AGROTECH
ISSN: 2773-4870 **eISSN:** 2821-3106
DOI: https://doi.org/10.53797/agrotech.v5i1.10.2026

Effects of Different Application Rates of Black Soldier Fly Frass on Growth of *Brassica juncea*

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Received 5 May 2026; Accepted 27 June 2026; Available online 30 June 2026

Abstract: Excessive reliance on chemical fertilizers in modern agriculture can contribute to nutrient wastage, soil degradation, and environmental pollution. Black soldier fly frass fertilizer (BSFFF), produced through the bioconversion of organic bio-waste by black soldier fly larvae, offers a nutrient-rich organic alternative that may support soil fertility and crop growth. This study evaluated the effects of BSFFF on mustard growth under greenhouse conditions at the Malaysian Agricultural Research and Development Institute (MARDI). Four treatments were tested: an unfertilized control (NF), NPK 16:16:16 fertilizer at 2.5 g (NPK), BSF frass at 2.5 g (BSF 2.5), and BSF frass at 5.0 g (BSF 5.0). Each treatment was replicated three times. Plant height, number of leaves, stem diameter, plant fresh weight, and root fresh weight were measured. Overall, plants treated with NPK showed the highest growth performance for plant height, stem diameter, plant fresh weight, and root fresh weight. However, both BSF frass treatments produced better growth than the unfertilized control, indicating that BSFFF supplied nutrients that supported mustard development. The lower performance of the BSF frass treatments may be associated with the use of fresh frass, which may require further composting to improve its stability and nutrient availability. Observations also indicated that aphids and whiteflies were more frequently found on plants receiving NPK fertilizer than on plants treated with BSF frass. Although NPK fertilizer produced the strongest growth response, BSFFF demonstrated potential as an organic fertilizer for mustard cultivation. Further studies should evaluate composted BSF frass, nutrient release patterns, and its effects on crop yield and pest incidence.

Keywords: Black soldier fly, frass, mustard plant, bio-compost, plant growth

1. Introduction

Black soldier fly or also known as Hermetia illucens is a common fly that can be found in Europe and Asian region. Unlike the common housefly, it does not disturb and affect human because they avoid meeting humans and can be found in various habitat such as forest, urban and sub-urban areas. These flies are categorized as beneficial insects like bees because of their contribution to the environment by breaking down organic matter and waste into biomass such as protein and oil and ultimately helping to reduce waste. Black soldier fly frass fertilizer (BSFFF) is the result of the conversion of organic bio-waste using BSF larvae into an organic fertilizer that is rich in nutrients and safe for the environment (Anyega et al., 2021). Anyega et al. (2021) also stated that a large amount of frass, which is a mixture of substrate, feces, and exuvia that is not consumed by the reproductive system of insects, and it has the potential to increase soil and crop productivity.

Although it has many positive effects, the use of BSFFF is less practiced in the agricultural sector especially in Malaysia because it is still under study and most farmers prefer to use chemical fertilizers such as NPK fertilizers because it is easier to get and gives a more immediate effect. Composting for black soldier fly frass, unlike traditional composting, only requires 5 weeks to produce stable organic fertilizer from organic waste, unlike the 8-24 weeks required for normal composting (Anyega et al., 2021). There are several studies on the effect of black soldier fly frass as a fertilizer on some

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types of crops such as tomatoes and peppers but the effectiveness of BSFFF in increasing the development, production, and nutritional value of mustard green is still unknown.

Therefore, the purpose of this study is to determine the effect of black soldier fly frass fertilizer on mustard green. This research can help provide a broad view of the goal of sustainable agriculture by reducing reliance on chemical fertilizers and their negative impact on the environment.

2. Materials and Methods

2.1 Experiment location

The experiment was conducted in greenhouse A13, Agrobiodiversity and Environment Research Centre, MARDI Serdang with a temperature range between 30 - 37°C and a relative humidity (RH) of 60-70%

2.2 Treatment groups

There were four (4) groups of treatment namely the control group (NF), the NPK group (NPK), the BSF group with 5.0 grams of frass (BSF 5.0) and 2.5 grams of frass (BSF 2.5). For the NPK group, NPK fertilizer with a ratio of 16:16:16 was used and the control group was unfertilized treatment. Each treatment had 3 replicates and was conducted in the greenhouse. The NPK 16:16:16 fertilizer was given according to the recommended quantity on the fertilizer package which is 2.5 grams.

