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Authors

Name	Akram La Kilo
ORCID iD	http://orcid.org/0000-0002-4885-1838
URL	https://scholar.google.co.id/citations?user=YWz4wUMAAAAJ&hl=en&oi=ao
Affiliation	Universitas Negeri Gorontalo
Country	Indonesia
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Principal contact for editorial correspondence.

Name	Sarmini A Iladat
Affiliation	Universitas Negeri Gorontalo
Country	Indonesia
Bio Statement	—
Name	Hendri Iyabu
Affiliation	Universitas Negeri Gorontalo
Country	Indonesia
Bio Statement	—

Title and Abstract

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Study on Content of Nitrogen, Phosphorus, and Potassium from Mixed Waste of Empty Fruit Bunch of Oil Palm and Banana Stem as Organic Fertilizer for Tomato

Akram La Kilo*, Hendri Iyabu, Sarmini A. Iladat*****
* Departement of Chemistry, Universitas Negeri Gorontalo
** Departement of Chemistry, Universitas Negeri Gorontalo
*** Departement of Chemistry, Universitas Negeri Gorontalo

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Akram La Kilo,
Department of Chemistry
Universitas Negeri Gorontalo

Email: akram@ung.ac.id

ABSTRACT

The purpose of this research was to study the levels of nitrogen, phosphorus, and potassium (NPK) contained in organic fertilizer made from a mixture of empty fruit bunch waste from oil palm and banana stems, as well as to determine the effects on the growth and development of tomato plants when applying the organic fertilizer made from the aforementioned mixture. The research involved analyzing the total nitrogen content using the Kjeldahl method, phosphorus (P) using UV-VIS, and potassium (K) using AAS, as well as conducting tomato planting experiments using a growing medium consisting of compost made from the mixture of empty fruit bunch waste from oil palm and banana stems. Based on the research results, it was found that the NPK content of the soil and compost mixture of empty fruit bunch waste from oil palm and banana stems met the SNI 19-7030-2004 standard for nitrogen (N) and phosphorus (P). The growth and development of tomato plants without using the organic fertilizer mixture from the mixture of empty fruit bunch waste from oil palm and banana stems underwent some changes, but the changes occurred at a slower pace compared to using the organic fertilizer mixture from the aforementioned mixture.

Keyword: Soil, Empty oil palm bunches, Banana trunk, NPK, tomato

1. INTRODUCTION

The Tomato plants (Solanum lycopersicum) were one of the popular horticultural crops with high economic value. To achieve optimal growth and yield, tomato plants required sufficient nutrients, especially macro-nutrients such as nitrogen (N), phosphorus (P), and potassium (K). The application of organic fertilizer could be an environmentally friendly alternative that had the potential to meet the nutritional needs of tomato plants (Annisa et al., 2022; Burhan, 2022; Salamati et al., 2022; sari et al., 2022; Shamita et al., 2022; Ziladi et al., 2021).

Industries such as palm oil and banana production generated waste materials like empty fruit bunches and banana stems, which were often discarded. However, these waste materials had the potential to be used as raw materials in organic fertilizer production, providing not only nutrients but also reducing the negative impact of waste disposal (Anhar et al., 2021; Danial et al., 2019; Hazra et al., 2023; Maricar et al., 2022; Syaiful et al., 2022; Yosephine et al., 2021). For example, the use of liquid organic fertilizer made from banana stem borers could improve soil fertility by increasing organic matter and nutrient availability, as well as enhancing the vegetative growth of oil palm seedlings (Yosephine et al., 2021). Additionally, the application of compost made from empty fruit bunch waste and liquid organic fertilizer from palm oil mill effluent could enhance the growth of Yellow Kepok banana seedlings (Yosephine et al., 2021). The potential of empty fruit bunch waste could also be utilized to produce solid organic fertilizer using geotextile cover material, effectively reducing the C/N ratio and meeting quality standards (Hazra et al., 2023). Furthermore, liquid organic fertilizer made from banana stem and rice wash could be used for cultivating mustard greens in home gardens during the COVID-19 pandemic (Maricar et al., 2022).

Studying the content of nitrogen, phosphorus, and potassium in empty fruit bunch waste from oil palm and banana stems as organic fertilizer for tomato plants was essential for evaluating their potential use (Anesti et al., 2017)(Wulandari et al., 2019). By understanding the nutrient content in these waste materials, appropriate dosages and combinations could be determined to enhance the growth and yield of tomato plants (Anesti et al., 2017)(Wulandari et al., 2019)(Wulandari et al., 2019)(Wulandari et al., 2019)(Wulandari et al., 2019)(Wulandari et al., 2019)(Wulandari et al., 2019)(Wulandari et al., 2019)(Wulandari et al., 2019)(Wulandari et al., 2019)(Wulandari et al., 2019)[14]. Empty fruit bunch waste from oil palm had high organic matter content and low heavy metal content, making it suitable for composting (Wulandari et al., 2019). Banana stem waste, on the other hand, was generally rich in carbon sources but required a nitrogen source to achieve the required C/N ratio as compost material (Wulandari et al., 2019). Nitrogen was an essential nutrient for the growth of rice and soybean plants (Adzima et al., 2022; Safriyani et al., 2022; Sagita et al., 2022). Efficient nitrogen fertilization was crucial for achieving optimal results (Adzima et al., 2022). Organic fertilizers such as empty fruit bunch waste from oil palm and banana stems could be used for nitrogen supplementation (Anesti et al., 2017). Additionally, the use of rhizobium bacteria in soybean plants could reduce the reliance on inorganic fertilizers, especially nitrogen, while increasing plant productivity (Adzima et al., 2022).

Previous studies evaluated the use of palm oil and banana waste as organic fertilizers, but further research was still needed to gain a deeper understanding of the nutrient content in these waste materials and their effectiveness in enhancing tomato plant growth. Several studies related to the use of waste as organic fertilizer and its impact on plant growth had been conducted. One study showed that the application of liquid organic fertilizer made from kepok banana peel had no significant effect on the growth of oil palm seedlings in the pre-nursery stage. Another study demonstrated that the use of POC Plus liquid organic fertilizer made from cow urine and banana peel waste could increase the fruit set percentage in tomato plants. Additionally, waste materials such as shallot peel, coconut husk, banana peel, coconut water, banana stem waste, eggshells, lamtoro leaves, and banana stem residue had been researched and proven to have the potential as effective raw materials for organic fertilizer, enhancing the growth and yield of crops such as chili, okra, mustard greens, spinach, and tomatoes. Therefore, further research was needed to expand the understanding of waste utilization as organic fertilizer and its potential in supporting tomato plant growth.

