TRAINING MATERIAL

Title:

The use of **biochar** as fertilizer

Training:

Main features of the subcategory

Biochar is above 400°C low temperature reductive thermal processed carboniferous material with high carbon content, produced from cellulose based plant or bio-based by-products. This product is expressively made for soil functional applications, which does not have economical important level of nutrient content itself but acting as soil improver.

The word "biochar" is a combination of "bio-" as in "biomass" and "char" as in "charcoal". It is obtained by charring/pyrolysis of plant or bio-byproducts, via a process of heating it in the absence of oxygen. Different types of pyrolysis process used to make biochar between the material core temperature ranges of 400°C to 550°C, including slow pyrolysis, fast pyrolysis and flash pyrolysis. There are currently processes on the market which enable energy-neutral processing of pig manure or other manure to biochar as well. This is a stable recycled carboniferous material which is beneficial for the soil, containing d stable carbon which is applied to the soil. The following materials are not classified as biochar products and materials: charcoal, HTC hydrochar, torrified products, char products that have no EU/MS Authority permits for production and use as soil functionality biochar, char products that are not labelled as of EU/MS Authority permits and all materials which are not produced from biomass. The carbon content of pyrolysed chars fluctuates between 25% and 95% of the dry mass, dependent on the feedstock and process temperature used. For instance the C content of pyrolysed beech wood is around 85% while that of poultry manure is around 25%. There are two major elements impacting biochar quality: primarily the carbonisation engineering design performance quality to efficiently thermal process the material and the input feed material characteristics. Biochar is used for soil improver, usually between 5 tons/ha and 20 tons/ha to reach soil improver effects.

Input material

Legal framework: According to the proposed CMC14 Pyrolysis and Gasification materials of the new Fertilising Products Regulation (EU 2019/1009) the input material for biochar product should be

- vegetable waste from the food processing industry and fibrous vegetable waste from virgin pulp production and from production of paper from virgin pulp, if not chemically modified.
- processing residues from the production of bioethanol and biodiesel.
- bio-waste within the meaning of point 4 of Article 3 of Directive 2008/98/EC resulting from separate bio-waste collection at source.

Materials originating from mixed municipal waste, sewage sludge, industrial sludge or dredging sludge are excluded as input material to make biochar.

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How to produce?

All biochar products are obtained through thermochemical conversion process under oxygen-limiting conditions in pyrolysis or gasification reactors. The specific thermo-chemical treatment conditions for safe biochar production are:

- pyrolysis processed above 400ºC material core temperature for at least 10 minutes residence time or
- gasified above 750ºC material core temperature for at least 2 seconds residence time.

The new Fertilising Products Regulation (EU 2019/1009) will legally set up the specific conditions which are still under development status.

Typical nutrient content and availability for plants

Nutrient Content (N-P_2O_5-K_2O %) of biochar**:** 1- 0.2 -0.5, TC:>80 %.

Biochar is a soil improver with low NPK content and high carbon content, that application is aiming water and nutrient retention, carbon sequestration and other beneficial effects

Examples for biochar product available on the NUTRIMAN Farmer Platform

- https://nutriman.net/farmer-platform/product/id_1571

The term “Terra-Preta biochar” is a specific quality product with unique characters, which is processed by the “3R” Recycle-Recover-Reuse high temperature pyrolysis technology and formulations.

Terra-Preta biochar product is plant biomass by-product based stabile carboniferous substance that is processed under true value reductive 3R thermal conditions. Wood biochar is used for soil improver to reach any soil improver effect and eco-safe carbon negative applications. Terra-Preta biochars are highly suitable for soil improver that is mainly based on high dose effects with high water retention capacity. This is very important as many plant crops are very sensitive to abiotic stress as too hot and dry weather, which climate change is already a reality of today.

This wood-based Terra-Preta biochar could be formulated to BIO-NPK-C in any compounds as of user/market demands for both organic and low input farming application cases. The product is a fully safe and innovative soil improver with primarily application in the horticultural organic/low input farming cultivations with combined beneficial and multiple effects. One of the properties of wood biochar is its high specific surface area that is influenced by the nature of the organic material and the conditions in which it is produced. It is a product rich in micro and macro-pores, which increase the water retention capacity, allow the development of microorganisms and retain nutrients, releasing them gradually over time.

Figure 1. Terra-Preta biochar product (ID:1571)

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Fields of application in agriculture: crop, dosages, application method and practical recommendations.

ID 1571 Terra Preta biochar product is used at 5-20 t/ha according to soil quality, season and crop uptake with application targets to improve the production of the horticultural cultivations, mainly in the field of fresh vegetables, permanent crops (fruit trees), grapes, rice and tobacco. The main application area is organic and low input farming but applicable in the conventional farming practices as well.