2.3 Data collection

Data were taken in the second and fourth weeks after the transfer of mustard seedlings from the nursery medium to the planting pot. Several parameters have been taken. The height of the tree was measured from the ground to the top of the leaf using a measuring tape. A vernier caliper was placed 2cm from the ground and used to measure the diameter of the tree trunk. Leaf area was measured by taking the length and width of the largest leaf for each plant and calculated using the formula stated by Dzepe et al. (2022), Leaf =(nLl)/4; where ratio = 3.14, L = length of the largest leaf and l = Width of the largest leaf. After harvesting, the wet mass of plants and roots was taken using a digital scale according to the method stated by Tangahu (2016). Root length was taken using a measuring tape.

2.4 Statistical analysis

All data were analyzed using IBM® SPSS® Statistics Version 27 (IBM Corp., New York, NY, USA). Data will be subjected to one-way ANOVA with Tukey HSD post-hoc test to evaluate independent variables. The values will be expressed as standard error of the mean (SEM) and will be considered significant at $p < 0.05$.

3. Results and Discussions

3.1 *P.xylostella* and *D.semiclausum* population

After 43 days, the effect of various fertilizers on mustard was observed. Plant growth is evaluated through several parameters, namely plant height, number of leaves, leaf area, plant stem diameter, plant and root wet mass, and root length. Figure 1 shows a bar graph representing the height of mustard using four different treatments. Height data was taken once a week for 4 weeks. All treatment groups showed a consistent increase in height, but the highest height was from the BSF 2.5 group, with a total height of 121.7cm at week 4, compared to NF, NPK, and BSF 5.0 which were 91.9cm, 88.7cm, and 107cm.

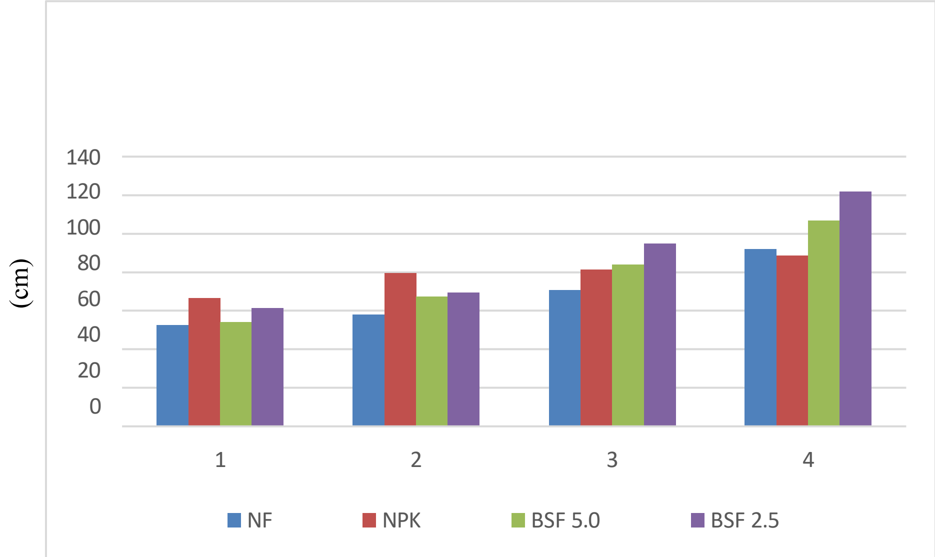

Fig. 1: Effects of different treatments on mustard plant height (cm) in four weeks

For the number of leaves parameter, Figure 2 shows the non-uniformity in the number of leaves. The highest total number of leaves can be seen at NPK 2.5, with 33 leaves in the second week. The decrease in the number of leaves is due to some wilted and infected leaves that need to be removed.

