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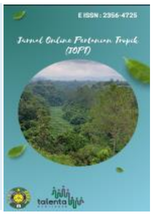

Characterization and effectiveness of moringa leaves (*Moringa oleifera* Lamk.) and *Azotobacter chroococcum* bio-organic fertilizer on the growth of green spinach

Elli Elfrida[*1], Benny Hidayat[2]

[1]*Department of Agrotechnology, Faculty of Agriculture, Universitas Medan Area, Medan, 20223, Indonesia*
[2]*Faculty of Agriculture, Universitas Sumatera Utara, Medan, Indonesia*
[*]Corresponding Author: alliafrida@staff.uma.ac.id

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ABSTRACT

The decline in spinach production is a challenge in sustainably increasing its productivity. One potential solution is the use of bio-organic fertilizer (BOF) derived from leaves of Moringa (*Moringa oleifera* Lamk.) and *Azotobacter chroococcum* because it contains essential nutrients for plant growth. This study aims to characterize moringa leaf BOF and its effectiveness in increasing green spinach growth (*Amaranthus tricolor* L.). The research was conducted experimentally using five treatments: P1 (10% Moringa leaves), P2 (15% Moringa leaves), P3 (20% Moringa leaves), K^- (0% Moringa leaves), and K^+ (Commercial Fertilizer). Observed parameters included fertilizer pH, temperature, color, plant height, and number of leaves. Fertilizer observation data were analyzed descriptively based on SNI standards and credible journals, while plant growth data were analyzed using ANOVA and ANCOVA at a 5% significance level. The BOF produced had a pH of 6–7, a temperature of 26–27 °C, and a dark brown color. The best performance was obtained with treatment P3, producing an average plant height of 26.6 cm and 14 leaves. These findings indicate that Moringa leaf-based BOF has potential as an effective and environmentally friendly organic fertilizer to improve green spinach growth.

Keyword: sustainable agriculture, moringa leaves, bio-organic fertilizer, *Azotobacter chroococcum*, plant nutrition

ABSTRAK

Penurunan produksi bayam merupakan tantangan dalam upaya meningkatkan produktivitasnya secara berkelanjutan. Salah satu solusi potensial adalah penggunaan pupuk organik hayati (bio-organic fertilizer/BOF) yang berasal dari daun kelor (*Moringa oleifera* Lamk.) dan *Azotobacter chroococcum* karena mengandung unsur hara esensial bagi pertumbuhan tanaman. Penelitian ini bertujuan untuk mengkarakterisasi BOF daun kelor serta mengetahui efektivitasnya dalam meningkatkan pertumbuhan bayam hijau (*Amaranthus tricolor* L.). Penelitian dilakukan secara eksperimental dengan lima perlakuan, yaitu P1 (kelor 10%), P2 (kelor 15%), P3 (kelor 20%), K^- (kelor 0%), dan K^+ (pupuk komersial). Parameter yang diamati meliputi pH pupuk, suhu, warna, tinggi tanaman, dan jumlah daun. Data hasil pengamatan pupuk dianalisis secara deskriptif berdasarkan standar SNI dan jurnal yang kredibel, sedangkan data pertumbuhan tanaman dianalisis menggunakan ANOVA dan ANCOVA pada taraf signifikansi 5%. BOF yang dihasilkan memiliki pH 6–7, suhu 26–27 °C, dan berwarna cokelat tua. Kinerja terbaik diperoleh pada perlakuan P3, dengan rata-rata tinggi tanaman 26,6 cm dan 14 helai daun. Temuan ini menunjukkan bahwa BOF berbasis daun kelor berpotensi menjadi pupuk organik yang efektif dan ramah lingkungan untuk meningkatkan pertumbuhan bayam hijau.

