


Reducing

the use of mineral fertilisers
and agro-chemicals by

recycling treated organic waste

as compost and bio-char

www.fertiplus.eu

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EDITORIAL

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PETER KUIKMAN
Fertiplus is coordinated by Dr. Peter Kuikman at ALTERRA at Wageningen University and Research Center.

THE JOINT ROLE OF BIOCHAR AND COMPOST IN A EUROPEAN FERTILIZER MARKET

Daniel Meyer-Kohlstock (Bauhaus-Universität Weimar) and Peter Kuikman (ALTERRA)

A potential replacement of synthetic fertilizers via compost and biochar depends strongly on two questions. 1) How much nutrients can they provide and 2) How much can they increase nutrient efficiency?

The answer to the first question can be found in Figure 1. Given that only one third of the bio-waste (Figure 2) and only one half of the waste water sludge is currently used as compost and bio solid, the replacement of synthetic fertilizers could be increased, but the potential altogether seems to be marginal. The same applies to biochar from woody bio-waste.

Much more nutrients are available in agricultural manure. However, since most of it is already applied in agriculture, it can hardly replace synthetic fertilizers, except for surplus manure from regions with dense livestock holding (see Figure 3).

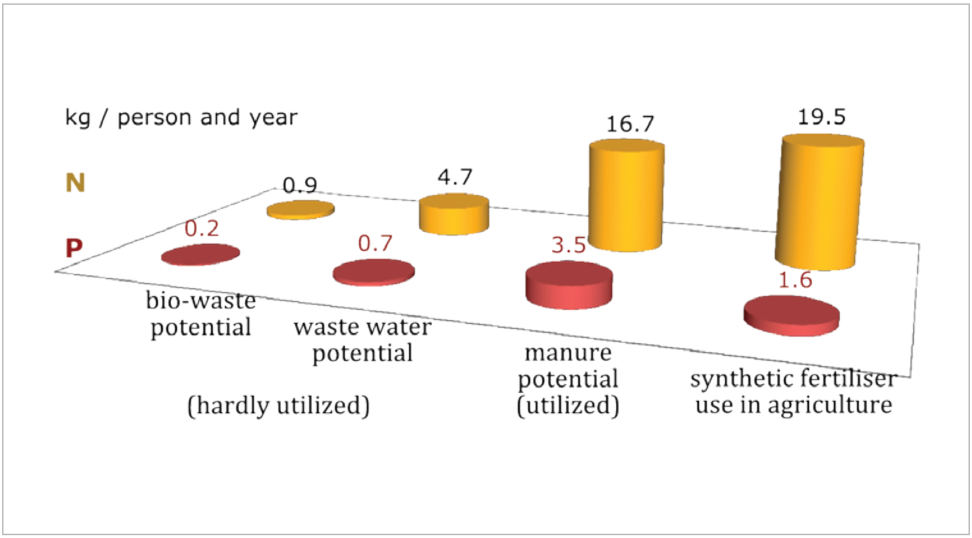

Figure 1. Nitrogen (N) and Phosphorus (P) potential and utilization per person and year in the EU

The answer to the second question is less precise, yet more important. While some research showed even greater agricultural yields than possible with synthetic fertilizers, it is difficult to analyze the complex relations between biochar, compost, and soil. However, they point to a possible role of biochar-compost substrates in the fertilizer market, i.e. to the reduction of applied nutrients by improving the nutrient efficiency, for organic as well as for synthetic fertilizers.

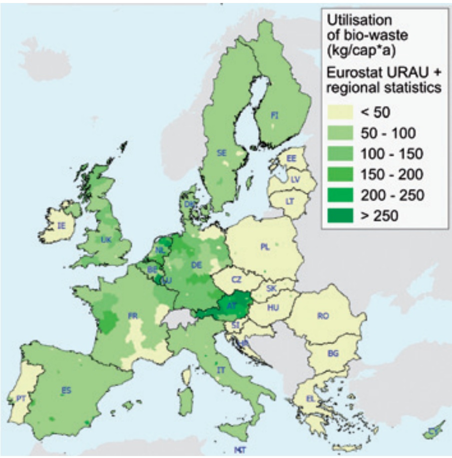

Figure 2. Bio-waste utilization in the European Union in kg per person and year

(source: doi:10.3390/resources4030457)

