The Effect of Fertilizer Variations from Organic Waste on the Growth of Mustard Plants (*Brassica juncea L.*) in Integration Farming System

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ABSTRACT
People in Indonesia are now starting to care about maintaining health and avoiding the use of chemical compounds in food ingredients. Mustard (*Brassica juncea L.*) is a type of vegetable that is well known in Indonesian society. The use of organic-based fertilizers is one of the way to produce mustard plants organically and make the product relatively healthier. This study aims to determine the effect of the use of organic fertilizer produced by BSF (Black Soldier Fly) (*Hermetia illucens*) maggot (frass) and liquid organic waste from catfish ponds on the growth of mustard (*Brassica juncea L.*) plants. This research was conducted at the Biological Physics Laboratory, Faculty of Agricultural Technology, Universitas Gadjah Mada. This study used a completely randomized design (CRD) with 4 treatments and 5 replications. P0: without fertilizer as a control, P1: BSF maggots frass from organic waste, P2: BSF maggots frass from chicken manure, P3: liquid organic waste from catfish ponds. The plant growth parameters which is measured are plant height (cm), number of leaves (strands), leaf area (cm2), and fresh plant weight (g). The results showed that the use of BSF frass has made an increase of the plant height, number of leaves, fresh plant weight, leaf area, and produced a healthier mustard plant, whilst the liquid waste of catfish pond application resulted in the plant's death. This study proves that Black Soldier Fly frass works as an organic fertilizer and capable of increasing mustard plant's growth and quality. Meanwhile, liquid waste from catfish pond still needs further treatment to be applicable into the system.

Keywords: *Mustard, Organic waste, Liquid organic waste.*

1. INTRODUCTION

Vegetable plants are a source of vitamins and minerals for humans. Some of them even contain antioxidants that are believed to inhibit cancer cells. Leaf vegetables are a source of essential vitamins and minerals and contain lots of fibre which helps facilitate digestion and can prevent cancer [1]. Mustard is a vegetable plant that is already familiar in Indonesian society. In Central Java alone, the harvested area of mustard plants is 8,520 hectares with a production of 87,597 tons and a productivity of 10.28 tons/ha [2]. There have been many Indonesian farmers who cultivate this vegetable because one of its advantages is that it is able to grow both in the lowlands and in the highlands. Besides that, the harvest age of mustard plants are relatively short, which is 40-50 days after planting and the profits gained from the market is quite high, which makes mustard plants feasible to be developed by Indonesian farmers [3].

Increasing the productivity of mustard plants can be done by using fertilizers. However, excessive use of fertilizers, especially chemical fertilizers can have an impact that actually damages the fertility of the soil itself. The use of organic-based fertilizers such as livestock manure waste can be used as an alternative to chemical fertilizers. The Integration System Technology of Plants – Livestock – Fish is a system that minimizes input from the outside of the system and is designed in an organic environment, meaning; constituent components or flow of inputs, processes and outputs as well as the internal environment of the system is free from non-organic materials that have destructive behaviour to the environment, both physically and non-physically. Each

sub-system of this Integration System Technology will produce outputs that can be utilized by other sub-systems, such as solid and liquid organic fertilizers. BSF (Black Soldier Fly) maggots waste can be used as an alternative organic fertilizer, while fish pond water waste in the fisheries sub-system can be used as liquid fertilizer. By using other sub-system outputs as the other sub-system's input, the hope is that it can reduce the financial cost needed in order to cultivate the system even further as a step to achieve a sustainable food production.

Organic fertilizers can be in the form of solid or liquid made from organic materials derived from animals and or plants or from agricultural waste that has been decomposed with the help of decomposers. Organic fertilizers come from organic materials which are rich in protein, carbohydrates, and fats [4]. According to Hadisuwito [5], the use of Liquid Organic Fertilizer is more easily absorbed by plants because the elements in it have been decomposed. The larvae of *Hermetia illucens L*. (Diptera: Stratiomyidae), better known as the Black Soldier Fly, have been widely recognized as a modifier of organic waste and as nutritious feed for chickens, pig farms and the cultivation of various aquaculture animals/plants [6]. These larvae produce solid and liquid materials when reducing organic waste.