By evaluating the content of nitrogen, phosphorus, and potassium, as well as utilizing mixed waste materials such as empty fruit bunches from oil palm and banana stems as organic fertilizer, it was hoped that sustainable solutions could be provided for industrial waste management while supporting the healthy and productive growth of tomato plants. This study was expected to provide useful information for farmers, researchers, and agricultural industries in their efforts to improve agricultural sustainability and waste management.

2. RESEARCH METHOD

2.1. Tools

The instruments used in this study were: a scale, a measuring tape, polybags, containers (buckets), a hoe, sacks, plastic, droppers, beakers, measuring cylinders, stirring rods, spatulas, Erlenmeyer flasks, a shaker, a mortar and pestle, volumetric flasks, an analytical balance, a burette, a set of titration equipment, a set of distillation equipment, a set of destruction equipment, Kjeldahl flasks, a watch glass, reagent bottles, a UV-VIS spectrophotometer, and an Atomic Absorption Spectrophotometer (AAS).

2.2. Materials

The sample materials used were empty fruit bunch (EFB) waste from oil palm and banana stems. The chemicals used included EM4 solution, H_2SO_4 solution, NaOH, selenium, BCG+MR indicator, H_3BO_3, HNO_3, vanadate molybdate, distilled water, and brown sugar.

2.3 Sample Preparation

The preparation of the empty fruit bunch (EFB) sample involved cleaning the EFB from dirt. A total of 30 kg of EFB samples were used for the research. The banana stem samples were taken from Unone Village, Bukal District, with a total of 30 kg of banana stem samples used for the research.

2.4 Production of Organic Fertilizer from Empty Fruit Bunch (EFB) Waste and Banana Stems

In the first process of producing organic fertilizer from empty fruit bunches, the EFB and banana stems were chopped to accelerate decomposition. Then, an EM4 solution was prepared using a composition of water, EM4, and sugar. The EM4 solution was briefly stirred and left for a few minutes, then mixed with the organic materials, which were the EFB and banana stems. The mixture was then composted by placing the materials in a tarpaulin-covered container and tightly sealing it. The pile was turned/mixed once a week for 3-4 weeks until the organic materials turned into mature organic fertilizer with a dark color. The composting process or the production of organic fertilizer from EFB waste and banana stems took approximately 3-4 weeks to produce good-quality fertilizer ready for application to plants.

2.5 Determination of Ash Content

To determine the ash content, the first step was to weigh 10 grams of the sample, and then the organic fertilizer sample from empty fruit bunch (EFB) waste was ashed in an oven at a temperature of 700°C for about 3 hours.

2.6 Analysis of Nitrogen Content

The determination of nitrogen in this research used the Kjeldahl analysis method, which involved three stages: destruction, distillation, and titration. In the first stage, the destruction stage, the sample was heated in concentrated sulfuric acid, which converted the nitrogen into ammonium sulfate $(NH_4)SO_4$. To accelerate the destruction process, a selenium mixture was added as a catalyst. The addition of the catalyst raised the boiling point of sulfuric acid, leading to faster destruction. In the second stage, the distillation stage, ammonium sulfate $(NH_4)SO_4$ was broken down into ammonia (NH_3) by adding NaOH to create a basic environment and heating the mixture. Since the reaction could not occur in an acidic environment, it was necessary to create a basic environment. To capture the generated NH_3, a 1% boric acid solution and BCG+MR indicator were used. The indicator was added to determine the excess of boric acid. In the third stage, the titration stage, the remaining boric acid that reacted with ammonium was titrated using 0.05 N H_2SO_4 until a color change to pink occurred.

2.7 Analysis of Phosphorus Content

One gram of finely ground soil was placed in an Erlenmeyer flask. Then, 25 mL of concentrated sulfuric acid (H_2SO_4) and concentrated nitric acid (HNO_3) were added. The mixture was heated on a hot plate. Then, 2.5 mL of concentrated sulfuric acid (H_2SO_4) was added, resulting in a black color similar to ash. Subsequently, concentrated nitric acid (HNO_3) was added gradually until the sample no longer emitted black smoke. After the combustion process, the sample was diluted with distilled water to a volume of 50 mL and shaken. It was then filtered into an Erlenmeyer flask, and 2.5 mL of vanadate molybdate solution was added, resulting in a yellow color. The phosphorus content was determined using a UV spectrophotometer with a maximum wavelength of 400 nm.

2.8 Determination of Potassium Content

One gram of finely ground soil was placed in an Erlenmeyer flask. Then, 25 mL of concentrated sulfuric acid (H_2SO_4) and concentrated nitric acid (HNO_3) were added. The mixture was heated on a hot plate. Then, 2.5 mL of concentrated sulfuric acid (H_2SO_4) was added, resulting in a black color similar to ash. Subsequently, concentrated nitric acid (HNO_3) was added gradually until the sample no longer emitted black smoke. After the combustion process, the sample was diluted with distilled water to a volume of 50 mL and shaken. It was then filtered into an Erlenmeyer flask. The potassium content was determined using a flame photometer/Atomic Absorption Spectrophotometer.

3. RESULTS AND ANALYSIS

3.1. Results

The results of producing compost from empty fruit bunches and banana stems involved the use of six different ratios as shown in table 1.

Table 1. Ratio of Empty Bunches and Banana Stems

Treatments	Ratio (%)	
	Empty Bunch	Banana Trunk
1	100	0
2	80	20
3	60	40
4	40	60
5	20	80
6	0	100

The composting of empty fruit bunches and banana stems began by chopping them into pieces measuring approximately 2-5 cm in size. The chopping process was carried out to accelerate the fermentation process. Subsequently, the empty fruit bunches and banana stems were mixed together, with each weighing 5 kg, according to the predetermined ratios. The mixture was then supplemented with 5 liters of diluted brown sugar solution and EM-4 as a microorganism activator. Once the mixture was thoroughly blended, it was placed into individual plastic bags and securely tied. The bags were then wrapped with tarpaulin to ensure controlled and stable airflow inside. The composting process took place for one month. Successful compost fermentation was indicated by a change in color to dark brown, easy decomposition, and the absence of unpleasant odors.

The growth and development of tomato plants resulting from the application of the prepared compost can be observed in Table 2.

