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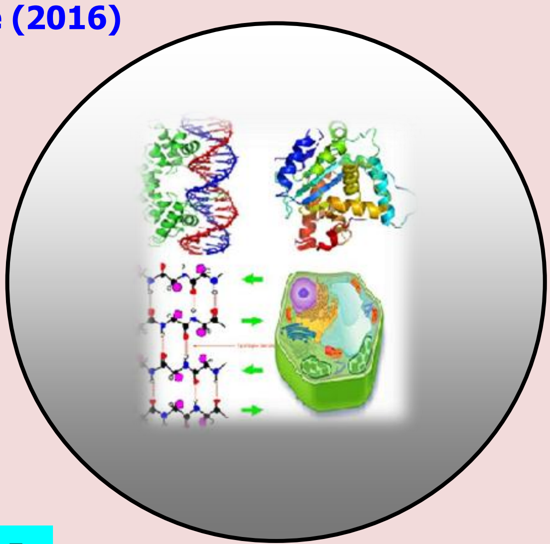

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RESEARCH PAPER

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Utilization Biochar of Bamboo and Compost in Improving Yield of Pakchoy Plant

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ABSTRACT

This study aims to determine the effect of biochar and compost and their interaction on the growth and yield of pakchoy plants. This research uses randomized block design with a factorial pattern. Treatment consists of two factors, namely: the dosage of biochar and compost. The first factor was the dosage of biochar consisting of 4 levels, namely: without biochar, 5 t ha-1, 10 t ha-1, 15 t ha-1. The second factor is the dosage of compost, which consists of 4 levels: without compost, 10 t ha-1, 20 t ha-1, and 30 t ha-1. The results showed that the interaction between the dosage of biochar and compost had no significant effect on all observed variables. The compost application had a very significant effect on all observed variables, while the biochar application had no significant effect on all observed variables. Biochar applications at various dosage were not significantly different, but the dosage of biochar 10 t ha-1 tended to give the highest yield of fresh weight of 18.68 g which increased by 19.32% when compared with the lowest yield on treatment without the dosage biochar that is 15.66 g. The application of 20 t ha-1 compost gave the highest yield of fresh weight of 19.75 g which increased by 44% compared to the lowest value in the composted treatment which was 13.71 g.
Keywords: Charcoal, Manure, Cow Dung and Mustard Vegetables.

INTRODUCTION

The pakchoy green mustard plant (*Brassica rapa* L) is a group of plants of the Brassica family that are used as vegetables. The growth of pakchoy vegetables is fast, strong and uniform. Leaf shape wide round with large and thick leaf stalk. The color of the leaves is bright green while the stalk is light green. Plant mustard can be planted in lowland and high (100 - 1.000 meters above sea level) and can already be harvested at the age of 30-35 day after plant. Potential production of mustard plants can reach 20-25 t ha^{-1} (Wahyudi, 2010).

