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Quality of *Moringa oleifera* Leaf and Kiambang (*Salvinia molesta*) Solid Organic Fertilizer with Banana Peel Bioactivator

Desvia Puput Apriani, Aminah Asngad*
Biology Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta.
Jl. A. Yani Tromol Pos I, Pabelan, Kartasura, Surakarta 57162, Jawa Tengah, Indonesia
*Corresponding Author. E-mail address: aa125@ums.ac.id

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ABSTRACT

Moringa oleifera leaves and kiambang (*Salvinia molesta*) can fulfill plants' N, P, and K elements to become solid organic fertilizers with banana peel waste as a bioactivation. This study aimed to determine the quality of solid organic fertilizers for *Moringa oleifera* leaves and Kiambang with banana peels as a bioactivator based on sensory tests and nutrient content. This study used an experimental method with a factorial pattern. As for factor 1, namely the comparison of ingredients, K1 = 300 g: 200 g and K2 = 200 g: 300 g. Factor 2 is the concentration of bioactivator, M1 = 25 mL and M2 = 30 mL. The results showed that the best quality of Fertilizer from sensory characteristics was demonstrated by the K2M2 treatment in black color, less pungent scent, crumb texture, and a pH of 7. In contrast, the N, P, and K content test was shown by the K1M1 treatment with N content (3.29%), P (0 .10%), and K (0.24%). So that, it can be concluded fertilizers for *Moringa oleifera* leaves and Kiambang (*Salvinia molesta*) with banana peel waste as bioactivator have good quality according to SNI 19-7030-2004.

1. INTRODUCTION

Waste is leftover material from human or community activities that, if appropriately managed, will positively impact the environment. The waste generated by the community is in the form of solid, liquid, and gas waste. Therefore, waste management in society could be more optimal. One of the solid wastes is household waste, both vegetable and fruit waste. An alternative to treating solid waste is to use it as organic Fertilizer. Fertilizer is an additional material given to agricultural land that can support plant growth and development. Fertilizers can be divided into two, namely organic fertilizers and inorganic fertilizers. Excessive use of inorganic fertilizers will cause a decrease in soil fertility. The use of organic fertilizers is more environmentally friendly than inorganic fertilizers. Solid organic fertilizers can improve soil structure and increase the soil's ability to retain water content (Anggraeni et al., 2019). One of the organic materials from a combination of moringa leaves and kiambang plants, with the addition of fruit peel waste as a bioactivator, can be used to make solid organic Fertilizers.

Moringa leaves are one part of the plant that contains many benefits. Moringa leaves have benefited from nutritional value, agriculture, therapy, industry, and health. Moringa leaf extract contains flavonoids, alkaloids, terpenoids, saponins, and tannins (Tenri & Rivai, 2020). Based on research that has been done (Wahyudi & Agustina, 2018) that Moringa leaf extract has a burn healing effect of up to 10 %. Moringa leaves can be used optimally in agriculture because contain many nutrients. Moringa leaves contain nutrients N (4.02%), P (1.17%), K (1.80%), Ca (12.3%), Mg (0.10%), and Na (1.16%) (Adiaha, 2017). The nutrient content in Moringa leaves is beneficial for plant growth, so it can be used as material for making organic Fertilizers.

Kiambang plant or apu wood (*Salvinia molesta*) is a plant that is often considered a pest in rice fields. Kiambang is abundant in nature; it is easy to find floating in pond waters and weed plants

in rice fields (Ashari, 2021). Kiambang has yet to be used optimally by the community. Kiambang (*Salvinia molesta*) has a reasonably high nutrient content and can be used for plant growth. Based on research (Sismiyanti et al., 2018), kiambang plants contain nutrients that have not been composted, namely C (39.90%), (N 4.50%), P (0.50%), K (2.90%), S (0.62%), lignin (17.00%), C/N 8.87, C/P 64.35, C/S 64.35. The high content of nutrients in the kiambang plant can be used to make solid organic Fertilizers to benefit plant growth.

