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Bio-Conversion and Decomposing With Black Soldier Fly to Promote Plant Growth

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Abstract.
Every country in the world, including Indonesia, is confronted with the problem of waste and is attempting to find viable solutions. The majority of recycled waste is inorganic waste, while there is also organic recycled waste, and the remaining 60-75% of waste is dumped in a landfill. By utilizing waste and by-products, bioconversion with black soldier fly (BSF) larvae could be a solution to help overcome the problem of organic waste; these larvae can also be used as a protein source in animal feed and in organic fertilizers rich in nutrients. The use of BSF as a decomposer of organic waste, specifically Black Soldier Fly Fertilizer (BSF Frass), and the liquid resulting from the bioconversion process, called micro bio stimulant (MBS), can be used to promote plant growth. The goal of this study was to assess how BSF Frass affected plant growth when compared to Synthetic fertilizers. Corn and Pak Choiwere the test plants that were planted in the field. The results showed that giving 50% BSF Frass to the tested plants resulted in better growth and development than the control.

Keywords: Bioconversion, Organic Fertilizer, Black Soldier Fly Compost, Frass.

1. Introduction

Waste problems, especially those in Indonesia, need to be handled optimally. Various types of waste accumulate ranging from organic waste and inorganic waste is currently undergoing rapid development. The composition of the most common types of waste found was organic waste originating from agro-industry, settlements, food loss/waste from hotels, restaurants, modern/traditional markets, and other domestic waste [1]. All of this waste is collected in landfills and has a negative impact on the environment. Landfill is getting denser, not yet sanitary landfill, some are already over capacity, waste has not been segregated, a small part is reuse and recycle. It needs the effective and useful waste management to become the solution of waste problem in Indonesia. How can we change and utilize this waste into something of added value and use, especially use for the agricultural sector. The need that exists in the agricultural sector is for fertilizers.

Bioconversion can be used as an alternative solution to solve the existing waste problem, namely by utilizing biological processes, enzymes, and microorganisms. Bioconversion using Black Soldier Fly on organic waste is being developed. Bioconversion process Black Soldiers Fly *(hermetia illucens)* in larvae stages can consume all rotten/fermented organics material and multiply their weight to 5000 times. During their fattening process their release enzyme sand microbes which is decomposing all substrates and convert to becoming valuable frass/compost faster than normal composting process with high quality of output that we can utilize as plant growth-promote *Rhizobacteria*. The development of BSF in Indonesia has increased after many parties realized the benefits of BSF as a decomposer of organic waste. The results of the decomposition of organic waste are in the form of larvae which can be used as animal feed and frass which can be used as organic fertilizer. The use of BSF frass as organic fertilizer has been widely carried out because of the ability of BSF frass to increase nitrogen absorption by plants so it makes the use of nitrogen fertilizers efficient [2].

Frass contains a lot of microorganisms that are useful as agents that promote plant growth and restore soil fertility. Some of these groups of microorganisms include nitrogen-fixing bacteria such as the genera *Azospirillum, Rhizobium, Azotobacter* and phosphate solubilizing bacteria such as the genera *Bacillus, Pseudomonas, Arthrobacter, Bacterium, and Mycobacterium* [3]. According to Purwanto, utilization of *Rhizobacteria* is one way to increase plant productivity. Plant Growth Promoting *Rhizobacteria* (PGPR) PGPR is a root bacterium that has a beneficial effect on plant growth and development [4]. The role of *Azotobacter* as a biofertilizer is not only for increase plant growth and yield but also to reduce level of Synthetic fertilizers that have been widely used. *Azotobacter* is the alternative of Synthetic fertilizers, pesticides, and artificial growth regulators which shows many side-effects to sustainable agriculture. For future usage of *Azotobacter* and increase their effectiveness in the field, a better formulation of *Azotobacter*-based biofertilizer is needed [5]. The combination of frass with Black Soldier Fly is able to produce fertilizer that has better content for plants. Better plant growth results compared to using only Synthetic fertilizers without mixing with BSF.

2. Materials and Methods

2.1. Corn

Corn field preparation. The land that will be used as experimental land is tilled and loosened, after loosening the land then mounds are formed with a spacing of 75 cm x

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25 cm using "jejer manten" method, locally manten mean bride or couple, jejer mean in the line, two plants will line up like a bride.

Treatment of 100% BSF Frass and spraying MBS with a concentration of 1%. The cultivated land that has been rolled is made a planting hole, the planting hole that has been made is then mixed with 50 grams of BSF and left for one week. After a week of planting corn. Re-spraying fertilization was carried out after the plants were 7, 28 and 45 days old.

