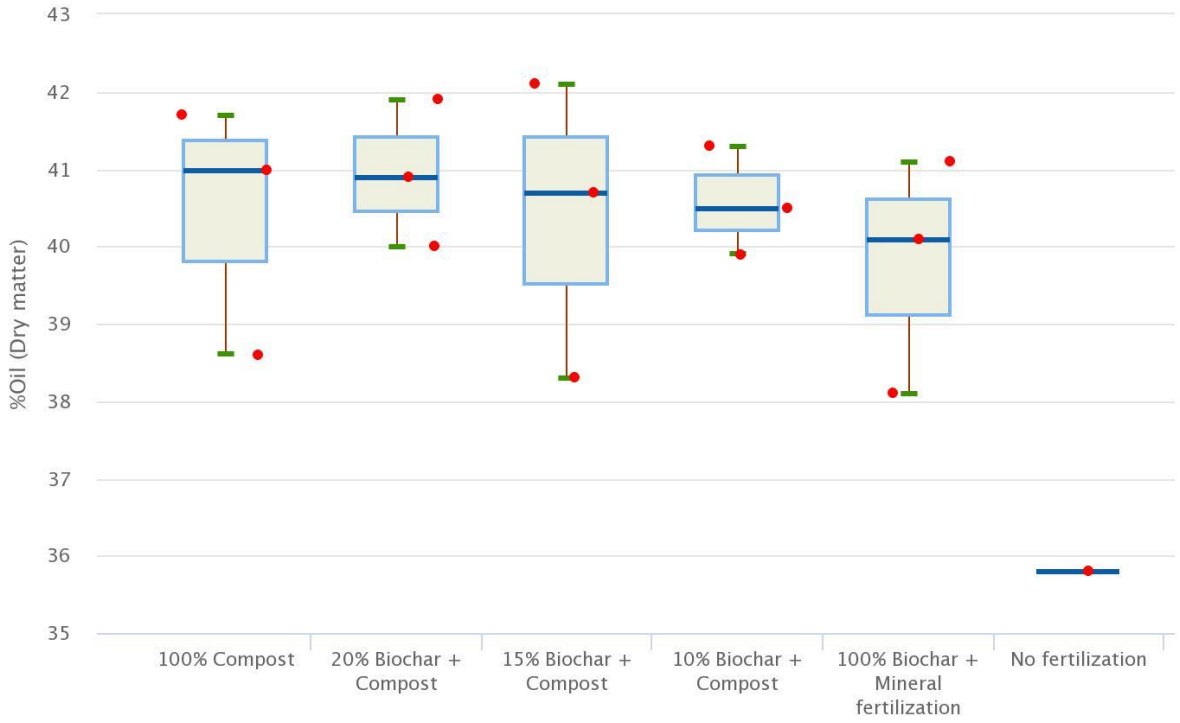

Figure 25. Seed quality characteristics: Moisture and oil content. L1 trial – Year 1.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Finally, the oleic acid results have not shown significant differences between treatments (Range of values: 0.67-0,71%).

Year 2 (Barley cultivation)

Cycle duration (days).

No fertilization treatment replicates were ready to be harvested on day 202 of the cycle. The rest of the treatments were not ready at this point and they were harvested 2 weeks later (day 216 of the cycle).

Yield (kg seed/ha)

The impact produced by the addition of compost has been higher than the biochar. However, mixes between biochar and compost treatments have registered the highest yields: 20%, 15% and 10% of biochar respectively.

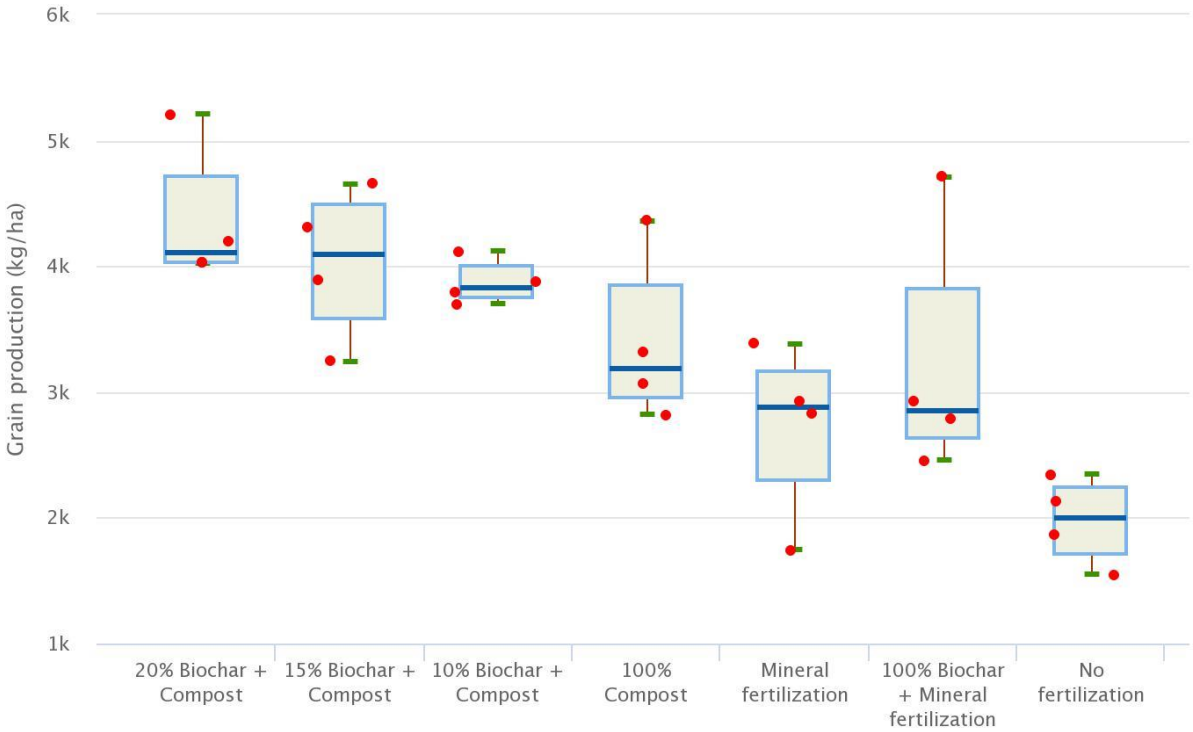

Figure 26. Seed yield in kg/ha. L1 trial – Year 2

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Seed quality characteristics

Grain protein content usually is indicative of nitrogen availability during the crop cycle. Protein content analyses do not show significant differences between treatments in this trial, although large differences between replicates have been observed.

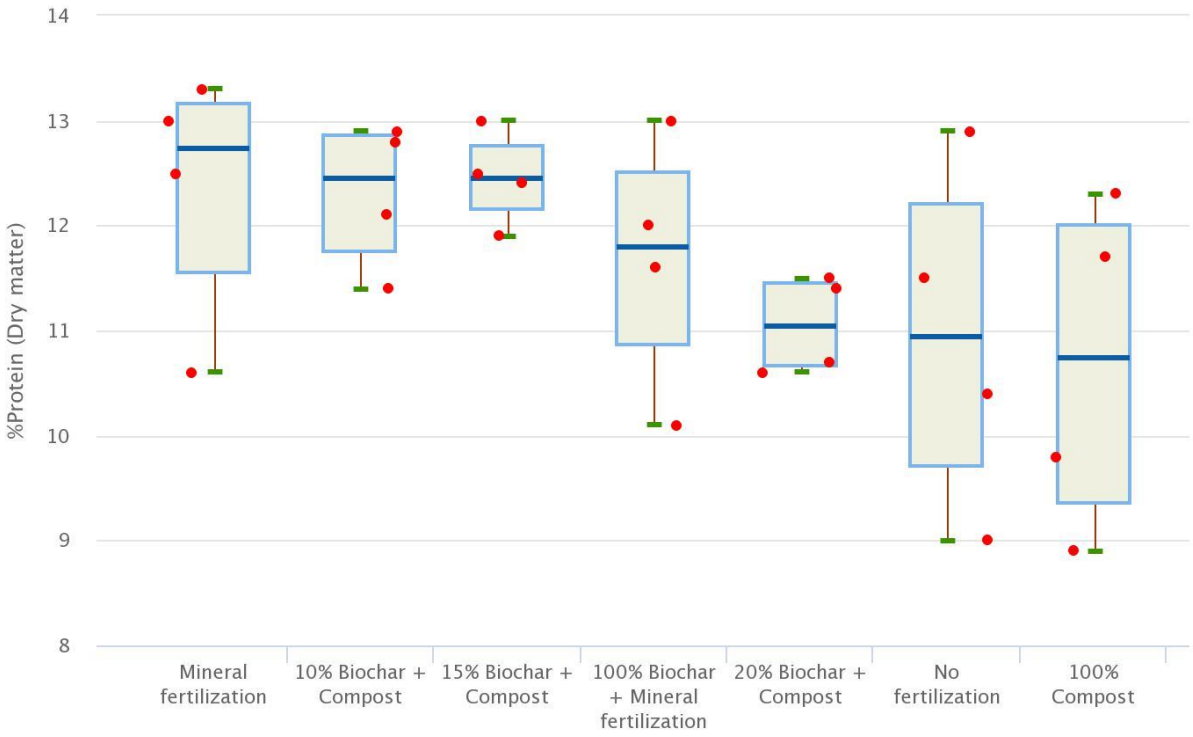

Figure 27. Seed quality characteristics: Dry matter content. L1 trial – Year 2.

- Replication values (Red spots)

- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Year 3 (Camelina cultivation)

Cycle duration (days)

The cycle duration in this trial was between 182 and 198 days. No significant differences related to the phenology have been observed between treatments.

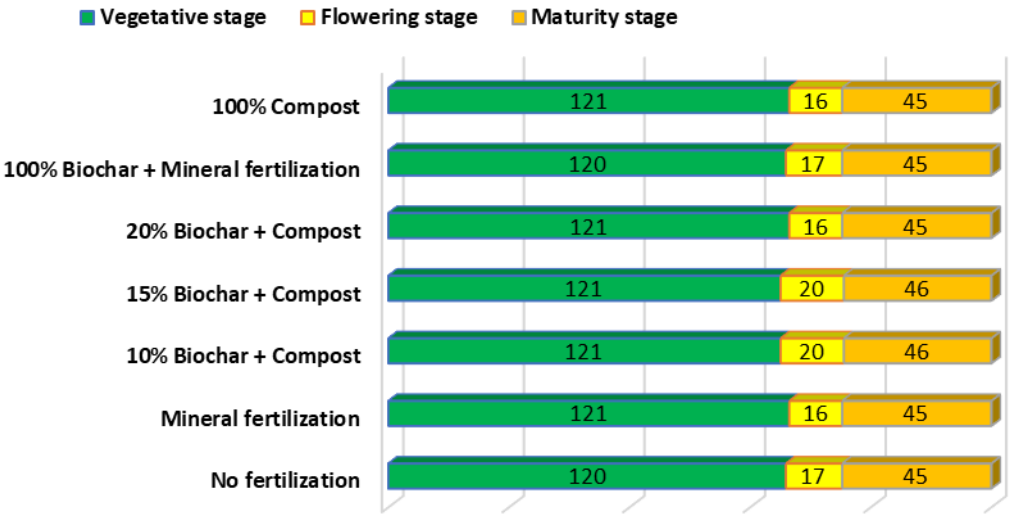

Figure 28. Cycle duration in days. L1 trial – Year 3.

Yield (kg seed/ha)

Results have shown a positive effect of biochar addition in camelina yield. The COMBI mixes with compost and biochar have shown the best performance in this trial, obtaining an increment between 380 and 480%. Mineral fertilization treatments (with and without biochar) and compost treatment (without biochar) have also shown a considerable yield increment compared to the no-fertilization treatment (250-270%), although to a much lesser extent.

