POSSIBLE REGULATORY APPROACH FOR AN INNOVATIVE AMENDMENT OBTAINED BY CO-COMPOSTING BIOCHAR WITH DIFFERENT TYPOLOGY OF COMPOSTABLE ORGANIC MATTER IN THE ITALIAN LAW FOR FERTILIZERS

David Casini[1], Tommaso Barsali[1], Francesco Primo Vaccari[2], David Chiaramonti*[1,3]

[1]Renewable Energy COnsortium for R&D (RE-CORD) Viale J. F. Kennedy, 182, 50038 Scarperia e San Piero (FI), ITALY
[2]Institute of Bioeconomy (IBe), National Research Council (CNR), Via G. Caproni 8, 50145 Florence, ITALY
[3]CREAR/Department of industrial Engineering, University of Florence, Viale Morgagni 40, 50134 Florence, ITALY

ABSTRACT

The Italian decree n.75/2010 (Annex 2, Amendments) regulating the use of fertilizers in agriculture allows the application of biochar and compost as soil amendments, separately. However, there is no specific category for a soil amendment (here called COM-BI) obtained through co-composting of biochar with compostable organic matter. COMBI, classified as a soil amendment, combines in a synergistic way the benefits of applying biochar and compost to soil separately. Moreover, co-composting with biochar can accelerate the process, reducing the residence time of the compost windrow and the rate of N-losses in atmosphere and leachate. The production process consists in aerobic bio-stabilization of the organic matter in presence of biochar, which is the solid residue of thermo-chemical process (slow pyrolysis and gasification) applied to ligno-cellulosic feedstock. Biochar, in general, is a rather highly porous material which, when added to soil, can increase the water holding capacity, improve the soil physical structure, favour the biological fertility, while at the same time sequestering C. These benefits are particularly relevant in regions with low fertility land prone to desertification. Compostable feedstocks used for Combi production could be the organic fraction of municipal solid waste (OFMSW), green wastes, animal manure and effluents, the solid fraction of digestate from anaerobic digestion plant. This study proposes a possible regulatory approach to deal with the use of co-composted matter in agriculture, promoting COMBI as a mean for circular economy. The establishment of a new product classification is proposed, which comprise different types of COMBI produced using various percentages of biochar blended with the other amendments already listed in Annex 2, and respecting the already existing specifications. Process parameters should be clearly defined in the new specifications in order to guarantee the quality of the product; furthermore, some major product characteristics should also be declared by the producer.

COM-BI, 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 [1]. 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 [2].

Biochar is the solid product from lignocellulosic biomass pyrolysis, characterized by a high content of stable C. It is mostly produced through slow pyrolysis, but also biochars from intermediate/fast pyrolysis and gasification are often discussed in literature, even if these biochar characteristics show different characteristics.

Figure 1: Biochar (left) and solid fraction of digestate (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 [3].

WHY CO-COMPOSTING

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 [4]. 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 [5].

Sanchez-Monedero et al. [4] 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.

Figure 2: COM-BI blend at 19.8 % w/w d.b. of biochar content

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.

POTENTIAL FEEDSTOCK

Biochar can be obtained by the carbonization of lignocelullosic 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 oproduct is to control the C/N ratio, the pH and moisture content of the starting windrow create.

COM-BI PRODUCTION

THE BIO4A PROJECT

BIO4A is a H2020 project that will scale up the industrial production and the market of sustainable aviation fuel, made from residual lipids; it will also investigate the alternative supply of sustainable feedstock by covering EU-MED marginal land for drought resistant crop production. In this contest COM-BI was produced through co-composting blends of biochar with digestate solid fraction, 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 [6]. 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 in a farm located in Scandicci (Florence), Italy.

Figure 3: 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 15.2% by weight on dry basis. Static windrows were formed within a farm-greenhouse and manually turned twice per week. Windrows were prepared starting from a first layer of digestate and finishing them with digestate covering the entire pile (Figure 4). 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 4: Windrow preparation

RESULTS

CB2 blend, having an initial biochar concentration of 11.2 % w/w d.b., attained a final concentration of 19.8% w/w d.b. (figure 2): it outperformed the other blends on all process and product parameters, showing the lowest stabilization time, the highest Net Oganic Matter (NOM) yield with the highest degree of humification and the lowest ammonium/nitrate ratio index. The compost obtained from the control (CD) met all main 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. Furthermore, 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.

