



Biochar

For a very productive & ecological agriculture mitigating global warming

Biochar (a form of ecological charcoal) has been called the “**Third Green Revolution**”. When used in fine granular form (less than 2 mm) and combined with organic fertilizers like camel or cow dung, it can be applied to different soil types across a variety of climatic conditions. The poorer the soils, the more the effect of biochar is spectacular.

Our experience under different climates has shown that a single application of approximately 10 tonnes per hectare can **increase crop productivity to levels that range from 50 to 200%**. Just one application provides and maintains long-lasting soil fertility benefits that enhance carbon sequestration in the soil, thus fighting climate change.

Today, biochar research shows measurable, replicable improvements in soil productivity:

- Enhances the soil biological activity (40% increase in mycorrhizal fungi)
- Improves nutrient retention in soils (50% increase in Cation Exchange Capacity)
- Improves the water retention capacity of soils (up to 18% increase)
- Increases the pH of acidic soils (1 point of pH increase)
- Increases soil organic matter



Adding biochar to the soil in the South of Algeria



Five weeks later – Biochar Super Vegetable Garden

Pro-Natura 1st Prize for technological innovation from the Altran Foundation

This innovation consists in recovering unused agricultural residues or other types of renewable biomass that cannot be used in another way, in order to carbonize them by continuous pyrolysis. For example, straws of wheat, rice, cotton stalks, millet, corn stalks, rice husks, coffee parches, bamboos, olive cake, dried palms, can be used to make biochar. The wood can also be charred in all its forms, including sawdust with a yield about 3 times higher than conventional carbonization processes.

This innovative technology, called CarboChar, is based on the use of a heated retort at 550°C through which the biomass flows in the absence of oxygen. The temperature of the retort is kept constant by the combustion of the pyrolysis gases which are recycled and burned in a



CarboChar-1

post combustion chamber, thus avoiding the emission of greenhouse gases (GHG). One of the originalities of the process is that once the machine is preheated, the process produces its own energy. Feeding the biomass, obtained by a small electric motor of low consumption, finally constitutes the only external energy demand of the system. This process is therefore virtually autonomous in terms of energy and its yield (weight of green coal produced relative to the weight of the biomass at 15% humidity) reaches 30% to 45% depending on the type of biomass. In addition to the benefits of the retort carbonization process, the operating cost of the reactor is reduced by continuous production.

This process also makes it possible to obtain optimum energy efficiency with regard to carbonization in a retort, thanks to the excellent control of the combustion of the pyrolysis gases ensuring the operating autonomy of the reactor and being able to co-generate renewable electricity.

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Biochar as a means to fight climate warming creating a large carbon sink

By growing plants absorb CO₂, producing biomass that contains carbon. Rather than allowing unused plants to decompose and emitting CO₂, pyrolysis converts about half of the carbon into a stable, inactive form. Photosynthesis absorbs CO₂ from the atmosphere, biochar stores carbon in a solid and beneficial form. Biochar also reduces emissions of other greenhouse gases, including methane and nitrous oxide. A recent study estimates that 12% of greenhouse gas emissions from human activity could be offset by the use of biochar, with 1 tonne of biochar being equivalent to 2.7 tonnes of CO₂.



The longevity of biochar in the soil can reach several thousand years, allowing them to be considered as carbon sinks (Woof D., Amonette J., Street-Perrot A. et al., Sustainable global biochar to mitigate climate change, Nature Communications, 2010).



In Belize, biochar-treated cacao tree on the left has started producing pod significantly earlier than the non-biochar treated tree on the right – both are three years old

Most biochar-related activity is linked to the International Biochar Initiative (IBI) based in the US: www.biochar-international.org

Summary of key scientific publications on biochar for main tropical crops

Type of crop	Authors	Location	Type of soils	Quantity of biochar (t/ha)	Yield increases (%)
Rice	Asai et al.	Houay-Khot, Nord du Laos	upland	8	70%
Rice	Steiner et al.	Manuas, Brésil	xanthic ferralsol / laterite	11	73%
Rice	Masulili et al.	Sungai Kakap, Indonesia	acid sulphate soil	10	93%
Rice	Zaitun et al.	Empretring, Indonesia	-	10	57%
Sugarcane	Chen et al.	Okinawa, Japan	shimajiri maji (clay)	7,2	78%
Tomato	Effah et al.	Kade, Ghana	forest ochrosol	7	177%
Cotton	Reddy	Midjil Mandal, Andhra Pradesh, India	alkaline	3,75	100%
Cabbage	Carter et al.	Siam Reap, Cambodia	sandy acidic	100	750%
Maize	Major et al.	Llanos Orientales, Colombia	savanna oxisol	8	71%
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Maize	Kimetu et al.	Vihiga, western Kenya	highly degraded ultisol	6	71%
Peanuts	Islami et al.	Malang, Indonesia	clay loam	15	54%
Cowpea	Tagoe et al.	Gifu, Japan	sandy loam	-	146%
Casava	Islami et al.	Malang, Indonesia	clay loam	15	32%
Onion	Pro-Natura	Senegal	-	10	50%

Summary of major scientific publications showing the effects of biochar on major temperate crops