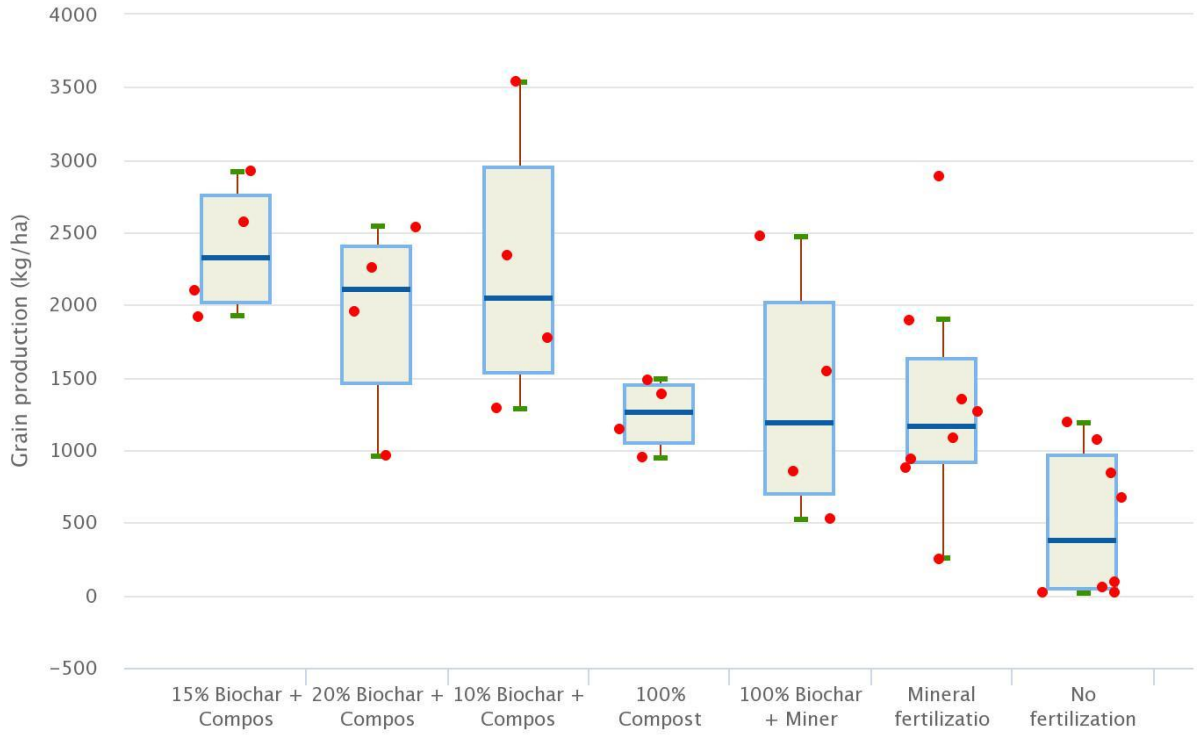

Figure 29. Seed yield in kg/ha. L1 trial – Year 3.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Weight of 1,000 seeds (TSW)

A positive correlation has been observed between seed weight and biochar addition (>6-15% regarding no fertilization treatment). In the same way but in lower measure, this effect has been also observed between seed size and compost fertilization (>4% regarding no fertilization treatment). Mineral fertilization has not shown any effect regarding the seed weight in comparison with no fertilization treatment.

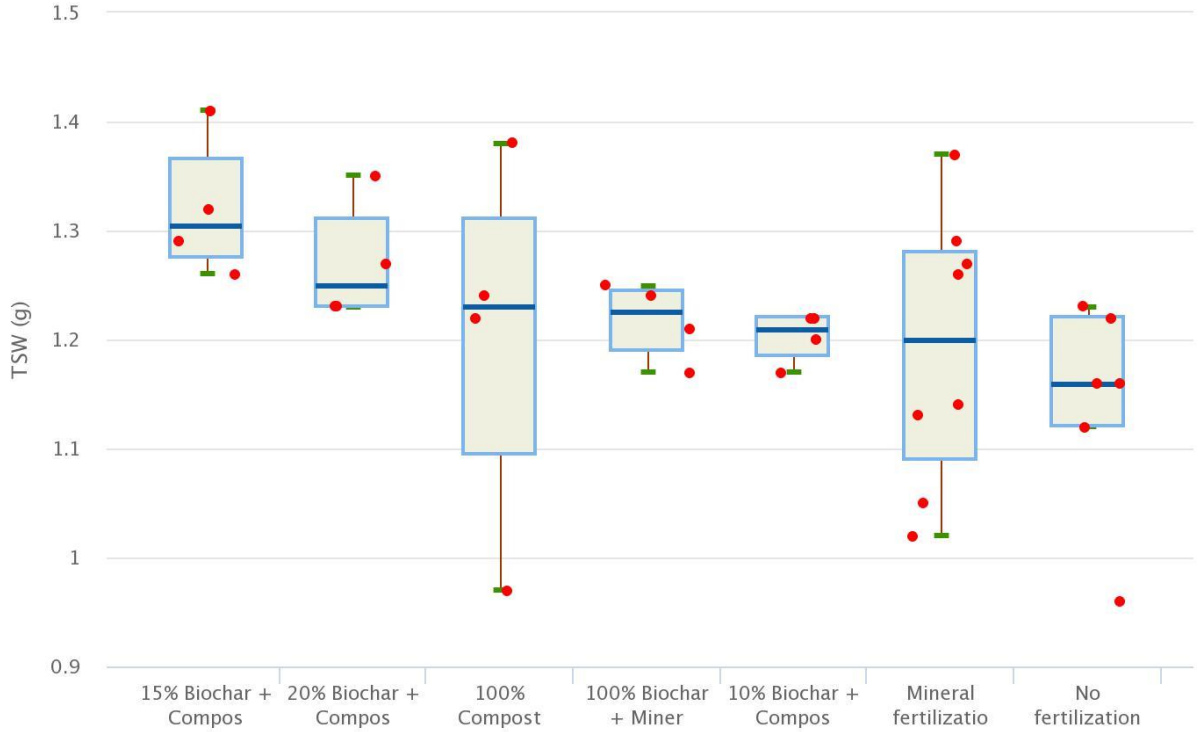

Figure 30. Thousand seed weight in grams. L1 trial – Year 3.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Seed quality characteristics

No statistical significant differences have been observed regarding the oil content between the different treatments. However, a positive trend related to the biochar addition and oil content can be observed.

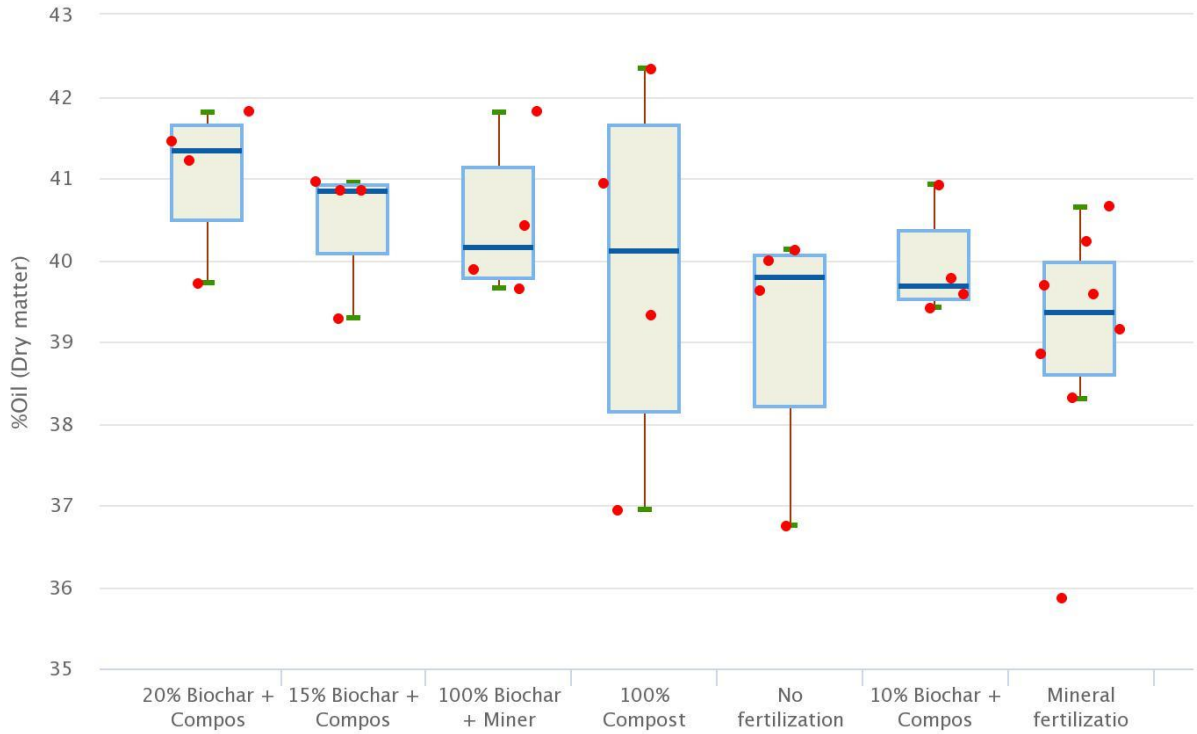

Figure 31. Seed quality characteristics: Moisture and oil content. L1 trial – Year 3.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

5.1.2 L2 – Finca Entresierras (Ciudad Real, Ciudad Real)

Year 1 (Camelina cultivation)

Cycle duration (days)

The cycle duration in this trial was 152 days distributed in 82 days of the vegetative stage (cotyledons and rosette), 20 days of flowering and 50 days of maturity. No significant differences have been observed between treatments.

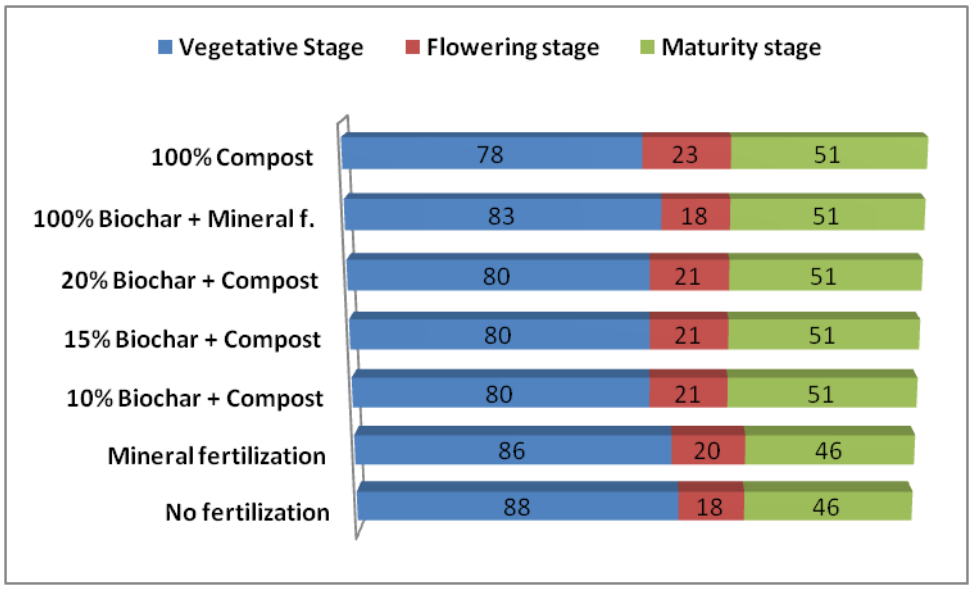

Figure 32. Cycle duration in days. L2 trial – Year 1.

Biomass yield (kg biomass/ha)

A unique replicate was harvested (by hand) to calculate the biomass production. The addition of Compost and Biochar have both increased biomass production.

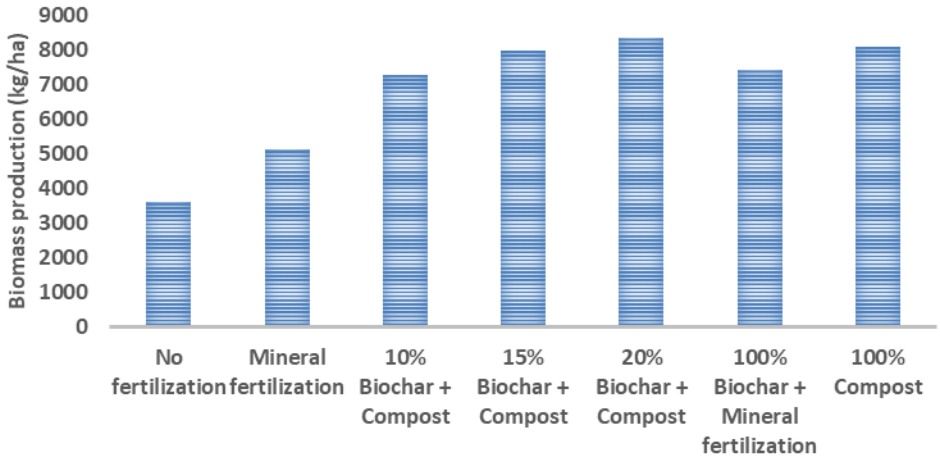

Figure 33. Biomass yield in kg/ha. L2 trial – Year 1.

Yield (kg seed/ha)

The treatments with an input of compost have shown a better yield. Additionally, biochar addition has also shown a positive correlation: Mineral fertilization+Biochar treatment has registered an increment higher than 150% than Mineral fertilization treatment (treatments where the biochar effect can be isolated).

