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Application of Compost Produced by Bioconversion of Coffee Husk by Black Soldier Fly Larvae (*Hermetia Illucens*) as Solid Fertilizer to Lettuce (*Lactuca Sativa* Var. Crispa) : Impact to Growth

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ABSTRACT

Lettuce is one of the most cultivated vegetables in West Java. Fertilizer plays important role for growth of this vegetables. Increasing cost of synthetic fertilizer and preference on less chemical residue agricultural products shifted the cultivation toward to application of more organic fertilizers. In this study, compost produced by bioconversion of coffee husk by black soldier fly larvae was applied as part of lettuce cultivation in order to observe the effect to growth. The result showed that lettuce cultivated with manure significantly produced highest plant height (20.37 ± 1.565 cm), number of leaves (12.20 ± 1.119), leaf area (129.45 ± 29.622 cm2), and chlorophyl content (5.92 ± 1.227 mg/liter). On the other hand, lettuce cultivated with compost originated from bioconversion process showed second best value which is higher than value of conventional compost of coffee husk.

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1. INTRODUCTION

Lettuce (*Lactuca sativa* var Crispa) is one of the major vegetables cultivated in Indonesia especially at West Java [1]. Monthly market demand, in Indonesia, for this vegetables is 1-1,5 ton [2]. During cultivation, lettuce required constant supply of nutrition through fertilizer, usually synthetic chemical fertilizer [3], [4]. However, increasing demand of agricultural product with low synthetic chemical fertilizer and price of the fertilizer encourage farmers to apply compost, originated from decomposition of organic wastes, as fertilizer [5].

One of the compost materials that relatively unused is agricultural wastes, like coffee husk. On average annuall coffee production in Indonesia is 685.089 ton [6] which potentially produces high amount of coffee husk as waste. Although this material can be used as compost material, most farmers reluctant to carry out the composting process due to low economic value of the compost. Thus, coffee husks were pilled up which caused some environmental problems [7]. In this study, coffee husks were decomposed by natural process which converted it into biomass of fungi, bacteria, or macrofaune on the process called bioconversion [8]. Agent used for bioconversion is Black Soldier Fly larvae (BSFL) which known for their ability to consume wide range of organic wastes such as agricultural wastes [9], [10], animal and human remains [11]-[12], fish offal [13], food waste [14]-[16], as well human and livestock feces [17]-[20]. During this process, undigested feed materials and feces produced by larvae is can be use as solid organic fertilizer for plant [21]. However, most of study on bioconversion only focussed only on biomass and the knowledge on the benefit of BSFL compost relatively

unexplored. Thus, in this study, we evaluated the effect of applying compost produced bioconversion of coffee husk by BSFL to growth of lettuce.

2. RESEARCH METHOD

2.1 Research Area

Study was conducted at Jatinangor Campuss of Institut Teknologi Bandung.

2.2 Compost production

Compost was originated from bioconversion of coffee husk by black soldier fly larvae (BSFL). Coffee husk used in this study produced as waste in coffee bean milling at Ciparay. During bioconversion, BSFL was fed with combination of milled coffee husk with water (60:40) until metamorphosed into prepupae. Residue (consisted of undigested feeding material and faecal produced by larvae) was collected and used as compost for this study. Some chemicals content of compost that related to cultivation (Nitrogen, Phosphor, Potassium, and C-organic) were analyzed in Balai Penelitian Tanaman Sayuran, Lembang, West Java (Table 1).

Table 1. Chemical content of Coffee Husk and BSFL Compost

Parameter	Coffee Husk	BSFL Compost
C-Organik (%)	51.31	31.10
N-Total (%)	1.64	1.27
C/N Rasio	31	24
P_2O_5 (%)	0.19	0.46
K_2O (%)	2.84	2.79

2.3 Compost application

In this study completely random design was applied. Plant was sowing in germination material for 14 days then removed to polybag (20 x 30 cm) filled with specific growth medium designed for this study. There were 5 types of growth medium

A : soil and cow's dung (1 : 1)
B : soil and BSFL compost (1 : 1)
C : soil and BSFL compost (2 : 1)
D : soil and coffee husk (1 : 1)
E : soil and coffee husk (2 : 1)

Plant watered with 200 ml water twice a day and organic pesticide was applied as pest control. All plants were harvested 30 days after planted.