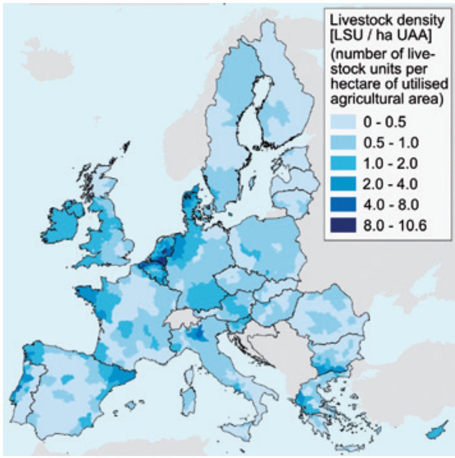

Figure 3. Livestock units (equivalent of a grazing adult dairy cow) per hectare agricultural land

(source: doi:10.3390/resources4030457)

BIOCHAR PRODUCTION AND ITS BENEFICIAL PROPERTIES FOR AGRICULTURAL USE

Andrew Ross (Univ. Leeds), Surjit Singh, (Univ. Leeds), Lydia Fryda (ECN) and Rian Visser (ECN)

The objective of this work has been to Explore feedstock, conversion technologies and modification towards functional biochar & hydrochar. The Hypothesis made is that 'No one size fits all biochar: There is a variation of soils and crops demand different types biochar' (Figure 4). Biochar characteristics are linked to (a) feedstock (b) process (c) modification (physical/ chemical activation) to improve adsorption capacity, Specific Surface Area, porosity Biochars vs. hydrochars show different physical and chemical properties; probably complementary reaction in.

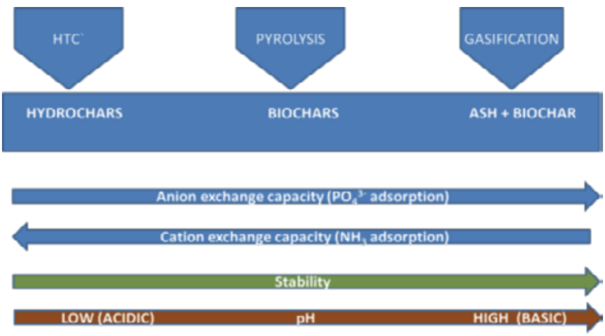

Figure 4. Biochar production routes, main properties and soil categories

(source: doi:10.3390/resources4030457)

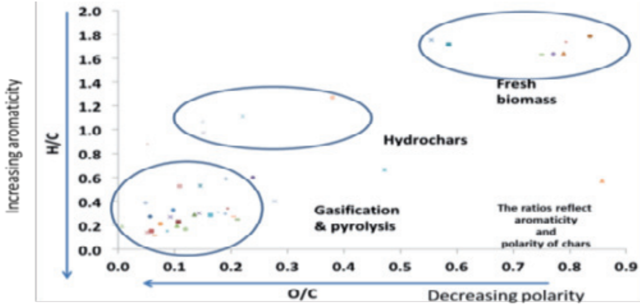

Figure 5. Van Krevelen diagram of the produced biochars

Biochar was produced at ECN , Univ. of Leeds and at the industrial partner Proininso, in an auger type slow pyrolyser at 400oC & 600oC (2) modified pilot fluidised bed gasifier, at 670oC & 750oC (continuous biochar production), (3) a hydrothermal carbonisation reactor, applying high pressure at 250 oC / 1 hr @ feed /water loading = 10 wt.% and a slow pyrolysis large scale unit. There is a clear distinction among the biochars produced in each reactor type, as shown in the Van Krevelen diagram in Figure 5. Figure 6 shows the measured PAHs according to EPA 16 PAH definition. Most biochars' are below the threshold proposed by IBI and EBC. The PAH content is mainly process related.

Furthermore the recalcitrance index, which is a measure of the lifetime of biochar in the soil, predicts that HTC hydrochars are less stable than pyrolysis biochars, as shown in Figure 7, as Class B chars ($0.50 \leq R50 < 0.70$, pyrolysis biochars) are more recalcitrant than Class C chars ($R50 < 0.50$, HTC biochars).

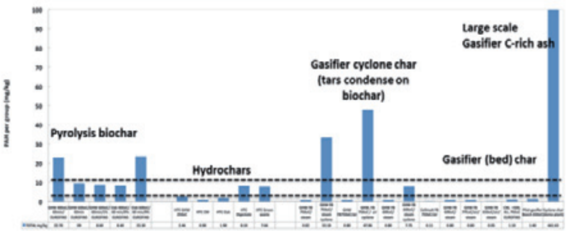

Figure 6. EPA 16 PAH concentration in biochar

Feedstock	HTC 250	Pyrolysis 400	Pyrolysis 600
Holm Oak	0.49	0.50	0.54
CellMatt	0.44	0.47	0.52
Presscake	0.41	0.48	0.50
Paprika waste	0.44	0.47	0.49
Green waste	0.40	0.49	0.49
Pig manure	0.44	0.49	0.49

Figure 7. Recalcitrance index of biochars

Finally, in the pyrolysis & gasification biochars an increase in macronutrients, micronutrients and heavy metals was noted, which is feedstock related while in the HTC chars the increase in some macronutrients (Ca, P) and micronutrients (Fe, Mn and Zn) is process related, the balances confirm elements in the effluent water.