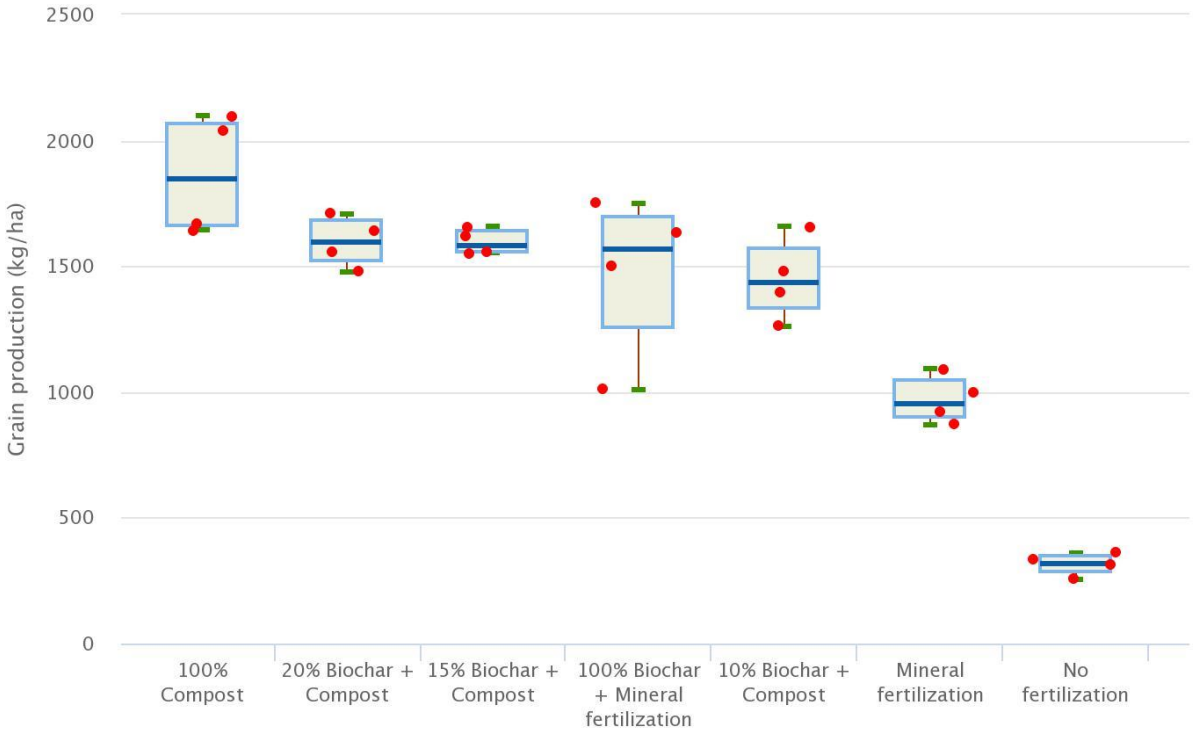

Figure 34. Seed yield in kg/ha. L2 trial – Year 1.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Weight of 1,000 seeds

The variety used for this trial has been a medium cycle camelina variety (CCE32), characterized by a medium to high seed size (1.0-1.4 g per 1000 seeds). The results show an overall low seed weight across treatments, except for the 100% compost treatment, with an increase in thousand seed weight compared to the rest of the treatments.

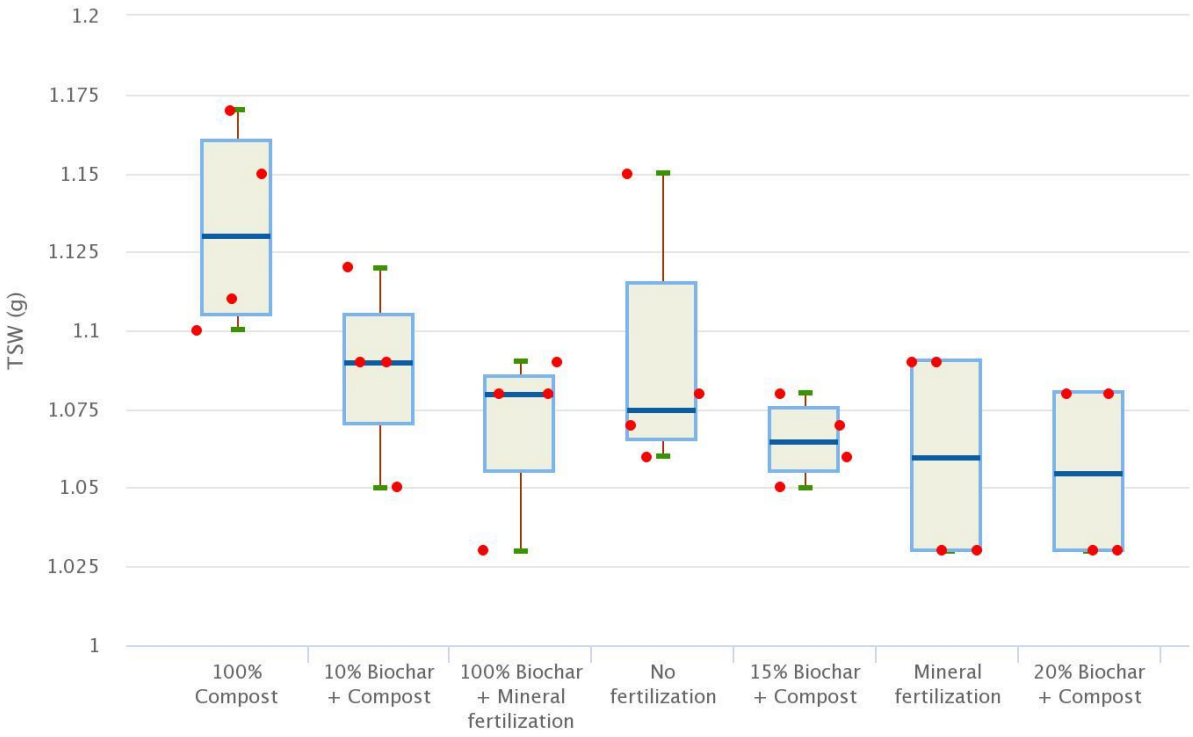

Figure 35. Thousand seed weight in grams. L2 trial – Year 1.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Seed quality characteristics

The treatments have not shown significant differences in moisture and oil content.

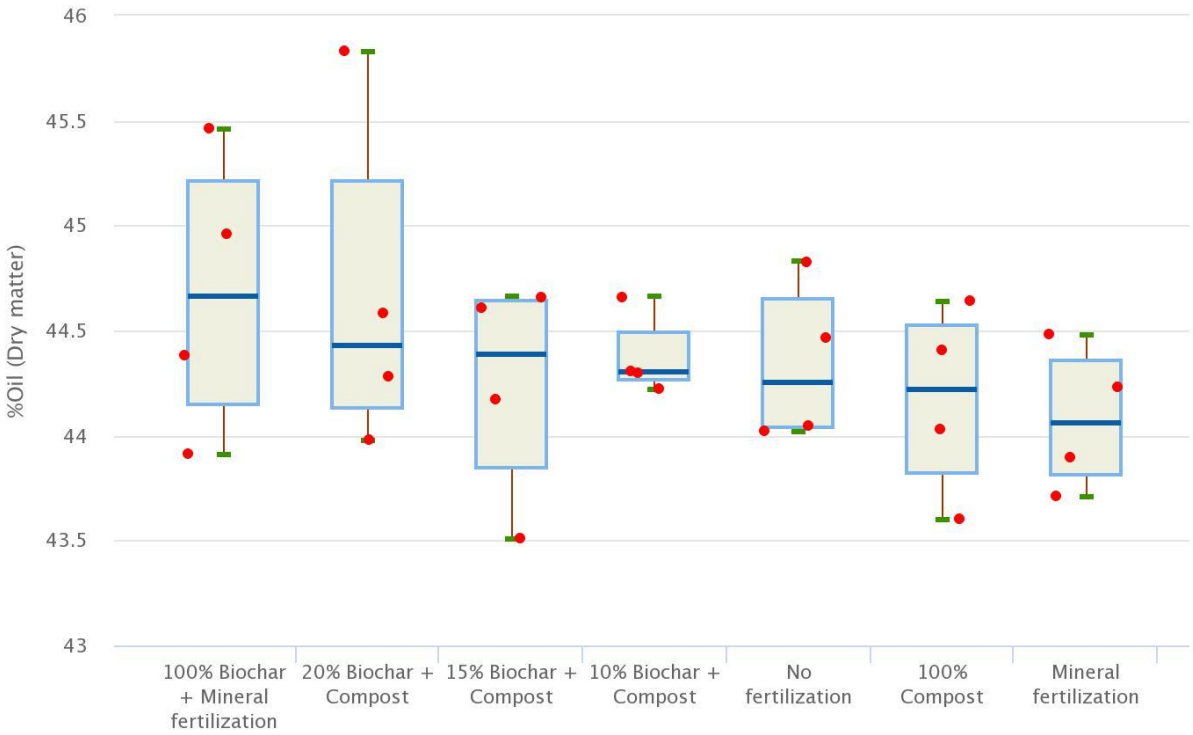

Figure 36. Seed quality characteristics: Moisture and oil content. L2 trial – Year 1.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

The oleic acid results have resulted much lower than L1 trial (about 0.35 in L2 trial instead of 0.7 from L1 trial). This is indicative of the better conditions during seed formation in L2. Also, no significant differences have been observed between treatments. It indicates that ambient conditions have been the cause of this effect.

Year 2 (Barley cultivation)

Cycle duration (days)

All treatments from this trial were ready to be harvested on day 201 of the cycle. However, “no-fertilization” and “mineral fertilization” treatments have shown a slower development than the rest of the treatments, reaching the flowering stage some days later. This effect is usually an indicator of lower nutrient availability for the plant.

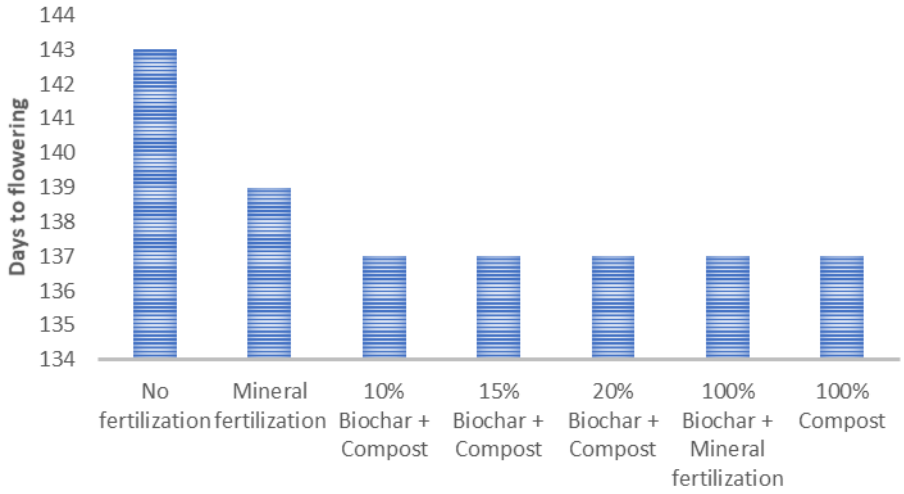

Figure 37. Days to flowering. L2 trial – Year 2.

Yield (kg seed/ha)

The treatments with an input of compost have shown a better yield, obtaining an increment of 126% (100% compost fertilization) with respect the mineral fertilization. On the other hand, Biochar addition has also shown a positive correlation, although more lightly: Mineral fertilization+Biochar treatment has obtained an increment of 118% of yield in comparison of the Mineral fertilization treatment (treatments where the biochar effect can be isolated).

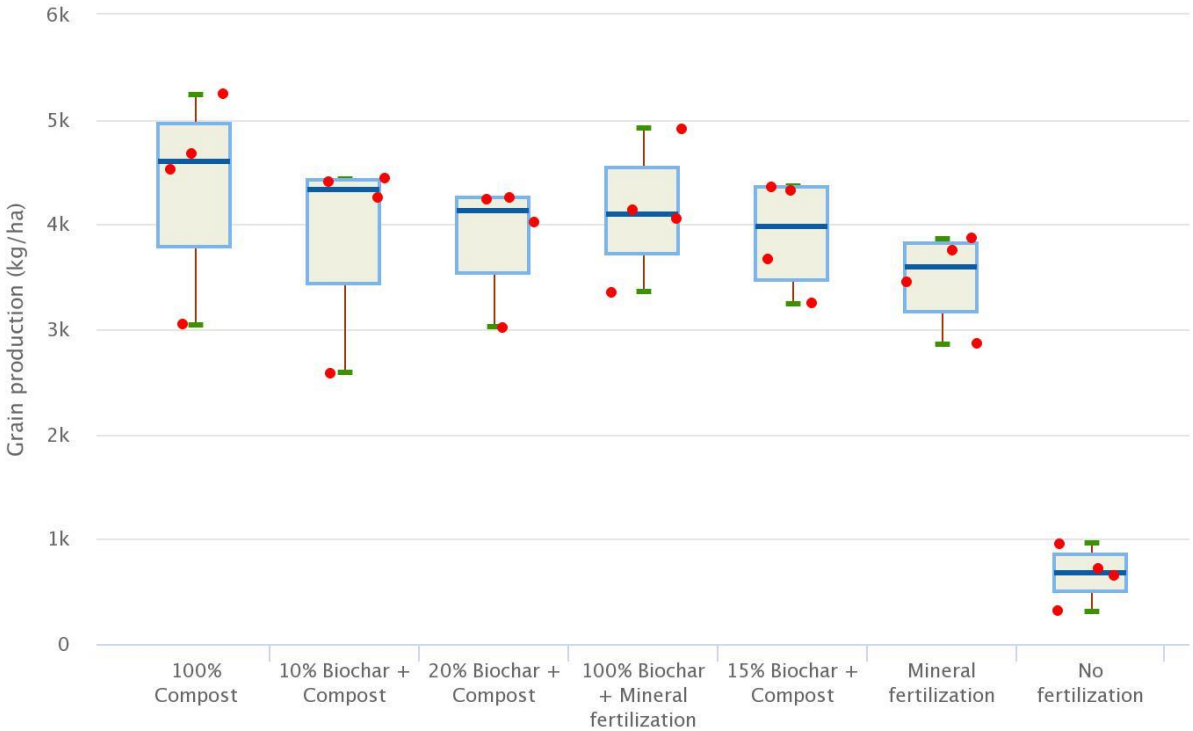

Figure 38. Seed yield in kg/ha. L2 trial – Year 2.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Weight of 1,000 seeds

No fertilization and compost fertilization treatments have registered higher thousand seed weight value than mineral fertilization. This trait has not shown a correlation with yield production.