Type of crop	Authors	Location	Type of soils	Quantity of biochar (t/ha)	Yield increases (%)
Rice	Lugato et al.	Northern Italy	aguic hapludalf	40	36%
Rice	Zhang et al.	Shenyang, China	sandy loam	30	40%
Maize	Uzoma et al.	Tottori, Japan	sandy soil	15	150%
Maize	Peng et al.	Yingtang, China	ultisol	2,4	64%
Soyabean	Tagoe et al.	Gifu, Japan	-	4	43%
Wheat	Van Zwieten	NSW, Australia	ferralsol	15	170%
Wheat	Vaccari et al.	Postoia, Italy	silty loam	30	33%
Canola	Pervej-Ahmed et al.	Saskatchewan, Canada	brown loam	1	20%
Barley	Gathorne-Hardy et al.	United Kingdom	light soil	20	43%
Choux	Jia et al.	Nanjing, China	fimi-orthic anthrosol	30	96%
Radish	Chan et al.	NSW, Australia	chromosol	10	42%
Sweet pepper	Graber et al.	Israel	commercial soilless mixture	8	79%
Citrus	Ishii et al.	Matsuyama, Japan	-	83	57%
Quinoa	Kamman et al.	Germany	sandy loam brown earth	100	44%

List of countries where Pro-Natura has a practical experience with biochar

Algeria: Biochar super vegetable gardens (SVGs) in Hassi Messaoud Region, the oil capital of Algeria (900 km South East of Algiers), and in Mostaganem.

Benin: Feasibility study for a co-generation biochar/green charcoal plant for renewable household energy.

Brazil/French Guyana:

- Agroforestry & biochar SVGs on both sides of the border.
- Small pyrolysis plant set up in Sao Paulo State for agroforestry development.
- Mini biochar SVGs grown on rooftops of the Mata Machado favela in Rio de Janeiro.

Burkina Faso: Biochar SVGs in the Central Plateau 150km East of Ouagadougou together with a larger development in train with a CarboChar-1 in Tanghin Dassouri.

Cameroon: Feasibility study in train to set up a CarboChar facility for biochar development, especially on coffee.

Chad: Biochar SVGs in the Batha Region 700km East of N'Djamena, 300km from Sudan border.

Egypt: Large scale development of biochar SVGs in the Suez Canal region.

France: Biochar SVGs at Bar-sur-Loup near Nice with the French Muslim Scouts.

Ghana: Pilot agroforestry and biochar SVGs in collaboration with the University of Ghana.

Haiti: Agroforestry and biochar SVGs training project for vetiver growers in Southern Haiti.

Agroforestry training, rural and urban biochar SVGs in Port au Prince & on the Central Plateau.

Ivory Coast: Pilot agroforestry and biochar SVGs project completed and a major biochar development planned with a CarboChar co-generation facility planned for rice, cacao, cashew and vegetables.

Turkmenistan: Biochar SVGs set up at Achgabat with a small pyrolysis unit.

Mauritania: Biochar SVGs in the Trarza Region at 164km South and South East of Nouakchott.

Mozambique: Biochar demonstration and training at Magaia, Cabo Delgado District.

Namibia: Feasibility study done for the development of biochar valorising renewable biomass from bush encroachment.

Nigeria: Pilot agroforestry and biochar SVGs project around the A.P. Leventis Ornithological Research Institute near Jos.

Rwanda: Biochar SVGs in collaboration with the cooperative of Tuzamurane in Cyeza.

Senegal: Over the past 20 years, Pro-Natura has tested different generations of its own pyrolysis technology in Ross Béthio in the Saint Louis Region, and over the past 12 years it has tested biochar on the main Senegalese crops with very good results in terms of yield and quality. It has also introduced biochar SVGs at Dagana, near the border with Mauritania.

Tanzania: Biochar SVGs, 700km West of Dar Es Salam, near the Mozambique border

New developments planned on the short term in: Kenya, Morocco and Oman.



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**Message to Pro-Natura about biochar and climate change from
Prof. Dominic Woolf of Cornell University (State of New York)**

"It is becoming increasingly clear that the world is not reducing greenhouse gas emissions fast enough nor deeply enough to avoid catastrophic climate change. The further we continue along this path, the more vital it will become to draw down excess carbon dioxide from the atmosphere to recover from an overshoot. Biochar-bioenergy systems provide an important tool to achieve this. Not least because of the promise of biochar to also improve food security in regions that are challenged by degraded soils.

In fact, when it is applied in the right places where soils can really benefit, the value of the biochar to agriculture can offset much of the cost of reducing atmospheric CO₂.

My recent research (www.nature.com/articles/ncomms13160) published on 21 October 2016 in Nature Communications shows that including it in a portfolio of options unlocks the ability to achieve earlier, deeper, and more cost-effective atmospheric CO₂ removal than would otherwise be possible. This may be a key component in allowing humanity to step away from our current path towards runaway climate change, and to transition to manageable levels of change.

The work being undertaken by Pro-Natura to push this exciting technology forwards, while benefiting smallholder farmers, is therefore an important effort, which will help to provide the experience and knowledge required to bring this technology to its full potential."



Pro-Natura International UK
29 Downside Crescent
London NW3 2AN

Email: guy.reinaud@pronatura.org
Mobile: +33 6 80 61 09 36

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www.pronatura.org