Benefits for farmers

Biochar products have wide range and multiple beneficial effects as soil improver – amendment - conditioning agent, reducing soil bulk density, improving aeration and water - nutrient holding capacity of soils, while reducing nutrient leaching losses. The biochar is potentially ”carbon negative,” taking more carbon out of the atmosphere than it puts back into it, and mitigating climate change by storing plant derived carbon in the soil in a very stable form that resists long term decomposition.

Bottlenecks of application. Potential risk or limitation.

As biochar incorporation to soil is irrevocable, that is applied in large dose scale, therefore only high quality properly manufactured and formulated biochar products to be applied which have EU/MS Authority permit, REACH certificate and EPR extended producer responsibility certificate from the supplier.

In some manure biochar cases Cu/Zn over-dose concentration is challenging. As of high dose, user costs might also be high that is challenging. The risk of the flow away, wind erosion and rain leach out of the low volume weight and often dusty plant biochar must pay high attention at use in open field. Regarding the application method, it is important to be cautious when handling dry biochar because it is very dusty and should not be spread in windy conditions.

The feedstock management and transport logistics is one of the most critical economical, production security, environmental and production efficiency issues of biochar operations. Storage infrastructure is an indispensable component of biochar supply chains. Storage is therefore unavoidable while at the same time one of the major sources of risk in the supply chain. The risk arises from technical issues during storage (such as fire) as well as the opportunity cost of tied-up capital. In a geographically dispersed area, feedstock prices increase as distance to biochar production plant increases because transport costs increase. A whole-of-the-chain perspective is therefore critical to balancing the reliability of transport and the location and size of storage facilities. Feedstock management and transport logistics organization variating from biochar case by case.

No legal bottleneck after the new EU 2019/1009 Regulation will enter into force by July 16, 2022.

Potential risk/P-phrases according to the Regulation 1272/2008 EC :

P102: Keep out of reach children

P264 Wash hands thoroughly after handling

P270 Do not eat, drink or smoke when using the product

P280 Wear protective gloves/eye protection/face protection

P501 Dispose of containers as wastes: handle as municipal waste

P302+P352: if on skin: wash with plenty of water

P305+P351+P338 if in eyes: rise cautiously with water for several minutes.

Re-entry time: 0 day

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No special regulation for transport of risk material.
Self ignition: very high risk, especially at freshly produced biochar cases.
Dust explosion risk: very high risk.

Legal framework for using

Specific national legal conditions

The biochar product shall have been registered pursuant to Regulation (EC) No 1907/2006
EU Fertilising Products Regulation (EU 2019/1009) Annex I. CMC 14 Pyrolysis and Gasification material (under development) will set the legal condition for:

- input material allowed to be used
- thermochemical process conditions
- Product characteristics
    - max. 6 mg/kg dry matter of PAH16 (notice: in some EU MS 1 mg/kg PAH19 limit applied since 2005, especially in NATURA 2000 areas)
    - max. 20 ng WHO toxicity equivalents of PCDD/F/kg dry matter
    - max. 0,8 mg/kg dry matter of PCB
    - max. 30 g/kg chlorine on a dry matter basis,
    - max. 2 mg/kg dry matter of thallium
    - H/Corg less than 0,7
    - organic carbon content: less than 50%.

The biochar products should fulfil the quality and safety requirements set up in the given Product Function Category of the EU Fertilising Products Regulation (EU 2019/1009). Biochar products above 1 t/y may only be applied when all mandatory EU/MS Authority and EU REACH permits are available for manufacturing, import, placing on the market application and use, and the product labelling is available according to regulations.

Important for all types of biochar use:

- All in order to ensure the high functionality in shorter time of the biochar, the product is usually formulated, activated, blended and/or at least wetted before use.
- Legally purchased EU made biochar (that meet the regulation quality specifications) from EU/MS Authority permitted supplier with Extended Producer Responsibility certificate is high quality and always safe to use according to labelling instructions.
- As biochar use in soil is irrevocable action, User is having full responsibility before purchase and use of biochar, to make sure that the product is having the full set of mandatory Authority permits available documented, including the Extended Producer Responsibility certificate.
- Illegal biochar with above 1 t/y capacity and no mandatory EU/MS Authrity permits and EPR certificates, e.g. no proper documents of safety available, should not be used for agricultural purposes.

Economic evaluation of the application of the biochar products

The technical and cost efficiency for the use of plant based biochar for soil improver (most importantly for water and nutrient retention) is highly depending on the biochar quality and application conditions. The biochar quality is primarily determined by the quality of the engineering design performance of the pyrolysis technology to make biochar (that is a unique fingerprint in all cases) and the character of the input feed materials. Low end pyrolysis technology design always producing low end quality schlock biochar output products, while in the case the feed material is contaminated than that contamination might also be reflected in the output. Plant based biochar does not have fertilizer content with economical importance.