The manufacture of solid organic Fertilizers is produced through a fermentation process for 30 days. The duration of fermentation will affect the physical and chemical characteristics of the fertilizer. Based on research (Tallo & Sio, 2019), the best fermentation time is 35 days. Microorganisms are needed to help speed up fermentation in fermenting solid organic fertilizers. Biological decomposition during fermentation can be assisted by bacteria, actinomycetes, fungi, protozoa, worms, and several types of larvae (Widyastuti et al., 2021). Materials that are commonly added to speed up the decomposition process are bio activators (Andriany, 2018). The bioactivator used can be derived from natural ingredients. Bioactivator materials that can be used are fruit waste, including bananas, mangoes, papayas, and apples, which are called local microorganisms (MOL) (Ali, 2016). The material for making bioactivator can use banana peels. Banana peel contains *Pseudomonas* sp. and *Bacillus* sp., which can accelerate the fermentation process to manufacture solid organic Fertilizers (Moiedi, 2013). Based on research (Fauzi, 2021), adding 30 mL MOL with a composting time of 23 days is the best treatment for making fertilizers. Based on research (Almastin, 2022), the combination of Moringa leaves and 300 grams of Kiambang leaves has the highest nitrogen content. Solid organic fertilizers can be tested by sensory tests, including smell, color, and texture, and can be tested for N, P, and K content. Based on research (by Asngad et al., 2019) states that the total N-value of solid organic fertilizers meets the requirements, namely >0.40%.

Based on the above background, the problem in this research is: What is the quality (N, P, and K content) of the solid organic fertilizer combination of Moringa leaves and Kiambang plant (*Salvinia molesta*) with the addition of fruit peel as a bioactivator based on SNI 19-7030-2004. Therefore, the objectives to be achieved in this study were: to determine the quality (N, P, and K content) of a solid combination organic fertilizer for Moringa leaves and kiambang (Salvinia molesta) with the addition of fruit peel as a bioactivator based on SNI 19-7030-2004.

While the benefits the results of this study are expected to provide information to 1). Provide information to researchers about the benefits of combining moringa leaves and kiambang (*Salvinia molesta*) with adding fruit peels as a bioactivator as solid organic Fertilizer. 2). Providing information to the public that combining moringa leaves and kiambang plants with fruit peels as a bioactivator can be used as solid organic Fertilizers. 3). Providing ideas in the field of biology, especially the use of a combination of moringa leaves and kiambang plants with the addition of fruit peels as a bioactivator that can be used as solid organic Fertilizers.

2. MATERIALS AND METHODS

This research was conducted at Tlangu RT 03 RW 01, Bulan, Wonosari, Klaten. This study used tools including basin, plastic, analog scales, knives, blenders, hoses, stirring rods, filters, containers, bottles and 1000 ml beaker glass, pH indicators, stationery, and documentation tools. In comparison, the materials used in this study were moringa leaves, kiambang plants, brown sugar, leri water, and water.

The research procedures include making banana peel waste bioactivator is mixing leri water and brown sugar water in a ratio of 1:1 as a food source for microorganisms, stirring and mixing with mashed banana peels, stirring and covering the container with a plastic bottle with holes perforated which is plugged with a hose (air can enter but flies cannot enter), ferment 5-7 days. Making solid organic fertilizer is prepare the activator solution that has been made, weigh the solid organic Fertilizer and activator solution according to the formulation, mix the dough until it is clenched by hand, then no water will come out of the dough, and if the fist is released the dough

expands again, the dough is closed using a lid for 4-5 weeks during the fermentation or incubation process.

The method used is the experimental method and completely randomized design (CRD) with two factors: a combination of moringa leaves and kiambang (*Salvinia molesta)* with adding a banana peel waste bioactivator. As for factor 1, namely the comparison of ingredients, K1 = 300 g: 200 g and K2 = 200 g: 300 g. Factor 2 is the concentration of bioactivator, M1 = 25 mL and M2 = 30 mL. This study used four treatments with three repetitions, and the technique used to analyze the data was descriptive qualitative analysis.

3. RESULTS AND DISCUSSION

3.1 N, P and K Content

Based on the results of laboratory tests for the macronutrient content, including nitrogen (N), phosphorus (P), and potassium (K) in the solid organic fertilizer combination of *Moringa oleifera* leaves and Kiambang plants (*Salvinia molesta*) with the addition of banana peel waste as a bio activator, it can be seen content test results in the following table 1.

Table 1. N, P, and K content in solid organic fertilizer combination of moringa leaves and kiambang plants (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator

Combination	Average Analysis Results		
	N (%)	P (%)	K (%)
K_1M_1	3,29	0,10**	0,24**
K_1M_2	2,22*	0,08	0,22
K_2M_1	2,45	0,08	0,20
K_2M_2	3,38**	0,07*	0,19*

Information : (*) highest result
(**) lowest result

The results of the analysis of the average content of N, P, and K in Table 2 show that the highest percentage of nitrogen (N) is owned by the K2M2 treatment combined with a test result of 3.38%, and the lowest percentage is owned by the K1M2 treatment combined with a test result of 2.22 %. In the test for the content of phosphorus (P) and potassium (K), the highest percentage was owned by the K1M1 combination with test results of 0.10% and 0.24%, and the lowest percentage content was in the K2M2 treatment combination with test results of 0.07% and 0.19%.

