CULTIVATING CAMELINA FOR SUSTAINABLE AVIATION FUELS IN EU-MED MARGINAL LAND RECOVERED WITH CO-COMPOSTED BIOCHAR AND DIGESTATE: PRELIMINARY RESULTS

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Bio4A Advanced Sustainable Biofuels for Aviation

INTRODUCTION

The H2020 BIO4A project aims at producing and deploying Sustainable Aviation Fuels (SAF) at large scale in Europe. A major oil refinery, owned and operated by Total, will run in non-segregated full jet-mode, targeting the production of 5 kt of ASTM-certified bio-based HEFA jet fuel. The produced SAF will then be used in commercial passenger flights: the demonstration activities will be complemented by market and policy analysis. While this part of BIO4A represent the industrial component of the project, the issue of **developing additional alternative routes for supplying sustainable lipids to the HVO process** represents the key R&D part: this addresses the **production of Camelina in EU MED marginal land, recovered by biochar or COMBI addition** (figure 1).

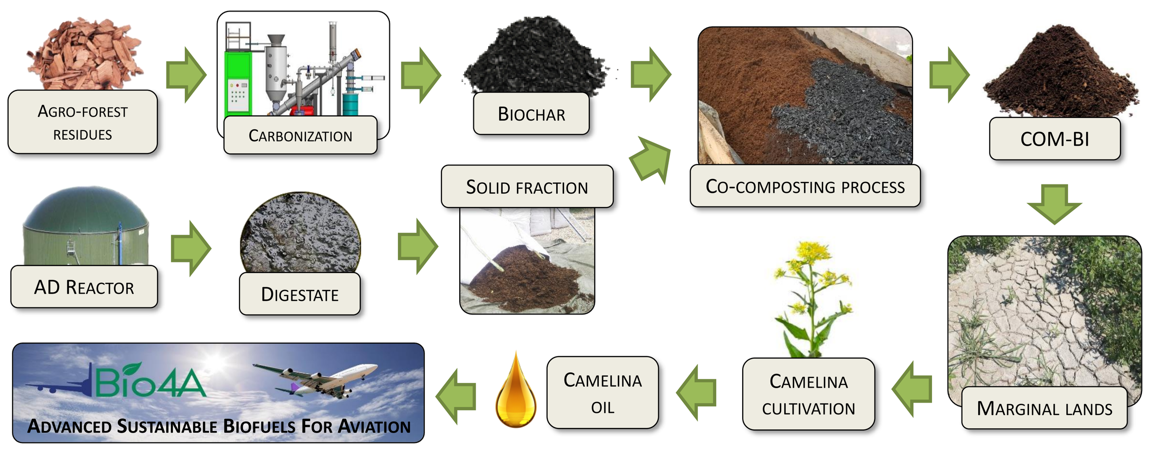

Figure 1: BIO4A sustainable lipid supply chain

The production of a novel soil amendment, here named COMBI (COMpost + BIochar), and the evaluation of its performances to increase soil resilience in marginal lands prone to desertification in Spain, are therefore the main R&D actions. Co-composted biochar and digestate obtained from biomass anaerobic digestion has been produced and characterized. **The use of Biochar and COMBI in marginal land mostly aims at increasing organic matter to the soil, favoring nutrient recycling and availability, increasing soil water holding capacity, and sequestering fixed carbon**, thus contributing to the Paris Climate agreement (Climate Change mitigation) and the UN Sustainable Development Goals. In particular, the carbon removed from the atmosphere, differently from most of the CCS routes, where C is stored, is employed to support the adaptation of difficult agricultural lands and regions to climate change, improving soil and agriculture resilience (Climate Change adaptation).

COMBI, AN INNOVATIVE PRODUCT

Composting is a well-known pathway to stabilize organic matter of various origins through a bio-oxidative process, which brings benefits as volume reduction, sanitization from pathogens, reduction of liquid contaminants, economic and environmental returns. The addition of a bulking agent in the compost pile is normally recommended, in particular when substrates as digestates are used, given the small particle size of the material, which generates risks of anaerobic conditions within the pile, leading to the production of undesired phenomena as ammonia volatilization. **Biochar** is the solid product from lignocellulosic biomass thermo-chemical conversion, characterized by a high content of stable C. Re-Cord has several equipment at different scale for Biochar production through slow pyrolysis process, among them (figure 2) a rotary kiln (input capacity 100 kg h^{-1}) and the CarbOn, equipped with a fixed bed, open-top, oxidative reactor (input capacity 50 kg h^{-1}).