Liquid waste from catfish cultivation is waste that comes from artificial feed that has a high protein content to sustain life or growth of fish leftovers that are not eaten, manure already contains macro and micro nutrients in the form of feces, urine, and additional food from green leaves. In addition, liquid waste from catfish cultivation is an organic waste that serves to improve soil structure and improve the life of soil microorganisms [7]. Catfish farming wastewater also contains nutrients needed by plants. Nutrient levels contained in liquid organic fertilizer from waste water of intensive system catfish cultivation ranged from 0.06-0.62% (C-organic), 0.49-1.32% (Nitrogen), 0.06-0.35 % (Phosphate), 0.22-4.97% (Potassium), and pH 5.67-8.00 [8].

In view of the above, the objective of the study is to determine the effect of the use of Black Soldier Fly (BSF) frass and liquid waste from catfish ponds on the growth of mustard plant (*Brassica juncea L*.).

2. MATERIALS AND METHODS

This research was conducted at the Biological Physics Laboratory, Faculty of Agricultural Technology, Universitas Gadjah Mada. The materials used in this study were mustard seeds of caisim variety, polybags, Black Soldier Fly (*Hermetia illucens*) frass, soil, tap water, liquid waste from catfish pond. The tools used were shovels, ruler, analytical balance, A4 papers, and plant growth light.

This study used a completely randomized design (CRD) with 4 treatments and 5 replications. P0: without fertilizer as a control, P1: BSF maggots frass from organic waste, P2: BSF maggots frass from chicken manure, P3: liquid organic waste from catfish ponds. The measured plant growth parameters are plant height (cm), number of leaves (strands), leaf area (cm^2),and fresh plant weight (g).

Plant height was measured using a ruler by measuring the plant from the soil surface up to the highest point of the leaves. Number of leaves was measured by counting the leaves visually. Leaf area was measured using the gravimetric method. Fresh plant weight was measured using analytical balance after the mustard plant is harvested.

3. RESULTS

3.1. Plant Height

Plant height was measured every 3 days for 28 days and the result is as follows:

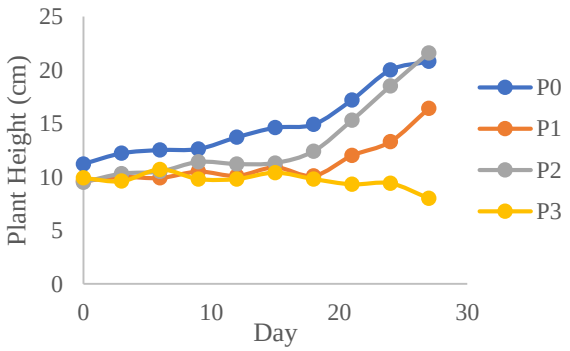

Figure 1 Height of mustard plants.

Figure 1 shows that the average height of mustard plants continued to increase except for P3 which height was decreasing from day-15 onwards. This is caused by the withering of P3 plants which eventually leads to the plants' death by the age of harvesting. The highest plant height is achieved by P2 at the age of harvest (21.6 cm).

3.2. Number of Leaves

Number of leaves was also measured every 3 days for 28 days and the result is as follows:

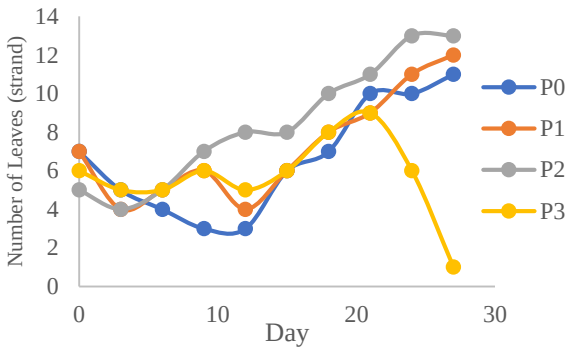

Figure 2 Number of leaves of mustard plants.