In Bali and Java, the expansion of agricultural areas (extensification) is no longer possible to increase production. Therefore, agricultural intensification efforts conducted to increase agricultural production as well as to increase soil fertility is by the provision of organic materials derived from biochar and compost. Various studies have shown that biochar and compost have the potential to improve soil structure and fertility. Utilization of biochar on a large scale in Indonesia is relatively new, in contrast to the compost whose utilization is well known widely in an effort to increase soil fertility. Biochar is a fine grain of porous bamboo charcoal substance. Biochar provides a good habitat for soil microorganisms, and generally, biochar that is applied can survive and not decay in the soil for hundreds of years. In the long run, biochar does not disturb the carbon-nitrogen balance, but it can hold and make water and nutrients more available to plants. The benefits of adding biochar to the soil include: increasing plant growth, reducing methane emissions, reducing fertilizer requirements, reducing nutrient leaching, storing carbon in a stable long-term, increasing soil pH, increasing soil aggregates, increasing retention of soil water, increase Mg, P and K, increase soil microbial respiration, increase soil microbial biomass, increase *arbuscular mycorrhizal* fungi, increase cation exchange capacity of soil, improve crop yield and improve plant product quality (Gani, 2009). Biochar is more effective in nutrient retention than other organic materials such as compost or manure. Biochar is more consistent in soil compared to other organic ingredients, so all the benefits associated with nutrient retention and soil fertility can run longer than any other organic ingredients (Nisa, 2010). Biochar made from bamboo has a very microporous structure, with adsorption efficiency about ten times higher than traditional wood biochar (Hua, 2009). The benefits of biochar lie in its two main properties, which have a high affinity for nutrients and are consistent in the soil. These two traits can solve some important agricultural issues, such as soil damage and food security, water pollution and climate change. Biochar has become the foundation of many developed and developing countries for the sustainability of the farming system and at the same time reducing the impact of climate change (Gani, 2009). Compost is the result of fermentation of organic materials such as crop residues, animal waste or other organic wastes (Indriani, 2008). Compost is formed by human intervention, while humus is formed naturally. Compost is obtained from weathering of plant materials or organic wastes such as straw, husks, leaves, grasses, organic waste, and organic waste. The composting treatment can be accelerated by the addition of decomposer or activator microorganisms (Musnawar, 2009). Compost can provide nutritions macro and micro, containing humic acid that can increase the cation exchange capacity (CEC), increase the activity of soil microorganisms, and on acid soil addition of compost can help increase soil pH (Novizan, 2007). Compost is necessary because the need for organic material for fertilization has not been met even though already available manure or green manure. Some of the factors that encourage the need for compost include: the difficulty of obtaining large amounts of mature manure, the obstacles in green fertilization due to time and land constraints to be planted green manure crops, fertilizing organic waste materials such as municipal waste, plantation processing waste, fresh organic matter occurring in soil may interfere with plant growth, and burning of organic matter will not provide nutrients into the soil and may cause air pollution (Musnawar, 2009). The effect of biochar and compost on the plant of pakchoy depends on the dosage used. The dosage of manure or compost for vegetable crops in Indonesia ranges from 10-20 t per hectare (Musnawar, 2009). The best growth response of maize crop was obtained at the treatment of dosage of biochar 10 t ha^{-1}, compost 20 t ha^{-1}, and phonska 300 kg ha^{-1} (Situmeang *et al*., 2015). Added that bamboo biochar dosage of 5-10 t ha^{-1} gave fresh weight the best cobs and compost dosage of 7.5 to 15.0 t ha^{-1} gave the best results in plant height, fresh weight of cobs, and fresh weight of sweet corn crops (Situmeang *et al*., 2017). Based on the above, it is necessary to conduct research for increasing crop productivity as well as for the development of wide biochar utilization, with various experiments of dosage of biochar and compost on mustard pakchoy plant.

MATERIAL AND METHODS

Location and Time of Research

The research was conducted in a greenhouse of Agriculture Faculty of Warmadewa University, Denpasar, with a height of 40 meters above sea level. This research started from September until November 2016.

Material and Tool

The materials used in this research are soil, varicella seeds of pakchoy green seed, biochar made from bamboo waste and compost fertilizer that comes from cow dung.

The tools used in this research are a hoe, scales, plastic polybag, paper label, hose or sprayer, ruler, oven, pencil, and other documentation tools.

Research Design

This experiment used a randomized block design (RBD) with a factorial pattern. Treatment consists of two factors, namely: the dosage of biochar (B) and compost (C). The first factor, the dosage of biochar (B) consists of 4 levels, namely: without biochar (B0), 5 t ha^{-1} (B1), 10 t ha^{-1} (B2), 15 t ha^{-1} (B3). The second factor, the dosage of compost fertilizer (C), consists of 4 levels: without compost (C0), 10 t ha^{-1} (C1), 20 t ha^{-1} (C2), and 30 t ha^{-1} (C3). Thus there were 16 treatment combinations and each treatment was repeated 3 times, so there were 48 pot experiments.

Variables Observed

The growth variable and the results observed in this study are maximum plant height, a number of leaves, fresh weight of economic yield, oven dry weight of economic yield, the total fresh weight of economic yield, and total oven dry weight per plant.

Data Analysis

The experimental data were analyzed according to the design used. The significant effect was followed by LSD test of 5% level, while to know the closeness of the relationship between the observed variables was done by the correlation analysis, then to know the correlation between the treatment given with the result obtained by regression analysis.