Table 2. Growth and development of tomato plant

HST	Ratio (%)	Number of Leaves	The Plant Height (cm)

7-13 HST	100 : 0	4	4
	80 : 20	5	4
	60 : 40	5	4
	40 : 60	5	4
	20 : 80	5	4
	0 : 100	5	4
14-20 HST	100 : 0	7	10
	80 : 20	8	18
	60 : 40	8	18
	40 : 60	9	17
	20 : 80	9	23
	0 : 100	9	24
21-27 HST	100 : 0	10	17
	80 : 20	12	27
	60 : 40	12	29
	40 : 60	13	29
	20 : 80	13	32
	0 : 100	13	33

From Table 2, it could be observed that the growth of tomato plants from day 7 to 13 in variation 1 yielded 4 leaves, while variations 2-6 had the same number of leaves, which was 5. The stem height for variations 1-6 was consistent at 4 cm. Conversely, the control group had fewer leaves, specifically 3 leaves, and a stem height of 3 cm. Progressing to the growth of tomato plants from day 14 to 20, variation 1 had 7 leaves, variations 2-3 had the same number of leaves, which was 8, and variations 4-6 also had the same number of leaves, amounting to 9. The stem height in variation 1 measured 10 cm, variations 2-3 were 18 cm each, variation 4 was 17 cm, variation 5 was 23 cm, and variation 6 measured 24 cm. The control group had 5 leaves and a stem height of 7 cm. Furthermore, the growth of tomato plants from day 21 to 27 indicated that variation 1 possessed 10 leaves, variations 2-3 had the same number of leaves, which was 12, and variations 4-6 also had the same number of leaves, totaling 13. The stem height in variation 1 measured 17 cm, variation 2 was 27 cm, variation 3 was 29 cm, variation 4 was 28 cm, variation 5 was 32 cm, and variation 6 measured 33 cm.

3.2. Analysis

In this study, the samples used were soil, empty fruit bunches, and banana stems. The soil samples were obtained from Unone Village. The parameters analyzed were nitrogen, phosphorus, potassium content, and tomato plant growth. Nitrogen, phosphorus, and potassium were essential macro nutrients compared to other micro and macro nutrients. Tomato plants required these nutrients for their growth processes.

According to SNI 19-7030-2004, mature compost had certain characteristics. It had a temperature similar to soil water temperature, a C/N ratio of 10-20, a texture resembling soil, an earthy smell, and a dark color. Based on the physical appearance of the compost, most of it had a soil-like texture and a dark color. However, compost with 40% moisture content still had a fragmented form and a brownish color, indicating partial decomposition. Overall, the compost produced met the quality standards set by SNI 19-7030-2004.

In this study, the compost made from empty fruit bunches and banana stems met the quality standards according to SNI 19-7030-2004. This was because it had a crumbly texture, no foul smell, and a dark brown color. In the composting process of empty fruit bunches and banana stems, EM-4 and brown sugar were added as activators. The addition of EM-4 was to decompose organic materials and accelerate the composting process, resulting in a fresh aroma instead of a foul odor. On the other hand, the addition of brown sugar provided glucose as a food source for microorganisms involved in the composting process.

Nitrogen (N):

Nitrogen was an essential nutrient required by plants for optimal growth and development. Nitrogen in the soil came from organic matter, fertilizers, and nitrogen-fixing bacteria. Plants obtained nitrogen in the form of nitrate and ammonium ions through root uptake. Nitrogen played a crucial role in various plant processes, including photosynthesis, protein synthesis, and overall plant vigor (Marschner, 2012).

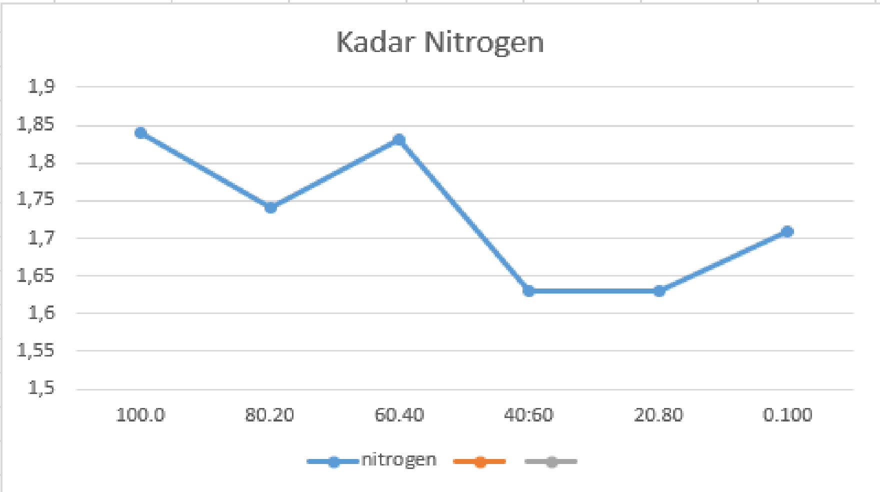

Figure 1. Content of nitrogen

The analysis results showed that the nitrogen content in the treatments ranged from 1.70%, 1.82%, 1.73%, 1.78%, 1.79%, to 1.80%. All the nitrogen content results from the treatments were above the standard set by the Indonesian National Standard (SNI) 19-7030-2004, which was 1.00%. The treatment with the highest nitrogen content was (80%:20%) with a percentage of 1.82%, while the treatment with the lowest nitrogen content was (40%:60%) with a percentage of 1.70%.

The effect of nitrogen on tomato growth and development is significant, as nitrogen is an essential nutrient for tomato growth and development (Li et al., 2023). However, high levels of nitrogen can make tomato plants release fewer volatiles and attract more Bemisia tabaci (Islam et al., 2017). The percentage of total nitrogen in tomato plant tissues can vary depending on the nitrogen levels (Islam et al., 2017). The effects of fertilization systems on nitrogen isotopic patterns can also affect the nitrogen amount and fruit yield of tomato plants (Trandel et al., 2018). Plant damage in urban agroecosystems can also affect tomato growth and development (Egerer et al., 2020).

Nitrogen is a key component of enzymes, vitamins, chlorophyll, and other cell constituents, all of which are essential for crop growth and development, making it one of the most important nutrients required for high tomato crop yields (Korob, 2022). The effects of nitrogen on tomato growth, yield, and root development, soil nitrogen, and water distribution can vary depending on the nitrogen and irrigation rates (Ayankojo et al., 2020). Nitrogen is the primary nutrient input to greenhouse vegetables during their growth, development, and yield (Ayankojo et al., 2020). Different nitrogen levels can affect the plant height of tomato, with readily available nitrogen encouraging more vegetative growth and development (Ayankojo et al., 2020). The form of nitrogen can also affect the growth, yield, and fruit quality of tomato under controlled alternate partial root zone irrigation .

