Effectiveness of BSF Frass, Bioslurry, and Organic Compost at Different Application Rates on the Growth and Biomass of Water Spinach (*Ipomoea reptans Poir*)

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Abstract *: Organic waste can be processed into environmentally friendly fertilisers that support plant growth and reduce environmental pollution. This study evaluated the effects of black soldier fly frass, bioslurry, and organic compost at different application rates on the growth and biomass of water spinach (Ipomoea reptans Poir.). The experiment was conducted from November 2025 to March 2026 at PT Swen Inovasi Transfer, Bogor, Indonesia, using a completely randomised design. Treatments consisted of three organic fertiliser types applied at 0, 100, 200, and 300 g per polybag. Plant height, leaf length, number of leaves, and fresh weight were observed. Data were analysed using analysis of variance followed by Duncan's Multiple Range Test at the 5% significance level. Fertiliser type, application rate, and their interaction did not significantly affect plant height, leaf length, or number of leaves, but significantly influenced fresh weight. The highest fresh weight of 8.40 g was obtained with 200 g frass and 200 g bioslurry treatments. These results indicate that frass and bioslurry at 200 g per polybag are promising for increasing water spinach fresh biomass.*

Keywords *: Bioslurry; Fresh Weight; Water Spinach; Frass; Organic Compost.*

Abstrak: *Limbah organik dapat diolah menjadi pupuk ramah lingkungan yang mendukung pertumbuhan tanaman sekaligus mengurangi pencemaran lingkungan. Penelitian ini mengevaluasi pengaruh frass lalat tentara hitam, bioslurry, dan kompos organik pada berbagai dosis terhadap pertumbuhan dan biomassa kangkung darat (Ipomoea reptans Poir.). Penelitian dilaksanakan pada November 2025 hingga Maret 2026 di PT Swen Inovasi Transfer, Bogor, Indonesia, menggunakan Rancangan Acak Lengkap. Perlakuan terdiri atas tiga jenis pupuk organik dengan dosis 0, 100, 200, dan 300 g per polibag. Parameter yang diamati meliputi tinggi tanaman, panjang daun, jumlah daun, dan bobot segar. Data dianalisis menggunakan analisis ragam dan dilanjutkan dengan Uji Jarak Berganda Duncan pada taraf 5%. Jenis pupuk, dosis aplikasi, dan interaksinya tidak berpengaruh nyata terhadap tinggi tanaman, panjang daun, dan jumlah daun, tetapi berpengaruh sangat nyata terhadap bobot segar. Bobot segar tertinggi sebesar 8,40 g diperoleh pada perlakuan frass 200 g dan bioslurry 200 g. Hasil ini menunjukkan bahwa frass dan bioslurry dosis 200 g per polibag berpotensi meningkatkan biomassa segar kangkung darat.*

Kata kunci: *Bioslurry; Bobot Segar; Kangkung Darat; Frass; Kompos Organik.*

INTRODUCTION

Water spinach (Ipomoea reptans Poir.) is a leafy vegetable widely consumed by the public because it is easy to cultivate, has a relatively short harvesting period, and has economic value for both household-scale and commercial farming. As a short-duration vegetable crop, the growth of water spinach is strongly influenced by nutrient availability, growing medium conditions, water supply, and environmental factors during cultivation. Adequate nutrient availability, particularly nitrogen, phosphorus, and potassium, plays an important role in vegetative tissue formation, leaf development, and biomass accumulation (Wirawan et al., 2021; Fayza et al., 2022). Therefore, fertilizer management is an important factor in improving the growth and yield of water spinach.

Continuous use of inorganic fertilizers can provide nutrients rapidly, but in the long term it may reduce soil quality if not balanced with organic matter inputs. Organic fertilizers offer a more environmentally friendly alternative because they not only supply nutrients but also improve the physical, chemical, and biological properties of soil. Organic amendments can increase soil organic matter, improve soil structure, enhance water-holding capacity, and support soil microbial activity (Diacono & Montemurro, 2010). In addition, the utilization of organic waste as fertilizer is an important environmental management strategy because it can reduce waste generated from household, agricultural, and livestock sectors (Susilo et al., 2022).