Figure 2 shows that P2 is having the most amount of leaves, followed by P1, P0, and then P3 with the least amount of leaves. The withering of P3 plants made the plants loses leaves more and more each day.

3.3. Leaf Area

Leaf area was measured using the gravimetric method. The measurement is done when the plants are ready to harvest. In gravimetric method leaf is first removed from plant and placed on white paper. Paper is cut-out according to the shape of leaf. The weight of this paper is compared to the weight of known area on the same paper and then the comparison is used to calculate the paper cut area which represents the leaf area.

The results are as follows:

1. P0 = $3.85\times10^{-3}m^2$
2. P1 = $3.95\times10^{-3}m^2$, and
3. P2 = $3.94\times10^{-3}m^2$.

The largest area of leaf measured is achieved by P1. Meanwhile the leaf area of P3 sample is not calculated due to the remaining leaves being under conditions that are not possible to measure.

3.4. Fresh Plant Weight

The fresh plant weight was measured after the plants has been harvested. The results are as follows:

1. P0 = 20 grams,
2. P1 = 24 grams, and
3. P2 = 32 grams.

P2 has the heaviest fresh plant weight while P0 is the lightest. P3 sample's weight was not measured because the sample is presumably dead and has no weight (<1 gram).

4. DISCUSSION

This research was conducted in a laboratory with temperatures ranging from 26-30°C and with humidity varying from 75-88%. This condition is already in an ideal value as the optimal temperature for the growth and production of mustard plants is between 27-32°C and Haryanto [9] also suggested that the appropriate humidity for the optimal growth of mustard plants is in the range of 80% - 90%.

The results shows that the chicken manure BSF frass (P2) is better than other treatments in terms of plant height, number of leaves, and fresh plant weight. The control treatment (P0) has better plant height growth than the organic waste BSF frass (P1), but the control treatment indicates a disease that makes it's leaves turn yellowish and the stems of the plants tends to limp as if they cannot support the weight of the plant itself. While other treatments, apart from hydroponic treatment (P3), grow healthier. This indicates that the use of BSF frass can increase the growth and quality of mustard plants. The yellowing of the P0 leaves can be caused by a lack of nutrients absorbed by the plant. This is normal for the control treatment because the soil used as the growing medium is not fertilized at all.

The hydroponic treatment (P3) has the worst growth in all aspects and even ended up dead by the day of harvesting. This happens because the plants received water directly from the catfish pond without any form of water-filtering. The problem was added by the fact that the catfish pond was not drained or cleaned. Handayani [10] also stated that catfish pond waste water has not been able to completely fulfil the nutrients needed by the mustard plants and still cannot outperform the AB mix solution.

5. CONCLUSION

Based on the results, the following conclusions can be drawn:

1. The highest plant height, number of leaves, and fresh plant weight parameter was achieved by P2 treatment with 21.6 cm height, 13 leaves, and 32 grams of fresh plant weight. P1 treatment has the highest leaf area of $3.95\times10^{-3}m^2$.
2. Black Soldier Fly (BSF) frass can be used as an alternative organic fertilizer for plants and has a good impact for plant growth and quality. Meanwhile, liquid organic waste from catfish pond still cannot be used as an alternative liquid fertilizer on hydroponic system and requires further treatment to function properly.

AUTHORS' CONTRIBUTIONS

1. Ilham Bintang Pratama: Collected the data, performed the analysis, wrote the paper.
2. Umi Hapsari: Conceived and designed the analysis, supervisor.

3. Yudha Dwi Prasetyatama: Conceived and designed the analysis.
4. Lilik Soetiarso: Conceived and designed the analysis.

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