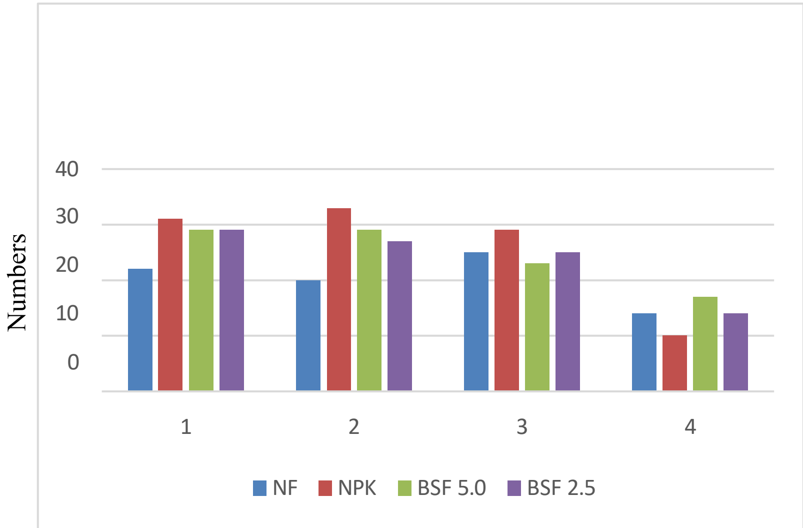

Fig. 2: Effect of different treatments on number of mustard leaves in four weeks.

Figure 3 shows the leaf area of four different treatment groups with the mean value ± SEM. NPK showed the highest total leaf area compared to NF, BSF 5.0, and BSF 2.5, and the lowest leaf area was from the NF group. For the control group, namely NF, the leaf area was the lowest at 93.62±23.60cm2, while for BSF 2.5, it was 163.86±31.39cm2. The second highest total leaf area was BSF 5.0 with 294.07±44.13cm2 while the highest leaf area comes from NPK with 299.04±42.16cm2. Analysis of variance, one-way ANOVA showed a statistically significant difference $F(3,12)=22.33$, $p < .001$) between groups. There were statistically significant differences between BSF 2.5 and NPK groups ($p<.001$), between BSF 5.0 and NF ($p<0.14$), and between BSF 5.0 and NPK ($p<.005$). There was no significant difference between BSF 2.5 and BSF 5.0 ($p<0.432$).

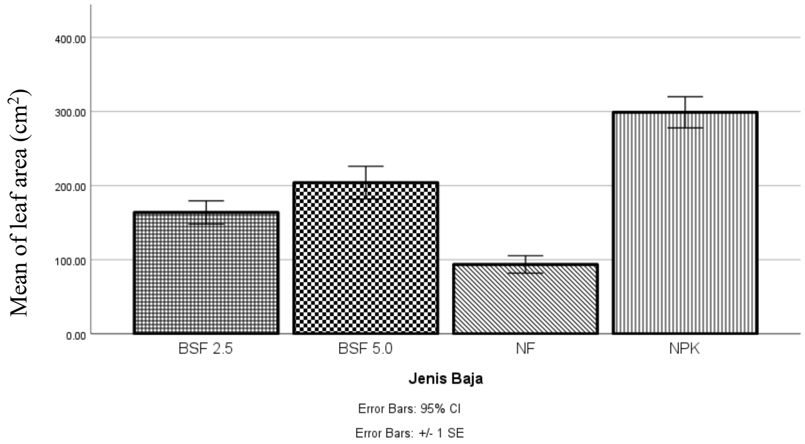

Fig. 3: Effects of different treatments on mean of leaf area (cm^2)

As shown in figure 4, it shows the effect of different treatments on stem diameter. NPK showed better results and increased rapidly from week one to week four compared to NF, BSF 2.5, and BSF 5.0. Stem diameter for the NPK group peaked at 2.67±0.35cm, followed by BSF 5.0 at 2.15±0.61cm. BSF 2.5 is the third highest with a stem diameter of 1.57±0.04cm, while the stem diameter for NF is 1.48±0.06cm. Post hoc analysis revealed statistically significant differences between groups. $F(3,12) = 9.885$, $p < .001$) between groups. There was a statistically significant difference between BSF 2.5 and NPK groups ($p<.004$) and between NF and NPK ($p<0.002$).