2.4 Data Collection

Variable observed in this study were plant height, number of leaves, leaf area. These parameters were observed weekly until harvest. Plant height measured border area between root and stem while only fully opened leaves were counted. Lettuce leaf area is calculated by approach length point width method. The length of the leaf is measured from the base of the leaf to the end of the leaf, while the width of the leaf is measured at the widest part of the leaf. The leaf area of the plant is calculated using the formula:

Leaf area = Constant x Length x Width (constant for lettuce was 0.759)……(1)

The measurement of chlorophyll content was done based on Wintermans and de Mots [22] method by using spectrophotometry with 649 nm and 665 nm wavelength. Total chlorophyll content then calculated using the following formula:

Total Chlorophyll (mg/l) = 20,0 D-649 + 6,10 D-665…….(2)

Where,

D-649: Results of spectrophotometer readings at 649 nm wavelength.
D-665: Results of spectrophotometer readings at 665 nm wavelength.

2.5 Statistical Analysis

Prior to analysis, all data was tested for normality by Kolmogorov-Smirnov test. Data with normal distributio were analyzed by using ANOVA test with 95% confidence level (α = 0,05). If there is significant difference, Tuckey test with 95% confidence level was applied as post hoc test. Data with non normal distribution will be tested using Kruskal Wallis test, if there is significant difference with Mann-Whitney test as post hoc test also with 95% confidence level (α = 0,05).

3. RESULTS AND ANALYSIS

3.1. Plant Height

Group A, B, and C showed growth in plant height while the growth of plant height was halted since the beginning of observation (Fig. 1). It seems the nutrient content of group D and E relatively unable to trigger the development of new cells on the tip meristem that responsible for development the height of the plants.

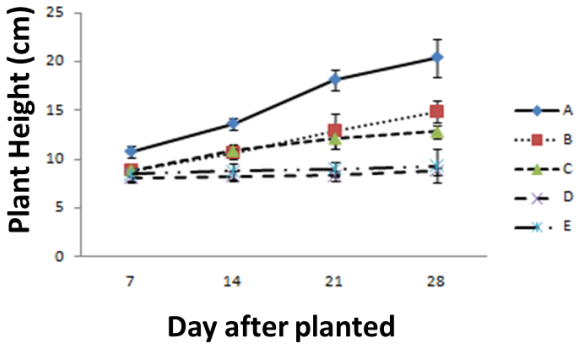

Figure 1. Change in lettuce height planted by different types of growing medium.
A : soil and cow's dung (1 : 1), B : soil and BSFL compost (1 : 1), C : soil and BSFL compost (2 : 1), D : soil and coffee husk (1 : 1), E : soil and coffee husk (2 : 1).

The average height of harvested plants of group A significantly higher than other groups (20.37 ± 1.565 cm) while all plant planted with coffee husk was the shortest (Table 2). This result indicated the low quality of growing medium made of coffe husk and application of BSFL as biocnversion agent may significantly improve it quality as growing medium.

Table 2 Plant Height 30 days after planted

Treatment	Plant height (cm)
A	20,37 ± 1,565a
B	14,86 ± 1,002b
C	12,39 ± 0,792c
D	9,23 ± 1,686d
E	8,79 ± 0,862d

Different letter indicated signficantly different value (P≤0,05)

3.3. Number of leaves

Leaf production has an increase every week for group A, B, and C while the leaf production was declined for group D and E at 14 and 21 DAP (Fig. 2). Lost of leaves due to malnutrition could explain this result and indicated that coffee husk relatively unsuitable to be use as growing medium for lettuce.

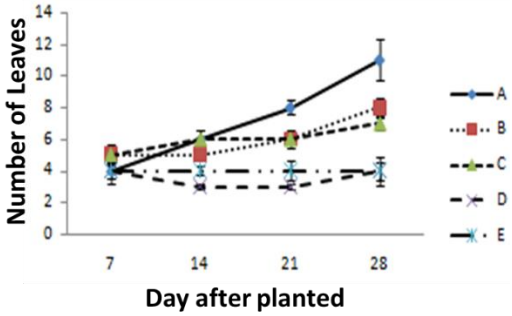

Figure 2. Change in number of leaves of lettuce planted by different types of growing medium.
A : soil and cow's dung (1 : 1), B : soil and BSFL compost (1 : 1), C : soil and BSFL compost (2 : 1), D : soil and coffee husk (1 : 1), E : soil and coffee husk (2 : 1)

Group A produced significantly more leaves than other groups (12.20 ± 1.119) while lettuce planted with coffee husk produced least number of leaves (Table 3).

