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# Biochar from waste banana peels as growth promoter for holy basil (*Ocimum tenuiflorum*) and chili pepper (*Capsicum annuum*)

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## ABSTRACT

Biochars are porous materials prepared by combustion of biomass under the presence of low oxygen levels. Its application as soil fertilizer has been shown to have positive effects on the plants by increasing the fertility and raising the soil pH, increasing nutrient cycling and moisture holding capacity, improving cation exchange capacity, and reducing the amount of pesticides and nutrients leaching to the surface and ground water [1, 2]. In this study, waste banana peels from Lakatan (*Musa x paradisiaca)* were pyrolized at temperatures 300, 400, 500 and 700 °C, the resulting basic char were obtained at 4-9% yield. The chars were characterized and evaluated as growth promoter for holy basil (*Ocimum tenuiflorum*) and chili pepper (*Capsicum annuum*). The results show that the ability of the char to promote growth were beneficial when the pyrolysis temperature is lower (300 - 500 °C) for both plants. Conversely, the soil containing 1 wt% of char was found to be beneficial to the growth of chili compared to the control.

***Keywords***: biochar, banana peel char, growth promoter

## 1 INTRODUCTION

Banana is a fruit commonly found in tropical places like the Philippines. It is is known to be rich in nutrients, especially in potassium. The peels consisted of ~30% of the fruit, and waste are obtained when the fruits are consumed. Hence, we are interested to convert these banana peels from Lakatan (*Musa x paradisiaca)* into a more vaulable material by investigating how charred peels can be effectively utilized for soil amendment and growth promotion of holy basil (*Ocimum tenuiflorum*) and chili pepper (*Capsicum annuum*).

## 2 SYNTHESIS OF BIOCHAR

Fresh Lakatan banana peels were fitted into a ceramic crucible and charged into a furnace. The heating program was set to reach the final pyrolysis temperatures of 300, 400, 500, and 700 °C, and held at constant temperature until the char formed. The char from the different pyrolysis conditions were obtained at 8.0 (total pyrolysis time=4 hours), 9.1 (3 hours), 5.2 (3 hours), and 4.4% yield (2 hours), respectively.

### 2.1 Physical properties of the char

A higher temperature of pyrolysis provided lesser char. These losses involved moisture and volatile matters found in the banana, along with some gasified carbon. The banana peel is composed of fibers, carbohydrates, proteins, and crude lipids which can easily decompose under elevated temperatures during pyrolysis [3]. The drop in the thermograms at 150 °C is attributed to the loss of water from the char, whereas the drop at 650°C is attributed to the gasification and further decomposition of the rest of the materials in the samples. The downward slope observed from the char samples pyrolized at 300 °C and 400 °C is indicative of the degredation of the cellulose and hemicellulose in these samples. The sharp drop at 450 °C is attributed to the degredation of the lignin found in the fruit peels observed with chars pyrolized at higher temperatures, 500 and 700 °C.

The surface morphology of the char appeared to be porous. Whereby the pore diameter was measured to be 5-13 µm for char pyrolized at 300°C, having the smallest pores; 13-47 µm for 400 °C, and 12-23 µm for 500 °C (Figure 1). For the char pyrolized at 700 °C, no pores were observed under these magnifications. Since the pyrolysis process involves the formation of aromatic compounds, it is expected that organic structures present will rearrange and polymerize, fusing together to form layers of graphitic sheets. These would appear more like a single solid material, especially under higher pyrolysis temperatures of 500 °C and 700 °C.

The pH of the char when suspended in water were found to be basic. The tests were carried out by suspending one gram of char in 50 mL of deionized water and stirred for 24 hours. After subjecting to filtration, the pH of the filtrate was tested, a pH = 8.0 for the char pyrolyzed at 300 °C, 9.2 for 400 °C, 11.2 for 500°C and 11.3 for 700 °C were obtained. It is important to note that the char pyrolized at 700 °C gave a clear solution immediately after filtration. Whereas the chars pyrolized at lower temperatures gave brown solutions, even after subjecting to multiple filtration attempts.

Boehm titration allowed the identification of acidic functional groups found on the surface of the char, where bicarbonate would react with the carboxylic acid moieties, carbonate would react to the carboxylic acids and lactols, and the hydroxide would react to all the carboxylic acids, lactols and phenols (equations 1-3). However, negative values were obtained for the tests with the chars suspended in bicarbonate and carbonate solutions. The results suggest the absence of carboxylic acids and lactols, and the presence of phenols in the char samples (Table 1).

Infrared spectra of the samples obtained using KBr supported the results from the Boehm titration, where the absence of peak at 1700 $cm^{-1}$ would suggest that no carbonyl-containing moieties (carboxylic acid or lactol) in the char (Figure 2). An overlap of the amino and hydroxyl stretching vibrations is observed along 3400 $cm^{-1}$. Whereas, C=C stretching vibrations are found along 1400 to 1600 $cm^{-1}$, indicating the presence of aromatic and alkene moieties.

## 2.2 Incorporation of biochar for soil amendment applications

Seven different pots containing 800 grams each of different soil mixtures were prepared with 3% char content (except noted): control (no char), 300 for 300 °C, 400 for 400 °C, and 500A (with 1% char) for 500 °C, 500B (with 3% char), 500C (with 5% char), 700 for 700 °C. There are four plots in each of the pots, two plots with 10 cm tall basil cutting and two plots with three chili pepper seeds each. The growth of the plant was then monitored by measuring the height of the visible part of the plant from the ground up to the tip of the stalk weekly.

