PRODUCTION AND USE OF CO-COMPOSTED BIOCHAR AS SOIL AMENDMENT FOR CANNABIS SATIVA SP. GROWTH

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ABSTRACT: Biochar is a carbonaceous by-product of thermochemical conversion of ligno-cellulosic biomass. Its application to soil positively influences various soil physico-chemical properties. Biochar high specific surface area and high micro and macro porosity raise the soil water retention and nutrients absorptivity from the soil, enhancing biomass yield. However, biochar itself contains low nutrients amount and its amendment properties could be improved through organic matter addition, rich in microelements and nutrients.
This work studies the integration of fresh organic matter and biochar in co-composting biochar process in order to investigate co-composted biochar (hereby called COMBI) effects on soil amelioration compared to biochar only.
Specifically, biochar used in this study is the result of thermochemical conversion of lingo-cellulosic biomass waste through PP30 30 kW gasification power plant. Green matter comes from CREA Institute in Anzola (Bologna) hemp fields: after the fibers harvest, the organic wastes was collected and co-composted with biochar (15% v/v) to achieve a mature COMBI. The co-composting biochar process has been carried out in a 105 L volume composter for 3 weeks. It has been mixed by turning the composter to allow oxygenation during organic matter degradation reactions. The temperature profile, the humidity and the C/N content were monitored during the maturation process of COMBI. Then, COMBI has been applied to *Cannabis sativa* sp. pot growth test (Finola cultivar), where the effects of no amendment soil was used for control plants (C), 5% v/v biochar only amendment (5% B), 10% and 20% v/v co-composting biochar (10% COMBI and 20% COMBI) amendment soil were investigated and compared. The biomass production of Finola plants, the flowers weight and THC-CBD content were analyzed and ANOVA statistical analysis was performed among the four groups of plants.

Keywords:, Co-composting, green waste, amendment, biochar, *C. sativa*.

1 INTRODUCTION

Biochar consists in the charcoal that is disposed from gasification and pyrolysis reactor. It is considered as soil amendment, thanks its showed capacity to enhance crop productivity and soil fertility [1], decrease nutrient leaching [2], sequester organic carbon [1], reduce NO_x and CO_2 greenhouse gases emissions [3] and to increase soil water-holding capacity [4]. Furthermore, it represents a highly recalcitrant form of carbon, for this reason its use as soil amendment as also the effect to convert the soil into an effective carbon sink [5].

At the same time, composting is the biological decomposition and stabilization of organic matter derived from green or food waste, through the action of diverse microorganisms under aerobic conditions [6]. The final product of this biological process is a stable substrate, being free of pathogens which can be beneficially applied to land as an agent for soil amelioration or as an organic fertilizer.

The idea of this work is to introduce biochar to the composting process enhancing the sustainability of the process itself and of the plant growing system, overcoming at the same time some limitations existing in biochar or compost use only.

Some Authors have started to show some encouraging results by biochar application as compost amendment, here call COMBI [7], [8]. Biochar during compost maturation increases the surface available for microorganism colonization, due to micro and mesopores; these at the same time enhance the sorption of carbon compounds from compost, enriching the final product in terms of nutrient availability [9]. The higher retention of nitrogen and carbon compounds by COMBI with respect to the compost without biochar [10], [11], [12] introduce the potential to decrease greenhouse gas emission by biochar during composting process and its application to the soil [7].

Moreover, biochar can increase compost temperature decreasing compost maturation time and making safer the final product [7].

This work wants to investigate co-composting process between green waste and biochar in order to study firstly compost maturation process, then COMBI effects on specific plant culture: *Cannabis sativa*.

Hemp global sector is a fast growing market thanks to the large variety of its possible applications into several activities and productions [13]. Textile industries as well as sustainable building companies are increasing the demand for hemp fiber [14]. Food industry founds in hemp seeds and oil valuable Omega-3, Omega-6 and protein supplier, while pharmaceutical and recreational industries are interested in the cannabinoid profile of the unpollinated flowers [15], [16].

This case study is an indoor growing facility where hemp is cultivated for cannabinol (CBD)-rich flower production. This paper investigates two levels of advantages from integration of biochar in hemp farms:

- Co-composting process of organic waste and biochar (COMBI);
- COMBI application as soil amendment and assessment of its effects on *C. sativa* on plant biomass production and flower harvesting.

2 MATERIALS AND METHODS

2.1. Co-composting system

Co-composting process was represented by aerated tumbler, adding 15% v/v biochar to *C. sativa* green waste. Biochar involved in this study has been produced through gasification, the thermo-chemical biomass conversion into fuel gas (syngas) [17], [18], [19]. The gasifier used is the ALL Power Labs Power Pallet PP30 (nominal power 25 kWel) co-generating thermal and electrical power (Figure 1) [APL website: www.allpowerlabs.com].