Several types of organic fertilizers have potential for use in vegetable cultivation, including black soldier fly frass, bioslurry, and organic compost. Black soldier fly frass, locally known as kasgot, is a residue from the bioconversion of organic waste by black soldier fly larvae. It contains organic matter and nutrients that may support plant growth. Previous studies have shown that BSF frass can supply nutrients, increase soil microbial activity, and support plant development (Beesigamukama et al., 2021; Fauzi et al., 2022). Bioslurry is a residue from anaerobic fermentation during biogas production and still contains macronutrients and organic matter, making it suitable for use as an organic fertilizer or soil amendment. Digestate or biogas residue has been reported to provide relatively available nitrogen and can support crop growth when applied at an appropriate rate (Möller & Müller, 2012; Sazli et al., 2023). Organic compost, meanwhile, is produced through aerobic decomposition of organic materials and is commonly used to improve soil fertility and growing medium conditions (Ansyari & Jasmi, 2022).

The effectiveness of organic fertilizers depends on raw material characteristics, processing method, maturity level, nutrient content, and application rate. A low application rate may not provide sufficient nutrients for plant requirements, whereas an excessive rate may create imbalances in the growing medium, including changes in moisture, aeration, pH, or nutrient concentration. Testing different application rates is therefore important to determine an appropriate dose for plant growth. In leafy vegetable cultivation, plant response can be assessed not only through plant height, leaf length, and number of leaves, but also through fresh weight as an indicator of fresh biomass accumulation.

Several studies have reported the benefits of individual organic fertilizers for plant growth. Frass has been reported to increase growth and fresh weight of mustard greens (Fauzi et al., 2022), bioslurry has shown potential in supporting oil palm seedling growth (Sazli et al., 2023), and organic compost has been found to affect the growth and yield of water spinach (Ansyari & Jasmi, 2022). However, studies comparing frass, bioslurry, and organic compost simultaneously at different application rates on the growth and biomass of water spinach remain limited. Such comparison is important for identifying the most suitable type and rate of organic fertilizer for water spinach cultivation.

Based on these considerations, this study aimed to analyze the effectiveness of frass, bioslurry, and organic compost at different application rates on the growth and biomass of water spinach (Ipomoea reptans Poir.). The observed parameters included plant height, leaf length, number of leaves, and fresh weight. The findings are expected to provide information on organic fertilizer types and application rates that are potentially useful for environmentally friendly water spinach cultivation.

RESEARCH METHOD

his study was conducted from November 2025 to March 2026 at PT. Swen Inovasi Transfer (Saung Hijau), Pagelaran Village, Ciomas District, Bogor Regency, West Java, Indonesia. The study used an experimental method with a completely randomized design. The treatments were arranged based on combinations of organic fertilizer type and application rate. The organic fertilizers consisted of frass, bioslurry, and organic compost. The fertilizer rates were 100, 200, and 300 g per polybag. A control treatment without organic fertilizer, or 0 g per polybag, was also included. Thus, the experiment consisted of ten treatments: control, frass 100 g, frass 200 g, frass 300 g, bioslurry 100 g, bioslurry 200 g, bioslurry 300 g, compost 100 g, compost 200 g, and compost 300 g. Each treatment was replicated three times, resulting in 30 experimental units. The organic fertilizers used in the study are shown in Figure 1.

(a) (b) (c)

Figure 1. Organic fertilizers used in the study: (a) bioslurry, (b) frass, and (c) organic compost.

The growing medium in each polybag consisted of soil, burned rice husk, eggshell powder, and lime in the same composition for all treatments. The basal medium was kept uniform across polybags so that differences in plant growth could be associated with the type and rate of organic fertilizer applied. The fertilizer rates were applied according to the treatments: 0, 100, 200, and 300 g per polybag. Polybags measuring 30 × 30 cm were used. The plant material used was water spinach (Ipomoea reptans Poir.). The tools used included 30 × 30 cm polybags, seedling trays, rulers, a digital scale, a soil tester, a room thermometer, a sprayer, a camera, and stationery. The materials included water spinach seeds, soil, burned rice husk, eggshell powder, lime, frass, bioslurry, organic compost, and water.

