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

BIOCHAR
THE THIRD GREEN REVOLUTION

"The Green Revolution, often associated with the name Norman Borlaug, was instrumental in greatly increasing the agricultural output of the lucky minority of farmers throughout the world who had enough money to buy seeds, fertiliser, and access to water for irrigation. Hence the importance of the second wave 'Evergreen Revolution' pioneered in India by M. S. Swaminathan and directed at the needs of the masses of small farmers bypassed by the first wave of the Green Revolution.

With biochar we find ourselves now on the threshold of a third wave, even more universal in its applications than the second one, insofar as it will also allow the families of millions of urban and peri-urban dwellers to improve their daily food consumption by cultivating highly productive vegetable gardens on tiny plots of land." **Professor Ignacy Sachs**

Chairman of the Advisory Board of Pro-Natura International -
Honorary Professor of the School for Advanced Studies in the Social Sciences, Paris

"One of the most exciting new strategies for restoring carbon to depleted soils, and sequestering significant amounts of CO_2 for 1,000 years and more, is the use of biochar". **Al Gore**

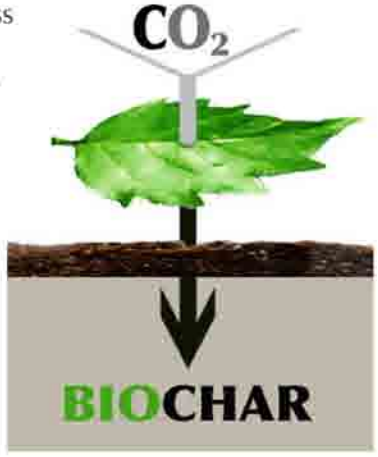
45th Vice President of the United States of America and 2007 Nobel Peace Prize Co-recipient.

THE PROBLEM WAS IN THE AIR AND WE BURIED IT

Biochar raises agricultural yields and reverses climate change

Throughout history indigenous peoples around the world have applied a simple, yet effective eco-technology to improve the quality of their soils and boost agricultural productivity. Now scientists are re-discovering the value of adding charred biomass (biochar) to soils. The process (pyrolysis) involves heating organic matter in the absence of oxygen, and the resulting carbon-rich product has been called biochar when it is intended for incorporation into soils.

In fine granular form (less than 2 mm), and combined with organic fertilisers, biochar can be applied to different soil types across a variety of environments. The long-lasting fertility of ancient biochar-amended soils, alongside a growing number of documented trials from many countries show that single applications of 5-20 tonnes per hectare can double crop productivity, and provide long-lasting soil fertility benefits [1].



The main scientifically approved reasons that biochar amendments have resulted in measurable improvements in soil productivity are that it:

- **Enhances soil biology (40% increase in mycorrhizal fungi) [2];**
- **Improves nutrient retention in soils (50% increase in Cation Exchange Capacity) [3];**
- **Improves the water retention capacity of soils (up to 18% increase) [4];**
- **Increases the pH of acidic soils (1 point pH increase) [5]; and,**
- **Increases soil organic matter [6].**

It is important to note, however, that the impact of biochar is likely to be much greater on disturbed, degraded or highly weathered soils than on those high in organic matter. Since biochar is particularly relevant for areas with severely depleted soils and water shortages, it could play a major role in improving soil quality and hence food security and human health in tropical agro-ecosystems including desert areas.

Research today is focused mainly on the mechanisms by which biochar effects soil properties, including the optimum conditions and models for biochar production and use.

Biochar as a practical strategy for mitigating runaway climate change

As plants grow, they draw down atmospheric carbon dioxide (CO_2) to produce biomass that contains carbon. Rather than allowing plant matter to decompose and emit CO_2, pyrolysis transforms around half of the carbon stored in plant tissue into a stable and inactive form of carbon. Thus whilst photosynthesis removes CO_2 from the atmosphere, biochar stores carbon in a solid and beneficial form. Since the production and use of biochar can remove more CO_2 from the atmosphere (by burying it in the form of a soil amendment) than is released, it is considered a carbon-negative technology. Biochar has also been shown to reduce emissions of other greenhouse gases from the soil, including methane and nitrous oxide (300 times more potent than CO_2). A recent study has estimated that 12% of current annual anthropogenic greenhouse gas emissions could be reduced through biochar [7].

1 Lehmann, J. and Joseph, S. (eds) (2009) Biochar for Environmental Management. Earthscan: London.

2 Warnock, D.D., Lehmann, J., Kuyper, T.W. & Rillig, M.C. (2007) Mycorrhizal responses to biochar in soil – concepts and mechanisms. Plant Soil (2007) 300:9–20

3 Glaser, B., Lehmann, J. and Zech, W. (2002) Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal - a review, Biology and Fertility of Soils 35, 219-230.

4 ibid

5 Lehmann J. and Rondon M. (2006) Bio-char soil management on highly weathered soils in the humid tropics. In Uphoff, N. (ed.) Biological Approaches to Sustainable Soil Systems. CRC Press, Boca Raton, FL, USA. pp. 517-530

6 See Note 1

7 Woolf, D., Amonette, J. E., Alayne Street-Perrott, F., Lehmann, J. and Joseph, S. (2010) Sustainable biochar to mitigate global climate change. Nature Communications, 1

WE SEE A BLACK FUTURE FOR NATURE
Pro-Natura's ecological production of biochar


The Pyro-6F

In 2002 Pro-Natura won the Altran Foundation's first prize for technological innovation with its pioneering pyrolysis unit, the Pyro-6F. That machine shows that it is possible to make a form of "green charcoal" from carefully selected and otherwise unused agricultural and/or forestry wastes in a highly ecological and efficient manner. Its cycle is:

a) Sustainable and continuous: once started, the unit can work 24 hours 7 days a week,

b) Virtuous and autonomous: after ignition, the unit generates heat only by burning the gases emitted during the biomass carbonisation, and

c) Polyvalent: all kinds of vegetal biomass can be turned into biochar. If necessary, a dryer and a crusher can be added in order to prepare the biomass for pyrolysis.