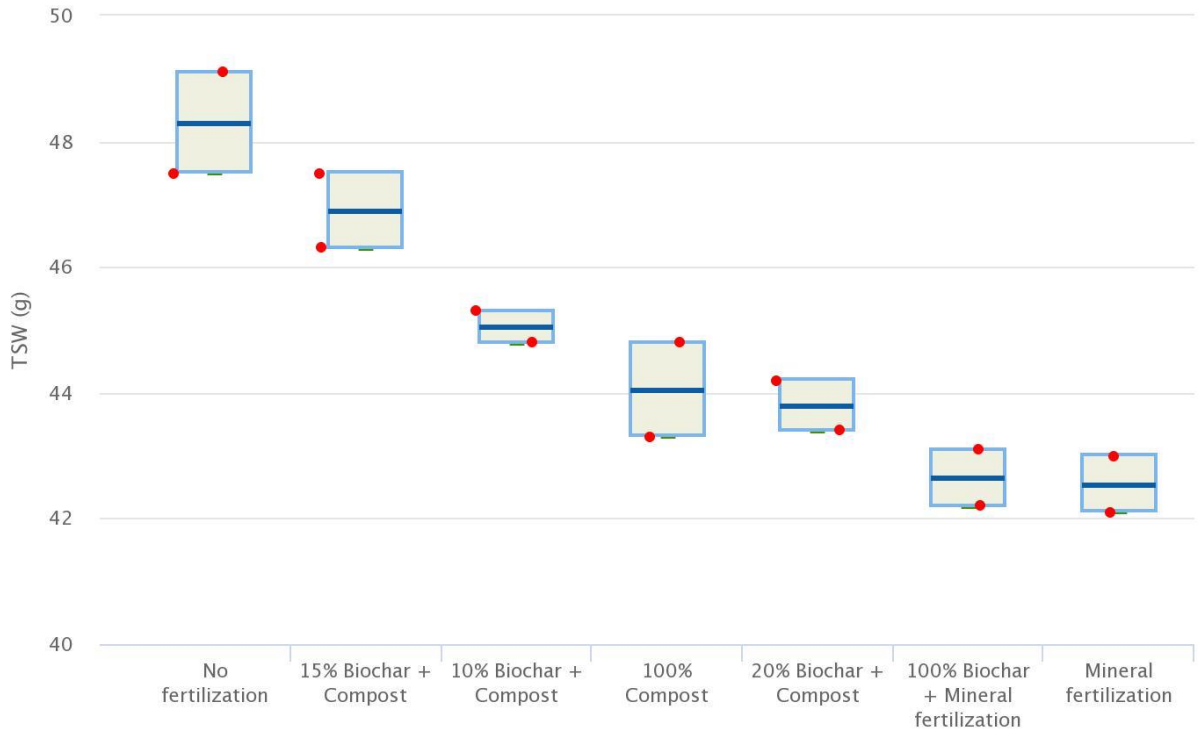

Figure 39. Thousand seed weight in grams. L2 trial – Year 2.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Year 3 (Camelina cultivation)

Cycle duration (days)

The cycle duration in this trial was between 184 and 195 days, depending on the treatment. It has been observed that nutrient availability entails a higher flowering precocity and a longer maturity period, while harvest time remains almost unchanged. However, no significant differences have been observed related to biochar addition and mineral/compost fertilization.

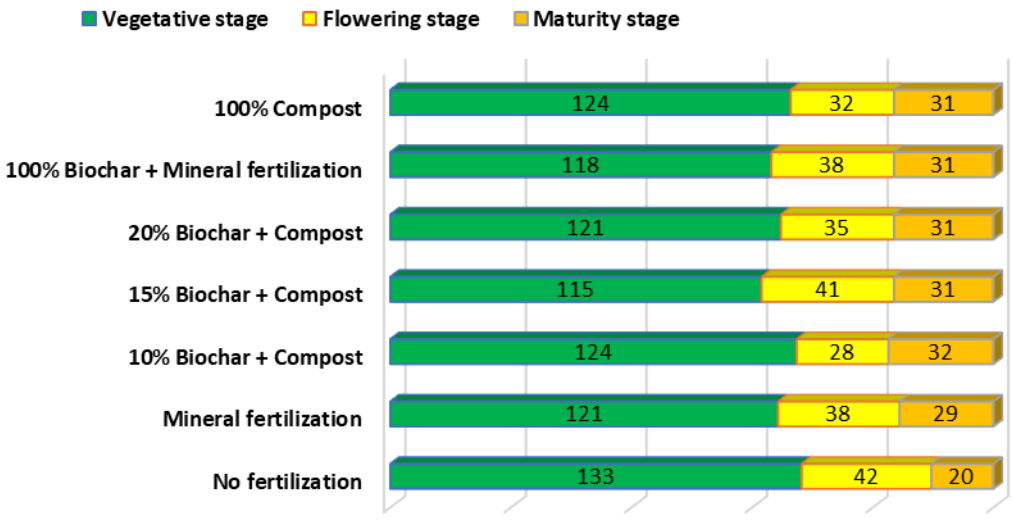

Figure 40. Cycle duration in days. L2 trial – Year 3.

Yield (kg seed/ha)

Yield results obtained from this trial have shown a high variability (one treatment has collected almost the total seed of the trial). This data has not correlated with the visual observations developed during the year.

Unfortunately, a malfunction in the combine occurred during the harvest of the trials in location L2. After revision of the combine, material accumulation in the combine internal circuit provoked a mixing of the harvest between microplots.

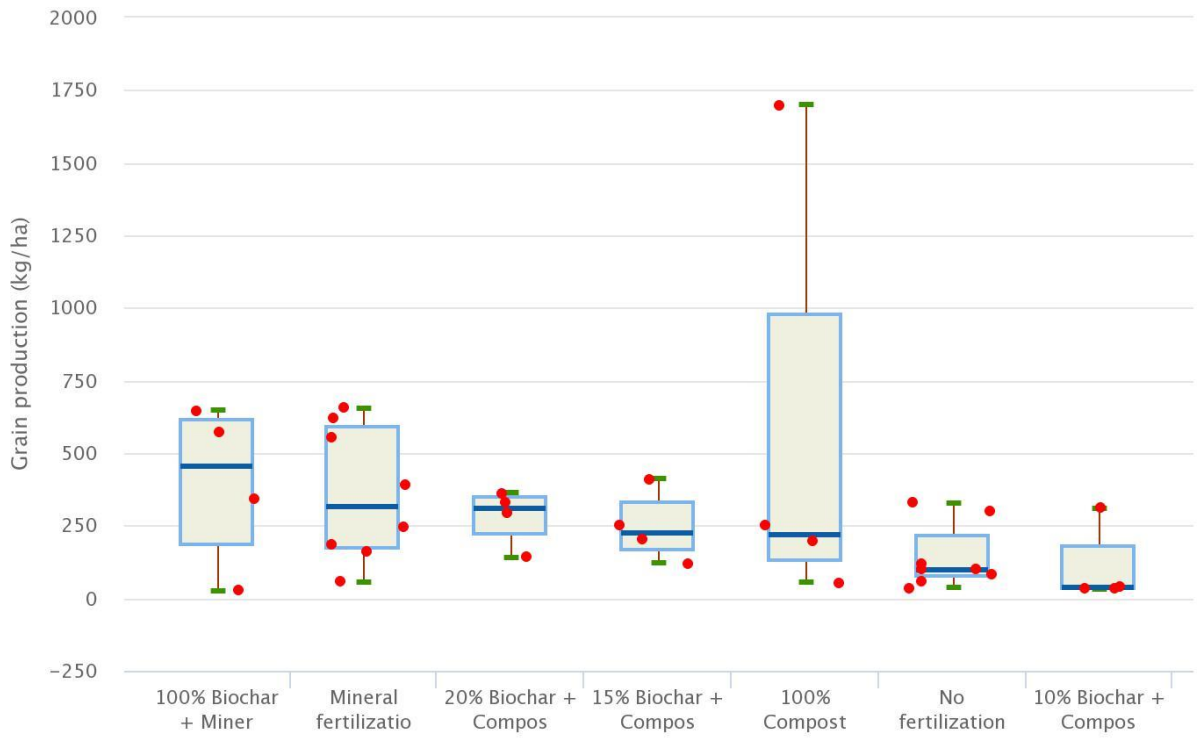

Figure 41. Seed yield in kg/ha. L2 trial – Year 3.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Weight of 1,000 seeds

As indicated above, a possible mix between treatments during the harvest could have affected the results presented below. Differences between the seed size measures of most of the treatments have not been significant. However, 20%biochar+compost treatment has registered an increment of 11% in comparison with 20%biochar+compost and no fertilization treatments.

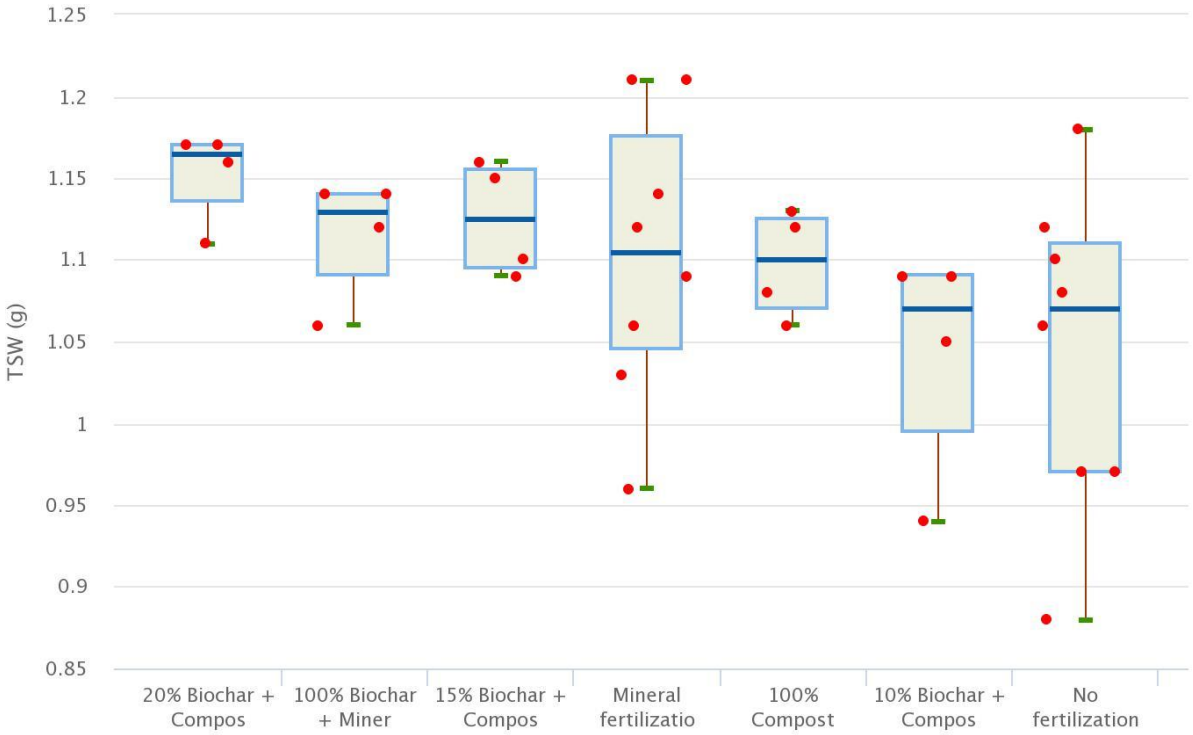

Figure 42. Thousand seed weight in grams. L2 trial – Year 3.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

Seed quality characteristics

As indicated above, a possible mix between treatments during the harvest could have affected the results presented below. A positive correlation between Biochar addition and oil content has been observed, registering an increment of this parameter between 7 and 10% in comparison to no fertilization treatment. This increment has been lower in compost fertilization (+6%) and mineral fertilization (+3%).