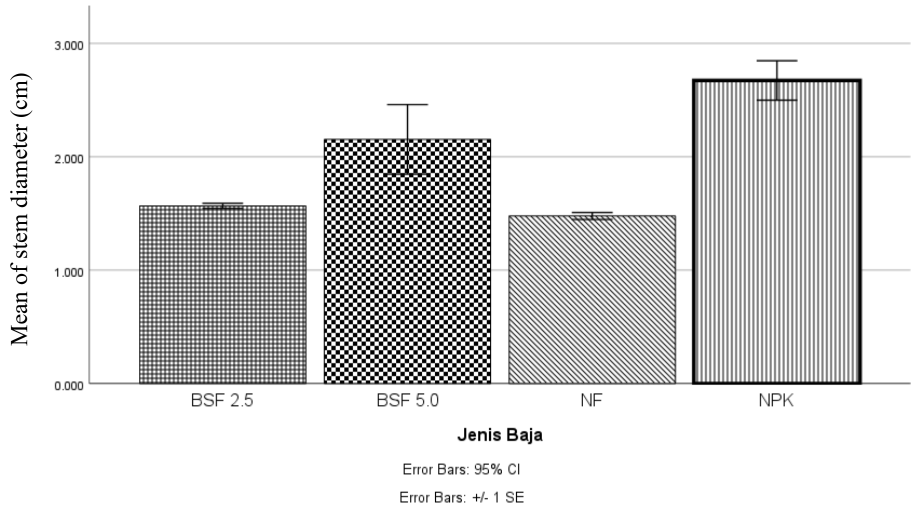

Fig. 4: Effects of different treatments on mean of stem diameter (cm)

Another parameter that has been taken is the wet mass of plants and roots. From the bar graph in Figure 5, the highest values for both plant and root wet mass came from the NPK group, followed by BSF 5.0, BSF 2.5, and NF. The total wet mass of NPK was 139g, followed by BSF 5.0, BSF 2.5 and NF, where 90g, 67g, and 21g, respectively. As for root length, it shows the opposite result; the highest result was BSF 5.0 with 67.4cm, followed by NF, NPK, and BSF 2.5 with 59.9cm, 39.3cm, and 37.6cm, respectively.

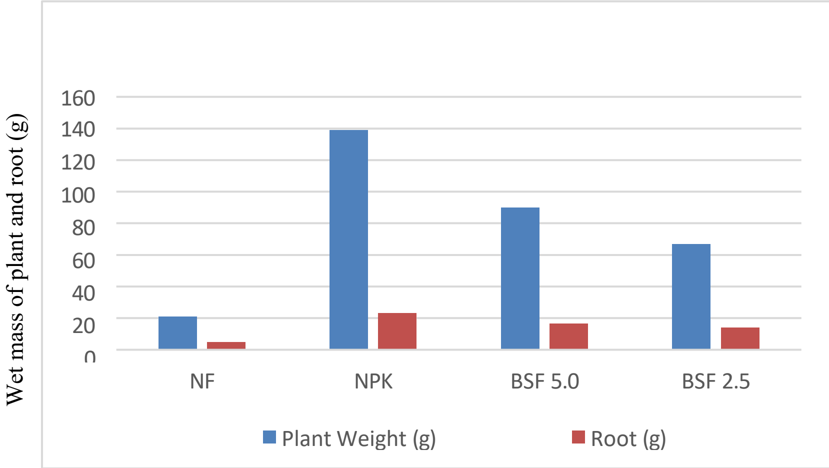

Fig. 5: Effects of different treatments on wet mass of mustard plant and root (g)

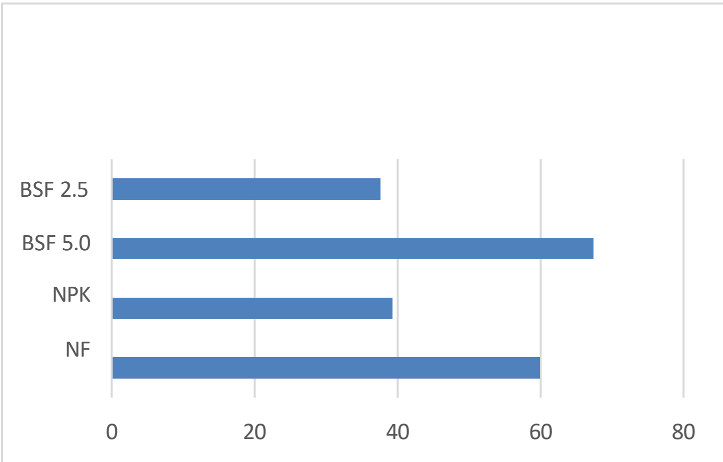

Fig. 6: Effects of different treatments on root length (cm)

