Research Note: Coconut biochar

Biochar is a form of charcoal attracting worldwide interest for its potential to improve soil health, crop productivity and sequester carbon over the long term. However, questions remain about its use in agriculture due to variability of the final product, limited scientific research to-date and a lack of commercial adoption. Biochar is made by heating a biomass in an oxygen-limited environment. This can be done in simple ground pits or in sophisticated pyrolysis kilns. The properties of the end-product depend on the type of biomass feedstock used and the conditions, such as temperature and residence time used during the biochar's production. One of the objectives of the ACIAR-funded CocoVeneer project is to determine if a locally-useful biochar could be produced using residues from harvested coconut palm logs as an end-product feedstock. For this, core material from Fijian coconut stems was recovered and converted into biochar under three temperature regimes. Analysis of the biochar showed significant levels of available potassium and phosphorous, and a relatively high pH under all regimes. The observed cation exchange indicated good nutrient retention properties, although sodium chloride levels were also high. Production temperature of the biochar showed some differences regarding the availability of macronutrients and liming values of the three biochars. Subsequent Research Notes will report results of field and pot trials with the produced biochar.

Introduction

This research note outlines the results of analyses conducted as part of an ACIAR-funded project for research and extension activities developing means to sustainably convert senile coconut stems into veneer and veneer- based products, and complementary agricultural products for export and for use in Pacific Island economies.

The project supports economic development in Fiji, Samoa and the Solomon Islands.

Senile coconut palms are potentially a valuable resource for veneer production in Fiji, Samoa and the Solomon Islands. However, harvesting and processing produces residue material and, due to the soft properties of the palm's inner cortex, only part of any processed stem may be suitable for veneer production.

Biochars are carbon-rich materials produced by heating a biomass in an environment with no or very low levels of oxygen. The product can then be added as a soil-conditioning treatment to sequester carbon and potentially maintain or improve soil functions. The analyses conducted in this study investigated the potential for using these residues for biochar production.

Figure 1*: Biochar may be in the form of dust, chips or chunks, depending on the feedstock.*

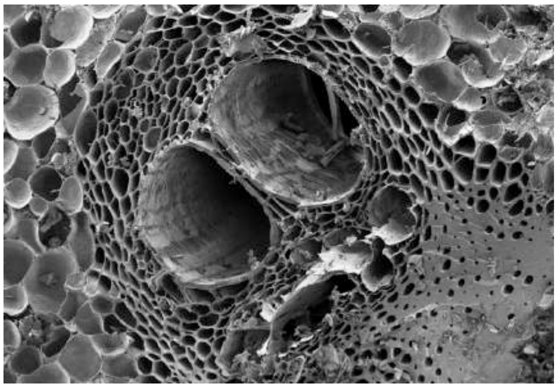

Figure 2*: Scanning Electron Microscopy (SEM-EDS) illustrating high porosity of coconut stem biochar*

Method

Residue cores of harvested logs were collected from a Fijian coconut wood milling facility and chipped, dried and fumigated in Fiji before being shipped to Brisbane, Australia in mid-2014. Chaotech Pty Ltd then processed the residue woodchip into biochar.

The material was heated with limited oxygen (pyrolysis) in a stationary kiln under three different temperature regimes (350°C, 500°C, and 750°C) to test the effect of temperature on the product's chemical and physical properties.

The resulting biochar was then sealed in steel drums and shipped to Tasmania, Australia for chemical analysis by AgVita Analytical, and scanning electron microscopy (SEM-EDS) at the University of Tasmania's Central Science Laboratory.

Results

Chemical analysis of the biochar showed elevated levels of available phosphorous and potassium (Colwell P and K in Table 1). The samples exhibited high pH levels indicating strong liming capabilities. Sodium chloride level was also high. Cation-exchange-capacity (CECe in Table 1) was favourably high.

The different biochar processing temperatures generated some differences regarding the availability of macronutrients and liming values. A high product porosity was consistent at all three temperatures. See Figure 2.

Table 1: Chemical analysis of the coconut Biochar product at three different production temperatures. Analysis and report by the AgVita Analytical, Tasmania. Australia.

		350 C		500 C		750 C	
Analyte	**Units**	**Result**	**Status**	**Result**	**Status**	**Result**	**Status**
pH ($CaCl_2$)	-	8.49	very high	9.02	very high	10.61	very high
EC	dS/m	2.01	moderate	2.24	moderate	3.96	high
Organic Carbon	%	9.38	high	8.48	high	6.5	high
Sodium (NH_4Cl)	meq/100g	47.83	very high	68.24	very high	130.8	very high
Aluminium (KCl)	meq/100g	0.01	very low	0.01	very low	0	very low
Colwell P	ppm	181	very high	277	very high	242	very high
Colwell K	ppm	1296.86	very high	1388.19	very high	2095.81	very high
Boron (hot water)	ppm	0.43	low	0.42	low	0.45	low
Copper (DTPA)	ppm	0.07	low	0.05	low	0.09	low
Iron (DTPA)	ppm	0.78	low	0.5	low	1.55	low
Zinc (DTPA)	ppm	0.18	low	0.31	low	2.01	very high
CECe	meq/100g	51.6	very high	76.08	very high	142.01	very high
Calcium (% CEC)	%	3.55	very low	6.62	very low	3.94	very low
Magnesium (% CEC)	%	1.4	very low	0.95	very low	0.88	very low
Potassium (% CEC)	%	2.35	low	2.74	low	3.07	low
Sodium (% CEC)	%	92.7		89.7		92.1	
Total Carbon	%	69.24		80.06		85.92	
Total Nitrogen	%	0.53		0.49		0.66	

Conclusion and next steps

Elevated levels of the biochar's phosphorous and potassium could result in release of these elements to the growing medium, consequently increasing their availability for plants. High cation exchange capacity indicated a strong ability of biochar to retain essential nutrients and improve overall soil quality. The elevated sodium chloride level can be considered unfavourable and could possibly antagonise the release of other elements. It is worth noting that a biochar's effect on soil nutrient status depends on both the soil type and the biochar's properties. A high-product porosity is considered very beneficial in promoting microorganisms-dependent soil processes.

The produced biochar was used in a field trial on Taveuni in Fiji and is being used in standard pot trails. The results of these trials will be reported in subsequent Research Notes.

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This research note is part of the ACIAR-funded CocoVeneer project FST/2009/062: Development of advanced veneer and other product from coconut wood to enhance livelihoods in South Pacific communities.

The project team includes researchers and collaborators from the University of Tasmania, the Queensland Department of Agriculture, and Fisheries (DAFF), the Secretariat of the Pacific Community (SPC), the Fiji Department of Forests; Forest Research and Development Section, Forestry Division, Ministry of Natural Resources and Environment, Samoa; Ministry of Forestry, the Solomon Islands, and industry in Australia and Pacific Islands. The project supports economic development in Fiji, Samoa and the Solomon Islands and includes activity in market and value-chain assessment, log harvesting, veneer production and product manufacture, and the development of viable uses for coconut residues at the harvest site or the production facility. More information about the project is available at www.cocowood.net.

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SPC Secretariat of the Pacific Community