RESULTS AND DISCUSSION

Research Result

The significance of biochar (B) and compost (C) and its interaction (BC) on the observed variables can be seen in Table 1. From Table 1 it can be seen that the interaction treatment between biochar with compost (BC) and single biochar has no significant effect ($P \geq 0.05$) on all observed variables, while the compost treatment (C) had a very real effect ($P<0.01$) on all observed variables.

Table 1. Significance of biochar and compost and its interaction with all observed variables.

Variablee	Treatment		
	Biochar (B)	Compost (C)	Interaction (BC)
1. Plant height	ns	**	ns
2. Number of Leaves	ns	**	ns
3. Fresh weight of economic yield	ns	**	ns
4. Dry weight of economic yield	ns	**	ns
5. Total fresh weight of plant	ns	**	ns
6. Total dry weight of plant	ns	**	ns

** = very significant ($P<0.01$), * = significant ($P<0.05$), ns = not significant ($P \geq 0.05$)

Plant Height

The result of statistical analysis on plant height showed that compost fertilizer (C) very significant effect ($P<0.01$), while biochar (B) and interaction (BC) treatment was not significant ($P \geq 0.05$) to plant height (Table 1). The average plant height on biochar and compost treatment is presented in Table 2.

Based on Table 2 it can be seen that the average plant height tends to be obtained at biochar dosage of 10 t ha^{-1} (B2) 14.97 cm is not significantly different with other biochar treatments, whereas the lowest plant value on without biochar (B0) is 13.03 cm. Maximum plant height was obtained at compost 30 t ha^{-1} (C3) 15.89 cm, significantly different from without compost (C0), and not significantly different with compost of 10 t ha^{-1} (C1) and 20 t ha^{-1} (C2), respectively with values of 14.78 cm and 15.13 cm. The relationship dosing biochar and compost to average plant height can be seen in Figure 1.

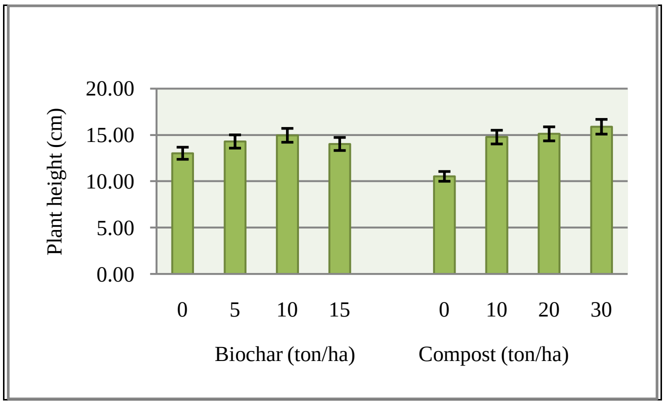

Figure 1. Relationship dosing biochar and compost with average plant height.

Number of Leaves

The result of statistical analysis on leaf number showed that compost fertilizer (C) had a very real effect ($P<0.01$), while the dosage of biochar (B) and interaction of treatment (BC) had no significant effect ($P\geq0.05$) to leaves number (Table 1). The average leaf number on biochar and compost is presented in Table 2.

Table 2. The average of plant height and leaf number on biochar and compost.

Treatment	Plant height (cm)	Number of Leaves (strands)
Dosage of Biochar		
0 t ha^{-1} (B0)	13.03 a	11.83 a
5 t ha^{-1} (B1)	14.30 a	13.25 a
10 t ha^{-1} (B2)	14.97 a	13.75 a
15 t ha^{-1} (B3)	14.03 a	12.67 a
LSD 5%	-	-
Dosage of Compost		
0 t ha^{-1} (C0)	10.54 b	11.25 b
10 t ha^{-1} (C1)	14.78 a	12.83 a
20 t ha^{-1} (C2)	15.13 a	13.58 a
30 t ha^{-1} (C3)	15.89 a	13.83 a
LSD 5%	1.57	1.47

Note: The average value followed by the same letter in the same treatment and column different, not significant at 5% LSD test level.

Table 2 shows that the highest average leaf number tends to be obtained at biochar dosage of 10 t ha^{-1} (B2) of 13.75 strands different, not significant with other biochar dosages, whereas the lowest leaf number values were obtained without biochar (B0) 11.83 strands.