The basil plants started to look healthy after two weeks of planting. However, the growth of the plants in most pots are not much better than the control, with exception of 500A which is higher than the control (Figure 3A). The plants in pots labeled 700 and 500C did not survive. Whereas, only one plant survived for 300, 500A, and 500B.

Chili growth for the pots labeled 300, 400 and 500B were higher than the control. Chilli plants in 700 had the lowest average height, even shorter than the control group (Figure 3B).

Although the char pyrolized at 700 °C and 500 °C have similar pH at 11.3 and 11.2, respectively. The soil in 700 and 500 have different effects on the plants, as the former was detrimental to the growth of the chili, the latter improved the growth.

Varying the amount of char added, the standard 3 wt % in 500B provided taller chilli plant compared to the control group (Figure 3C). However, increasing in the amount of char at 5 wt% in 500C, the growth diminished significantly. This is similar to the observation by Hilber with biochars obtained from polycyclic aromatic hydrocarbons [4]. In contrast, reducing the amount of char with 1 wt% in 500A, dramatically increased the height of the chili plant.

# 3 EQUATIONS

$$[\text{carboxylic acids}] = [HCO_3^- \text{ reacted}] \quad (1)$$

$$[\text{lactols}] = [CO_3^{2-} \text{ reacted}] - [HCO_3^- \text{ reacted}] \quad (2)$$

$$[\text{phenols}] = [OH^- \text{ reacted}] - [CO_3^{2-} \text{ reacted}] \quad (3)$$

# 4 TABLES AND ILLUSTRATIONS

Table 1. Acid functional groups in Char

| Pyrolysis Temperature (°C) | Carboxylic acids (mol/g) | Lactols (mol/g) | Phenols (mol/g) |
|---|---|---|---|
| 300 | -0.026 | 0.019 | 0.009 |
| 400 | -0.012 | 0.008 | 0.005 |
| 500 | -0.016 | -0.010 | 0.024 |
| 700 | -0.028 | -0.013 | 0.039 |

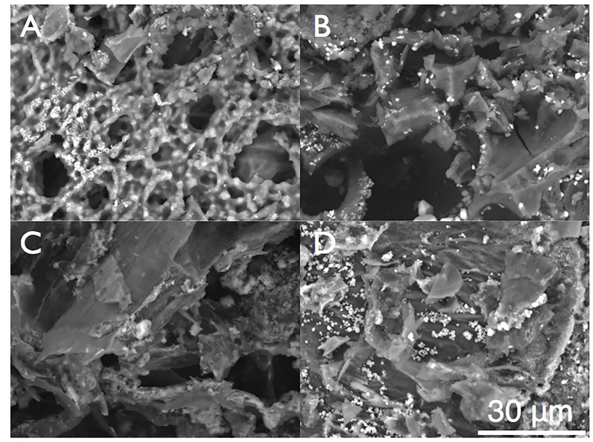


Figure 1. SEM images of Lakatan banana peel char pyrolized at 300 °C (A), 400 °C (B), 500 °C (C), and 700 °C (D) at 2000x magnification.

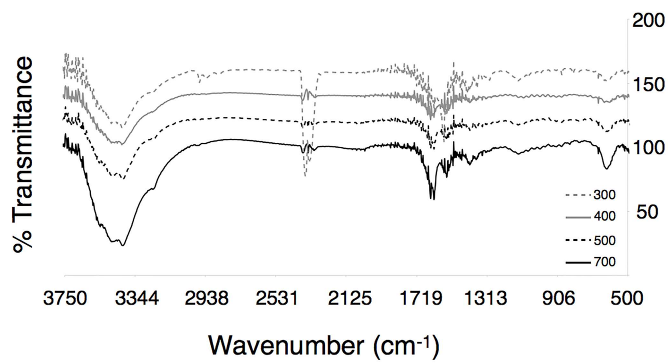


Figure 2. IR spectra of banana peel char pyrolized at 300 °C, 400 °C, 500 °C and 700 °C; run in KBr pellet.

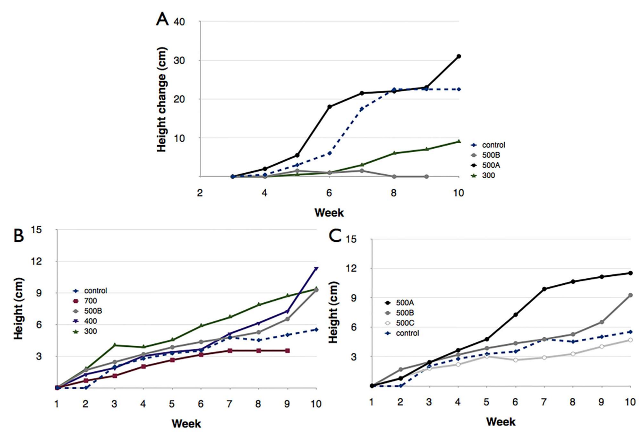


Figure 3. (A) Height increase of Holy Basil plant using 3 wt% of char prepared at different pyrolysis temperature. Measurements were done using height change, height of the taller plant minus the original stem planted. (B) Height of Chili pepper plant using 3 wt% of char prepared at different pyrolysis temperature. (C) Height of Chili pepper plant using various amounts of char, 1 (500A), 3 (500B), 5 (500C) wt% prepared at 500 °C pyrolysis conditions.

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