3.1.1 Nitrogen Content (N)

Based on the test results for the N, P, and K content in Table 1, nitrogen (N) has a higher percentage of content test results than P and K. The total N content in each treatment combination shows a percentage difference; the highest nitrogen content is found in the combination of the treatment of moringa leaves and plant kiambang (*Salvinia molesta*) and more activators, namely 3.38%. Meanwhile, the lowest nitrogen content was found in the combined treatment of moringa leaves and kiambang (*Salvinia molesta*) with more bioactivators, namely 2.22%. This shows that the nitrogen content of four treatments obtained meets the excellent quality of solid organic Fertilizers according to SNI 19-7030-2004, which states that the

quality standard for solid organic fertilizer content is a minimum of 0.40% (Andriawan, 2022).

Table 2. The results of a two-way ANOVA statistical analysis of the nitrogen content of a combination of Moringa leaf and kiambang (*Salvinia molesta*) fertilizer with the addition of banana peel waste as a bioactivator

Tests of Between-Subjects Effects

Dependent Variable: Nitrogen Content Test Results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.091[a]	3	1.030	877.021	.000
Intercept	96.447	1	96.447	82082.298	.000
Faktor_2	.015	1	.015	12.511	.008
Faktor_1	.077	1	.077	65.362	.000
Faktor_2 * Faktor_1	3.000	1	3.000	2553.191	.000
Error	.009	8	.001		
Total	99.548	12			
Corrected Total	3.101	11			

a. R Squared = ,997 (Adjusted R Squared = ,996)

The Two Way Anova analysis results in Table 2 show a significant result: the combination of Moringa leaf and *Salvinia molesta* treatments has a significant probability. 0.000 < 0.05. The probability of the number of moles factor has sig. 0.008 < 0.05. The probability is sig in the interaction between treatment combinations and the number of moles. 0.000 < 0.05. From these results, factor 1, factor 2, and the interaction of both have significant results in solid organic Fertilizers that affect the level of nitrogen content produced. The nitrogen analysis test results showed that the K2M2 treatment combination had the highest nitrogen content, 3.38%. This is under the statistical calculations of the mean K2, 2.9150, and M2, 2.8700. So that the results of the mean statistical calculations are by the results of the nitrogen content test that the K2M2 treatment has the highest nitrogen content.

When viewed from the composition of the essential ingredients, Fertilizer with a higher concentration of *Salvinia molesta* will have the highest percentage of nitrogen content test results because it has a protein content of 15.90% (Warasto et al., 2013), while young Moringa leaves have a protein content of 1.3092 % and old Moringa leaves 11.3473 % (Saputri, 2019). The fermentation process used in making solid organic Fertilizer, a combination of moringa leaves and kiambang (*Salvinia molesta*), affects the results of nitrogen tests on fertilizers; in research (Arafat, 2017) that during the fermentation process using bioactivators, the final result of the fermented product will experience a decrease in protein content.

3.1.2 Fosfor Content (P)

Based on the test results for the content of N, P, and K in Table 1, the content of phosphorus (P) in each treatment combination showed a percentage difference;

the highest test results were found in the K1M1 treatment combination, which was 0.10%, while the lowest test results were in the K2M2 treatment combination, namely 0.07%. The high and low content of phosphorus (P) can be influenced by the content of the nutrient phosphorus (P) found in Moringa leaves based on research (Adiaha, 2017) 1.17% more than in kiambang plants 0.50%.

Table 3. The results of a two-way ANOVA statistical analysis of the phosphorus content of a combination of Moringa leaf and kiambang (*Salvinia molesta*) fertilizer with the addition of banana peel waste as a bioactivator

Tests of Between-Subjects Effects

Dependent Variable: Phosphorus Content Test Results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.001[a]	3	.000	.905	.480
Intercept	.082	1	.082	155.571	.000
Faktor_2	.001	1	.001	1.286	.290
Faktor_1	.001	1	.001	1.286	.290
Faktor_2 * Faktor_1	7.500E-005	1	7.500E-005	.143	.715
Error	.004	8	.001		
Total	.087	12			
Corrected Total	.006	11			

a. R Squared = ,253 (Adjusted R Squared = -,027)