The treatment 30 t ha^{-1} (C3) compost gave the highest number of leaves as much as 13.83 strands, which was significantly different from the compost (C0), and was not significantly different with the treatment of 10 t ha^{-1} (C1) and 20 t ha^{-1} (C2) in a row with values of 12.83 and 13.58 strands respectively. The relationship dosing biochar and compost to average leaf number can be seen in Figure 2.

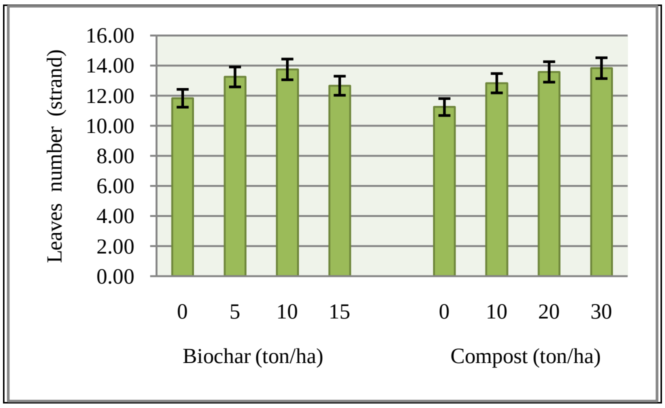

Figure 2. Relationship dosing biochar and compost with average leaves number.

Fresh Weight of Economic Yield

The statistical analysis showed that compost fertilizer (C) very significant effect ($P<0.01$), while treatment of biochar dosage (B) and interaction (BC) had no significant effect ($P\geq0.05$) to fresh weight of economic yield (Table 1). The average fresh weight of economic yields on biochar and compost treatment is presented in Table 3.

Based on Table 3 it can be seen that the average fresh weight of the highest economic yield tends to be obtained at the treatment of dosage biochar 10 t ha^{-1} (B2) 18.68 g which is not significantly different with other biochar dosage treatment, while the lowest value is obtained without biochar (B0) 15.66 g.

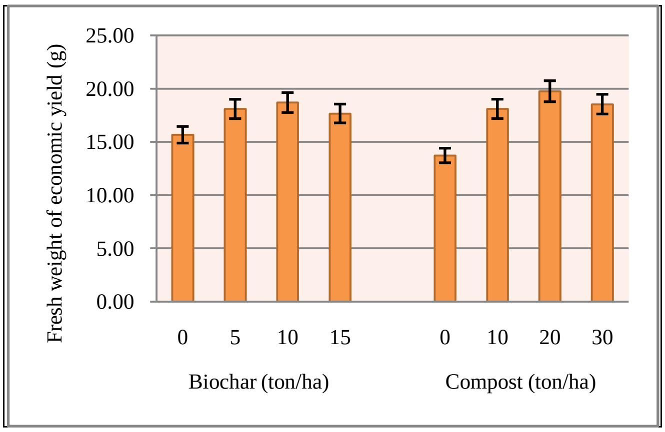

Figure 3. Relationship dosing of biochar and compost with fresh weight of economic yield.

The highest fresh weight of the highest economic yield was obtained at a dosage of 20 t ha^{-1} (C2) 19.75 g, significantly different from biochar (B0), and not significantly different from 10 t ha^{-1} (C1) and 30 t ha^{-1} (C3) were 18.09 and 18.53 g respectively. The relationship dosing biochar and compost to the average fresh weight of economic yields can be seen in Figure 3.

Dry Weight of Economic Yield

The statistical analysis showed that the compost fertilizer (C) very significant effect (P<0.01), while treatment of biochar dosage (B) and interaction (BC) had no significant effect (P≥0.05) to dry weight of economic yield (Table 1). The average dry weight of economic yields on biochar and compost treatment is presented in Table 3. From Table 3 it can be seen that the average oven dry weight of the highest economic result tends to be obtained at dosage biochar 10 t ha^{-1} (B2) that are 2.08 g which is not significantly different with other biochar dosage treatment, while the lowest value is obtained at the treatment without biochar 1.72 g. The highest dry weight was obtained at 20 t ha^{-1} compost fertilizer that was 2.11 g significantly different with no treatment (C0) 1.52 g and was not significantly different with the compost of 10 t ha^{-1} and 30 t ha^{-1} respectively with values of 1.85 g and 2.10 g. The relationship dosing biochar and compost to dry weight of economic yields can be seen in Figure 4.