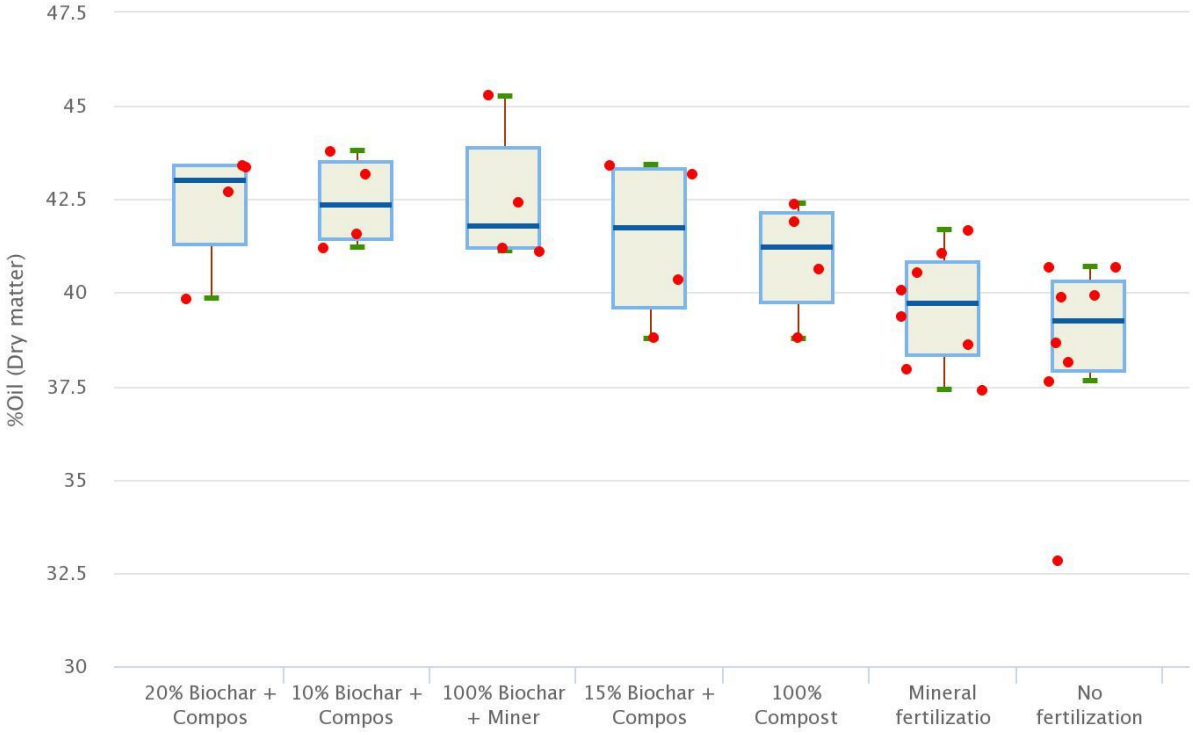

Figure 43. Seed quality characteristics: Moisture and oil content. L2 trial – Year 3.

- Replication values (Red spots)
- Lower to upper quartile (Blue area)
- Median (Dark blue line)
- Minimun to maximun (Segment)

6 Discussion

6.1 Effect on plant phenology

Favourable conditions (water and nutrients availability) produce a positive effect on the metabolism of the plant, speeding up the crop development. Phenology results have shown a similar behaviour regarding the days to flowering in these three years of the project.
The treatments including organic fertilizer (compost, COMBI) in the background fertilization have shown the fastest development, followed by mineral fertilization treatments.
There is no clear evidence of the biochar effect on the plant's phenology.

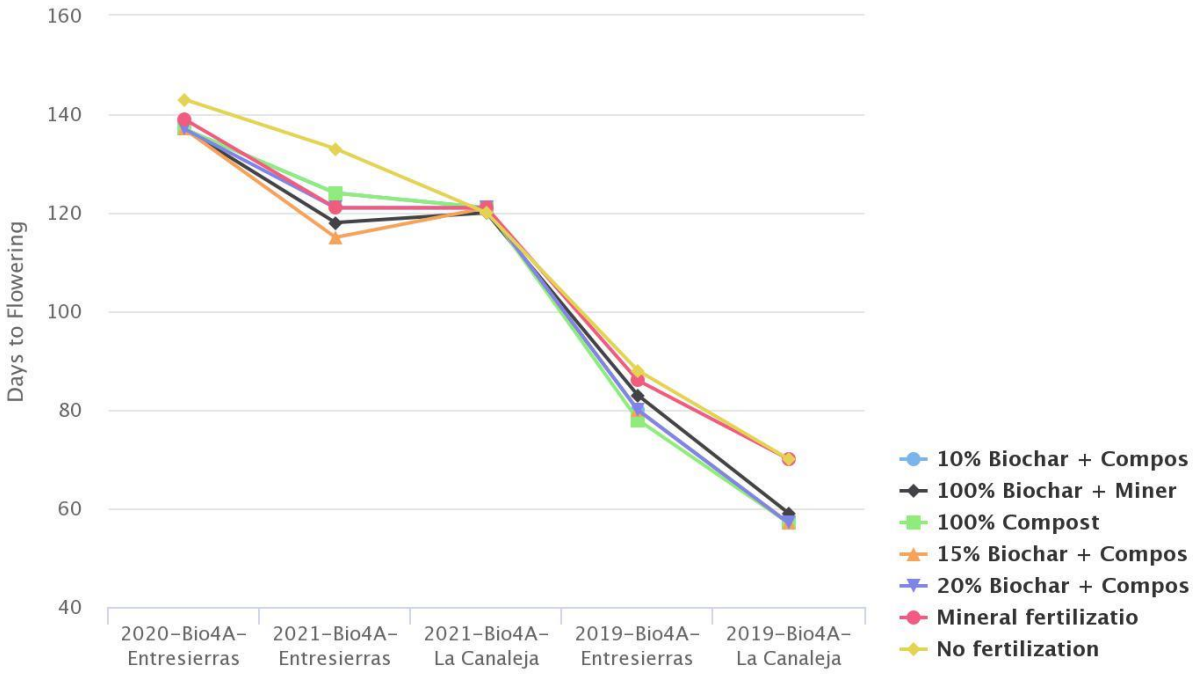

Figure 44. Influence of the treatments on the crop phenology.

6.2 Effect on seed yield

An increment of the water and nutrient availability supposes an increment of seed yield.
Production results have registered the same tendency during the three first years of trials:

- No fertilization treatment has obtained the lowest production in all trials (an average of 677 kg/ha).
- The application of mineral fertilization has increased yield production, reaching an average yield of 1491 kg/ha (>120% regarding No fertilization treatment).
- The addition of biochar to the mineral fertilization treatment has shown an increment of 20% in productivity compared with mineral fertilization.
- The best yield results have been observed with the compost fertilization and with the co-composted biochar, with an increment in the production in the range of 29%-37% compared with mineral fertilization.
- Co-composted biochar (COMBI) at 15 and 20 percent levels of biochar w/w resulted in the highest mean yield compared to all treatments (2044 and 2048 kg/ha respectively), increasing the seed yield by 6% in comparison to the 100% compost treatment (1924 kg/ha). COMBI at 10 percentage levels of biochar w/w has shown a similar result to 100% compost treatment (1957 kg/ha).

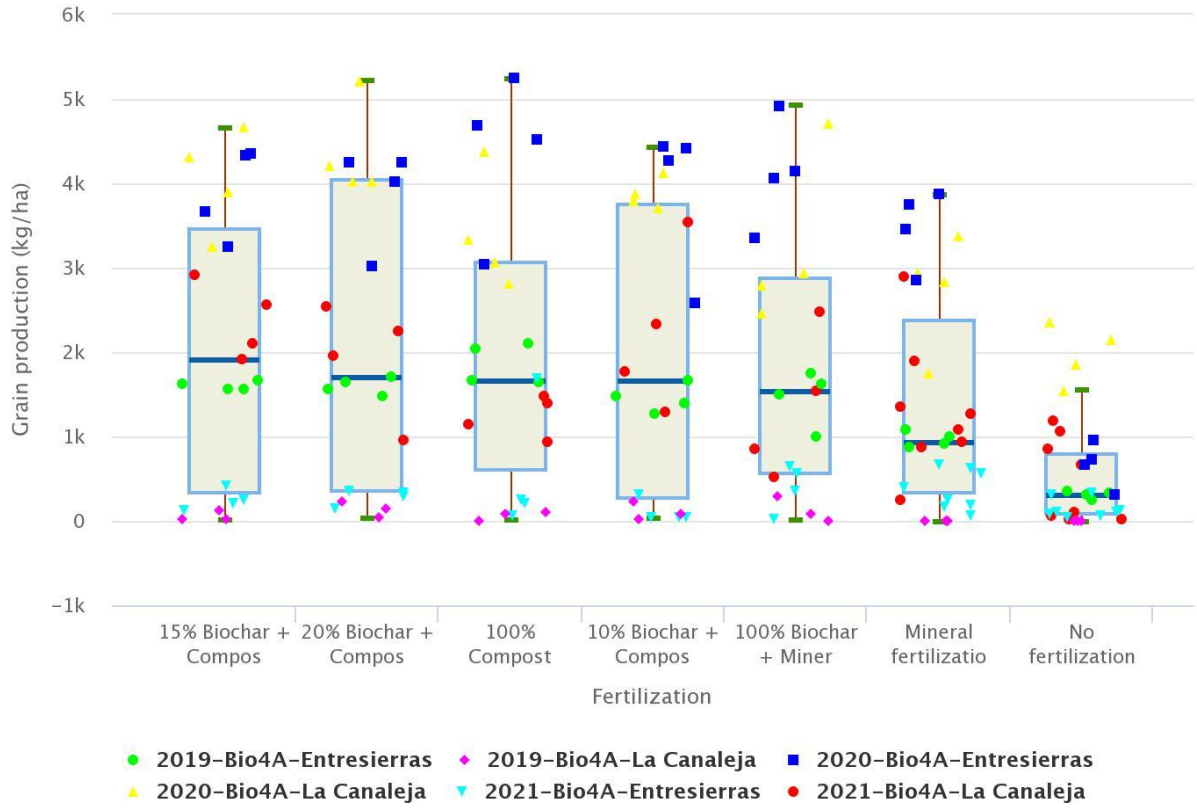

Figure 45. Influence of the treatments on crop productivity

6.3 Effect on seed weight

Seed weight is a trait intimately linked with the genetic of the crop. On the other hand, this parameter can be linked with the fertilization and an increment of the TSW (Thousand seed weight) has been observed when these conditions have been favourable for the plant development.

A study to normalize values has been developed in order to understand the effect of the treatments on the seed weight (2019 L1 and L2, 2020 L2, 2021 L1 and L2):

$$\%Ntreatment = Average\frac{(TSWtreatment - TSWmin)}{(TSWmax - TSWmin)}$$

The results of this study are presented below:

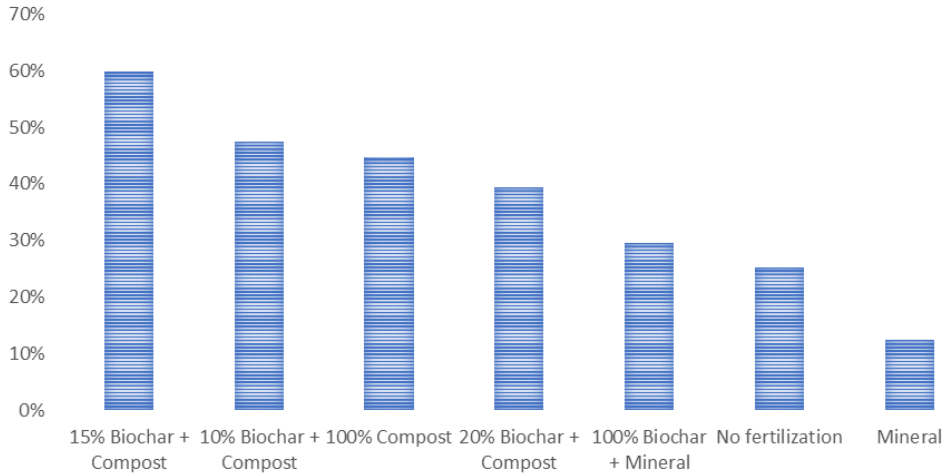

Figure 46. Influence of the treatments on the seed weight

The main conclusions are:

- Compost application has shown a positive correlation with seed weight.
- Biochar addition has shown a positive effect on seed weight.
- Mineral fertilization has provoked a negative effect on seed weight.

6.4 Effect on seed oil content

Several factors affect in different ways the oil content:

- Nitrogen availability is usually linked with an increment of seed protein content, typically reducing seed oil content.
- Water availability favours the biosynthesis of triacylglycerides, increasing the seed oil content.
- High temperatures during the filling grain process usually reduce the oil content of the seed.