Further results will be obtained after the end of field trials in Spain, Madrid (figure 4), where COM-BI application in directly compared with common soil improver applications for the cultivation of Camelina (a non food energy crop).

Figure 4: BIO4A field trials in Madrid (Spain)

ITALIAN LAW FOR FERTILIZERS

In 2012 ICHAR made request to the Italian Ministry of Agriculture for the inclusion of biochar in the list of soil amendment allowed in Italian agriculture. In August 2015 the request has been approved by the Ministry of Agriculture, opening a new phase for biochar production, commercialisation and use in Italy. The Italian agriculture is now in the position to provide an effective contribution in mitigating climate change and ICHAR hopes that this will be an example for other European countries to approve the use of biochar.

Table 1: Biochar in annex n°2 (Amendments) of D.L. n.75 29/04/2010 [7]

Type denomination	Production technology and main characteristics	Minimum title in elements and/or useful substances. Criteria on the evaluation. Other characteristics required	Other indications on denomination or type	Elements or useful substances whose title must be declared. Different characteristics to be declared. Other characteristics required	Notes
Biochar from pyrolysis or from gasification	Process of carbonization of products and residues of vegetable origin coming from agriculture and forestry, olive pomace, grape marcs, cereal bran, fruit stones and wood-shells, non-treated residues of wood processing, and other residues of the above mentioned activities. The process of carbonization is the loss of hydrogen, oxygen and nitrogen from the organic matter that follows the application of heat in absence, or in limited presence, of the oxidating agent, typically oxygen. This thermochemical conversion is defined as pyrolysis or pyrodecomposition. Gasification accounts for a further oxidation process of the charcoal produced by pyrolysis.	C tot of biologic origin (#) % d.m. ≥20 e ≤30 (Cl(*)3) >30 e ≤60 (Cl (*)2) > 60 (C(*)1) Salinity mS/m □1000 (§) $pH_{(H2O)}$ 4-12 Umidity % 20 for powder products(°) Ashes % d.m. >40 and ≤ 60 (Cl(*)3) ≥10 and ≤ 40 (Cl(*)2) <10 (Cl(*)1) H/C (molar)(^) ≤0,7		Granulometry (bypasses mm 0,5-2-5) Nitrogen tot Potassium tot Phosphorous tot Calcium tot Magnesium tot Sodium tot % C from carbonates Phytotossicity test and growth (worm test and/or germination/growth test Water retention max	(#) subtracting C from carbonates (*) Quality class (§) <100 in case of use as amendment in substrates for horticulture (°) data to be declared (^) index of C stability

NEW AMMENDANT CATEGORY: COM-BI

A specific request to the Italian Ministry of the Agriculture will be done in order to insert the COM-BI in the list of the allowed amendants in agriculture. In the request will be specifically identified the composting process and the list of the biomass that will be used to obtain the COM-BI. The new soil amendant in any case must respond to the tresholds of pollutants that are fixed by law and quite obviously it must pass the Phytotossicity test.

SELECTED LITERATURE REFERENCES

[1] Raza S, Ahmad J (2016) Composting process: a review. Int J Biol Res 4:102.

[2] Bustamante MA, Restrepo AP, Alburquerque JA, et al (2013) Recycling of anaerobic digestates by composting: effect of the bulking agent used. J Clean Prod 47:61–69.

[3] Agegnehu G, Srivastava AK, Bird MI (2017) The role of biochar and biochar-compost in improving soil quality and crop performance: A review. Appl. Soil Ecol. 119.

[4] Sánchez-García M, Alburquerque JA, Sánchez-Monedero MA, et al (2015) Biochar accelerates organic matter degradation and enhances N mineralisation during composting of poultry manure without a relevant impact on gas emissions. Bioresour Technol 192:272–279.

[5] Oldfield TL, Sikirica N, Mondini C, et al (2018) Biochar, compost and biochar-compost blend as options to recover nutrients and sequester carbon. J Environ Manage 218:465–476.

[6] Rizzo AM, Pettorali M, Nistri R, Chiaramonti D (2019) Mass and energy balances of an autothermal pilot carbonization unit. Biomass and Bioenergy 120:144–155.

[7] Italian Ministry of Agriculture and Forestry (MIPAAF). Attachment numer 2 of Italian legislative decree n°75 of 29th April 2010, Reorganization and revision of the discipline regarding fertilizers.

CORRESPONDING AUTHOR: ENG. DAVID CASINI
EMAIL: david.casini@re-cord.org