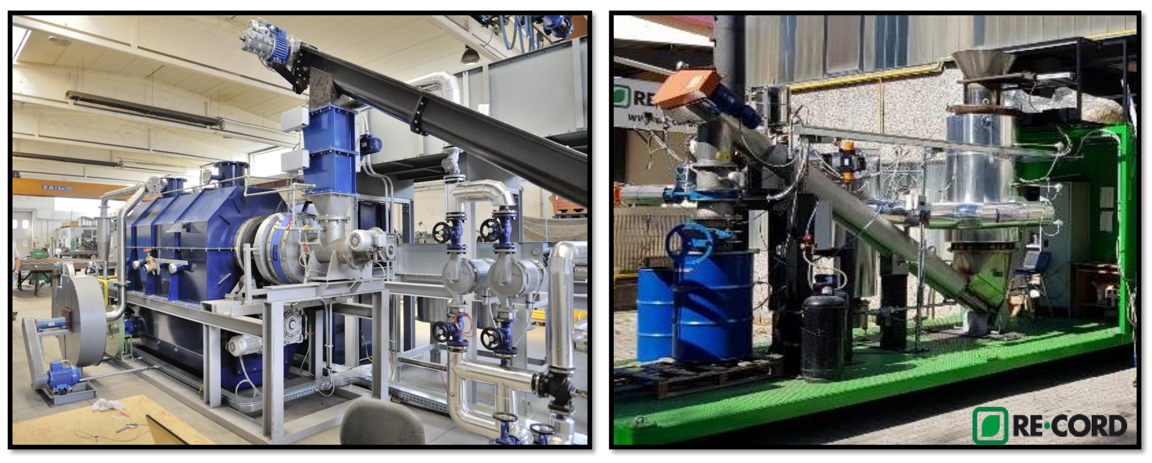

Figure 2: Re-Cord equipment for Biochar production: rotary kiln in the left, CarbOn in the right.

Biochar is a highly porous material with a wide range of possible uses, including sustainable agriculture, as it improves the water holding capacity and the organic matter content in soil, in particular in marginal lands and regions where rain is scarce, and irrigation is difficult for a number of environmental or economic reasons.

Co-composting of organic matter and biochar, if compared to conventional composting, **can positively affect the composting residence time, reducing N-compound losses in the atmosphere and leaching, favoring the microbiological activity and in turn increasing the humification process, eliminating or reducing the need for additional bulking agent.**

Biochar, alone or co-composted, also contributes to long-term atmospheric C sequestration in soil, offering a rather low-complexity solution if compared to most available C sequestering state-of-the-art technologies.

Sanchez-Monedero et al. reviewed biochar applications to composting, suggesting application rates at the beginning of the co-composting process: the proposed rate was approximately equal to 10% by weight on dry basis of the composting pile. This amount seemed to optimize the process performances, but the suggested range bringing positive results to the process was indicated among a minimum of 3% to a maximum of 20% w/w on dry basis.

Figure 3: Chestnut Biochar on the left, the solid fraction of digestate from anaerobic digestion (AD) on the right.

Biochar can be obtained by the carbonization of lignocellulosic material, such us agro-forest residues. In a circular economy perspective it is possibile to find a lot of exemples for organic material suitable for co-composting, e.g. crop residues, animal manure, food waste, agro-industrial wastes (such as marc and pomace), et cetera. **Very important for the process so to obtain a quality product is to control the C/N ratio, the pH and moisture content of the starting windrow create.**

COMBI PRODUCTION

MATERIALS AND METHODS

In BIO4A project **COMBI** was produced through co-composting blends of biochar with digestate solid fraction (figure 3), and the addition of a small amount of cereal straw as bulking agent. **Biochar was produced in the oxidative CarbOn pilot plant developed by RE-CORD** (figure 2). CarbOn is a continuous biomass carbonization system based on open top, downdraft technology, operating under oxidative pyrolysis regime. **The characterization of the biochar produced confirms that it qualifies for the EBC premium grade quality.** Digestate solid fraction was supplied by an industrial anaerobic digestion plant located in the North of Italy, mainly fed with manure as feedstock. **The co-composting process adopted followed the ECN-QAS recommended procedures and was performed during the summer season** (batch 1) **and winter season** (batch 2) **in a farm** located in Scandicci (Florence), Italy (figure 4).

Figure 4: COM-BI production in farm environment

The experiment duration was 60 days, with no additional curing time. 4 different blends of biochar/digestate were considered for composting, increasing starting biochar rate from 0% to 20% by weight on wet basis. **Static windrows were formed within a farm-greenhouse and manually turned twice per week during Summer, once during Winter.** Windrows were prepared starting from a first layer of digestate and finishing them with digestate covering the entire pile (Figure 5). Biochar and straw layers were separated by digestate layers. At the end of the windrows preparation, all piles accounted for the same volume. This layer configuration lasted until the first turning, which occurred after a week.