WHAT DOES LIFE CYCLE ANALYSIS CONTRIBUTE TO THE ENVIRONMENTAL IMPACT OF USING BIOCHAR IN AGRICULTURE?

Nataša Sikirica (Alterra), Tom Oldfield (Renetech), Guadalupe López (Tecnova)

FertiPlus project applies Life Cycle Analysis (LCA) in order to achieve the goals of its Working Package 5 (WP5). LCA is a tool which serves to analyse the environmental aspects and potential impacts throughout a product's life-cycle. It allows a systematic comparison of environmental performance of products, from 'cradle to grave', i.e. from raw material until the end of life.

Below Figure 8 gives an example of life-cycle of biochar, modelled with "GaBi" model, an LCA model.

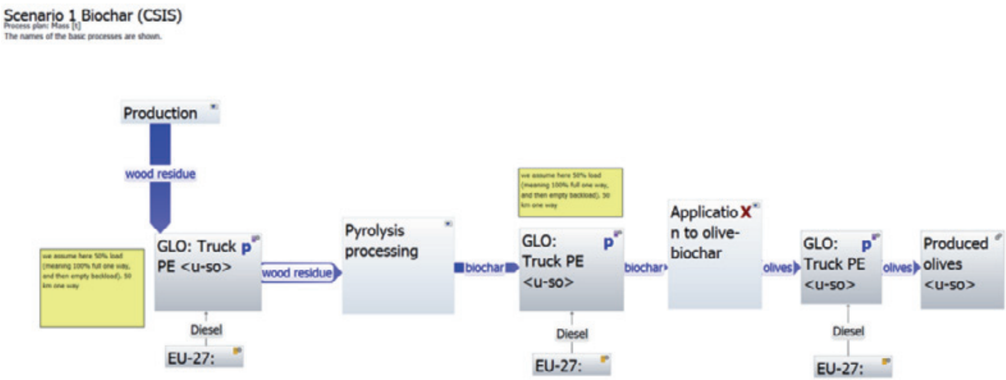

Figure 8. Life-cycle of biochar, modelled with "GaBi" model, an LCA model

The aims of the WP5 are: 1) to assess the environmental performance of recovering nutrients from various waste streams via the production of biochar and their subsequent application in agriculture; 2) to assess the environmental performance of producing and using compost and biochar-compost blend against biochar. The analysis is still ongoing; however, the results will answer questions such as: a) Does - and how - biochar addition to compost benefit the environment?; b) Is biochar better (looking at the environment) than compost?; c) Where are 'hotspots' in supply chain? With LCA a wide range of environmental impacts can be captured, for instance, global warming potential, eutrophication, acidification, etc. Below Figure 9 shows an example of environmental impacts of biochar, via only several chosen impact categories.

The Figure 9 serves here only as an example, thus, it does not present the results of the assessment.

Figure 9. Example of environmental impacts of biochar

As conclusion: LCA helps to establish (organic) waste treatment hierarchy; it helps understand environmental consequences of decisions farmers make; and it supports creation of science-based policies that focus on minimal environmental impact.

INTERACTION OF BIOCHAR AND COMPOST WITH PLANT HEALTH, YIELD AND SOIL QUALITY: BALANCING RISKS AND OPPORTUNITIES!

Bart Vandecasteele (ILVO), Jane Debode (ILVO), Tommy D'Hose (ILVO), Nicole Viaene (ILVO), Tania Sinicco (CRA), Claudio Mondini (CRA) and Miguel Ángel Sánchez-Monedero (CSIC)

Biochar can be applied as a pure soil amendment, but can also be processed with other biomass before being added to the soil. We tested the effect of adding biochar during or after composting or ensiling (Figure 10). This was tested for compost based on the organic fraction of municipal solid waste mixed with green waste, and for silages of vegetable crop residues and maize straw. We observed that biochar may alleviate suboptimal processes, both for silage and for composting.

