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# The Use of Bamboo Biochar as a Soil Improver on the Growth and Yield of Mustard Plants

**Yohanes Parlindungan Situmeang**

Agriculture Faculty, Warmadewa University, Denpasar, Bali, Indonesia
*Corresponding author: ypsitumeang63@gmail.com

**Abstract**
*This study aims to obtain the right dose of biochar in mustard plants. The design used was a completely randomized design with a one-factor pattern. The biochar treatment was studied at four dose levels and one control. The application of biochar significantly affected plant height, total fresh weight, and total dry weight, except for the number of leaves which was not significant. The highest total dry weight yield was achieved at 9 t ha-1 biochar with a weight of 10.80 g or an increase of 60% compared to 6.75 g without biochar. From the regression analysis, the effect of biochar on total dry weight was found on the quadratic regression line with the equation: $\hat{Y} = 6.717 + 0.8217\ X - 0.04381\ X^2$ ($R^2$ = 91.80%), biochar with an optimal dose of 9.38 t ha $^{-1}$ and a maximum total dry weight of 10.70 g.*

***Keywords:*** *Charcoal; bamboo biochar; mustard greens*

## 1. Introduction

Mustard plant (*Brassica juncea* L.) is one of the vegetable plants that is widely known by the public because it is very easy to cultivate, both in the highlands and in the lowlands [1]. In general, the production of mustard plants is strongly influenced by the type and dose of fertilizer used, both inorganic and organic fertilizers. Currently, there are still many farmers who use inorganic fertilizers for the cultivation of mustard plants. Inorganic fertilizers can indeed increase yields quickly, but if you use this fertilizer frequently, the soil will become dense and can no longer absorb nutrients and water. Soil that is often fed with inorganic fertilizers will eventually turn sour and liming is required to improve it, thus requiring additional costs. Efforts to avoid this require the use of organic fertilizers such as biochar soil enhancer which is rich in carbon and is very beneficial for plant growth and development. Commonly used soil amendments are lime, organic matter, natural phosphate material, zeolite, and biochar. One of the soil enhancers that can be used to increase soil fertility is biochar. Biochar is biological charcoal resulting from incomplete combustion which leaves nutrients that can fertilize the soil.

Biochar has the characteristics of being able to supply carbon because of its large surface, large volume, micropores, density content, macro pores, and high water holding capacity. Biochar can also reduce $CO_2$ emissions from the atmosphere by binding it to the soil [2]. Biochar is generally made from various agricultural biomass which is produced through an incomplete combustion process to become charcoal. Biochar application on dry land that is poor in nutrients can increase soil fertility and agricultural land quality [3, 4]. In the long term, biochar can maintain a carbon-nitrogen balance, making more nutrients and water available in the soil.

Various studies of biochar as a soil enhancer have provided benefits for improving soil fertility and improving crop yields. The application of biochar at a dose of 10 t ha$^{-1}$ gave the best growth response for maize [5]. The biochar treatment of 5-15 t ha$^{-1}$ had no significant effect on the yield of pakchoy [6], but the biochar dose treatment of 6-9 t ha$^{-1}$ had a significant effect on water spinach [7] and Amaranth [8]. The application of biochar to agricultural crops must pay attention to the right amount or dose. The purpose of this study was to determine the appropriate dose of bamboo biochar in increasing the growth and yield of mustard greens.

## 2. Materials and Methods

This experiment was conducted at the Greenhouse, Faculty of Agriculture, Warmadewa University, Bali. The research took place from July to August 2018. The materials used in this study were mustard plants, bamboo biochar, and polybags filled with soil.

This study is a one-factor experiment using a completely randomized design (CRD). The treatments were tested for biochar with 4 dose levels: B0 = 0 t $ha^{-1}$ (without biochar), B1 = 3 t $ha^{-1}$ (4.2 g $pot^{-1}$), B2 = 6 t $ha^{-1}$ (8.4 g $pot^{-1}$), B3 = 9 t $ha^{-1}$ (12.6 g $pot^{-1}$), B4 = 12 t $ha^{-1}$ (16.8 g $pot^{-1}$). The treatment was repeated three times to obtain 15 experimental units (15 polybags).