Treatment 50% BSF frass, concentration 0,5% MBS and 50% Synthetic fertilizer. The cultivated land has been mixed with 25 grams of planting hole BSF and then left for one week, a week then seeding is done. Re-spraying fertilization was carried out after the plants were 7, 28 and 45 days old with a dose on day 7 of 25 g of BSF with holes for planting, 0.5% of MBS, 50 kg/ha of urea, 75 kg/ha of sp36 and 50 kg/ha of kcl. Dosage on day 28, BSF 25 gr of planting hole BSF, 0.5% MBS, 75 kg/ha urea. On the 45th day, 25 grams of planting hole BSF, 0.5% MBS, 50 kg/ha urea.

100% Synthetic fertilizer treatment. Land that has been tilled and sown is fertilized after the plants are 7, 28 and 45 days old with doses on day 7 100 kg/ha urea, 150 kg/ha sp36 and 100 kg/ha kcl. The 28th day dose, 150 kg/ha urea. Day 45, 100 kg/ha urea.

2.2. Pak Choi

Pak Choi plant land preparation. Qualitative test of IAA production activity was conducted by grown the isolates on TSB media (10 g pep).

Control Treatment. Qualitative test of IAA production activity was conducted by grown the isolates on TSB media (10 g pep).

BSF frass treatment. Qualitative test of IAA production activity was conducted by grown the isolates on TSB media (10 g pep).

Treatment 50% BSF frass and 50% Synthetic fertilizer. Qualitative test of IAA production activity was conducted by grown the isolates on TSB media (10 g peptone, 22 g agar, 2,5 g NaCl, and 1000 mL aquadest). After that the isolates was inoculated at the core of a petri dishes containing TSB media and incubated for 2-5 days at room temperature (28-300 C). Colonies that grow are then dripped with Salkowsky's solution of approximately 1 ml. Pink colonies indicated the isolates was able to produce IAA (positive) (Gravel. 2007)

3. Result and Discussions

The results of the analysis of microbiological content carried out in the IPB lab on liquid fertilizer produced by the bioconversion process by BSF obtained several important microorganisms such as *Azotobacter, Azospirillum*, phosphate solubilizing bacteria, and Lactobacillus which function as rhizo-bacteria that promote plant growth. Some of the benefits of this content such as *Azotobacter* are widely used as nitrogen fixation organisms and provide growth hormones such as IAA and antifungals that can be used by plants for protection from fungal pathogens. *Azospirillum* contained in bioconversion liquid fertilizer is as beneficial as *Azotobacter*, these bacteria are widely used as nitrogen fixing bacteria and produce antifungals which are also used by plants as protection from diseases caused by fungi.

In the fertilizer obtained from the bioconversion process, it is possible that it has been mixed with excretions from the digestive tract of BSF larvae which contain many microorganisms that can produce digestive enzymes. According to Felicia [6], BSF larvae found several enzyme activities such as proteolytic (protein degrading), amylolytic (starchy degrading), chitinolytic (chitin degrading), and cellulolytic (cellulose degrading) are the enzyme that is useful for fertilizer. The chitinolytic content contained in BSF can be used as an anti-pest for insect pests. Testing the microbial content in the results of the organic waste decomposition process contains the following contents in Figure 1:

TEST RESULT REPORT (TRT)
TEST RESULT

Request number : 053/IPBCC/An. Mik/09/2020
Sample number : 227 and 228
Sample code : A and B

MICROBIAL TEST ANALYSIS RESULT
Liquid fertilizer

No. Example	Test Parameter	Result	Unit	Test Method
227	*Azotobacter*	2,1 x 10^3	Cfu/ml	TPC
	Azospirillium	5,0	MPN/ml	MPN
	Phosphate solubilizing bacteria	2,7 x 10^3	Cfu/ml	TPC
	pH	5		
228	*Azotobacter*	4,2 x 10^3	Cfu/ml	TPC
	Azospirillium	8,0	MPN/ml	MPN
	Phosphate solubilizing bacteria	5,0 x 10^3	Cfu/ml	TPC
	pH	5		

Figure 1: MBS test result report.

The activity of chitinolytic enzymes such as chitinase is widely used in agricultural techniques to be used as biocontrol agents for pests such as insect pests and fungus by inhibiting the formation of insect skin and fungal cell walls. Field-scale testing was carried out on two types of commodities, namely corn and Pak Choi to see the effect on plant growth. The effects of growth observed in maize plants were the impact of maize plant height, green color of maize leaves, and flowering of maize plants. Whereas in Pak Choi Plant, several things that were observed were weight, height, and diameter of Pak Choi Plant.

Table 1: Effect of type of fertilization on corn plant height.

Treatment	Individu	Mean (cm)
BSF frass and mbs doses 100% (A)	10	215[a]
BSF frass and mbs doses 50% and Synthetic fertilizer 50% (B)	10	214[a]
Control (C)	10	218[a]

Note: Numbers followed by the same subset are not significantly different

The type of fertilization treatment on plant height for the highest average was seen in treatment A, which was 218 cm, followed by treatments A and B. It can be seen in Table 1. The comparison between the results of treatment and control based on Duncan test analysis showed no difference. The results of the plant data obtained when compared with the details of the bisi-18 variety from the ministry of agriculture are 230 cm.