Based on the Two Way Anova analysis results in Table 3, there were insignificant results, namely the combination of Moringa leaf treatment and *Salvinia molesta* sig. 0.290 > 0.05 while the number of moles is sig. 0.290 > 0.05. The probability of the interaction of the two has a significant value. 0.715 > 0.05. From these results, the combination of treatments and the number of moles used in solid organic fertilizers did not affect the level of phosphorus content produced. In terms of the results of the average test for phosphorus content, there is a difference. However, statistically, there is no significant difference because the test results for each treatment are slightly different. The results of the phosphorus analysis test found that the K1M1 treatment combination had the highest phosphorus content, namely 0.10%. This follows the statistical calculations of the mean K1, which is 0.0900, and M1, which is 0.0900. So that the results of calculating the mean statistic are under the results of the phosphorus content test that the K1M1 treatment combination has the highest phosphorus content.

3.1.3 Potassium Content (K)

Based on the test results for the content of N, P, and K in Table 1, the content of potassium (K) in each treatment combination showed a percentage difference; the highest test result could be seen in the K1M1 treatment combination, which was

0.24%, while the lowest test result was in the K2M2 treatment, namely 0.19%. The potassium nutrient content influences this in the raw material for Moringa leaves from research (Adiaha, 2017), 1.90%, while the potassium nutrient content in *Salvinia molesta* is 2.90% (Sismiyanti et al., 2018).

Table 4. The results of a two-way ANOVA statistical analysis of the potassium content of a combination of Moringa leaf and kiambang (*Salvinia molesta*) fertilizer with the addition of banana peel waste as a bioactivator.

Tests of Between-Subjects Effects

Dependent Variable: Potassium Content Test Results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.004[a]	3	.001	4.538	.039
Intercept	.542	1	.542	1667.308	.000
Faktor_2	.001	1	.001	2.077	.188
Faktor_1	.004	1	.004	11.308	.010
Faktor_2 * Faktor_1	7.500E-005	1	7.500E-005	.231	.644
Error	.003	8	.000		
Total	.549	12			
Corrected Total	.007	11			

a. R Squared = ,630 (Adjusted R Squared = ,491)

Based on the Two Way Anova analysis results in Table 4, there were significant results, namely the combination of Moringa leaf treatment and *Salvinia molesta* sig. 0.010 <0.05 while not significant for the number of sig moles. 0.188 > 0.05. The probability of the interaction of the two has a significant value. 0.644 > 0.05. From these results, the combination of treatments used in solid organic fertilizers affects the level of potassium content produced. In contrast, the number of moles and the interaction between the two does not affect it. From the results of the potassium analysis test, it was found that the K1M1 treatment combination had the highest phosphorus content, namely 0.24%. This is by the statistical calculations of the mean K1, 0.2300, and M1, 0.2200 so that the results of the mean statistical calculations follow the potassium level test results that the K1M1 treatment combination has the highest potassium content.

3.2. Sensory Test

Based on the results of sensory observations that have been carried out, including color, scent, texture, and degree of acidity (pH) in solid organic Fertilizer, a combination of moringa leaves and kiambang plants (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator can be seen in the following table 5.

Table 5. The results of sensory observations on solid organic fertilizer combinations of moringa leaves and kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator after being fermented for 30 days.

Combination	Average Observation Results			
	Color	**Scent**	**Texture**	**pH**
K_1M_1	Dark brown	Pungent	Rather rough	7
$K1M_2$	Black	Less Pungent	Rather subtle	7
K_2M_1	Dark brown	Pungent	Rather rough	7
K_2M_2	Black	Less Pungent	Crumb	7

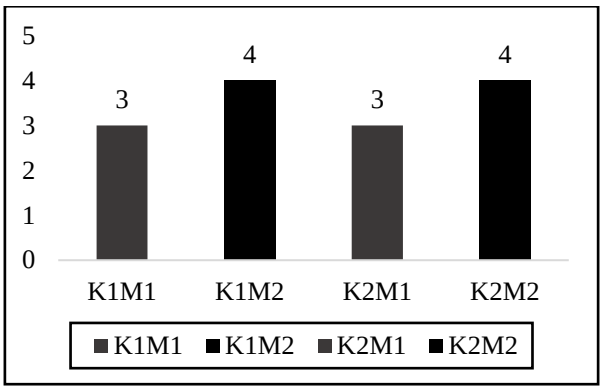
Information:
K_1M_1 = Solid organic Fertilizer with a concentration of 300 g of Moringa leaves and 200 g of Kiambang with the addition of 25 mL banana peel bioactivator.
$K1M_2$ = Solid organic Fertilizer with a concentration of 300 g of Moringa leaves and 200 g of kiambang with 30 mL banana peel bioactivator.
K_2M_1 = Solid organic Fertilizer with a concentration of 200 g of Moringa leaves and 300 g of Kiambang with the addition of 25 mL banana peel bioactivator.
K_2M_2 = Solid organic Fertilizer with a concentration of 200 g of Moringa leaves and 300 g of Kiambang with the addition of 30 mL banana peel bio activator.