The starting biomass employed to into gasifier was vine prunings pellets. Before this work, gasifier was already tested with several biomass types: wood chips, residues of river maintenance, chipped giant reed, corn stover, protein cake from vegetable oil extraction and corn cobs [20]–[23].

Figure 1 APL PP30

Green waste comes from Finola cultivar field in Bologna, CREA Institute (Figure 2), in particular, plant residues from fiber processing were collected, then dried until their input into composting system.

Figure 2: *C. sativa* plants from CREA's fields (Centro di ricerca Cerealicoltura e Colture Industriali, Bologna) used a source of green waste for co-compost process.

The total volume into the tumbler was 100 L: together with biochar and green waste, 200g of mature compost inoculum was added in order to allow the biochemical degradation being started by microorganisms. Before starting the process, the mixed material was poorly watered. The co-composting material has been turned into tumbler once a day during the entire experimental period.

The maturation process lasted totally 4 weeks. Temperature of co-compost, its humidity and C/N rate were recorded and calculated weekly.

Temperature was measured by PCE 320 Psycrometer equipped by thermocouple K type; humidity (H) was calculated according (1)

$$H\ \% = [(FW - DW)/ FW]*100 \qquad (1)$$

Where:
FW= co-compost sample fresh weight (g)
DW= co-compost sample dry weight (g), achieved into the heater, at 105°C for 24 hours.

C/N rate was measured according to Standard method n°248 by Gazzetta Ufficiale (21-10-1999).

2.2. Plant growth test

COMBI was then deployed as soil amendment in *C. sativa* pot growth test. The experimental design involved eight repeated pots, with a volume of 5 liters, for each studied thesis: two different percentages of COMBI: 10% v/v and 20%v/v; 5% v/v biochar and control, where no amendment was added. The substrate used was a mix of coconut fiber and perlite. The three types of tested amendments (COMBI 10%-COMBI 20% and biochar 5%) were mixed and homogenized before filling the pots.

The test started as soon as cutting have been planted into the pots and set into the greenhouse (Figure 3), where air relative humidity was kept under control (70%±5) by a HVAC system; two High Pressure Sodium lamps (500 W each) give averagely 490±51 μmol/m^2/s of Photosynthetically Active Radiation (PAR) to the growing plants (Figure 3).

The plants growth is subdivided in two macro-phases: vegetative (45 days) and flowering (60 days). During the vegetative growing, a light-dark cycle of 18 light and 6 dark is adopted, instead during flowering the light-dark cycle is 12-12 hours.

At the end of the experimental test, produced biomass of the entire plant and fresh flower biomass were measured for each plant; furthermore, cannabinol (CBD) and tetrahydrocannabinol (THC) contents were analyzed into each group of flowers.

Figure 3: Experimental test into greenhouse system: *C. sativa* cuttings on growing.

2.3 Cannabinoid analysis

Cannabinoids are a class of organic compounds produced as secondary metabolites by hemp, which are studied mostly for their interesting pharmacological properties [24], [25]. Among this group, cannabinol (CBD) is a non-psychoactive cannabinoid, while tetrahydrocannabinol (THC) has instead euphoriant effects due to very low amount of that contents (<0.5%, w/w). Their level in the plant need to be monitored because it is absolutely necessary its compliance to European and Italian legislation [26], [27]. In this study cannabinoids concentrations were measured in order to evaluate possible effects of COMBI or biochar on their contents, ensuring at the same time the quality and safety of the product. The analytical method followed was based on liquid chromatography coupled to a ultraviolet detector (HPLC-UV) [28].

3 RESULTS

3.1 Co-compost maturation

The composting process has showed high temperature during the first phase of aerobic degradation, reaching 44.1°C. After 5 days, the temperature started to be similar to ambient temperature (20±5°C), as represented in Figure 4.

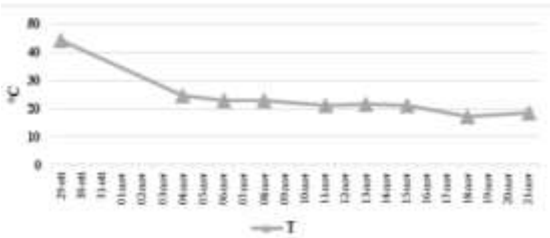

Figure 4: Co-compost temperature during maturation process. Each data is the average of 5 different points measurements.

In Table 1, C/N rates and COMBI humidity are presented. While the humidity doesn't significantly change through the maturation time, C/N slightly increase between starting and final time (+16.5%)

Table I: C/N and humidity data of co-compost during maturation process. T0, T1, T2, T3 refers respectively to data at the starting point of the process (T0) and the following weeks of maturation.