Table 2: The effect of the type of fertilization on the green color of the leaves of corn plants.

Treatment	Individu	Mean (Leaf color chart)
BSF frass and mbs dosage 100% (A)	10	3,4[b]
BSF frass and mbs dosage 50% and Synthetic fertilizer 50% (B)	10	4,2[a]
Control (C)	10	4,3[a]

Note: Numbers followed by the same subset are not significantly different

Observational data on the treatment of green leaves showed the highest green scale results were found in the control treatment, namely on a scale of 4.3, followed by treatment B on a scale of 4.2 and the lowest on treatment A 3.4. Based on the results of the analysis, it can be seen that the control treatment and the 50% dose treatment did not have a difference, which is also seen in Figure 2. According to Hodge *et al* [7] stated that the availability of nitrogen in the soil was more than 50% lost depending on the type of soil and the environment. The use of BSF frass 50 and mbs 50 gave the same results as the application of 100% Synthetic fertilizer, this was because the results of the test of BSF frass 50 had a low C:N ratio value of 11.27. It can be seen in Table 2.

Based on the quality standard, this value has met the compost standard. In treatment A, the results were different from the other two treatments, which showed symptoms of deficiency of elements such as nitrogen and phosphorus (Figure 3), this was presumably because the nitrogen and phosphorus content in BSF frass 50 and MBS 50 still did not meet the standard standards. Nitrogen deficiency in plants looks yellowish and dry at the bottom of the plant and phosphorus deficiency shows plants having a purplish color line [8]

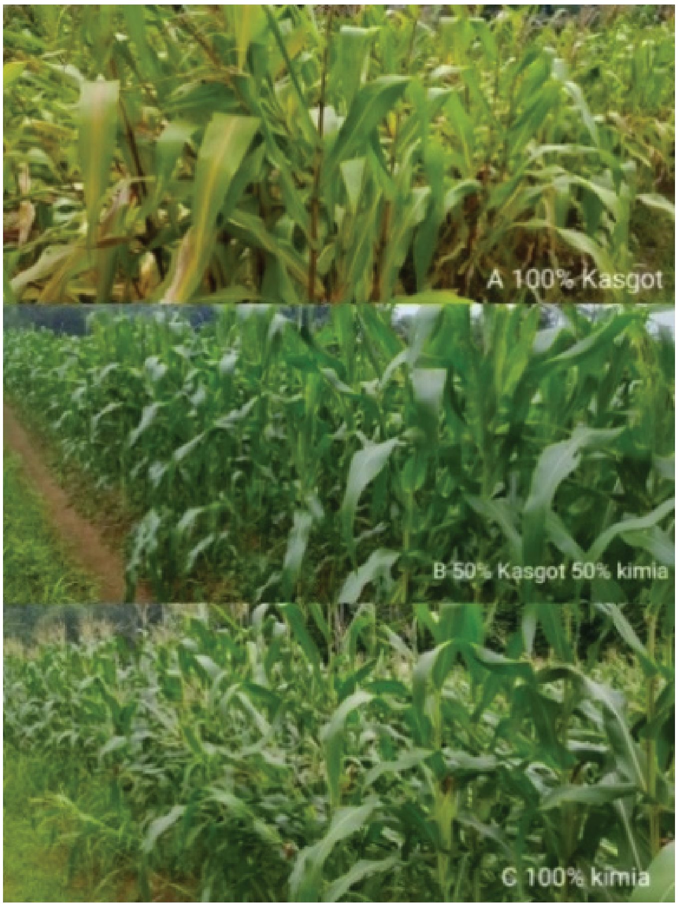

Figure 2: Visual comparison of corn plants for each treatment.

Table 3: The effect of the type of fertilization on the early flowering period of corn plants.

Treatment	Individu	Mean (week)
BSF frass and mbs doses 100% (A)	10	6^a
BSF frass and mbs doses 50% and Synthetic fertilizer 50% (B)	10	$9,1^c$
Control (C)	10	$7,3^b$

Note: Numbers followed by the same subset are not significantly different

Table 4: Comparison of Pak Choi plant weight in each treatment.

Treatment	Individu	Mean (gram)
Control	60	$106,1^b$
BSF frass and mbs doses 50% and Synthetic treatment 50% (B)	60	$483,2^a$
BSF frass 100%	60	$506,8^a$

Note: Numbers followed by the same subset are not significantly different

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Figure 3: Symptoms of nitrogen and phosphorus deficiency in corn plants.

Table 5: Comparison of Pak Choi plant height in each treatment.