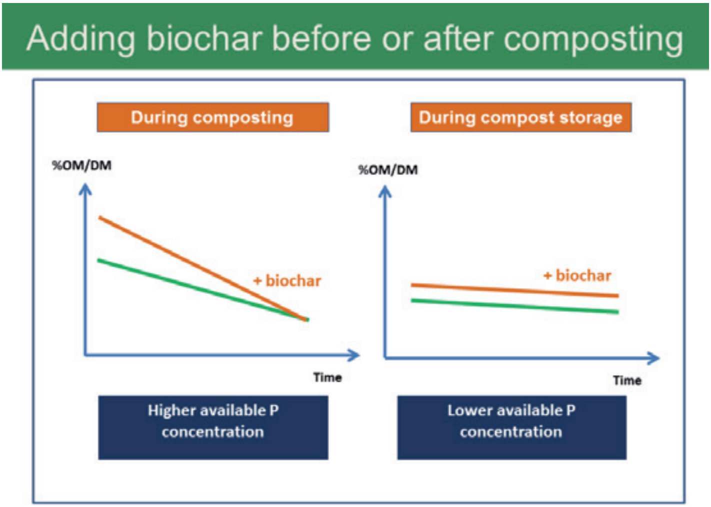

Figure 10. Adding biochar before or after composting

Besides assessing the effect on the process and on the product quality, these products were also tested as soil amendments in bioassays and field trials, allowing to study the effects on plant and soil quality as well. Bioassays with lettuce-basal rot, strawberry-gray mold and potato-cyst nematodes were executed to quantify the effects of biochar, compost and biochar-blended compost on different agronomical aspects related to plant and soil health.

The effect on disease suppression (Figure 11) dependes on the plant-pathogen-soil/substrate system tested and product-specific responses were associated with significant shifts in rhizosphere microbiology.

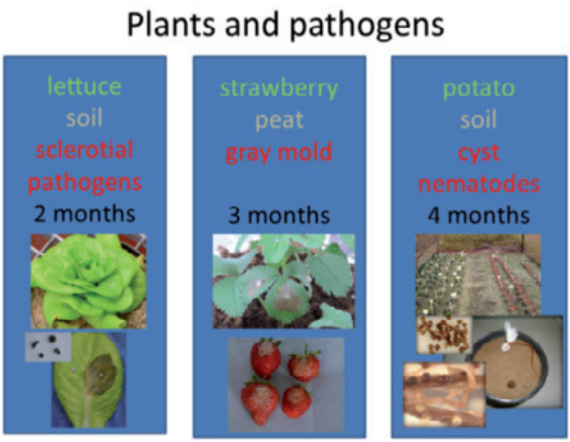

Figure 11. Plants and Pathogens

We assessed the effect of compost, biochar and their mixture on soil organic C content, chemical, physical and biological soil quality in field trials, and compared this with the effect of other soil and crop management practices. In the first field trial, the effect of biochar is compared with compost and biochar-blended compost at a single rate of 10.9 t C ha-1, in a crop rotation with cereals, leek and ryegrass. In a second field trial, the effect of a yearly compost dose at a rate of 2 t C ha-1 was assessed.

We tackled the question whether the effects on soil quality are generic or rather depending on climatic conditions, soil type, type of compost applied and crop rotation. Single application of biochar/compost in field soils with high nutrient status resulted in an increase of pH and C content, while the repeated application of compost also led to higher disease resistance and higher soil biodiversity without inducing higher nutrient losses.

SOIL PROPERTIES AND DESIRED AGRONOMICAL VALUE OF BIOCHAR IN COMBINATION WITH COMPOST APPLICATION

Guadalupe López (TECNOVA) and Carolina Martínez (TECNOVA)

Information about farmers requirement has been collected during FERTIPLUS project by making questionnaires and organizing a workshop (Figure 12) to introduce biochar properties and to solve their Questions and doubts.

Only few farmers were aware of biochar product and the characteristics and benefits that can get to the soil. They are receptive to the incorporation of new organic amendments to the soil, however, they demand specific information on nutritional composition, expected improve of fruit yield and quality. The price of the final product and the security of the product are the main concerns of farmers.

Figure 12. Fertiplus Farmers Workshop. Almería (Spain)

Some identified key points to help biochar acceptation by large farming system are:

- **Standardisation** of properties and characteristics to provide
- **Tailor made** biochars
- Fundings for **price reduction**
- **Compost: combinations** in final product or in the composting process

The agronomical results of field trials in FERTIPLUS project are not conclusive, and need further research on the long –term effects of its application in soil. Some conclusions are:

- **WHEN** soil presents a limiting factor (pH, nutrients deffiency, organic carbon, water holding capacity…) Biochar, compost or Biochar blended compost can help in alleviating limiting factors for crop yields and crop health.
- **NO** effects observed in Yields
- **NO** effects observed in nutritional status of plant
- **SOME POSITIVE** effects observed in fruit quality parameters (tomato)
- **SOME POSITIVE** effects observed in natural strength of plants and soils (tested on pot experiments in strawberry)
- **BIOCHAR** has a great potential to offset climate change

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