Table 3. The average fresh weight of economic yields and dry weight of economic yield on biochar and compost treatment.

Treatment	Fresh weight of economic yield (g)	Dry weight of economic yield (g)
Dosage of Biochar		
0 t ha^{-1} (B0)	15.66 a	1.72 a
5 t ha^{-1} (B1)	18.08 a	1.81 a
10 t ha^{-1} (B2)	18.68 a	2.08 a
15 t ha^{-1} (B3)	17.65 a	1.98 a
LSD 5%	-	-
Dosage of Compost		
0 t ha^{-1} (C0)	13.71 b	1.52 b
10 t ha^{-1} (C1)	18,09 a	1.85 a
20 t ha^{-1} (C2)	19.75 a	2.11 a
30 t ha^{-1} (C3)	18.53 a	2.10 a
LSD 5%	2.22	0.28

Note: The average value followed by the same letter in the same treatment and column different, not significant at 5% LSD test level.

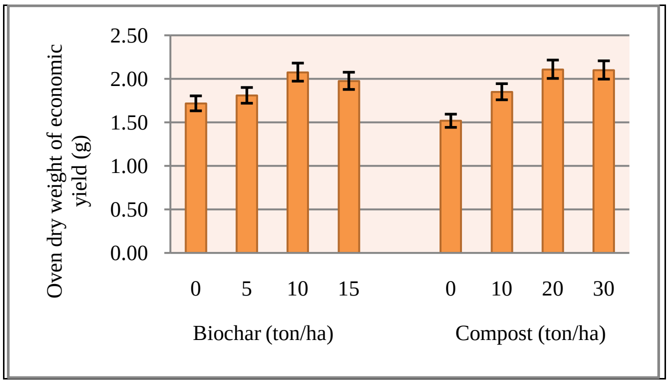

Figure 4. Relationship dosing biochar and compost with average oven dry weight of economic yield.

Total Fresh Weight of Plant

The result of the statistical analysis showed that compost fertilizer (C) very significant effect (P <0.01), while treatment of biochar dosage (B) and interaction (BC) had no significant effect (P≥0.05), to total fresh weight plant (Table 1). The average total fresh weight of the plant on biochar and compost treatment is presented in Table 4.

From Table 4 it can be seen that the highest average total fresh weight of the plant tends to be obtained at the treatment of 10 t ha^{-1} (B2) dosage of 21.98 g which is not significantly different with other biochar treatments, whereas the lowest value is obtained in the treatment without biochar of 18.81 g.

Table 4. Average total fresh weight and total dry weight of plant on biochar and compost.

Treatment	Total fresh the weight of the plant	Total dry the weight of the plant
Dosage of Biochar	............(g)...........	...........(g)...........
0 t ha^{-1} (B0)	18.81 a	2.03 a
5 t ha^{-1} (B1)	20.19 a	2.26 a
10 t ha^{-1} (B2)	21.98 a	2.38 a
15 t ha^{-1} (B3)	20.03 a	2.17 a
LSD 5%	-	-
Dosage of Compost		
0 t ha^{-1} (C0)	15.62 c	1.80 b
10 t ha^{-1} (C1)	20.14 b	2.23 a
20 t ha^{-1} (C2)	23.33 a	2.48 a
30 t ha^{-1} (C3)	21.91 ab	2.32 a
LSD 5%	2.31	0.28

Note: The average value followed by the same letter in the same treatment and column different, not significant at 5% LSD test level.

The highest total fresh weight was obtained in the treatment of 20 t ha^{-1} (C2) compost fertilizer that was 23.33 g which was significantly different with without treatment (C0) of 15.62 g, and not significantly different from the treatment of 10 t ha^{-1} C1) and 30 t ha^{-1} (C3) respectively with values of 20.14 g and 21.91 g. The relationship dosing biochar and compost to an average total fresh weight of plant can be seen in Figure 5.

