



**PRO-NATURA**  
INTERNATIONAL

Innovation towards Sustainable Development  
Member of IUCN, the International Union for Conservation of Nature

NEWSLETTER SEPTEMBER 2019

## BIOCHAR FOR A VERY PRODUCTIVE AND ECOLOGICAL AGRICULTURE MITIGATING CLIMATE 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)
- In terms of carbon sequestration, 1 tonne of biochar is equivalent to 2.7 tonnes of CO<sub>2</sub>
- 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 a Biochar Super Vegetable Garden*

### Pro-Natura has won 1<sup>er</sup> Prize for technological innovation from the Altran Foundation



*CarboChar-1*

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.

Each CarboChar-3 is producing around 5 tonnes of biochar per day.

## Innovation Towards Sustainable Development

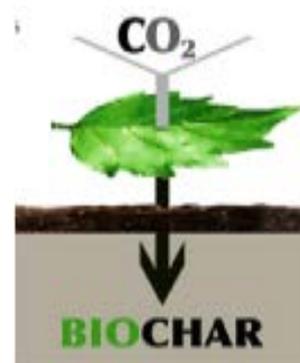
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This innovative technology is based on the use of a heated retort at 550 ° C through which the biomass flows in the absence of oxygen. The temperature of the retort is kept constant by the combustion of the pyrolysis gases which are recycled and burned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

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

By growing plants absorb CO<sub>2</sub>, producing biomass that contains carbon. Rather than allowing unused plants to decompose and emitting CO<sub>2</sub>, pyrolysis converts about half of the carbon into a stable, inactive form. Photosynthesis absorbs CO<sub>2</sub> 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 CO<sub>2</sub>.



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, Lehmann J, Joseph S, sustainable global biochar to mitigate climate change, Nature Communications 2010).



*In Belize biochar-treated cacao tree on the left has started producing pods 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 based in the US:  
[www.biochar-international.org](http://www.biochar-international.org)

### Summary of key scientific publications regarding biochar on the 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%
Maize	Major et al.	Llanos Orientales, Colombia	savanna oxisol	20	140%
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	aguiic 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 Zwietaan	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 in Hassi Messaoud Region *the oil capital of Algeria* - 900 km South East of Algiers and in Mostaganem.

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

**Brazil/French Guyana:** Agroforestry and biochar super vegetable gardens on both sides of the border between French Guyana and the State of Amapa in Brazil.

Small pyrolysis plant set up in the Sao Paulo State for agroforestry development.

Mini biochar super vegetable gardens grown on the rooftops of the Mata Machado favela in Rio de Janeiro.

**Burkina Faso:** Biochar super vegetable gardens in the Central Plateau 150 km 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 super vegetable gardens in the Batha Region 700 km East of N'Djamena, 300 km from Sudan boarder.

**Egypt:** Large scale development of biochar super vegetable gardens in the Suez Canal region.

**France:** Biochar super vegetable gardens at Bar-sur-Loup near Nice with the French Muslim Scouts.

**Ghana:** Pilot agroforestry and biochar super vegetable gardens in collaboration with the University of Ghana.

**Haiti:** Agroforestry and biochar super vegetable gardens training project for vetiver growers in Southern Haiti. Agroforestry training, rural and urban biochar super vegetable gardens in Port au Prince and on the Central Plateau.

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

**Turkmenistan:** Biochar super vegetable gardens set up at Achgabat with a small pyrolysis unit.

**Mauritania:** Biochar super vegetable gardens in the Region of Trarza at 164 km 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 super vegetable gardens project around the A.P. Leventis Ornithological Research Institute near Jos.

**Rwanda:** Biochar super vegetable gardens 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 super vegetable gardens at Dagana, near the border with Mauritania.

**Tanzania:** Biochar super vegetable gardens, 700 km West of Dar Es Salam, near the Mozambique border.

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

## **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 CO<sub>2</sub>.

My new research (<http://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 CO<sub>2</sub> 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.”