Phosphorus was an important nutrient needed by plants for optimal growth and development. Phosphorus in the soil came from organic matter, fertilizers, and phosphate minerals. Plants acquired phosphorus in the form of water-soluble phosphate compounds through binding and release processes by the soil (Kumar et al., 2006).

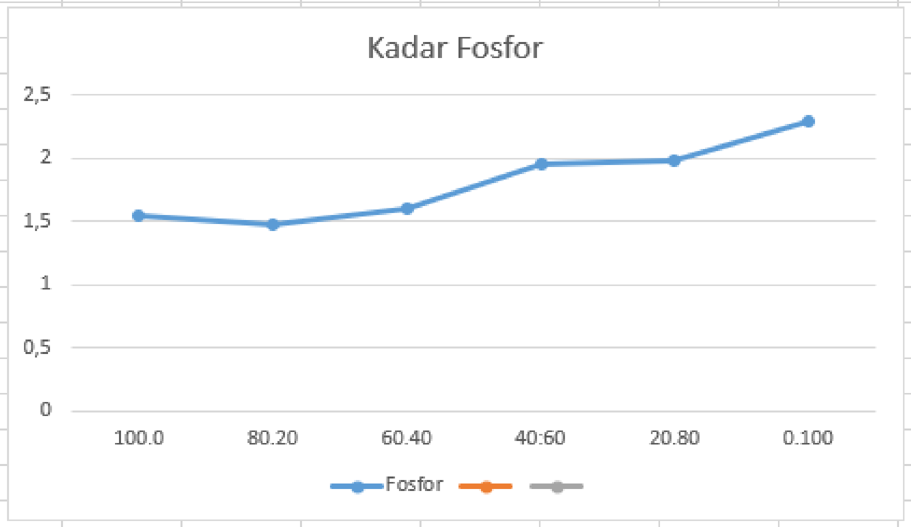

Figure 2. Content of phosphorus

The analysis results showed that the phosphorus content in the treatments ranged from 1.78%, 1.82%, 1.83%, 1.88%, 1.94%, to 1.79%. All the phosphorus content results from the treatments were above the standard set by SNI 19-7030-2004, which was 0.20%. The treatment with the highest phosphorus content was (80%:20%) with a percentage of 1.94%, while the treatment with the lowest phosphorus content was (60%:40%) with a percentage of 1.78%.

Potassium was a vital macro nutrient in plant growth and development. Soils naturally contained potassium in the form of minerals such as potassium feldspar and mica. Potassium in the soil could be bound to soil colloids and released in the form of potassium ions that could be utilized by plants (Savci, 2012).

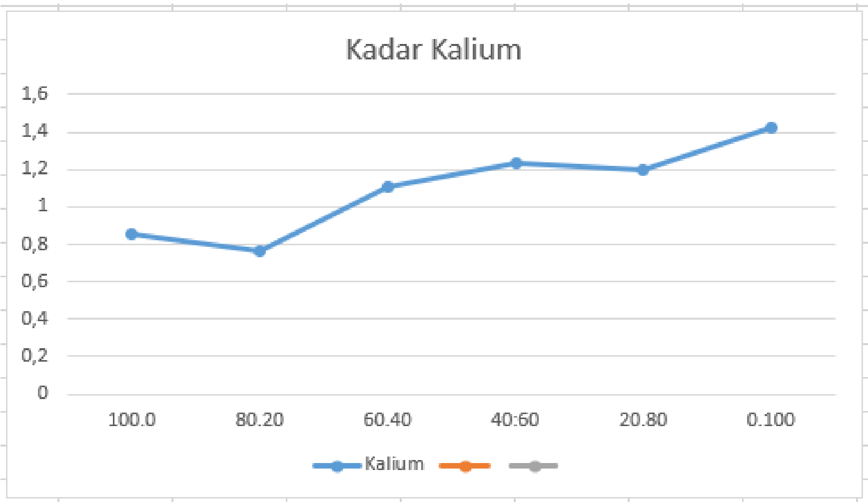

Figure 2. Content of potasium

Based on the analysis results, the potassium content in the treatments ranged from 1.83%, 1.91%, 1.83%, 1.78%, 1.79%, to 1.80%. All the potassium content results from the treatments were above the standard specified by SNI 19-7030-2004, which was 0.20%. The highest potassium content was found in the (80%:20%) treatment with a percentage of 1.91%. The lowest potassium content was found in the (60%:40%) treatment with a percentage of 1.78%.

3.3 Tomato Plant Growth

Tomato plant growth was observed in this study through plant height, leaf count, and fresh weight. The observation results showed that treatments with higher nitrogen, phosphorus, and potassium content tended to have better tomato plant growth. The treatment with a composition of (100%:0%) showed the most optimal results in all plant growth parameters. Plant height: The plant heights for the (100%:0%), (80%:20%), (60%:40%), and (40%:60%) treatments were 41.7 cm, 40.2 cm, 37.5 cm, and 35.9 cm, respectively. The (100%:0%) treatment had the tallest plant height, while the (40%:60%) treatment had the shortest plant height. Leaf count: The leaf counts for the (100%:0%), (80%:20%), (60%:40%), and (40%:60%) treatments were 21, 20, 19, and 18 leaves. The (100%:0%) treatment had the highest number of leaves, while the (40%:60%) treatment had the lowest number of leaves. Fresh weight of plants: The fresh weights of plants in the (100%:0%), (80%:20%), (60%:40%), and (40%:60%) treatments were 164.3 g, 158.2 g, 150.8 g, and 145.6 g, respectively. The (100%:0%) treatment had the highest fresh weight of plants, while the (40%:60%) treatment had the lowest fresh weight of plants.

Based on the findings of this research, it can be concluded that the use of compost made from oil palm empty fruit bunches and banana stems in tomato plant growth resulted in compost quality that met the standards specified by SNI 19-7030-2004. Furthermore, the increased nitrogen, phosphorus, and potassium content in the compost also contributed to better growth in tomato plants.