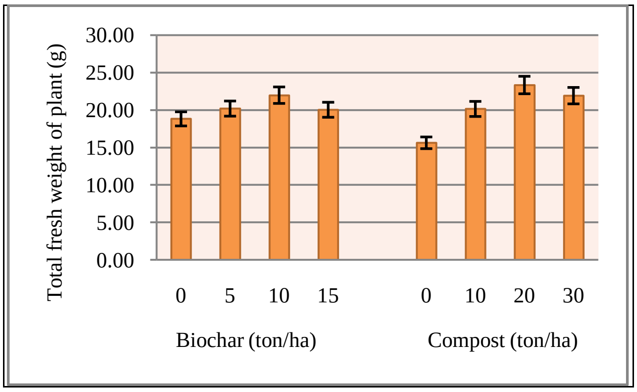

Figure 5. Relationship biochar and compost with total fresh of plant.

Total Dry Weight of Plant

The statistical analysis result showed that compost fertilizer (C) very significant effect (P<0.01), while treatment of biochar dosage (B) and interaction (BC) had no significant effect (P≥0.05) to a total dry weight of plants (Table 1). The mean total dry weight of the plant in biochar and compost treatment is presented in Table 4.

From Table 4 it can be seen that the average total dry weight of the highest economic result tends to be obtained at biochar dosage 10 t ha^{-1} (B2) of 2.38 g which is not significantly different with other biochar dosages, while the lowest value is obtained in the treatment without biochar (B0) that are 2.03 g.

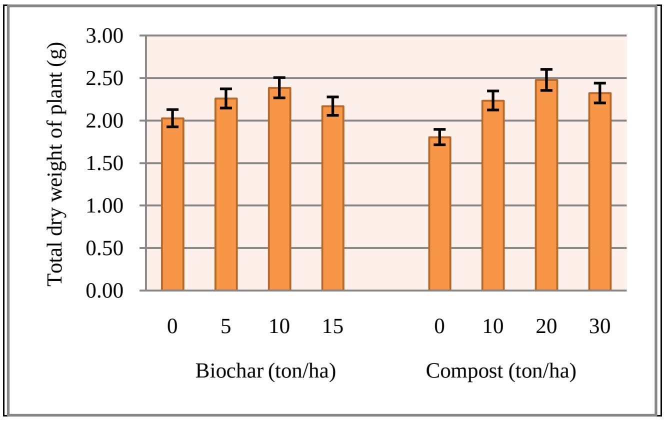

Figure 6. Relationship biochar and compost with total dry weight of plant.

The highest dry weight of plant oven was obtained at compost fertilizer 20 t ha^{-1} (C2) that was 2.48 g which was significantly different with no treatment (C0), and was not significantly different with treatment of 10 t ha^{-1} (C1) and 30 t ha^{-1} (C3) respectively with values of 2.23 g and 2.32 g. The relationship dosing biochar and compost to the average total dry weight of plant can be seen in Figure 6.

DISCUSSION

The results of this study indicate that treatment of biochar dosage at different dosage is not real, but the dosage of biochar 10 t ha^{-1} tends to give the highest yield of fresh weight of the highest economic yield of 18.68 g which increased by 19.32% The lowest yield on treatment without biochar was 15.66 g (Table 2). Biochar made from raw bamboo biomass is porous. This porous nature, causing biochar has the ability to bind nutrients and water and provide a habitat for soil microorganisms. Nutrient retention can store nutrients and in time is used for plant growth otherwise, it is suspected that the biochar effect can increase the porosity of the soil and decrease the volume of soil which causes the soil to become looser.

The highest yield of fresh weight was obtained 19.75 g at compost fertilizer 20 t ha^{-1} which increased by 44% compared to the lowest value in without compost of 13.71 g (Table 2). The increase of fresh weight of economic result on the treatment of compost fertilizer 20 t ha^{-1} caused by compost fertilizer can improve physical properties, chemistry, and biology of soil. By composting, the soil structure becomes crumb and soil becomes looser, macronutrients (N, P, K, Ca, Mg) and micro (Mn, Fe, Cu, Zn) are required for more available plants, soil cation exchange capacity and the activity of microorganisms in the soil is increasing (Novizan, 2007). This is in line with (Peni dan Teguh, 2007), that compost improves soil properties due to their very important role in the improvement of physical, chemical and biological properties of the soil. The materials in this compost become rotted and rotten when in wet and damp conditions, just as the leaves become obsolete when they fall to the ground and blend into the ground. During the change and decomposition of organic matter, nutrients will be free to form soluble and can be absorbed by plants. Before undergoing the process of change, the remaining animals and plants are not useful for plants because the nutrients are still in a bound form that can not be absorbed by the plant.