	T0	T1	T2	T3
C/N	32.7	31.7	38.1	38.1
Humidity	62.2	64.5	64.9	64.4

3.2 Plant growth test

After 105 days from plantation, hemp plants were harvested and fresh biomass was measured. Results are summarized in Figure 5. The mean biomass of each thesis is the result of 8 plants from the same substrate type. The control samples produced averagely more fresh plant and flower biomasses, than the amendment thesis, even if control show a larger variability among different samples. In details, fresh weights of plants biomass resulted to be: 213±70g in control, 168±17g in COMBI 10%, 184±31g in COMBI 20% and 163.6±36g in biochar 5%; fresh weights measured on flowers are respectively: 24±7g, 17.3±2g, 19.4±7.6g, 14.1±19g.

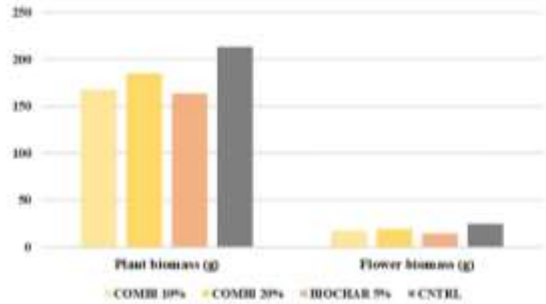

Figure 5: Biomass production comparison among three different theses (COMBI 10%, COMBI 20% and biochar 5%) ad control.

3.3 Cannabinoids analysis

Since the cannabinoids contents could significantly vary depending from environmental factors, such as substrate type [29], it was essential to analyze their contents into plants grown on biochar and COMBI amendments. As shown in Figure 6 (a, b), in this case, COMBI had the best performances on both groups of cannabinoids, CBD.

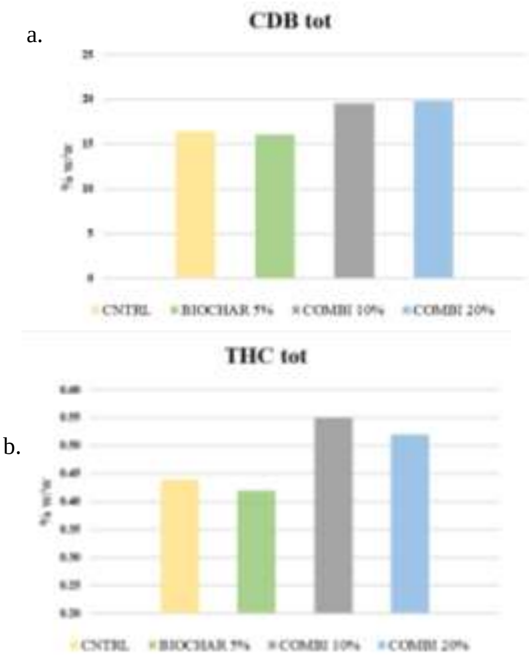

Figure 6 (a, b): Cannabinoids (CBD, THC) production comparison among three different theses (COMBI 10%, COMBI 20% and biochar 5%) ad control.

4 DISCUSSION

This is a preliminary study about agronomic effects on co-composted biochar to plant growth, here investigated on *C. sativa*. In this work, plants without amendments had a better performance in terms of plant and flower biomass production. Some remarks should be considered. Each pot involved in the study was watered every day through the same amount of water: at the end of the growth, biochar and COMBI's pots resulted to be wetter than control pots. The phenomenon can be explained through the higher water holding capacity of biochar and COMBI, which consequently request less water compared to control soil to maintain the health balance among oxygen, water and radical gas exchange into the soil. However, comparing biochar 5% and COMBI growth test, COMBI 10% and COMBI 20% increased by 2,7% and 12,7% respectively plant biomass production compared with plant biomass grown on biochar 5%. Furthermore, COMBI 10% and COMBI 20% increased 22% and 37% respectively flower biomass production compared with flower biomass grown on biochar 5%.

As regards of cannabinoids analysis, the results show a different situation. Both COMBI 10% and COMBI 20% highlight a significant increase of THC (25% and 18.2% respectively) and CBD (19.2% and 21% respectively) production compared with control and biochar 5%, without overcoming law thresholds (0.6% for THC).

5 CONCLUSION

Co-composting of green waste and biochar should be considered in future researches to investigate the potentials of organic matter rich-biochar to improve soil fertility and plant biomass production. Even though COMBI results in this work less performant in plant biomass production than control soil, it shows a higher productivity compared to biochar 5%, both on biomass and metabolites production. This preliminary results should be employed to continue the research with the aim to ameliorate sustainable amendments production through co-composting.

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8 LOGO SPACE