The variables observed included plant length, number of leaves, fresh weight of economic yield, and oven-dry weight of economic yield. Data from the study were analyzed statistically using the F test (ANOVA) and Duncan's Multiple Distance Test (DMRT) [9].

## 3. Results and Discussion

### 3.1. Results

The treatment of several levels of biochar dose had a significant effect ($P<0.05$) on mustard plant height, total fresh weight, and total dry weight of mustard greens, except that the number of leaves had no significant effect ($P\geq0.05$) (Table 1).

**Table 1.** Significance of the effect of bamboo biochar dose on all observed variables

| Variable | Dosage of Bamboo Biochar |
|---|---|
| 1. Plant high (cm) | * |
| 2. Number of leaves (strands) | ns |
| 3. Total fresh weight (g) | * |
| 4. Total dry weight (g) | * |

ns = not significant ($P\geq0.05$), * = real effect ($P <0.05$)

**Height of plants and number of leaves**

The maximum plant height was reached at 9 t $ha^{-1}$ biochar, which was not significantly different from the application of biochar 3, 6, and 12 t $ha^{-1}$, but differed real from those without biochar (Table 2). The highest average number of leaves was obtained at the 9 t $ha^{-1}$ biochar dose of 9.00 strands, while the lowest value was obtained without biochar as many as 6.50 strands.

**Table 2.** Effect of biochar application on plant height and number of leaves

| Biochar dosage ( t $ha^{-1}$) | Height of plants (cm) | Number of leaves (strands) |
|---|---|---|
| 0 | 17.68 b | 6.50 a |
| 3 | 19.93 ab | 7.00 a |
| 6 | 21.98 ab | 8.00 a |
| 9 | 24.00 a | 9.00 a |
| 12 | 22.25 ab | 8.25 a |
| Coefficient of Diversity (%) | 11.46 | 17.31 |

**The total fresh weight and total dry weight**

The highest value of the total fresh weight was achieved at biochar 9 t $ha^{-1}$ which was 27.60 g, which did not differ significantly from the application dosages 3, 6, and 12 t $ha^{-1}$, but differed significantly from the lowest value of the total fresh weight obtained in applications without biochar weighing 17.73 g (Table 3). The highest total dry weight was achieved at biochar 9 t $ha^{-1}$ weighing 10.80 g, which did not differ significantly from application doses 3, 6, and 12 t $ha^{-1}$, but differed significantly with an application without biochar which is 6.75 g.

**Table 3.** Effects of biochar application on total plant fresh weight and total dry weight of plants


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| Biochar dosage (t ha$^{-1}$) | The total fresh weight (g) | The total dry weight (g) |
|---|---|---|
| 0 | 17.73 b | 6.75 b |
| 3 | 21.75 ab | 8.78 ab |
| 6 | 25.00 ab | 9.90 ab |
| 9 | 27.60 a | 10.80 a |
| 12 | 25.88 a | 10.18 a |
| Coefficient of Diversity (%) | 16.74 | 19.81 |

The same lowercase letter in the same column is not significantly different from the Duncan test 5%.

### 3.2. Discussion

The highest results of the total dry weight were achieved at 9 t ha$^{-1}$ biochar weighing 10.80 g or an enhancement of 60% when compared with applications without biochar of 6.75 g. The high results of the total dry weight are supported by the closeness of the relationship between variables with very real and positive correlations such as the height of plants (r = 0.98**), number of leaves (r = 0.95**), total fresh weight (r = 0.99**). This is because biochar, known as a soil amendment, has been able to increase soil fertility, especially by improving the physical properties of the soil followed by increasing biological and chemical properties in the soil. Improvements in the physical properties of the soil are indicated by improved vegetative growth of plants that will encourage plants to carry out photosynthesis to produce photosynthates. This photosynthate is transferred to the active metabolic process to encourage the growth of parts of roots, stems, branches, twigs, and leaves for maximum plant production.