Based on the table data, it is known that the sensory observations in the samples have similarities, namely in the sensory test results for the pH parameter. Meanwhile, the sensory test results for color, scent, and texture have differences.

3.2.1 Color Parameters

After observing the color of the solid organic fertilizer combination of Moringa leaves and Kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator, which was carried out by organoleptic or sensory tests using the senses, the observations showed that the colors were different. Treatment samples K1M1 and K2M1 were blackish brown, while K2M1 and K2M2 were black. The color difference occurs due to the decomposition activity of the Fertilizer by bacteria. In addition, the compounds in these fertilizers' organic matter can affect the Fertilizer's color from brown to black. Moringa leaves have phenolic color pigments. This aligns with research (Kurang, 2020) that the phenolic compounds in Moringa leaves can cause a black color.

The sensory observations show that the four combination fertilizer treatments of Moringa leaves and Kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator had color differences caused by the organic matter in the solid organic fertilizer can be seen in following figure.



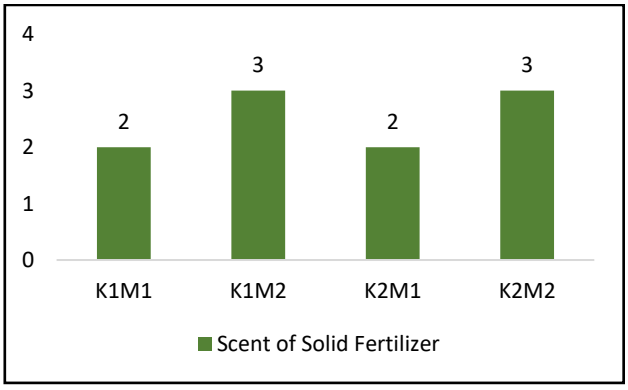
Information: 1 = light brown; 2 = brown; 3 = dark brown; 4= black

Figure 1. Color parameters of solid organic fertilizer combination of moringa leaves and kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator

Based on Figure 1, there are color differences in the four treatment combinations observed. In the treatment combinations, K1M1 and K2M1 had a blackish brown color, while in the treatment combinations K1M2 and K2M2, the Fertilizer had a black color. This difference is influenced by mixing solid organic fertilizer ingredients, which were initially green in color, to produce a blackish brown Fertilizer to very black. This follows research (Mustika, 2019) that was seen in SNI 19-7030-2004. The process of composting organic Fertilizers will gradually change the color of the compost material towards blackish brown due to the ongoing transformation of organic matter and forming humus substances so that the four treatments have fertilizer colors that follow SNI 19-7030-2004.

3.2.2 Scent Parameters

Sensory observations of scent in solid organic fertilizer combination of moringa leaves and kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator with organoleptic tests using the sense of smell can be seen in the following figure.



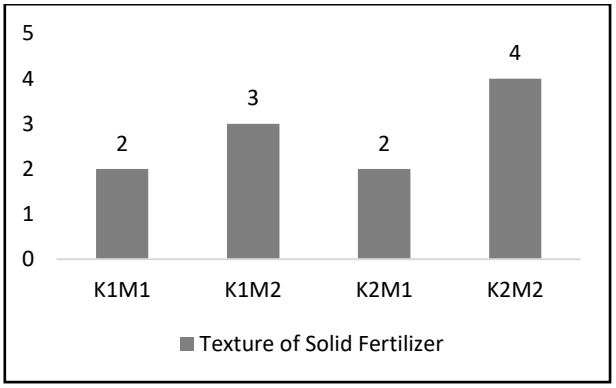
Information: 1 = sewage; 2 = pungent; 3 = less pungent; 4 = earthy.

Figure 3. Scent parameters in solid organic fertilizer combination of Moringa leaves and Kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator.