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Plant based biochar is highly suitable for soil improver, that is mainly based on the high dose effects with high water and nutrient retention capacity. The combination of biochar with compost or another organic fertilizer is most encouraging for agronomic performance.

Best management practice guideline

Taking into account of specific conditions of the given territory, for the use of the product to the specific applications (soil improvers, growing media, organic fertilisers etc.).

Guideline for biochar use according to the specific applications: Soil improver

Filed and cereal crops:

- Soil preparation by mechanical ploughing up to 20-30 cm depth. However tilling destroys large amounts of the fungal hyphae, therefore full tilling is not recommended.
- Spreading of biochar with fertilizer-spreader or by hand at 5-20t/ha according to crop uptakes and soil conditions. To be carried out in autumn or, if already activated, 3-5 days before sowing.
- Tilling with a mechanical cultivator and sowing.

Vegetable crops:

- Soil preparation by mechanical ploughing up to 20-30 cm depth. However tilling destroys large amounts of the fungal hyphae, therefore full tilling is not recommended.
- Spreading of biochar with fertilizer-spreader or by hand at 1-10t/ha, or on the row, at 1-5t/ha, according to crop uptakes and soil conditions. To be carried out in autumn or, if already activated, 3-5 days before sowing/transplanting.
- Tilling with a mechanical cultivator and sowing/transplanting

Fruit crops and grape:

- Soil preparation by mechanical ploughing up to 20-30 cm depth.
- Spreading of biochar with fertilizer-spreader or in the case of smaller plots by hand at 5-20t/ha in case of plant based biochar according to crop uptakes and soil conditions. Usually to be carried out in autumn.
- Tilling with a mechanical cultivator and sowing/transplanting.
- After planting: Spreading of biochar locally, on the row, at 5-20t/ha according to crop uptakes and soil conditions.

Guideline for biochar use according to the specific applications: Plant disease suppressions

Even though biochar does not have a microorganisms mix, there are lot of ways in which biochar may induce systemic plants resistances such as improve nutrient supply.

Greenhouse crops:

- Mix it to the growing media up to 20% v/v, at least 48 hours prior to sowing/transplanting.
- Do not steam sterilize it.
- It is better to use biochar that is microbiologically formulated with microbials.

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Filed crops:

- Soil preparation by mechanical ploughing up to 20-30 cm depth.
- Spreading of biochar with fertilizer-spreader or at smaller plots by hand at 5-20t/ha, or on the row according to crop uptakes and soil conditions.
- Tilling with a mechanical cultivator and sowing/transplanting.
- Do not disinfest the soil after the application.
- It is possible to integrate it with soil solarization, biofumigation, grafting and other agronomical practices.
- It is better to use biochar microbiologically formulated with microbials.

Guideline for biochar use according to the specific applications: Growing media

Vegetable crops:

- Analyse pH and E. C. of biochar.
- If E.C. is lower than 1000 µS/cm, it is possible to mix it to the growing media up to 20% v/v, at least 48 hours prior to sowing.
- If E.C. is higher than 1000 µS/cm, it is recommended to mix it to the growing media at maximum 10% v/v, at least 48 hours prior to sowing.

Ornamentals and flower crops:

- Analyse pH and E. C. of biochar.
- If E.C. is lower than 1000 µS/cm, it is possible to mix it to the growing media up to 20% v/v, at least 48 hours prior to sowing.
- If E.C. is higher than 1000 µS/cm, it is recommended to mix it to the growing media at maximum 10% v/v, at least 48 hours prior to sowing.
- If pH is higher than 7.5 and acidophilus plants are considered, it is recommended to mix it to the growing media at maximum 5% v/v.

Biochar and compost can be used separately combined or together to make synergistic effects. These are not competing products and usually made of different by-product streams as well. While input feed materials to make biochar are dry, the feed materials to compost usually of high moisture content. Biochar addon to composting may results shorter composting time, reduced rates of GHG emissions, reduced ammonia losses, and reduced odor. a.s.o. At the same to biochar will retain moisture and nutrients.

Compost integrated application positively influences soil structure, including reduction of bulk density; increase of aggregate stability; improvement of pore volume and hydraulic conductivity; improved water retention; improved air balance; reduction of soil erosion and run-off; stimulating microbial growth and respiration rates; improved heat balance of soils and increase of Cation Exchange Capacity.

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How to store, apply to land, machinery needs.

Storage requirements: dry, covered and well ventilated place, protected from direct sunlight, below 20 degree C, in the original closed packaging.

Crops: fresh vegetables and strawberries, permanent crops (fruit trees), grapes, rice, tobacco, medicinal herbs, aromatic plants and other higher added value cultovations.

Practical recommendations: In open field and greenhouse cultivation before sowing and before planting, working in the soil.

Time for distribution, distribution modes: before sowing

For more information:

- https://nutriman.net/farmer-platform/product/id_1571

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