Water spinach seeds were first germinated for seven days to obtain relatively uniform seedlings. Uniform seedlings were then transplanted into polybags containing the growing medium and fertilizer according to the assigned treatment. Each polybag was planted with three water spinach seedlings. In this study, one polybag was considered one experimental unit. Data on plant height, leaf length, and number of leaves were obtained from the average of the three plants in each polybag. Plant maintenance consisted of regular watering in the morning and afternoon, along with observation of plant condition throughout the study. Growth observations were conducted every seven days for four weeks. The observed parameters included plant height, leaf length, number of leaves, and fresh weight. Plant height was measured from the base of the stem to the highest growing point using a ruler. Leaf length was measured on fully developed leaves. The number of leaves was counted based on leaves that had fully expanded. Fresh weight was measured at the end of the study by weighing the harvested fresh plants. Statistical analysis was performed on the final observation data for each parameter. Environmental parameters, including air temperature, humidity, and growing medium pH, were also recorded as supporting data to describe the conditions during the experiment. The number of replications was determined using Federer's formula:

a. $(t-1)(r-1) \geq 15$ b.

where (t) is the number of treatments and (r) is the number of replications. The data were statistically analyzed using SPSS version 26. Prior to analysis of variance, the data were tested for normality using the Shapiro–Wilk test and for homogeneity using Levene's test. When the assumptions of normality and homogeneity were met, analysis of variance was performed at the 5% significance level. Because the treatments consisted of combinations of fertilizer type and application rate, along with a control without fertilizer, the analysis was conducted across all treatments to determine differences in water spinach growth response. When significant differences were detected, Duncan's Multiple Range Test was used at the 5% level to identify differences among treatments.

RESULTS AND DISCUSSION

Growth observations of water spinach (Ipomoea reptans Poir.) were made on four parameters: plant height, leaf length, number of leaves, and fresh weight. The analyzed data represent the mean final observations for each combination of organic fertilizer type and application rate. The mean growth and biomass of water spinach in each treatment are presented in Table 1.

Table 1. Mean growth and biomass of water spinach under different organic fertilizer types and application rates

Fertilizer type	Rate (g)	Plant height (cm)	Leaf lenght (cm)	Number of leaves (helai)	Fresh weight (g)
Bioslurry	0	12,3	4,5	7,6	4,4
Bioslurry	100	12,8	4,6	7,4	6,4
Bioslurry	200	11,1	4,4	7,1	8,4
Bioslurry	300	12,7	4,6	7,5	7,4
Frass	0	7,5	4,5	7,2	3,4
Frass	100	11,9	4,6	7,3	5,4
Frass	200	14,7	4,8	7,7	8,4
Frass	300	14,0	4,7	7,6	7,4
Organic compost	0	10,5	4,5	7,3	4,6
Organic compost	100	12,2	5,0	7,6	5,6
Organic compost	200	11,7	4,8	7,5	7,3
Organic compost	300	12,5	4,1	7,3	6,6

As shown in Table 1, plant height ranged from 7.5 to 14.7 cm. The highest numerical value was observed in the 200 g frass treatment, while the lowest was observed in the 0 g frass treatment. Leaf length ranged from 4.1 to 5.0 cm, with the highest value recorded in the 100 g organic compost treatment. The number of leaves ranged only from 7.1 to 7.7, indicating relatively small variation among treatments. In contrast, fresh weight showed a wider range, from 3.40 to 8.40 g. The highest fresh weight was obtained from the 200 g frass and 200 g bioslurry treatments, while the lowest was recorded in the 0 g frass treatment.

These results indicate that differences in fertilizer type and application rate did not produce large differences in plant height, leaf length, or number of leaves. A clearer response was observed in plant fresh weight. This pattern suggests that the response of water spinach to organic fertilizer application was more evident in fresh biomass accumulation than in simple morphological traits such as plant height, leaf length, and number of leaves. The analysis of variance for all growth parameters is presented in Table 2.

Table 2. Analysis of variance for the effects of fertilizer type, application rate, and their interaction on water spinach growth

Parameter	Source of variation	SS	df	MS	F	p
Plant height	Fertilizer	43,435	2	21,718	1,727	0,182
	Rate	36,662	3	12,221	0,972	0,408
	Fertilizer × Rate	82,975	6	13,829	1,100	0,366
	Error	1659,608	132	12,573		
Leaf length	Fertilizer	0,437	2	0,219	0,122	0,885
	Rate	0,916	3	0,305	0,171	0,916
	Fertilizer × Rate	4,327	6	0,721	0,403	0,876
	Error	235,985	132	1,788		
Number of leaves	Fertilizer	0,283	2	0,141	0,085	0,918
	Rate	0,463	3	0,154	0,093	0,964

	Fertilizer × Rate	2,362	6	0,394	0,238	0,963
	Error	218,530	132	1,656		
Fresh weight	Fertilizer	2,527	2	1,264	31,158	<0,001
	Rate	77,512	3	25,837	637,084	<0,001
	Fertilizer × Rate	5,324	6	0,887	21,879	<0,001
	Error	0,973	24	0,041		

Note. SS = sum of squares; df = degrees of freedom; MS = mean square. A p-value below 0.05 indicates a significant effect.