Based on the research results on the scent parameters in Figure 3, it is known that the scent of the four combinations of fertilizer treatments smells less pungent than pungent. For example, combining treatments K1M1 and K2M1 had a pungent odor, while K1M2 and K2M2 had a less pungent scent. This indicates the presence of a fermented scent influenced by using a bioactivator from banana peels. The four treatments show that the quality of solid fertilizers follows SNI-19-7030-2004 following Mustika's research (2019), which states that mature compost is characterized by an odor that does not sting or smell like earth because the material it contains resembles soil. This follows the National Standardization Agency SNI-19-7030-2004, which states that ripe compost will smell of earth.

3.2.3 Texture Parameters

After sensory observation of texture on solid organic fertilizer combination of moringa leaves and kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator with organoleptic tests using the sense of touch can be seen in the following figure.



Information: 1 = rough; 2 = rather rough; 3 = rather subtle; 4 = crumb.

Figure 4. Texture parameters of solid organic fertilizer combination of moringa leaves and kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator.

The results of the texture parameter research can be seen in Figure 4 that there are differences in each treatment combination; K1M1 and K2M1 have a somewhat rough texture, K1M2 has a relatively smooth texture, and K2M2 has a crumbly texture. In the fermentation process of solid organic fertilizers, the coarse material will break down into smaller sizes, causing the texture of the Fertilizer to become relatively smooth and even crumbly. According to Mustika's research (2019), the characteristics of good compost are crumb structure and loose consistency. Based on the research results, four treatments of solid organic fertilizer combination of Moringa leaves and Kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator meets good quality based on the National Standardization Agency for SNI 19-7030-2004.

3.2.4 pH Parameters

Sensory observations on solid organic fertilizer combinations of Moringa leaves and Kiambang (*Salvinia molesta*) with the addition of banana peel waste as a bioactivator were carried out by measuring the degree of acidity in the Fertilizer which can be observed in the image below.

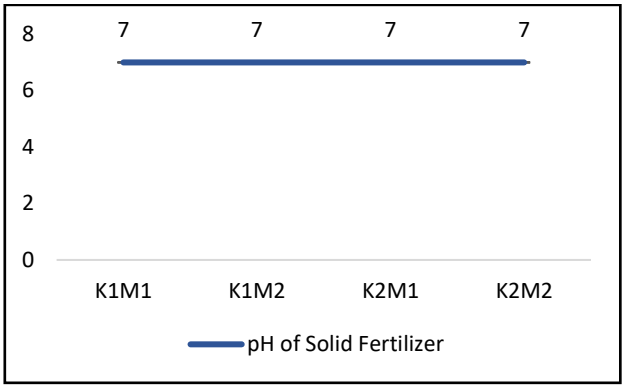


Figure 5. Line Diagram of pH Parameters of Solid Organic Fertilizer Combination of Moringa Leaves and Kiambang Plant (*Salvinia molesta*) with the Addition of Banana Peel Waste as a Bioactivator.

Based on the research results, the degree of acidity (pH) parameter can be observed in Figure 5 that the four treatment combinations have the same pH, namely 7. The pH value or degree of acidity is measured after a solid organic fertilizer combination of Moringa leaves and *Salvinia molesta* with the addition of banana peel waste as a bioactivator ripe. The pH value is 7, according to the requirements for solid organic Fertilizers based on the National Standardization Agency for SNI 19-7030-2004, and the standard pH for good quality compost is between 6.80 – 7.49. The pH value dramatically influences decomposer organisms' growth in the fermentation process. The pH value can increase; according to research by Dewilda (2017), the increase in pH is due to the composting process producing nitrogen and ammonia gas, so the pH value changes to alkaline due to increased bacterial activity. Based on the results of the study, the results showed that the pH content of four treatments of solid organic fertilizers combined with Moringa leaves and *Salvinia molesta* with the addition of banana peel waste as a bioactivator was classified as good because it met the quality standards of SNI 19-7030-2004.

4. CONCLUSIONS

Based on the study's results, it was shown that moringa leaves and kiambang plants (*Salvinia molesta*) could be used as solid organic Fertilizers with banana peel waste as activators. This can be seen from sensory observations: the color is brown-black, the smell is less pungent, the crumb texture, and the pH is acidic, namely, 7. Furthermore, in the observations of tests for the content of N, P, and K, it also meets good fertilizer quality standards. Thus, by using sensory observations and testing the content of nitrogen (N), phosphorus (P), and potassium (K), the average quality of fertilizers is good because the quality of the four combinations of fertilizers follows SNI 19-7030-2004.

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