Good compost is a sufficiently weathered and characterized by a color that is different from the color of the forming material and odorless. The added that the compost can improve the soil structure of the clay so that it becomes light, enlarge the sandy soil binding capacity so that the soil does not stagnate, increase the water holding capacity, improve drainage and air conditioning in the soil, enhance the soil bonding capacity, complete nutrients, help the process of weathering mineral materials, and provide the availability of food for microbes (Indriani, 2008).

This is thought to be due to improved soil physical properties or overall soil fertility due to composting. This condition can be seen from the growth of plant vegetative parts such as maximum plant height and maximum number of leaves in the treatment of compost fertilizer 20 t ha^{-1}, the improved vegetative growth of this plant leads to increased sunlight interception by the leaves to produce photosynthesis and in subsequent developments These photosynthates will be transferred to the organ organs that actively hold metabolic processes so that the growth of roots, stems and leaves of plants to be better and will further affect the results of fresh weight of the plant economy.

Compost can improve the physical properties of the solid soil becomes loose so it facilitates the processing of the soil. Sandy soil becomes compact and clay becomes more friable. The cause of this compact and loose is the polysaccharide compounds produced by the decomposing microorganisms and mycelium or hyphae that act as the adhesive of the soil particles. With good soil structure, this causes the diffusion of oxygen will be better so the physiological process at the root will be smooth. The improvement of soil aggregate becomes more crumb will facilitate the absorption of water into the soil so that the erosion process can be prevented. High levels of organic matter in the soil provide a darker soil color so that more sunlight energy absorption and soil temperature fluctuations in the soil can be avoided.

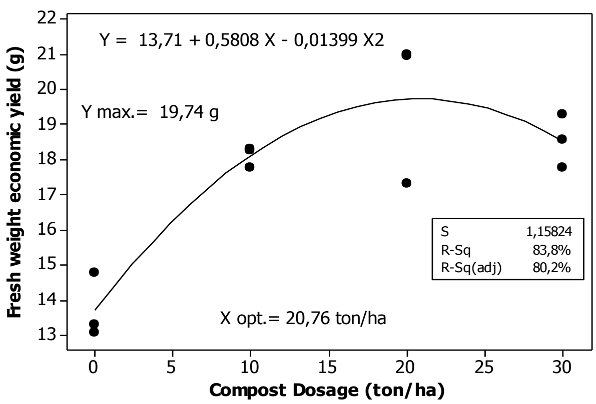

Figure 7. Relationship of compost dosage with fresh weight is economic yield.

The regression analysis of compost dosage with a fresh weight of economic yield showed quadratic correlation with regression line equation: $\hat{Y} = 13.71 + 0.5808\ X - 0.01399\ X^2$ with the coefficient of determination (R^2) equal to 83.80% (Figure 7). From the regression analysis, the optimum compost dosage was 20.76 t ha^{-1}, with the fresh weight of maximum economic yield of 19.74 g. Based on the results of regression analysis showed that the fresh weight of economic results is higher with increasing the dosage of compost to optimum, then decreased when exceeding the optimum dosage

CONCLUSIONS

The interaction treatment between biochar with compost and single biochar had no significant effect on all observed variables, but compost treatment had the significant effect on all observed variables.

The dosage of biochar 10 t ha^{-1} and 20 t ha^{-1} compost can be used to improve the pakchoy yield. The treatment biochar at different dosage was not significant, but the dosage of biochar 10 t ha^{-1} gave the highest yield of fresh weight of 18.68 g or an increase of 19.32% when compared with the lowest yield on treatment without biochar dosage of 15.66 g.

The highest fresh weight of the highest yield was 19.75 g at 20 t ha^{-1} compost fertilizer, which increased by 44% when compared to the lowest value in the treatment without compost of 13.71 g. From the regression analysis, the optimum compost dosage was 20.76 t ha^{-1}, with the fresh weight of maximum economic yield of 19.74 g.

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