The analysis of variance showed that fertilizer type, application rate, and their interaction did not significantly affect plant height, leaf length, or number of leaves. For plant height, the p-values for fertilizer type, application rate, and their interaction were 0.182, 0.408, and 0.366, respectively. For leaf length, the corresponding p-values were 0.885, 0.916, and 0.876. For number of leaves, the p-values were 0.918, 0.964, and 0.963. Since all values were greater than 0.05, differences in the means among treatments could not be considered statistically significant.

By contrast, fertilizer type, application rate, and their interaction had a highly significant effect on fresh weight, with p-values below 0.001. This result indicates that plant fresh weight was influenced by specific combinations of fertilizer type and application rate. Because the interaction between fertilizer type and application rate was significant, interpretation of fresh weight should focus mainly on treatment combinations rather than on the main effects of fertilizer type or application rate alone. The results of Duncan's Multiple Range Test for fresh weight are presented in Table 3.

Table 3. Duncan's Multiple Range Test for water spinach fresh weight under different combinations of organic fertilizer type and application rate

Treatment	Fresh weight (g)	DMRT group
Frass 0 g	3.40	a
Bioslurry 0 g	4.40	ab
Organic compost 0 g	4.63	ab
Frass 100 g	5.40	bc
Organic compost 100 g	5.60	bc
Bioslurry 100 g	6.40	cd
Organic compost 300 g	6.63	cd
Organic compost 200 g	7.30	de
Bioslurry 300 g	7.40	de
Frass 300 g	7.40	de
Bioslurry 200 g	8.40	e
Frass 200 g	8.40	e

Note. Values followed by the same letter are not significantly different according to Duncan's Multiple Range Test at the 5% level.

Table 3 shows that the 200 g bioslurry and 200 g frass treatments produced the highest fresh weight, each at 8.40 g, and were included in the same DMRT group. This indicates that the two treatments did not differ significantly from each other but produced higher biomass responses than most other treatments. The 0 g frass treatment produced the lowest fresh weight, 3.40 g, and was included in group a. These results suggest that the 200 g application rate of frass and bioslurry was the most promising combination for increasing the fresh biomass of water spinach under the experimental conditions. The non-significant results for plant height, leaf length, and number of leaves suggest that organic fertilizer treatments did not produce sufficiently large vegetative morphological changes to result in statistical differences. Numerically, the 200 g frass treatment showed the highest plant height, 14.7 cm, and the highest number of leaves, 7.7. However, because the ANOVA results showed p-values greater than 0.05, this pattern should be interpreted only as a numerical tendency rather than as evidence of a statistically significant treatment effect.

This result may be explained by the fact that plant height, leaf length, and number of leaves do not always change rapidly in short-duration leafy vegetables. These traits can be influenced by seedling uniformity, light intensity, water availability, plant density within the polybag, and environmental conditions during cultivation. When these factors are relatively uniform, morphological responses among treatments may appear similar despite differences in organic fertilizer type and application rate. Thus, the present study indicates that organic fertilizer variation had a clearer effect on fresh biomass than on simple morphological parameters.

Fresh weight is a more integrative parameter of plant growth because it reflects water uptake, new tissue formation, plant vigor, and biomass accumulation during the growth period. Unlike plant height or number of leaves, which represent specific morphological traits, fresh weight captures a broader growth response. Therefore, the significant effect on fresh weight suggests that organic fertilizer application more strongly influenced biomass accumulation and tissue water content than stem elongation or leaf number formation.

The 200 g frass treatment produced the highest fresh weight together with the 200 g bioslurry treatment. This response may be associated with the characteristics of frass as an organic fertilizer derived from black soldier fly larval bioconversion, which contains organic matter and nitrogen that can support vegetative growth. Nitrogen is essential for chlorophyll formation, protein synthesis, cell division, and tissue development. This finding is consistent with Fauzi et al. (2022), who reported that frass application increased the growth and fresh weight of mustard greens. Supporting fertilizer quality data also showed that frass contained 2.34% total nitrogen and had a C/N ratio of 12, suggesting its potential to supply nitrogen and undergo relatively faster mineralization than organic materials with higher C/N ratios.