From the regression analysis, the application of biochar to the total dry weight was found in the quadratic regression line with the equation: $\hat{Y} = 6.717 + 0.8217\ X - 0.04381\ X^2$ ($R^2 = 91.80\%$), biochar with an optimal dosage of 9.38 t ha$^{-1}$ and maximum dry weight total of 10.70 g (Figure 1). The results of this regression analysis indicate that the total dry weight is higher with increasing doses of biochar being optimal, it will decrease if it exceeds the optimal dose.

The addition of biochar to the soil will increase nutrient and water retention and changes in microbial soils which ultimately increase soil fertility and crop yields. The long-term benefits for nutrient availability are related to the stabilization of higher organic carbon along with the release of nutrients that are slower than the commonly used organic materials [10].

The biochar application can improve physical, biological, and chemical properties in the soil [11] and improve soil fertility, soil quality, and crop yield [12]. The properties of the soil are very low, the physical properties of water and nutrients, and the increase in pH and CEC in the soil. Biochar in the soil can increase nitrogen fixation in the soil [13]. Nitrogen washing can be reduced by giving biochar to the planting media [14]. Biochar can increase soil risk and nutrients, especially for K and $NH_4$-N. In addition, biochar can withstand P which cannot be retained by ordinary organic matter [15].


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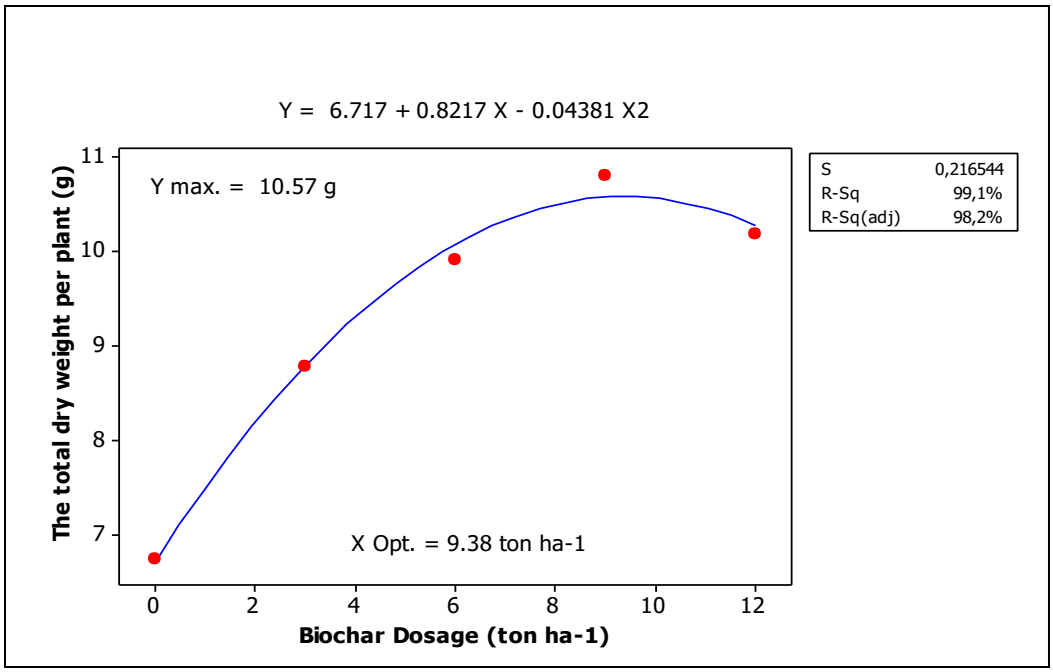


**Figure 1.** Effect of biochar on the total dry weight

## Conclusion

The biochar application showed a real effect on the height of the plant, total fresh weight, and total dry weight, but it does not have a real effect on leaf numbers. The highest total dry weight is achieved on biochar 9 t $ha^{-1}$ (10.80 g) or enhanced by 60% when compared to treatment without biochar (6.75 g). Calculation of regression tests achieved the optimal dose of biochar is 9.38 t $ha^{-1}$ and the maximum results from total dry weight is 10.70 g.

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