However, the increment of oil production (on a per hectare basis) is usually more linked with seed productivity more than seed oil content. Average results of the different studies where camelina crop was planted are shown below:

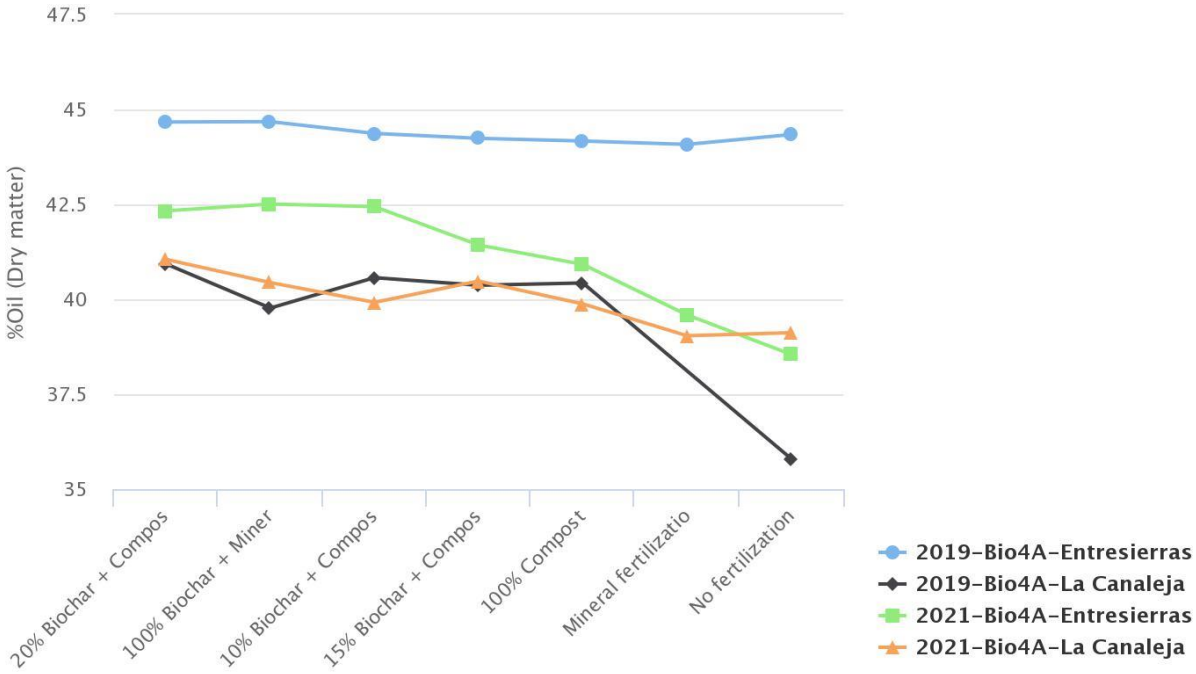

Figure 47. Average oil content of the studies where camelina crop was sown.

A study to normalize values has been developed in order to understand the effect of the treatments on the seed oil content (2019 and 2021 - L1 and L2 results; camelina crop):

$$\%Ntreatment = Average\frac{(\%OILtreatment - \%OILmin)}{(\%OILmax - \%OILmin)}$$

The results of this study are presented below:

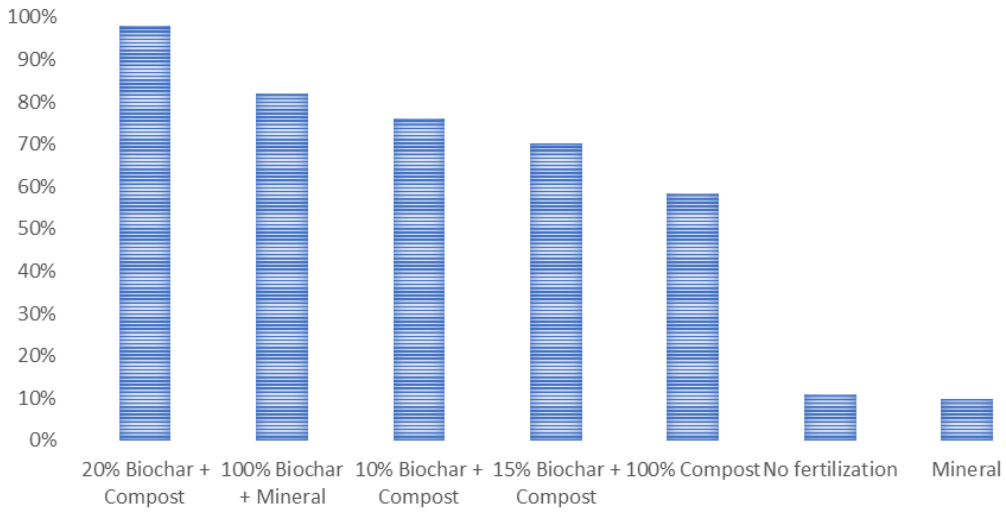

Figure 48. Influence of the treatments on the seed oil content

The main conclusions are:

- Biochar application has shown a positive correlation with seed oil content.
- Compost fertilization has also provoked an increment in seed oil content.
- Mineral fertilization has registered a negative effect on seed oil content.

6.5 Height

The height of a crop is a trait that has been traditionally linked with seed productivity. This parameter has an intimate relation to root development. Results of these three years of study show that the addition of biochar shows a positive correlation with plant height. Compost fertilization has also shown a positive effect related to crop height.

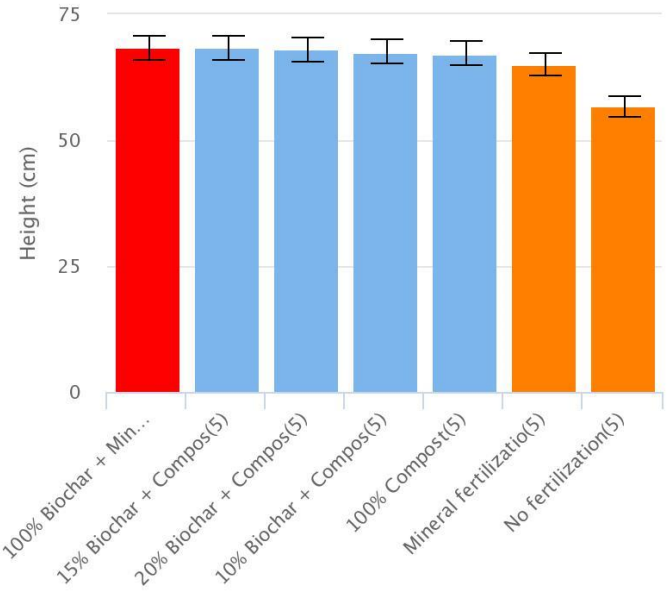

Figure 49. Influence of the treatments on plant height

7 Annexes

2019 – L1 Results (Camelina crop)

Code	Treatment	Background fertilization	Seeding date	Flowering date	End of flowering	Days of flowering	Harvest date	Area (m2)	Biomass (g)	Biomass yield (kg/ha)	Seed sample (g)	%Seed/biomass	Yield (kg/ha)	Moisture%	Protein%	Oil%	TSW (g)
1	No fertilization	N/A	14/03/2019	23/05/2019	05/06/2019	13	21/06/2019	0.28	21	750.0	0.076	0.4%	2.7	7.21	32.90	33.20	N/A
2	No fertilization	N/A	14/03/2019	23/05/2019	05/06/2019	13	21/06/2019	0.28	20	714.3	0	0.0%	0.0	N/A	N/A	N/A	N/A
3	No fertilization	N/A	14/03/2019	23/05/2019	05/06/2019	13	21/06/2019	0.28	22	785.7	0	0.0%	0.0	N/A	N/A	N/A	N/A
4		N/A	14/03/2019	N/A	N/A	N/A	N/A	0.28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	Mineral fertilization	07/03/2019	14/03/2019	23/05/2019	07/06/2019	15	21/06/2019	0.28	44	1571.4	0.02	0.0%	0.7	N/A	N/A	N/A	N/A
6	NPK	07/03/2019	14/03/2019	23/05/2019	07/06/2019	15	21/06/2019	0.28	24	857.1	0.039	0.2%	1.4	N/A	N/A	N/A	N/A
7	NPK	07/03/2019	14/03/2019	23/05/2019	07/06/2019	15	21/06/2019	0.28	33	1178.6	0	0.0%	0.0	N/A	N/A	N/A	N/A
8		07/03/2019	14/03/2019	N/A	N/A	N/A	N/A	0.28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9	10% Biochar + Compost	07/03/2019	14/03/2019	10/05/2019	31/05/2019	21	21/06/2019	0.28	63	2250.0	0.593	0.9%	21.2	7.12	30.15	37.61	N/A
10	10% Biochar + Compost	07/03/2019	14/03/2019	10/05/2019	31/05/2019	21	21/06/2019	0.28	75	2678.6	6.166	8.2%	220.2	6.83	29.26	38.49	0.802
11	10% Biochar + Compost	07/03/2019	14/03/2019	10/05/2019	31/05/2019	21	21/06/2019	0.28	71	2535.7	2.267	3.2%	81.0	6.85	30.24	37.17	0.721
12		07/03/2019	14/03/2019	N/A	N/A	N/A	N/A	0.28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	15% Biochar + Compost	07/03/2019	14/03/2019	10/05/2019	31/05/2019	21	21/06/2019	0.28	82	2928.6	0.337	0.4%	12.0	7.03	28.17	39.14	N/A
14	15% Biochar + Compost	07/03/2019	14/03/2019	10/05/2019	31/05/2019	21	21/06/2019	0.28	77	2750.0	0.508	0.7%	18.1	6.95	31.34	35.60	N/A
15	15% Biochar + Compost	07/03/2019	14/03/2019	10/05/2019	31/05/2019	21	21/06/2019	0.28	98	3500.0	3.658	3.7%	130.6	6.90	29.73	37.89	0.740
16		07/03/2019	14/03/2019	N/A	N/A	N/A	N/A	0.28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	20% Biochar + Compost	07/03/2019	14/03/2019	10/05/2019	30/05/2019	20	21/06/2019	0.28	79	2821.4	0.929	1.2%	33.2	6.91	30.54	37.19	0.696
18	20% Biochar + Compost	07/03/2019	14/03/2019	10/05/2019	30/05/2019	20	21/06/2019	0.28	81	2892.9	6.338	7.8%	226.4	6.80	28.92	39.05	0.818
19	20% Biochar + Compost	07/03/2019	14/03/2019	10/05/2019	30/05/2019	20	21/06/2019	0.28	97	3464.3	4.146	4.3%	148.1	6.99	29.19	38.08	0.696
20		07/03/2019	14/03/2019	N/A	N/A	N/A	N/A	0.28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21	100% Biochar + NPK	07/03/2019	14/03/2019	12/05/2019	31/05/2019	19	21/06/2019	0.28	49	1750.0	0.177	0.4%	6.3	6.84	30.79	35.46	N/A
22	100% Biochar + NPK	07/03/2019	14/03/2019	12/05/2019	31/05/2019	19	21/06/2019	0.28	90	3214.3	2.559	2.8%	91.4	6.96	29.34	38.26	0.796
23	100% Biochar + NPK	07/03/2019	14/03/2019	12/05/2019	31/05/2019	19	21/06/2019	0.28	113	4035.7	8.243	7.3%	294.4	7.04	29.81	37.25	0.685
24		07/03/2019	14/03/2019	N/A	N/A	N/A	N/A	0.28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
25	100% Compost	07/03/2019	14/03/2019	10/05/2019	31/05/2019	21	21/06/2019	0.28	46	1642.9	0.192	0.4%	6.9	7.06	31.51	35.86	N/A
26	100% Compost	07/03/2019	14/03/2019	10/05/2019	31/05/2019	21	21/06/2019	0.28	90	3214.3	2.963	3.3%	105.8	7.01	29.42	38.15	0.732
27	100% Compost	07/03/2019	14/03/2019	10/05/2019	31/05/2019	21	21/06/2019	0.28	61	2178.6	2.596	4.3%	92.7	6.89	28.91	38.81	0.745
28		07/03/2019	14/03/2019	N/A	N/A	N/A	N/A	0.28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note. Trials were irrigated after seeding to assure an adequate germination

2019 – L2 Results (Camelina crop)