Table 3. Number of Leaves 30 days after planted

Treatment	Number of Leaves
A	12.20 ± 1.119a
B	9.00 ± 0.333b
C	7.27 ± 0.435c
D	4.93 ± 0.641d
E	4.67 ± 0.972d

Different letter indicated signficantly different value (P≤0,05)

Lower number of leaves highly related to the quality of growing medium and wellness of the plant. As C/N ratio of coffee husk generally higher than recommended value of 10-20 (SNI 19-7030-2004) [23], there was possibility lack of available nutrient hampered the leaves production as high C/N ratio slowing down the decomposition process. This condition is unfavorable for agricultural industry as economic value of harvested lettuce depended on the leaves condition.

3.4. Leaf Area

Each group has different growth rate of leaf area from 7 to 28 DAP. Groups A, B and C showed steady increased on leaf area every week while ther was decline in leaf area growtg in group D at 21 to 28 DAP (Fig. 3). The decline in leaf area due to increased number of dead leaves which suspected to be caused by the lack of nutrient content in the growing medium.

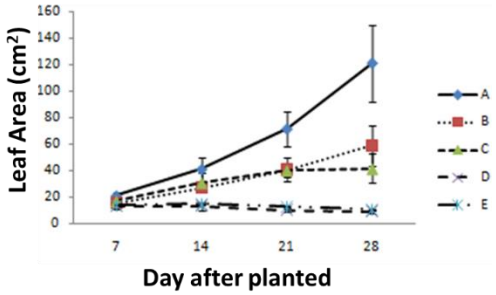

Figure 3. Change in leaf area of lettuce planted by different types of growing medium.
A : soil and cow's dung (1 : 1), B : soil and BSFL compost (1 : 1), C : soil and BSFL compost (2 : 1), D : soil and coffee husk (1 : 1), E : soil and coffee husk (2 : 1)

Leaf area is a parameter used to know the growth and production of a plant, in addition to the number of leaves [24]. This leaf area parameter can provide an overview of the process and rate of photosynthesis of a plant. The larger the area of the lettuce leaves the greater the sunlight will be and the photosynthesis process will run well [3].

The largest leaf area of harvested biomass was recorded in group A (129.45 ± 29.622 cm^2) and significantly larger than other groups while the significantly smallest leaves recorded in group E (9.17 ± 3.735 cm^2) (Table 4).

Table 4 Leaf Area 30 days after planted

Treatment	Leaf Area (cm^2)
A	129.45 ± 29.622a
B	53.89 ± 7.230b
C	42.46 ± 10.762c
D	9.91 ± 2.920d
E	9.17 ± 3.735e

Larger leaves in medium A could be related with higher nitrogen content. On the other hand, all BSF compost treatment showed larger leaves than coffee husk treatment. This result could be related to lower C/N ratio of BSFL compost which was in accordance with the compost quality standard of SNI 19-7030-2004, between 10-20 [23]. C/N ratio have great importance related to nutrient availability for plants. A high value of more than 30 will prolonged decomposition process due to insufficient nitrogen required for cellulolytic process by microflora thus slowing down rate of nutrient availability for plants Craig et al. [25].

3.3. Chlorophyll Content

The highest total chlorophyll content was recorded from group A (5.92 ± 1.227 mg/l) while the lowest was group D (2.44 ± 0.539 mg/l) (Table 5).

Table 5. Chlorophyll Content 30 days after planted

Treatment	Total Chlorophyll (mg/liter)
A	5,92 ± 1,227a
B	5,12 ± 1,103ab
C	3,57 ± 0,399bc
D	2,44 ± 0,539c
E	3,16 ± 0,544c

Leaf chlorophyll content is highly affected by nutrient concentration, distribution of chlorophyll in leaves, and plant genotype [26], [27]. It seems that growth medium A and B, despite medium A slightly better, provide ample amount of available nitrogen, phosphor, and potassium which highly affect the total number of leaf chlorophyll [28], [29]. Higher leaf chlorophyll at plant planted in compost also reported by Atiyeh et al. [30] and Ancuta and Renata [31]. Chlorophyll is in photosynthesis to produce carbohydrate which is needed by plants to grow and develop as in the process of photosynthesis [32]. Healthy plant usually reflected by chlorophyll content of leaves since it related to photosynthesis capacity [24], [33]-[36]. This result could explain the lower biomass production of lettuce growth in coffee husk and BSFL compost compared with cow's dung.

4. CONCLUSION

BSFL compost showed potency to be applied as solid organic fertilizer. Although combination of soil and cow's dung produced better value for all observed parameters, benefit on agricultural waste and low investment in human power during composting process in long term may provide better benefit of application of BSFL compost. Further study required to improve the quality of BSFL compost in order to encourage the bioconversion approach for organic wastes management.

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