The temperature and time that the biomass stays in the machine are configurable to make the most suitable biochar out of every type of organic waste. Depending on the nature of the biomass input, the Pyro-6F can process up to 500 kg of biomass per hour, for an hourly production of 200 kg of biochar. The Pyro-6F units are now manufactured and sold by the company Green Charcoal International (www.green-charcoal.com). Another example of a biochar production technology is the "LuciaStove" developed by WorldStove Corporation (www.worldstove.com). This range of pyrolysis stoves enables households to cook using vegetal waste as a fuel and produces around 450 grams of biochar per hour. Biochar is being manufactured and is available commercially in several countries including the USA, UK, Germany, Australia and New Zealand. Furthermore, in Japan and the UK biochar made from organic feedstock has been certified for use as a soil amendment in organic agriculture.

RESPONSIBLE AND SUSTAINABLE DEVELOPMENT OF BIOCHAR

Besides the issue of its permanency in the soil, several concerns have been raised about biochar:

1. What should be the source of feedstock for biochar?

Sources of biomass selected for biochar production must be appropriate and able to withstand a comprehensive Life Cycle Analysis.

Sustainable biomass-feedstock availability

In order not to repeat the same mistakes caused by the global expansion of biofuels, only biomass resources that can be obtained sustainably, that is without endangering food security, biodiversity/habitat or soil conservation, should be used to produce biochar. This takes into account the importance of leaving some plant residues on the soil in order to provide organic matter and nutrients. According to such sustainability criteria, scientists have recently calculated that globally 4.54 billion tonnes biomass feedstock is available annually, of which 0.56 billion tonnes is rice husks and paddy rice straw not used for animal feed [8] . In addition to rice residues this biomass includes other cereal straw and stover, waste bagasse, peanut and coconut shells, cocoa husks, bamboo and typha reeds, sugarcane field trash, manures, biomass crops, forestry residues, agroforestry, green/wood waste.

Pro-Natura's biochar is produced exclusively from renewable and readily available waste biomass such as agricultural or forestry residues, invasive species, etc. not used for animal feed or to enrich the soil. Currently large amounts of agricultural, municipal and forestry waste are burnt or left to decompose in fields after harvesting, which releases greenhouse gases into the atmosphere. By using this biomass as feedstock for biochar production, Pro-Natura therefore contributes to climate change mitigation. Furthermore, the use of tree prunings from agroforestry systems, or food processing residues such as nut shells and fruit pits successfully incorporates biochar production into food production systems, again leading to a win-win solution for those using biochar and their environment.

8 Based on figures from Woolf et al. (2010) (see note 7), and the assumption that dry biomass is 50% carbon by weight.

2. How safe is biochar?

The fact that some cultures have incorporated charcoal into their soils for millennia provides reassurance as to its safety, although it is advisable to assess environmental and health impacts on a case-by-case basis [9]. Pro-Natura observes some simple biochar production and handling procedures which significantly reduce any potential risks. These include careful control over the type of feedstock used and relatively low pyrolysis temperatures (<550°C). This helps to avoid the occurrence of compounds in biochar that could have etrimental effects on the soil such as heavy metals, dioxins and polycyclic aromatic hydrocarbons. In addition, those handling biochar are advised to wear gloves and a mask to prevent inhalation of biochar dust, since small particles of any substance can be harmful. Properly incorporating biochar into the soil also helps to reduce dust-related problems.

3. What are the effects of biochar on the soil and crop production?

Different pyrolysis conditions and feedstock characteristics result in different biochars, and as a result not all biochars are suitable for a given application. Simple chemical and biological tests can be used to screen biochar that might be toxic to soil micro-fauna and/or inhibit plant germination and growth. It is also necessary to carry out field trials in order to determine the effect of a certain type of biochar on specific soils and crops. The risks involved in the production and use of biochar can therefore be managed, and are considered worth taking in light of its proven benefits.

WORLDWIDE DEVELOPMENT OF BIOCHAR

Pro-Natura has been pioneering the development of biochar with smallholder farmers in developing countries, in close collaboration with the world's leading scientists working on biochar.

Our main interest in biochar stems from its ability to increase retention of water and nutrients in highly-weathered tropical soils. As single applications can provide benefits over many years, biochar has potential for increasing the self-reliance and resilience of small-scale subsistence producers. It would therefore be most useful for improving nutritional status when integrated into family farming systems such as kitchen gardens (e.g. the Biochar Super Garden), and approaches such as organic agriculture, agroforestry and permaculture.

Pro-Natura has developed protocols and a field manual for biochar trials that are being used in ongoing trials and demonstrations in Senegal, Mali and Egypt and has plans to extend activities to Ghana. In Latin America, Pro-Natura is poised to launch biochar production centres, farmer trials and demonstrations. In Haiti, Pro-Natura has started a project to increase vegetable production with Biochar Super Gardens integrated into agroforestry systems. This project is being implemented in partnership with the Papaye Peasant Movement [10] and JTS Semences [11], with financial support from the French embassy in Haiti.
Pro-Natura is also publishing a training manual - "Introduction to Biochar in Tropical Agriculture".

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9. Sohi, S., Lopez-Capel, E., Krull, E. and Bol, R. (2009) Biochar's roles in soil and climate Change: A review of research needs. CSIRO Land and Water Science Report 05/09, 64 pp. / 10. Mouvman Peyizan Papay: http://www.mpphalti.org/ / 11. http://www.jtssemences.com/