Figure 5: Windrow preparation

RESULTS

It is difficult, producing COMBI in farm environment, to predict the final biochar rate by weight, dry basis (Figure 6): **mainly due to the uncertainty of the efficiency of the process (influenced by climate and digestate properties seasonal variation).** There were important differences during Summer and Winter production tests, as well as expected: the process started easily in Summer, reaching also sanitizing temperature process and a higher organic matter devolatilization for all the blends. In Winter, windrows needed a heating system for allowing the process to start, assuring also an adequate sanitization phase.

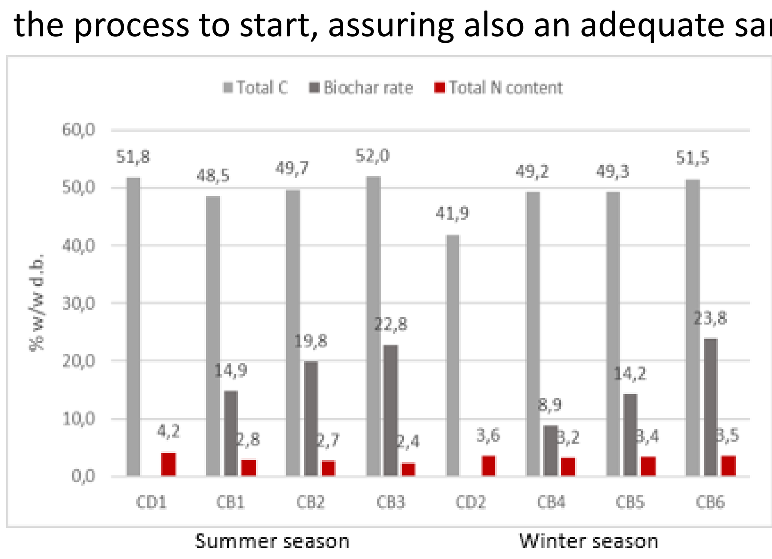

Figure 6: Final biochar rate, Total C and N content for every blend tested during Summer and Winter season

CB2 blend (figure 7), having an initial biochar concentration of 11.2 % w/w d.b., attained a final concentration of 19.8% w/w d.b. (figure 6): it **outperformed the other blends on all process and product parameters, showing the lowest stabilization time, the highest Net Organic Matter (NOM) yield with the highest degree of humification and the lowest ammonium/nitrate ratio index.** The compost obtained from the control met reference limits (ECN-QAS), but products characteristics, in terms of a quantitative comparison with CB2, were always lower, in particular, regarding the product stabilization obtained.

Figure 7: COMBI product (CB2)

It can be speculated that, if applied to soil as an amendment, CB2 could outperform the other blends in terms of OM increase in soil, considering its humification rate; however, this has to be further investigated in agronomic field trials. Stability of the recalcitrant carbon contained in biochar can also contribute to the carbon sink of soil for the mitigation of greenhouse gas emissions.

A qualitative result of the experiment, which should be highlighted, is dust reduction in biochar: after mixing the windrows, the typical black dust that normally develops when handling biochar, could not be visually observed. This represent a tremendous advantage in terms of logistics, handling, health and safety of biochar, when it is transported, stored and applied to fields.

FIELD TRIAL TESTS ONGOING

Further results will be obtained after the end of field trials in Spain, Madrid (figure 8), where **COMBI application is directly compared with common soil improver applications for the cultivation of Camelina (a non food energy crop), by Camelina Company España.** The products were applied to two sites in Spain, before seeding Camelina crop: each site comprised 7 different microplots of 10 m2 each, and 4 repetitions. The microplots included soil without fertilization (control), soil with NPK fertilization, soil with three different blends of COMBI, soil with only biochar, soil with composted digestate alone. **Field trial sites will continue to be tested in normal rotation with barley over the following two years.**

Figure 8: BIO4A field trials in Madrid (Spain) by CCE

PRELIMINARY RESULTS

- **Location 1 showed low cumulative pluviometry (86.2 mm) from germination to harvest: Control and NPK yield approx. 0, Combi and Biochar maximum grain yield were higher than Compost.**
- Location 2 showed adequate cumulative pluviometry (109.6 mm) from germination to harvest: Compost, Combi and Biochar expressed highest maximum grain yield compared to control and NPK (+40/50%).

Notes: All replications showed great variability, statistically consolidated data necessary.

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