The 200 g bioslurry treatment also produced the same high fresh weight as the 200 g frass treatment. Bioslurry is an anaerobic fermentation residue containing organic matter and macronutrients that may support plant growth. In addition to supplying nutrients, bioslurry may improve the physical properties of the growing medium, particularly its ability to retain water. Adequate water availability supports cell turgor, tissue expansion, and fresh biomass accumulation. This agrees with Fitriyah et al. (2024) and Marpaung et al. (n.d.), who reported that bioslurry can support plant growth through its contribution to nutrient availability and improvement of the growing medium. Supporting fertilizer quality data showed that bioslurry contained 28.07% organic carbon and had a C/N ratio of 22.6, indicating its potential as a source of organic matter and a soil amendment.

Organic compost also increased fresh weight up to the 200 g application rate, reaching 7.30 g, although this value remained lower than those of frass and bioslurry at the same rate. Organic compost functions as a soil amendment by improving structure, porosity, water retention, and microbial activity in the growing medium. Ansyari and Jasmi (2022) reported that compost application improved the growth and yield of water spinach. However, in the present study, the response to compost was lower than the responses to frass and bioslurry. This may be due to differences in nutrient content, mineralization rate, or nutrient release patterns among the organic fertilizers. Supporting data showed that the compost contained 2.16% total K_2O and 25.39% organic carbon, suggesting that it may support plant growth mainly as a soil amendment and potassium source.

Interestingly, the 300 g rate did not produce the highest fresh weight for any of the three organic fertilizers. In the frass treatment, fresh weight decreased from 8.40 g at 200 g to 7.40 g at 300 g. In the bioslurry treatment, fresh weight also decreased from 8.40 g to 7.40 g. In the compost treatment, fresh weight declined from 7.30 g to 6.63 g. This pattern indicates that increasing the rate of organic fertilizer does not necessarily increase plant biomass. Physiologically, an excessive organic fertilizer rate may create imbalances in the growing medium. Possible explanations for the lower response at 300 g include excessive moisture, disruption of the air–water balance in the medium, asynchronous nutrient release relative to plant demand, or accumulation of certain compounds that may inhibit root function. However, these explanations remain tentative because the study did not measure medium water content, electrical conductivity, salinity, or microbial activity.

Environmental conditions during the study were generally supportive of water spinach growth. The mean temperature was 27°C, relative humidity was 73%, and the growing medium pH was 7. These values fall within a suitable range for water spinach growth. Appropriate temperature supports physiological processes such as photosynthesis, respiration, and enzyme activity. Adequate humidity helps maintain water balance in plant tissues, while neutral pH supports the availability of macronutrients such as nitrogen, phosphorus, and potassium. The relatively stable environmental conditions suggest that differences in fresh weight were more closely related to the combinations of fertilizer type and application rate than to extreme environmental factors.

Table 4. Environmental parameters during the study

Environmental parameter	Mean value
Temperature	27°C
Humidity	73%
Soil pH	7

Overall, the findings indicate that frass, bioslurry, and organic compost have potential as environmentally friendly organic fertilizers for water spinach cultivation. Their effectiveness, however, was more evident in fresh weight than in plant height, leaf length, or number of leaves. The 200 g per polybag rate was the most promising application rate because it produced the highest fresh weight in the frass and bioslurry treatments. These findings suggest that the success of organic fertilizer use depends not only on fertilizer type but also on the appropriateness of the application rate. Therefore, organic fertilizer application in water spinach cultivation should consider the balance between nutrient availability, physical conditions of the growing medium, and crop requirements during the growth period.

CONCLUSION

The application of frass, bioslurry, and organic compost at different rates produced different responses in the growth and biomass of water spinach (Ipomoea reptans Poir.). Fertilizer type, application rate, and their interaction did not significantly affect plant height, leaf length, or number of leaves. However, these factors had a highly significant effect on plant fresh weight. The 200 g frass and 200 g bioslurry treatments produced the highest fresh weight, 8.40 g, and belonged to the same DMRT group. These findings indicate that frass and bioslurry applied at 200 g per polybag are the most promising treatments for increasing the fresh biomass of water spinach under the conditions of this study. Thus, organic fertilizer application in water spinach cultivation should consider both fertilizer type and application rate, as increasing the rate to 300 g per polybag did not necessarily result in higher plant biomass.

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