Plot	Treatment	Rep	Date of background fertilizatio	Seeding date	Flowering date	End of flowering	Days of flowering	Harvest date	Height (cm)	Lodging	Shattering	Biomass (sample)	Biomass yield (kg/ha)	Seed sample (g)	Seed Yield (Biomass sample)	%Seed/bio mass	Yield (kg/ha)	%Moisture	%Protein	%Oil	TSW (g)
1	No fertilization	1	N/A	14/01/2019	12/04/2019	30/04/2019	18	15/06/2019	76	0	0	N/A	N/A	N/A	N/A	N/A	312.1	6.17	24.12	42.06	1.065
2	No fertilization	2	N/A	14/01/2019	12/04/2019	30/04/2019	18	15/06/2019	76	0	0	N/A	N/A	N/A	N/A	N/A	256.0	6.45	24.7	41.18	1.072
3	No fertilization	3	N/A	14/01/2019	12/04/2019	30/04/2019	18	15/06/2019	76	0	0	360	3600	58	580	16.1%	336.8	6.11	25.1	41.75	1.079
4	No fertilization	4	N/A	14/01/2019	12/04/2019	30/04/2019	18	15/06/2019	76	0	0	N/A	N/A	N/A	N/A	N/A	360.4	6.99	24.46	40.97	1.149
5	Mineral fertilization	1	11/01/2018	14/01/2019	10/04/2019	30/04/2019	20	15/06/2019	82	0	0	N/A	N/A	N/A	N/A	N/A	869.5	6.15	25.52	41.2	1.092
6	Mineral fertilization	2	11/01/2018	14/01/2019	10/04/2019	30/04/2019	20	15/06/2019	82	0	0	N/A	N/A	N/A	N/A	N/A	1091.4	5.8	25.54	41.66	1.035
7	Mineral fertilization	3	11/01/2018	14/01/2019	10/04/2019	30/04/2019	20	15/06/2019	82	0	0	513	5130	127	1270	24.8%	997.1	5.84	25.82	41.16	1.027
8	Mineral fertilization	4	11/01/2018	14/01/2019	10/04/2019	30/04/2019	20	15/06/2019	82	0	0	N/A	N/A	N/A	N/A	N/A	919.1	5.88	24.93	41.86	1.09
9	10% Biochar + Compost	1	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1478.9	5.92	25.18	41.68	1.054
10	10% Biochar + Compost	2	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1657.3	5.81	24.99	41.74	1.093
11	10% Biochar + Compost	3	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	728	7280	196	1960	26.9%	1394.5	5.39	25.77	41.84	1.092
12	10% Biochar + Compost	4	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1261.5	5.84	24.9	42.05	1.115
13	15% Biochar + Compost	1	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1553.2	6	24.73	41.98	1.058
14	15% Biochar + Compost	2	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1616.9	5.9	25.43	41.56	1.053
15	15% Biochar + Compost	3	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	796	7960	234	2340	29.4%	1657.3	5.87	26.13	40.96	1.08
16	15% Biochar + Compost	4	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1558.8	6.05	24.48	41.91	1.067
17	20% Biochar + Compost	1	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1709.2	5.92	24.54	41.94	1.034
18	20% Biochar + Compost	2	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1556.2	5.71	23.84	43.21	1.081
19	20% Biochar + Compost	3	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	835	8350	241	2410	28.9%	1643.8	5.88	25.39	41.39	1.078
20	20% Biochar + Compost	4	11/01/2018	14/01/2019	04/04/2019	25/04/2019	21	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1477.7	5.81	25.22	41.71	1.032
21	100% Biochar + Mineral fertilization	1	11/01/2018	14/01/2019	07/04/2019	25/04/2019	18	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1634.9	5.91	25.26	41.76	1.026
22	100% Biochar + Mineral fertilization	2	11/01/2018	14/01/2019	07/04/2019	25/04/2019	18	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1502.3	5.7	23.9	42.87	1.094
23	100% Biochar + Mineral fertilization	3	11/01/2018	14/01/2019	07/04/2019	25/04/2019	18	15/06/2019	84	0	0	741	7410	220	2200	29.7%	1751.6	5.83	25.63	41.35	1.076
24	100% Biochar + Mineral fertilization	4	11/01/2018	14/01/2019	07/04/2019	25/04/2019	18	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1009.2	5.78	24.8	42.36	1.085
25	100% Compost	1	11/01/2018	14/01/2019	02/04/2019	25/04/2019	23	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	1642.3	6.19	25.35	41.3	1.103
26	100% Compost	2	11/01/2018	14/01/2019	02/04/2019	25/04/2019	23	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	2095.2	5.87	25.42	41.8	1.173
27	100% Compost	3	11/01/2018	14/01/2019	02/04/2019	25/04/2019	23	15/06/2019	84	0	0	810	8100	238	2380	29.4%	1670.8	5.96	25.88	41	1.113
28	100% Compost	4	11/01/2018	14/01/2019	02/04/2019	25/04/2019	23	15/06/2019	84	0	0	N/A	N/A	N/A	N/A	N/A	2036.4	6.01	24.8	41.96	1.15

2020 – L1 Results (Barley crop)

Treatment			Sowing		Background fertilization			Dressing fertilization			Herbicides			Harvest			
Code	Treatment	Replicate	Date	Sowing rate (kg/ha)	Date	Type	(kg/ha)	Date	Type	(kg/ha)	Date	Type	Dose	Date	Days of cycle	Height (cm)	Yield (kg/ha)
No fertilization-1	No fertilization	1	08/11/2019	180	N/A						N/A	N/A	N/A	28-5	202	55	1546.1
Mineral fertilization-1	Mineral fertilization	1	08/11/2019	180	07/11/2019	8-24-8	250	05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	46	1744.3
10% Biochar + Compost-1	10% Biochar + Compost	1	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	45	3698.6
15% Biochar + Compost-1	15% Biochar + Compost	1	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	45	3243.6
20% Biochar + Compost-1	20% Biochar + Compost	1	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	51	4024.6
100% Biochar + Mineral fertilization-1	100% Biochar + Mineral fertilization	1	08/11/2019	180	07/11/2019	8-24-8	250	05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	49	2454.3
100% Compost-1	100% Compost	1	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	52	3069.3
No fertilization-2	No fertilization	2	08/11/2019	180	N/A						N/A	N/A	N/A	28-5	202	45	1862.5
Mineral fertilization-2	Mineral fertilization	2	08/11/2019	180	07/11/2019	8-24-8	250	05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	46	3382.5
10% Biochar + Compost-2	10% Biochar + Compost	2	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	50	3874.6
15% Biochar + Compost-2	15% Biochar + Compost	2	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	52	3896.1
20% Biochar + Compost-2	20% Biochar + Compost	2	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	48	5209.7
100% Biochar + Mineral fertilization-2	100% Biochar + Mineral fertilization	2	08/11/2019	180	07/11/2019	8-24-8	250	05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	45	4710.0
100% Compost-2	100% Compost	2	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	45	2818.6
No fertilization-3	No fertilization	3	08/11/2019	180	N/A						N/A	N/A	N/A	28-5	202	45	2344.3
Mineral fertilization-3	Mineral fertilization	3	08/11/2019	180	07/11/2019	8-24-8	250	05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	44	2933.2
10% Biochar + Compost-3	10% Biochar + Compost	3	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	49	3791.4
15% Biochar + Compost-3	15% Biochar + Compost	3	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	53	4658.6
20% Biochar + Compost-3	20% Biochar + Compost	3	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	55	4202.1
100% Biochar + Mineral fertilization-3	100% Biochar + Mineral fertilization	3	08/11/2019	180	07/11/2019	8-24-8	250	05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	51	2793.2
100% Compost-3	100% Compost	3	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	47	3323.4
No fertilization-4	No fertilization	4	08/11/2019	180	N/A						N/A	N/A	N/A	28-5	202	42	2137.5
Mineral fertilization-4	Mineral fertilization	4	08/11/2019	180	07/11/2019	8-24-8	250	05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	49	2835.0
10% Biochar + Compost-4	10% Biochar + Compost	4	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	52	4120.4
15% Biochar + Compost-4	15% Biochar + Compost	4	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	58	4305.7
20% Biochar + Compost-4	20% Biochar + Compost	4	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	49	4027.9
100% Biochar + Mineral fertilization-4	100% Biochar + Mineral fertilization	4	08/11/2019	180	07/11/2019	8-24-8	250	05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	49	2928.6
100% Compost-4	100% Compost	4	08/11/2019	180	N/A			05/03/2020	NAC 27%	180	N/A	N/A	N/A	11-6	216	55	4365.3

2020 – L2 Results (Barley crop)

Treatment			Sowing		Background fertilization			Dressing fertilization			Herbicides			Harvest			
Code	Treatment	Replicate	Date	Sowing rate (kg/ha)	Date	Type	(kg/ha)	Date	Type	(kg/ha)	Date	Type	Dose	Date	Days of cycle	Height (cm)	Yield (kg/ha)
No fertilization-1	No fertilization	1	29/11/2019	375 seeds/m2/Barley Variety Sfera							18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		660
Mineral fertilization-1	Mineral fertilization	1	29/11/2019	375 seeds/m2/Barley Variety Sfera	29/11/2019	N-P-K (Mg-S): 10-12-20(2-25)	150 kg/ha	14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		3750
10% Biochar + Compost-1	10% Biochar + Compost	1	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		4262
15% Biochar + Compost-1	15% Biochar + Compost	1	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		3663
20% Biochar + Compost-1	20% Biochar + Compost	1	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		4028
100% Biochar + Mineral fertilization-1	100% Biochar + Mineral fertilization	1	29/11/2019	375 seeds/m2/Barley Variety Sfera	29/11/2019	N-P-K (Mg-S): 10-12-20(2-25)	150 kg/ha	14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		4063
100% Compost-1	100% Compost	1	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		4679
No fertilization-2	No fertilization	2	29/11/2019	375 seeds/m2/Barley Variety Sfera							18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201	50	317
Mineral fertilization-2	Mineral fertilization	2	29/11/2019	375 seeds/m2/Barley Variety Sfera	29/11/2019	N-P-K (Mg-S): 10-12-20(2-25)	150 kg/ha	14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201	57	3450
10% Biochar + Compost-2	10% Biochar + Compost	2	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201	66	4408
15% Biochar + Compost-2	15% Biochar + Compost	2	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201	60	4358
20% Biochar + Compost-2	20% Biochar + Compost	2	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201	62	4242
100% Biochar + Mineral fertilization-2	100% Biochar + Mineral fertilization	2	29/11/2019	375 seeds/m2/Barley Variety Sfera	29/11/2019	N-P-K (Mg-S): 10-12-20(2-25)	150 kg/ha	14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201	67	4142
100% Compost-2	100% Compost	2	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201	70	4525
No fertilization-3	No fertilization	3	29/11/2019	375 seeds/m2/Barley Variety Sfera							18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		725
Mineral fertilization-3	Mineral fertilization	3	29/11/2019	375 seeds/m2/Barley Variety Sfera	29/11/2019	N-P-K (Mg-S): 10-12-20(2-25)	150 kg/ha	14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		3867
10% Biochar + Compost-3	10% Biochar + Compost	3	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		4433
15% Biochar + Compost-3	15% Biochar + Compost	3	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		4325
20% Biochar + Compost-3	20% Biochar + Compost	3	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		4250
100% Biochar + Mineral fertilization-3	100% Biochar + Mineral fertilization	3	29/11/2019	375 seeds/m2/Barley Variety Sfera	29/11/2019	N-P-K (Mg-S): 10-12-20(2-25)	150 kg/ha	14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		4917
100% Compost-3	100% Compost	3	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		5242
No fertilization-4	No fertilization	4	29/11/2019	375 seeds/m2/Barley Variety Sfera							18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		961
Mineral fertilization-4	Mineral fertilization	4	29/11/2019	375 seeds/m2/Barley Variety Sfera	29/11/2019	N-P-K (Mg-S): 10-12-20(2-25)	150 kg/ha	14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		2863
10% Biochar + Compost-4	10% Biochar + Compost	4	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		2588
15% Biochar + Compost-4	15% Biochar + Compost	4	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		3245
20% Biochar + Compost-4	20% Biochar + Compost	4	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		3020
100% Biochar + Mineral fertilization-4	100% Biochar + Mineral fertilization	4	29/11/2019	375 seeds/m2/Barley Variety Sfera	29/11/2019	N-P-K (Mg-S): 10-12-20(2-25)	150 kg/ha	14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		3353
100% Compost-4	100% Compost	4	29/11/2019	375 seeds/m2/Barley Variety Sfera				14/02/2020	ABONO D-CODER TOP 20N-6P-6K-2Mg-20S	230 kg/ha	18/02/2020	granstar super 50 sx	45 g/ha	17/06/2020	201		3049

2021 – L1 Results (Camelina crop)

Plot	Treatment	Rep	Variety	Date of background fertilization	Seeding date	Flowering date	End of flowering	Days of flowering	Harvest date	Lodging	Shattering
1	No fertilization	1	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
2	No fertilization	2	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
3	No fertilization	3	Control	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
4	No fertilization	4	Control	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
5	NPK	1	v5	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0
6	NPK	2	v5	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0
7	NPK	3	Control	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
8	NPK	4	Control	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
9	10% Biochar + Compost	1	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
10	10% Biochar + Compost	2	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
11	10% Biochar + Compost	3	Control	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0
12	10% Biochar + Compost	4	Control	N/A	09/12/2020	09/04/2021	09/05/2021	30	25/06/2021	Medium	0
13	15% Biochar + Compost	1	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0
14	15% Biochar + Compost	2	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
15	15% Biochar + Compost	3	Control	N/A	09/12/2020	09/04/2021	09/05/2021	30	25/06/2021		0
16	15% Biochar + Compost	4	Control	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0
17	20% Biochar + Compost	1	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0
18	20% Biochar + Compost	2	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0
19	20% Biochar + Compost	3	Control	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
20	20% Biochar + Compost	4	Control	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
21	100% Biochar + NPK	1	v5	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
22	100% Biochar + NPK	2	v5	19/11/2019	09/12/2020	05/04/2021	25/04/2021	20	09/06/2021		0
23	100% Biochar + NPK	3	Control	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0
24	100% Biochar + NPK	4	Control	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0
25	100% Compost	1	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
26	100% Compost	2	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
27	100% Compost	3	Control	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
28	100% Compost	4	Control	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
29	No fertilization	5	v5	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
30	No fertilization	6	v5	N/A	09/12/2020	05/04/2021	25/04/2021	20	09/06/2021		0
31	No fertilization	7	Control	N/A	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
32	No fertilization	8	Control	N/A	09/12/2020	05/04/2021	25/04/2021	20	09/06/2021		0
33	NPK	5	v5	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
34	NPK	6	v5	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021		0
35	NPK	7	Control	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0
36	NPK	8	Control	19/11/2019	09/12/2020	09/04/2021	25/04/2021	16	09/06/2021	Medium	0