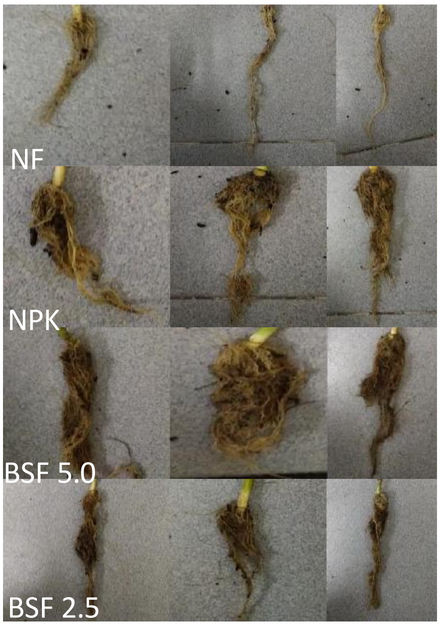

Fig. 7: Root conditions for different treatments, NF, NPK, BSF 5.0 and BSF 2.5

Most of the parameters showed that the NPK group had a greater effect on mustard growth in number, diameter of plant stem, and wet mass of plants and roots. In some investigations, the lack of compost stability may have contributed to the low growth (Lopes et al., 2022). In this experiment, frass was produced fresh rather than composted afterwards. Composting treatment can ensure the stability and maturity of the frass. Furthermore, the nutritional content depends on the type of food the larvae eat. Microbial indicators are often used to determine stability (Wu et al., 2000). Mature compost is a material that does not have negative effects when used in plant media such as the presence of phytotoxic chemicals and the destruction of organic matter in plant media (Wichuk & McCartney, 2010). Because it degrades quickly and contains potentially phytotoxic chemicals, frass is a biologically unstable product. Compared to NPK 16-16-16, which has been balanced with the same ratio of the three main nutrients that plants need to grow.

The number of leaves in the NPK treatment was decreased because some leaves were affected for some reason. Throughout the observation, most plant pests, such as aphids and whiteflies, tended to come to plants that had been treated with NPK compared to BSF 2.5 and BSF 5.0. According to Gärttling et al. (2020), chitin is often found in insect frass. Therefore, due to the action of chitin, chitinase can strengthen the plant's defense mechanism by deactivating the fungal cell skin without damaging the plant (Kumar et al., 2018). Various studies show that chitin protects plants from disease, insect pests, and physiological issues. In addition, NPK is also an inorganic fertilizer that releases nutrients quickly compared to black soldier fly frass (Ichwan et al., 2022). This can cause excessive application of fertilizers on plants. Although NPK contributes to the reduction of leaf volume, it has a high leaf area due to its higher phosphorus content, it plays an important role in the respiration process of adenosine triphosphate, which increases leaf area and the rate of photosynthesis (Olowoboko et al., 2017).

Although the longest root length came from BSF 5.0, the root wet mass was lower compared to the NPK treatment. NPK has thicker roots based on root wet mass, which can contribute to plant growth because thicker roots can absorb more nutrients. This can be proven by the wet mass graph of the tree which shows the NPK treatment gives better results compared to BSF 5.0, BSF 2.5, and NF. BSF 5.0 had the longest roots compared to the other three treatment groups. The water content in cells will increase with the absorption of water and increased nutrients, and this water will be used for various cell activities, including photosynthesis and the distribution of photosynthesis products throughout the plant (Barita et al., 2018). Therefore, this is the reason for the increase in the wet mass of the plant.

4. Conclusion

In conclusion, although the NPK treatment showed better results on mustard compared to the BSF 2.5 and BSF 5.0 treatments, the effects of the evaluated parameters proved that there were nutrients available in the BSF frass when compared to the control group. Based on several studies, there are reports stating that BSF frass can increase plant growth through soil fertilization and reduce plant disease attacks. As stated by Rosmiati et al. (2017), that lettuce plants grown with BSF frass from coffee husks do well, as it has been proven that the BSFF treatment improves compared to the control treatment. This distribution highlights the richness and diversity of insect life in the sampled area. However, it also suggests potential variations in abundance and ecological significance among different insect orders, warranting further investigation into the local ecosystem dynamics and conservation priorities.

Acknowledgement

Much grateful to the Director of the Agrobiodiversity & Environment (BE) Research Center and the Deputy Director of the Biological Control Program for their support in conducting this experiment. I would also like to thank the Biological Control Program staff for their direct and indirect contributions to the fieldwork or laboratory work.

Conflict of Interest

The authors declare no conflicts of interest.

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