4. CONCLUSION

An evaluation was conducted on the sodium, phosphorus, and potassium (NPK) content of mixed waste from oil palm empty fruit bunches and banana stems to assess their effect on plant growth. The best results were obtained from the third variation. Since this study focused on the vegetative growth of tomato plants, the nitrogen content was the main focus, and it was varied in the third variation with higher nitrogen levels than the mixture of empty fruit bunches and banana stems. The analysis of NPK nutrient content from the six treatments of soil mixed with empty fruit bunch compost and banana stem compost showed that the N content in all six treatments met the SNI 19-7030-2004 standard, which was 0.40%. The N content in the six treatments was 1.84%, 1.74%, 1.83%, 1.63%, 1.63%, and 1.71%, respectively, with relatively high N content in these four treatments. The P content in the six treatments was 1.55%, 1.47%, 1.60%, 1.95%, 1.98%, and 2.29%, all of which met the SNI 19-7030-2004 standard of 0.10%. The K content in the six treatments was 0.85%, 0.76%, 1.11%, 1.23%, 1.20%, and 1.42%, all of which met the SNI 19-7030-2004 standard of 0.20%. The development and growth of tomato plants improved after using the organic fertilizer mixture of empty fruit bunches from oil palm and banana stems.

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Study on Content of Nitrogen, Phosphorus, and Potassium from Mixed Waste of Empty Fruit Bunch of Oil Palm and Banana Stem as Organic Fertilizer for Tomato

Akram La Kilo[1], Hendri Iyabu[2], Sarmini A. Iladat[3]
* Departement of Chemistry, Universitas Negeri Gorontalo

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Corresponding Author:

Akram La Kilo,
Department of Chemistry
Universitas Negeri Gorontalo

Email: akram@ung.ac.id

ABSTRACT

The purpose of this research was to study the levels of nitrogen, phosphorus, and potassium (NPK) contained in organic fertilizer made from a mixture of empty fruit bunch waste from oil palm and banana stems, as well as to determine the effects on the growth and development of tomato plants when applying the organic fertilizer made from the aforementioned mixture. The research involved analyzing the total nitrogen content using the Kjeldahl method, phosphorus (P) using UV-VIS, and potassium (K) using AAS, as well as conducting tomato planting experiments using a growing medium consisting of compost made from the mixture of empty fruit bunch waste from oil palm and banana stems. Based on the research results, it was found that the NPK content of the soil and compost mixture of empty fruit bunch waste from oil palm and banana stems met the SNI 19-7030-2004 standard for nitrogen (N) and phosphorus (P). The growth and development of tomato plants without using the organic fertilizer mixture from the mixture of empty fruit bunch waste from oil palm and banana stems underwent some changes, but the changes occurred at a slower pace compared to using the organic fertilizer mixture from the aforementioned mixture.

Keyword: Soil, Empty oil palm bunches, Banana trunk, NPK, tomato

1. INTRODUCTION

The Tomato plants (Solanum lycopersicum) were one of the popular horticultural crops with high economic value. To achieve optimal growth and yield, tomato plants required sufficient nutrients, especially macro-nutrients such as nitrogen (N), phosphorus (P), and potassium (K). The application of organic fertilizer could be an environmentally friendly alternative that had the potential to meet the nutritional needs of tomato plants (Annisa et al., 2022; Burhan, 2022; Salamati et al., 2022; sari et al., 2022; Shamita et al., 2022; Ziladi et al., 2021).

Industries such as palm oil and banana production generated waste materials like empty fruit bunches and banana stems, which were often discarded. However, these waste materials had the potential to be used as raw materials in organic fertilizer production, providing not only nutrients but also reducing the negative impact of waste disposal (Anhar et al., 2021; Danial et al., 2019; Hazra et al., 2023; Maricar et al., 2022; Syaiful et al., 2022; Yosephine et al., 2021). For example, the use of liquid organic fertilizer made from banana stem borers could improve soil fertility by increasing organic matter and nutrient availability, as well as enhancing the vegetative growth of oil palm seedlings (Yosephine et al., 2021). Additionally, the application of compost made from empty fruit bunch waste and liquid organic fertilizer from palm oil mill effluent could enhance the growth of Yellow Kepok banana seedlings (Yosephine et al., 2021). The potential of empty fruit bunch waste could also be utilized to produce solid organic fertilizer using geotextile cover material, effectively reducing the C/N ratio and meeting quality standards (Hazra et al., 2023). Furthermore, liquid organic fertilizer made from banana stem and rice wash could be used for cultivating mustard greens in home gardens during the COVID-19 pandemic (Maricar et al., 2022).

Studying the content of nitrogen, phosphorus, and potassium in empty fruit bunch waste from oil palm and banana stems as organic fertilizer for tomato plants was essential for evaluating their potential use (Anesti et al., 2017)(Wulandari et al., 2019). By understanding the nutrient content in these waste materials, appropriate dosages and combinations could be determined to enhance the growth and yield of tomato plants (Anesti et al., 2017)(Wulandari et al., 2019). Empty fruit bunch waste from oil palm had high organic matter content and low heavy metal content, making it suitable for composting (Wulandari et al., 2019). Banana stem waste, on the other hand, was generally rich in carbon sources but required a nitrogen source to achieve the required C/N ratio as compost material (Wulandari et al., 2019). Nitrogen was an essential nutrient for the growth of rice and soybean plants (Adzima et al., 2022; Safriyani et al., 2022; Sagita et al., 2022). Efficient nitrogen fertilization was crucial for achieving optimal results (Adzima et al., 2022). Organic fertilizers such as empty fruit bunch waste from oil palm and banana stems could be used for nitrogen supplementation (Anesti et al., 2017). Additionally, the use of rhizobium bacteria in soybean plants could reduce the reliance on inorganic fertilizers, especially nitrogen, while increasing plant productivity (Adzima et al., 2022).

Previous studies evaluated the use of palm oil and banana waste as organic fertilizers, but further research was still needed to gain a deeper understanding of the nutrient content in these waste materials and their effectiveness in enhancing tomato plant growth. Several studies related to the use of waste as organic fertilizer and its impact on plant growth had been conducted. One study showed that the application of liquid organic fertilizer made from kepok banana peel had no significant effect on the growth of oil palm seedlings in the pre-nursery stage. Another study demonstrated that the use of POC Plus liquid organic fertilizer made from cow urine and banana peel waste could increase the fruit set percentage in tomato plants. Additionally, waste materials such as shallot peel, coconut husk, banana peel, coconut water, banana stem waste, eggshells, lamtoro leaves, and banana stem residue had been researched and proven to have the potential as effective raw materials for organic fertilizer, enhancing the growth and yield of crops such as chili, okra, mustard greens, spinach, and tomatoes. Therefore, further research was needed to expand the understanding of waste utilization as organic fertilizer and its potential in supporting tomato plant growth.

By evaluating the content of nitrogen, phosphorus, and potassium, as well as utilizing mixed waste materials such as empty fruit bunches from oil palm and banana stems as organic fertilizer, it was hoped that sustainable solutions could be provided for industrial waste management while supporting the healthy and productive growth of tomato plants. This study was expected to provide useful information for farmers, researchers, and agricultural industries in their efforts to improve agricultural sustainability and waste management.