Treatment	Individu	Mean (cm)
Control	60	19,7^{b}
BSF frass and mbs doses 50% and Synthetic fertilizer 50% (B)	60	30,7^{a}
BSF frass 100%	60	30,3^{a}

Note: Numbers followed by the same subset are not significantly different

Table 6: Comparison of Pak Choi stem diameter in each treatment.

Treatment	Individu	Mean (cm)
Control	60	5,1^{b}
BSF frass and mbs doses 50% and Synthetic fertilizer 50% (B)	60	9,1^{a}
BSF frass 100%	60	9,1^{a}

Note: Numbers followed by the same subset are not significantly different

Based on the results of observations in this case is the result of flowering on corn plants using BSF frass, it is found that in an average period of 6 weeks there will be flowering on corn plants. This can be seen from Table 3. Observations made include observations of the early flowering period and harvest yields. Observations at the beginning of the flowering period showed that the fastest flowering was obtained from the test on treatment A, namely at the age of 6 weeks or 42 days after planting (DAT) followed by treatment C 52 DAP and then B treatment 64 DAP. Based on the details of varieties issued by agricultural R&D, the flowering period of corn plants begins at the age of 57 days after planting which when compared with control (C) and treatment A, it can be seen that treatment A has a faster flowering start compared to control and details of varieties by agricultural R&D. According to Bruce *et al* [9], several factors that affect maize flowering include drought, population density and lighting, soil fertility.

The observations that have been made on the Pak Choi Plant, Table 4 shows that the average weight in the Pak Choi plant by using additional doses of BSF frass in it can produce a greater weight. Field-scale testing to see the effectiveness of using BSF frass on Pak Choi (*Brassica rapa L.)* plants had better yields than using only Synthetic fertilizers Then when viewed from the height of the Pak Choi Plant, the results obtained are higher Pak Choi Plant, it can be seen in Table 5. This is followed by the results of larger plant diameters. This can be seen from Table 6. Generative observations were also carried out to see the results of the development of corn and Pak Choi Plant based on the treatment test. The use of frass can increase crop productivity and reduce the use of Synthetic fertilizers. It can be seen in Figure 4, the results from the use of frass have a fresher appearance and a larger plant size compared to using only Synthetic fertilizers.

Figure 4: Appearance of Pak Choi Plant in each treatment.

Observations on the root area were also carried out to see whether the microorganism content in the frass had a role in root growth. It can be seen in Figure 5 that the root of the Pak Choi plant using frass looks longer and the root fibre is more. According to Gomes *et al* [10], the application of plant growth-promoting bacteria can increase the growth of shoots and roots in plants. Plant roots with a higher number of fibers can increase the ability of plants to obtain nutrients in the soil for crown growth. The use of frass on Pak Choi Plant also had better shoot and root growth results compared to using only NPK in the experiment conducted by Agustiyani *et al* [2]. This will make the plant stronger and can reach the source in the soil.

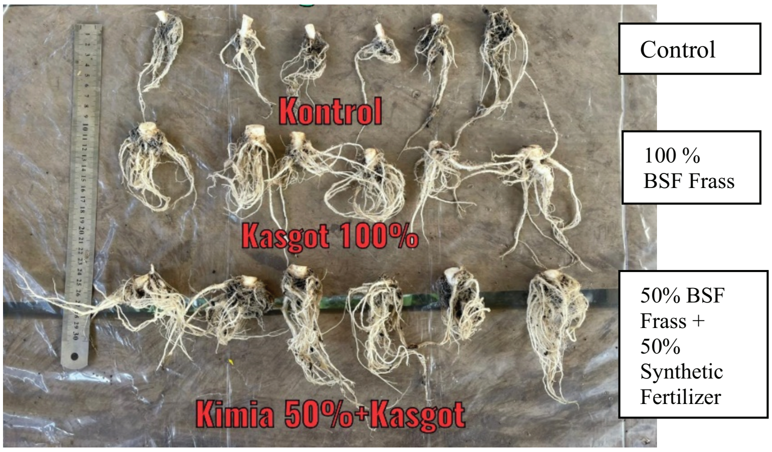

Figure 5: Appearance of Pak Choi Plant roots in each treatment.

4. Conclusion

The experimental results for the field scale show that the application of Black Soldier Fly frass and Micro Bio Stimulant as Liquid Fertilizer can increase plant vegetative growth and reduce the use of Synthetic fertilizers. Treatment with the use of 50% BSF and 50% Synthetic fertilizer is the best combination for this growth. Giving BSF (Black Soldier Fly) can also play a role in accelerating the flowering process of the test plant and gives and provide good growth. In Fact decomposition of organic waste from every resources through bioconversion with Black Soldier Fly larvae stage is faster comparing to others methodology. Through bioconversion, we can improve waste management while at the same time obtaining high quality fertilizers in a short time.

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