Variety	Treatment	Sample	Grain produc	Moisture%	%Protein (Dry	%Oil (Dry mat	TSW (g)
V5	No fertilization	1A	5.1				
V5	No fertilization	1B	17.8				
V5	No fertilization	2A	243.2	5.03	24.59	41.32	1.108
V5	No fertilization	2B	96.2				1.159
Control	No fertilization	3A	83.4				1.119
Control	No fertilization	3B	19.1				
Control	No fertilization	4A	1.5				
Control	No fertilization	4B	61.3				0.964
V5	NPK	8A	1389.1	5.06	25.23	39.47	1.101
V5	NPK	8B	1900.1	5.47	26.64	39.69	1.143
V5	NPK	7A	2776	5.22	24.54	41.04	1.169
V5	NPK	7B	2888.5	5.5	25.11	40.23	1.049
Control	NPK	6A	2954.4	5.42	24.55	41.1	1.199
Control	NPK	6B	1268.9	5.29	24.45	40.65	1.275
Control	NPK	5A	620.7	5.26	25.81	38.84	1.044
Control	NPK	5B	254.2	5.3	26.68	35.87	1.022
V5	10% Biochar + Compost	9A	1024.7	5.26	25.4	41.09	1.205
V5	10% Biochar + Compost	9B	1286.9	5.23	26.26	40.92	1.166
V5	10% Biochar + Compost	10A	2206.4	4.86	26.89	40.7	1.26
V5	10% Biochar + Compost	10B	2343.2	5	26.12	39.59	1.215
Control	10% Biochar + Compost	11A	3611.4	4.59	27.77	39.7	1.263
Control	10% Biochar + Compost	11B	3535.8	4.75	27.54	39.77	1.2
Control	10% Biochar + Compost	12A	1827.9	4.49	25.24	40.77	1.228
Control	10% Biochar + Compost	12B	1771.7	4.88	26.07	39.41	1.217
V5	15% Biochar + Compost	16A	1936	3.86	24.98	42.81	1.275
V5	15% Biochar + Compost	16B	1920	4.74	25.88	40.95	1.26
V5	15% Biochar + Compost	15A	2485.8	4.87	25.32	41.97	1.279
V5	15% Biochar + Compost	15B	2571.7	4.52	26.81	40.85	1.293
Control	15% Biochar + Compost	14A	2642	4.54	27.02	39.36	1.394
Control	15% Biochar + Compost	14B	2921.4	4.28	27.42	40.86	1.409
Control	15% Biochar + Compost	13A	1864.4	4.69	25.77	41.39	1.309
Control	15% Biochar + Compost	13B	2099.8	4.68	27.6	39.28	1.32
V5	20% Biochar + Compost	17A	1022.4	4.7	26.37	39.16	1.217
V5	20% Biochar + Compost	17B	958	4.68	24.14	41.81	1.229
V5	20% Biochar + Compost	18A	1714.4	4.69	27.64	41.01	1.321
V5	20% Biochar + Compost	18B	1956.1	4.79	26.47	39.72	1.349
Control	20% Biochar + Compost	19A	1542.2	4.49	23.74	41.32	1.319
Control	20% Biochar + Compost	19B	2542.3	5.32	24.93	41.22	1.229
Control	20% Biochar + Compost	20A	1991.3	5.18	24	41.48	1.198
Control	20% Biochar + Compost	20B	2260.3	5.04	24.63	41.46	1.272
V5	100% Biochar + NPK	24A	2266	4.69	26.42	38.93	1.276
V5	100% Biochar + NPK	24B	527.7	4.51	22.91	41.81	1.208
V5	100% Biochar + NPK	23A	1317.7	4.64	22.7	40.08	1.195
V5	100% Biochar + NPK	23B	2474.4	4.99	25.38	40.42	1.251
Control	100% Biochar + NPK	22A	1514.4	4.69	22.93	41.52	1.181
Control	100% Biochar + NPK	22B	850.1	4.82	23.86	39.89	1.169
Control	100% Biochar + NPK	21A	1988.9	4.86	26.89	38.74	1.325
Control	100% Biochar + NPK	21B	1544.5	5.1	26.16	39.65	1.236
V5	100% Compost	25A	1390.2	4.58	22.96	41.17	1.246
V5	100% Compost	25B	946.3	4.78	23.71	40.93	1.221
V5	100% Compost	26A	993.6	4.91	23	41.71	1.189
V5	100% Compost	26B	1489.3	3.77	24.31	42.34	1.385
Control	100% Compost	27A	1923.5	4.55	25.67	40.96	1.221
Control	100% Compost	27B	1389.3	5.06	24.08	39.32	1.239
Control	100% Compost	28A	1302.4	4.74	24.64	40.81	1.178
Control	100% Compost	28B	1144.4	4.98	26.49	36.94	0.97
V5	No fertilization	32A	580.3	4.67	25.67	38.37	1.322
V5	No fertilization	32B	847.2	4.96	22.53	39.98	1.121
V5	No fertilization	31A	1424.1	4.85	24.29	38.27	1.197
V5	No fertilization	31B	1192	4.92	23.3	40.12	1.163
Control	No fertilization	30A	265				1.278
Control	No fertilization	30B	674.4	4.87	23.64	39.63	1.224
Control	No fertilization	29A	995.6	4.94	24.51	39.27	1.309
Control	No fertilization	29B	1070.9	4.82	25.14	36.75	1.233
V5	NPK	33A	988	5.12	25.58	37.49	1.164
V5	NPK	33B	1081.2	4.61	28.61	38.86	1.371
V5	NPK	34A	302.6				1.055
V5	NPK	34B	940.9	4.66	26.42	39.14	1.295
Control	NPK	35A	697.5	4.75	23.46	40.52	1.105
Control	NPK	35B	873.2	4.38	23.19	39.57	1.131
Control	NPK	36A	806.5	4.43	22.62	40.51	1.119
Control	NPK	36B	1356.8	4.68	25.69	38.31	1.264

2021 – L2 Results (Camelina crop)

Plot	Treatment	Rep	Variety	Date of background fertilization	Seeding date	Flowering date	End of flowering	Days of flowering	Harvest date	Height (cm)	Lodging	Shattering	Yield (kg/ha)	%Moisture	%Protein (Dry matter)	%Oil (Dry matter)	TSW (g)
1	No fertilization	1	Control	25/11/2020	25/11/2020	07/04/2021	19/05/2021	42	08/06/2021	52.5	0	0	36.5	5.85	27.42	32.81	0.966
2	No fertilization	2	V5	25/11/2020	25/11/2020	07/04/2021	19/05/2021	42	08/06/2021	52.5	0	0	99.0	5.32	25.86	38.66	1.183
3	No fertilization	3	Control	25/11/2020	25/11/2020	07/04/2021	19/05/2021	42	08/06/2021		0	0	81.3	4.29	23.32	38.13	1.097
4	No fertilization	4	V5	25/11/2020	25/11/2020	07/04/2021	19/05/2021	42	08/06/2021		0	0	60.5	5.33	26.32	39.89	0.876
5	NPK	1	V5	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021	62.5	0	0	57.3	5.79	25.48	39.38	1.091
6	NPK	2	Control	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021	67.5	0	0	656.3	4.4	24.32	40.53	1.139
7	NPK	3	V5	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021		0	0	553.9	4.68	24.82	41.67	1.214
8	NPK	4	Control	25/11/2020	25/11/2020	20/03/2021	12/05/2021	53	08/06/2021		0	0	248.7	4.06	23.33	38.63	1.211
9	10% Biochar + Compost	1	Control	25/11/2020	25/11/2020	01/04/2021	26/04/2021	25	28/05/2021	62.5	0	0	312.5	4.2	24.09	41.21	1.049
10	10% Biochar + Compost	2	V5	25/11/2020	25/11/2020	01/04/2021	26/04/2021	25	28/05/2021	65	0	0	31.3	4.62	24.81	43.79	1.089
11	10% Biochar + Compost	3	Control	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021		0	0	35.6	4.3	23.92	43.17	1.094
12	10% Biochar + Compost	4	V5	25/11/2020	25/11/2020	01/04/2021	26/04/2021	25	28/05/2021		0	0	40.3	4.93	24.22	41.58	0.936
13	15% Biochar + Compost	1	V5	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021	65	0	0	250.0	4.25	23.64	43.16	1.104
14	15% Biochar + Compost	2	Control	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021	70	0	0	119.8	4.22	23.44	40.37	1.148
15	15% Biochar + Compost	3	V5	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021		0	0	203.3	4.82	26.51	38.78	1.089
16	15% Biochar + Compost	4	Control	25/11/2020	25/11/2020	20/03/2021	12/05/2021	53	08/06/2021		0	0	409.9	4.34	24.34	43.42	1.158
17	20% Biochar + Compost	1	Control	25/11/2020	25/11/2020	01/04/2021	12/05/2021	41	08/06/2021	62.5	0	0	296.9	4.15	24.02	42.71	1.159
18	20% Biochar + Compost	2	V5	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021	67.5	0	0	328.1	4.17	23.65	43.37	1.174
19	20% Biochar + Compost	3	Control	25/11/2020	25/11/2020	01/04/2021	26/04/2021	25	28/05/2021		0	0	142.3	4.71	24.45	43.4	1.108
20	20% Biochar + Compost	4	V5	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021		0	0	362.9	4.19	24.33	39.84	1.165
21	100% Biochar + NPK	1	V5	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021	65	0	0	343.8	4.58	23.4	42.43	1.061
22	100% Biochar + NPK	2	Control	25/11/2020	25/11/2020	01/04/2021	26/04/2021	25	28/05/2021	67.5	0	0	572.9	4.2	24.18	41.21	1.115
23	100% Biochar + NPK	3	V5	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021		0	0	645.3	3.89	23.79	45.28	1.139
24	100% Biochar + NPK	4	Control	25/11/2020	25/11/2020	20/03/2021	12/05/2021	53	08/06/2021		0	0	26.9	4.31	24.12	41.12	1.137
25	100% Compost	1	Control	25/11/2020	25/11/2020	20/03/2021	26/04/2021	37	28/05/2021	60	0	0	1697.9	4.29	24.2	38.79	1.083
26	100% Compost	2	V5	25/11/2020	25/11/2020	01/04/2021	26/04/2021	25	28/05/2021	72.5	0	0	250.0	4.16	23.8	41.88	1.12
27	100% Compost	3	Control	25/11/2020	25/11/2020	01/04/2021	26/04/2021	25	28/05/2021		0	0	198.2	4.43	23.9	40.63	1.13
28	100% Compost	4	V5	25/11/2020	25/11/2020	01/04/2021	12/05/2021	41	08/06/2021		0	0	53.8	4.03	24.54	42.39	1.057
29	No fertilization	5	V5	25/11/2020	25/11/2020	07/04/2021	19/05/2021	42	08/06/2021	62.5	0	0	119.8	5.01	25.57	40.69	1.115
30	No fertilization	6	Control	25/11/2020	25/11/2020	07/04/2021	19/05/2021	42	08/06/2021	62.5	0	0	302.1	4.55	23.84	40.69	1.064
31	No fertilization	7	V5	25/11/2020	25/11/2020	07/04/2021	19/05/2021	42	08/06/2021		0	0	330.3	5.14	24.94	39.91	1.083
32	No fertilization	8	Control	25/11/2020	25/11/2020	07/04/2021	19/05/2021	42	08/06/2021		0	0	100.8	4.63	25.33	37.63	0.966
33	NPK	5	Control	25/11/2020	25/11/2020	01/04/2021	19/05/2021	48	08/06/2021	57.5	0	0	161.5	4.35	24.51	40.09	1.062
34	NPK	6	V5	25/11/2020	25/11/2020	01/04/2021	26/04/2021	25	28/05/2021	62.5	0	0	390.6	5.13	24.69	37.39	1.033
35	NPK	7	Control	25/11/2020	25/11/2020	01/04/2021	26/04/2021	25	28/05/2021		0	0	182.9	4.25	23.81	37.96	1.122
36	NPK	8	V5	25/11/2020	25/11/2020	01/04/2021	12/05/2021	41	08/06/2021		0	0	618.3	4.4	24.88	41.04	0.957