2. RESEARCH METHOD

2.1. Tools

The instruments used in this study were: a scale, a measuring tape, polybags, containers (buckets), a hoe, sacks, plastic, droppers, beakers, measuring cylinders, stirring rods, spatulas, Erlenmeyer flasks, a shaker, a mortar and pestle, volumetric flasks, an analytical balance, a burette, a set of titration equipment, a set of distillation equipment, a set of destruction equipment, Kjeldahl flasks, a watch glass, reagent bottles, a UV-VIS spectrophotometer, and an Atomic Absorption Spectrophotometer (AAS).

2.2. Materials

The sample materials used were empty fruit bunch (EFB) waste from oil palm and banana stems. The chemicals used included EM4 solution, H_2SO_4 solution, NaOH, selenium, BCG+MR indicator, H_3BO_3, HNO_3, vanadate molybdate, distilled water, and brown sugar.

2.3 Sample Preparation

The preparation of the empty fruit bunch (EFB) sample involved cleaning the EFB from dirt. A total of 30 kg of EFB samples were used for the research. The banana stem samples were taken from Unone Village, Bukal District, with a total of 30 kg of banana stem samples used for the research.

2.4 Production of Organic Fertilizer from Empty Fruit Bunch (EFB) Waste and Banana Stems

In the first process of producing organic fertilizer from empty fruit bunches, the EFB and banana stems were chopped to accelerate decomposition. Then, an EM4 solution was prepared using a composition of water, EM4, and sugar. The EM4 solution was briefly stirred and left for a few minutes, then mixed with the organic materials, which were the EFB and banana stems. The mixture was then composted by placing the materials in a tarpaulin-covered container and tightly sealing it. The pile was turned/mixed once a week for 3-4 weeks until the organic materials turned into mature organic fertilizer with a dark color. The composting process or the production of organic fertilizer from EFB waste and banana stems took approximately 3-4 weeks to produce good-quality fertilizer ready for application to plants.

2.5 Determination of Ash Content

To determine the ash content, the first step was to weigh 10 grams of the sample, and then the organic fertilizer sample from empty fruit bunch (EFB) waste was ashed in an oven at a temperature of 700°C for about 3 hours.

2.6 Analysis of Nitrogen Content

The determination of nitrogen in this research used the Kjeldahl analysis method, which involved three stages: destruction, distillation, and titration. In the first stage, the destruction stage, the sample was heated in concentrated sulfuric acid, which converted the nitrogen into ammonium sulfate $(NH_4)SO_4$. To accelerate the destruction process, a selenium mixture was added as a catalyst. The addition of the catalyst raised the boiling point of sulfuric acid, leading to faster destruction. In the second stage, the distillation stage, ammonium sulfate $(NH_4)SO_4$ was broken down into ammonia (NH_3) by adding NaOH to create a basic environment and heating the mixture. Since the reaction could not occur in an acidic environment, it was necessary to create a basic environment. To capture the generated NH_3, a 1% boric acid solution and BCG+MR indicator were used. The indicator was added to determine the excess of boric acid. In the third stage, the titration stage, the remaining boric acid that reacted with ammonium was titrated using 0.05 N H_2SO_4 until a color change to pink occurred.

2.7 Analysis of Phosphorus Content

One gram of finely ground soil was placed in an Erlenmeyer flask. Then, 25 mL of concentrated sulfuric acid (H_2SO_4) and concentrated nitric acid (HNO_3) were added. The mixture was heated on a hot plate. Then, 2.5 mL of concentrated sulfuric acid (H_2SO_4) was added, resulting in a black color similar to ash. Subsequently, concentrated nitric acid (HNO_3) was added gradually until the sample no longer emitted black smoke. After the combustion process, the sample was diluted with distilled water to a volume of 50 mL and shaken. It was then filtered into an Erlenmeyer flask, and 2.5 mL of vanadate molybdate solution was added, resulting in a yellow color. The phosphorus content was determined using a UV spectrophotometer with a maximum wavelength of 400 nm.

2.8 Determination of Potassium Content

One gram of finely ground soil was placed in an Erlenmeyer flask. Then, 25 mL of concentrated sulfuric acid (H_2SO_4) and concentrated nitric acid (HNO_3) were added. The mixture was heated on a hot plate. Then, 2.5 mL of concentrated sulfuric acid (H_2SO_4) was added, resulting in a black color similar to ash. Subsequently, concentrated nitric acid (HNO_3) was added gradually until the sample no longer emitted black smoke. After the combustion process, the sample was diluted with distilled water to a volume of 50 mL and shaken. It was then filtered into an Erlenmeyer flask. The potassium content was determined using a flame photometer/Atomic Absorption Spectrophotometer.

3. RESULTS AND ANALYSIS

3.1. Results

The results of producing compost from empty fruit bunches and banana stems involved the use of six different ratios as shown in table 1.

Table 1. Ratio of Empty Bunches and Banana Stems

Treatments	Ratio (%)	
	Empty Bunch	Banana Trunk
1	100	0
2	80	20
3	60	40
4	40	60
5	20	80
6	0	100

The composting of empty fruit bunches and banana stems began by chopping them into pieces measuring approximately 2-5 cm in size. The chopping process was carried out to accelerate the fermentation process. Subsequently, the empty fruit bunches and banana stems were mixed together, with each weighing 5 kg, according to the predetermined ratios. The mixture was then supplemented with 5 liters of diluted brown sugar solution and EM-4 as a microorganism activator. Once the mixture was thoroughly blended, it was placed into individual plastic bags and securely tied. The bags were then wrapped with tarpaulin to ensure controlled and stable airflow inside. The composting process took place for one month. Successful compost fermentation was indicated by a change in color to dark brown, easy decomposition, and the absence of unpleasant odors.

The growth and development of tomato plants resulting from the application of the prepared compost can be observed in Table 2.

Table 2. Growth and development of tomato plant

HST	Ratio (%)	Number of Leaves	The Plant Height (cm)
7-13 HST	100 : 0	4	4
	80 : 20	5	4
	60 : 40	5	4
	40 : 60	5	4
	20 : 80	5	4
	0 : 100	5	4
14-20 HST	100 : 0	7	10
	80 : 20	8	18
	60 : 40	8	18
	40 : 60	9	17
	20 : 80	9	23
	0 : 100	9	24

HST	Ratio (%)	Number of Leaves	The Plant Height (cm)
21-27 HST	100 : 0	10	17
	80 : 20	12	27
	60 : 40	12	29
	40 : 60	13	29
	20 : 80	13	32
	0 : 100	13	33

From Table 2, it could be observed that the growth of tomato plants from day 7 to 13 in variation 1 yielded 4 leaves, while variations 2-6 had the same number of leaves, which was 5. The stem height for variations 1-6 was consistent at 4 cm. Conversely, the control group had fewer leaves, specifically 3 leaves, and a stem height of 3 cm. Progressing to the growth of tomato plants from day 14 to 20, variation 1 had 7 leaves, variations 2-3 had the same number of leaves, which was 8, and variations 4-6 also had the same number of leaves, amounting to 9. The stem height in variation 1 measured 10 cm, variations 2-3 were 18 cm each, variation 4 was 17 cm, variation 5 was 23 cm, and variation 6 measured 24 cm. The control group had 5 leaves and a stem height of 7 cm. Furthermore, the growth of tomato plants from day 21 to 27 indicated that variation 1 possessed 10 leaves, variations 2-3 had the same number of leaves, which was 12, and variations 4-6 also had the same number of leaves, totaling 13. The stem height in variation 1 measured 17 cm, variation 2 was 27 cm, variation 3 was 29 cm, variation 4 was 28 cm, variation 5 was 32 cm, and variation 6 measured 33 cm.

3.2. Analysis

In this study, the samples used were soil, empty fruit bunches, and banana stems. The soil samples were obtained from Unone Village. The parameters analyzed were nitrogen, phosphorus, potassium content, and tomato plant growth. Nitrogen, phosphorus, and potassium were essential macro nutrients compared to other micro and macro nutrients. Tomato plants required these nutrients for their growth processes.

According to SNI 19-7030-2004, mature compost had certain characteristics. It had a temperature similar to soil water temperature, a C/N ratio of 10-20, a texture resembling soil, an earthy smell, and a dark color. Based on the physical appearance of the compost, most of it had a soil-like texture and a dark color. However, compost with 40% moisture content still had a fragmented form and a brownish color, indicating partial decomposition. Overall, the compost produced met the quality standards set by SNI 19-7030-2004.

In this study, the compost made from empty fruit bunches and banana stems met the quality standards according to SNI 19-7030-2004. This was because it had a crumbly texture, no foul smell, and a dark brown color. In the composting process of empty fruit bunches and banana stems, EM-4 and brown sugar were added as activators. The addition of EM-4 was to decompose organic materials and accelerate the composting process, resulting in a fresh aroma instead of a foul odor. On the other hand, the addition of brown sugar provided glucose as a food source for microorganisms involved in the composting process.

Nitrogen (N):

Nitrogen was an essential nutrient required by plants for optimal growth and development. Nitrogen in the soil came from organic matter, fertilizers, and nitrogen-fixing bacteria. Plants obtained nitrogen in the form of nitrate and ammonium ions through root uptake. Nitrogen played a crucial role in various plant processes, including photosynthesis, protein synthesis, and overall plant vigor (Marschner, 2012).

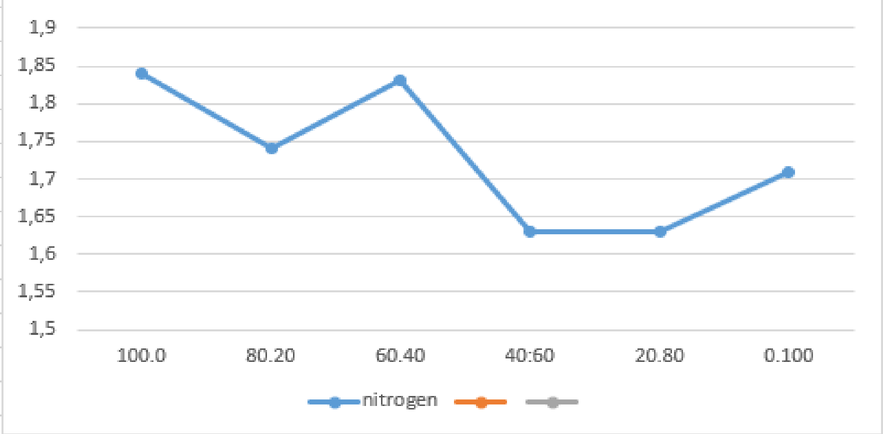

Figure 1. Content of nitrogen

The analysis results showed that the nitrogen content in the treatments ranged from 1.70%, 1.82%, 1.73%, 1.78%, 1.79%, to 1.80%. All the nitrogen content results from the treatments were above the standard set by the Indonesian National Standard (SNI) 19-7030-2004, which was 1.00%. The treatment with the highest nitrogen content was (80%:20%) with a percentage of 1.82%, while the treatment with the lowest nitrogen content was (40%:60%) with a percentage of 1.70%.

The effect of nitrogen on tomato growth and development is significant, as nitrogen is an essential nutrient for tomato growth and development (Li et al., 2023). However, high levels of nitrogen can make tomato plants release fewer volatiles and attract more Bemisia tabaci (Islam et al., 2017). The percentage of total nitrogen in tomato plant tissues can vary depending on the nitrogen levels (Islam et al., 2017). The effects of fertilization systems on nitrogen isotopic patterns can also affect the nitrogen amount and fruit yield of tomato plants (Trandel et al., 2018). Plant damage in urban agroecosystems can also affect tomato growth and development (Egerer et al., 2020).

Nitrogen is a key component of enzymes, vitamins, chlorophyll, and other cell constituents, all of which are essential for crop growth and development, making it one of the most important nutrients required for high tomato crop yields (Korob, 2022). The effects of nitrogen on tomato growth, yield, and root development, soil nitrogen, and water distribution can vary depending on the nitrogen and irrigation rates (Ayankojo et al., 2020). Nitrogen is the primary nutrient input to greenhouse vegetables during their growth, development, and yield (Ayankojo et al., 2020). Different nitrogen levels can affect the plant height of tomato, with readily available nitrogen encouraging more vegetative growth and development (Ayankojo et al., 2020). The form of nitrogen can also affect the growth, yield, and fruit quality of tomato under controlled alternate partial root zone irrigation .

Phosphorus was an important nutrient needed by plants for optimal growth and development. Phosphorus in the soil came from organic matter, fertilizers, and phosphate minerals. Plants acquired phosphorus in the form of water-soluble phosphate compounds through binding and release processes by the soil (Kumar et al., 2006).

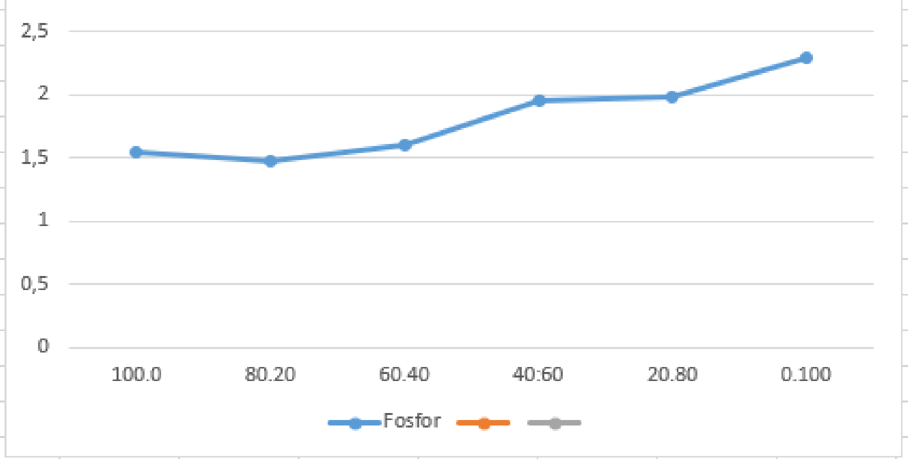

Figure 2. Content of phosphorus

The analysis results showed that the phosphorus content in the treatments ranged from 1.78%, 1.82%, 1.83%, 1.88%, 1.94%, to 1.79%. All the phosphorus content results from the treatments were above the standard set by SNI 19-7030-2004, which was 0.20%. The treatment with the highest phosphorus content was (80%:20%) with a percentage of 1.94%, while the treatment with the lowest phosphorus content was (60%:40%) with a percentage of 1.78%.

Potassium was a vital macro nutrient in plant growth and development. Soils naturally contained potassium in the form of minerals such as potassium feldspar and mica. Potassium in the soil could be bound to soil colloids and released in the form of potassium ions that could be utilized by plants (Savci, 2012).

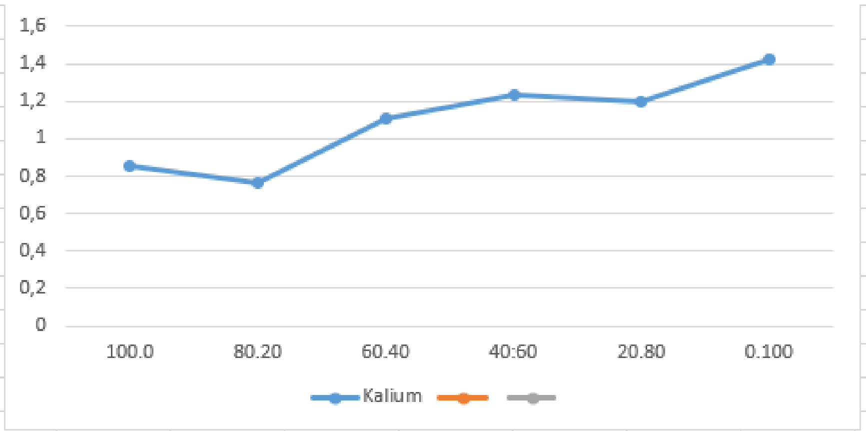

Figure 2. Content of potasium

Based on the analysis results, the potassium content in the treatments ranged from 1.83%, 1.91%, 1.83%, 1.78%, 1.79%, to 1.80%. All the potassium content results from the treatments were above the standard specified by SNI 19-7030-2004, which was 0.20%. The highest potassium content was found in the (80%:20%) treatment with a percentage of 1.91%. The lowest potassium content was found in the (60%:40%) treatment with a percentage of 1.78%.

3.3 Tomato Plant Growth

Tomato plant growth was observed in this study through plant height, leaf count, and fresh weight. The observation results showed that treatments with higher nitrogen, phosphorus, and potassium content tended to have better tomato plant growth. The treatment with a composition of (100%:0%) showed the most optimal results in all plant growth parameters. Plant height: The plant heights for the (100%:0%), (80%:20%), (60%:40%), and (40%:60%) treatments were 41.7 cm, 40.2 cm, 37.5 cm, and 35.9 cm, respectively. The (100%:0%) treatment had the tallest plant height, while the (40%:60%) treatment had the shortest plant height. Leaf count: The leaf counts for the (100%:0%), (80%:20%), (60%:40%), and (40%:60%) treatments were 21, 20, 19, and 18 leaves. The (100%:0%) treatment had the highest number of leaves, while the (40%:60%) treatment had the lowest number of leaves. Fresh weight of plants: The fresh weights of plants in the (100%:0%), (80%:20%), (60%:40%), and (40%:60%) treatments were 164.3 g, 158.2 g, 150.8 g, and 145.6 g, respectively. The (100%:0%) treatment had the highest fresh weight of plants, while the (40%:60%) treatment had the lowest fresh weight of plants.

Based on the findings of this research, it can be concluded that the use of compost made from oil palm empty fruit bunches and banana stems in tomato plant growth resulted in compost quality that met the standards specified by SNI 19-7030-2004. Furthermore, the increased nitrogen, phosphorus, and potassium content in the compost also contributed to better growth in tomato plants.

4. CONCLUSION

An evaluation was conducted on the sodium, phosphorus, and potassium (NPK) content of mixed waste from oil palm empty fruit bunches and banana stems to assess their effect on plant growth. The best results were obtained from the third variation. Since this study focused on the vegetative growth of tomato plants, the nitrogen content was the main focus, and it was varied in the third variation with higher nitrogen levels than the mixture of empty fruit bunches and banana stems. The analysis of NPK nutrient content from the six treatments of soil mixed with empty fruit bunch compost and banana stem compost showed that the N content in all six treatments met the SNI 19-7030-2004 standard, which was 0.40%. The N content in the six treatments was 1.84%, 1.74%, 1.83%, 1.63%, 1.63%, and 1.71%, respectively, with relatively high N content in these four treatments. The P content in the six treatments was 1.55%, 1.47%, 1.60%, 1.95%, 1.98%, and 2.29%, all of which met the SNI 19-7030-2004 standard of 0.10%. The K content in the six treatments was 0.85%, 0.76%, 1.11%, 1.23%, 1.20%, and 1.42%, all of which met the SNI 19-7030-2004 standard of 0.20%. The development and growth of tomato plants improved after using the organic fertilizer mixture of empty fruit bunches from oil palm and banana stems.

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