Keyword: pertanian berkelanjutan, daun kelor, pupuk organik hayati, *Azotobacter chroococcum*, nutrisi tanaman

1. Introduction

The demand for green spinach (*Amaranthus tricolor* L.) continues to increase due to its high nutritional content, including vitamins A, E, and C, calcium, fiber, beta-carotene, and iron (3.9 mg/100 g), which play important roles in maintaining health and preventing anemia through hemoglobin formation (Kundaryanti et *al.*, 2019; Yudhistira et *al.*, 2018). However, the productivity of spinach in Indonesia tends to be unstable. According to the 2023 Horticultural Fixed Numbers Survey, spinach production decreased by 0.08%, from 170.82 tons in 2022 to 170.688 tons in 2023, while the harvested area also decreased by 0.51%, from 47.049 ha to 46.81 ha.

Continuous use of inorganic fertilizers is one of the factors contributing to this decline (Khoirurrozzikin et *al.*, 2023). Globally, the use of chemical fertilizers increased from 82 to 112 kg ha^{-1} between 2000 and 2021 (Brief, 2023). These fertilizers commonly contain nitric acid and ammonium nitrate, which are key components in the production of NPK and calcium ammonium nitrate fertilizers due to their high nitrogen content (15.5–34.5%) (Alhasan et *al.*, 2024; Ma et *al.*, 2023). However, excessive and continuous application of these materials can cause soil acidification and alter the composition and structure of soil microbial communities (Yang et *al.*, 2023; Zhou et *al.*, 2024).

As a more sustainable alternative to these problems, biological-organic fertilizer (BOF) has been developed to enhance soil health and provide balanced nutrients for plants (Ali et *al.*, 2024). BOF contains beneficial microorganisms that can increase nutrient availability, improve soil fertility, and produce metabolite compounds that support plant growth (Mazid & Khan, 2014). Azotobacter is one of the key bacteria capable of fixing atmospheric nitrogen and solubilizing phosphate that is not directly available to plants (Martínez-Dalmau et *al.*, 2021). *Azotobacter chroococcum* converts free nitrogen into ammonium (NH_4^+) or nitrate (NO_3^-) ions that can be readily absorbed by plants (Zhu et *al.*, 2021). Several studies have shown that Azotobacter inoculation enhances the growth, yield, and nutrient content of lettuce, maize, and pakcoy through phosphate solubilization, siderophore, and ACC deaminase production (Husnaeni & Setiawati, 2018; Razmjooei et *al.*, 2022; Sagar et *al.*, 2022).

In addition to functional microorganisms, BOF also contains macro and micro nutrients derived from organic materials such as animal manure, food waste, agricultural residues, and various plant species (Chojnacka et *al.*, 2020; Oji & Godgift, 2020). One potential source of nutrients for BOF is Moringa (*Moringa oleifera* Lamk.), which is rich in minerals such as Na, K, P, Ca, Fe, Cu, S, Zn, and Mg (Meireles et al., 2020). One hundred grams of fresh Moringa leaves contain 1240 mg N, 70 mg P, 259 mg K, 440 mg Ca, 42 mg Mg, and 0.85 mg Fe (Mashamaite et *al.*, 2022). Moringa leaves are also rich in protein, vitamins A and C, amino acids, fiber, riboflavones, phenolic compounds, free proline, and phytohormones such as cytokinins, auxins, and gibberellins (Srivastava et *al.*, 2023).

The incorporation of Moringa leaves in BOF formulation not only increases nutrient content but also enhances microbial activity and nutrient absorption efficiency in plants. The combination of organic matter from Moringa leaves and *Azotobacter chroococcum* is expected to produce an effective and high-quality BOF. Characterization is necessary to determine the extent to which the fertilizer meets the nutritional requirements of plants. Therefore, this study aims to characterize Moringa leaf-based bio-organic fertilizer through pH, color, and temperature analysis, and to evaluate its effectiveness in supporting the growth of green spinach (*Amaranthus tricolor* L.).

2. Methods

The research was conducted from January to March 2025 in the Green House at coordinates 7°57'41.3" S and 112°37'4.3" E and Microbiology Laboratory of State University of Malang at coordinates 7° 57′ 39.5″ S and 112° 37′ 08.0″ E.

The main materials used in this study were Moringa oleifera leaves, Azotobacter chroococcum, EM4, molasses, rice washing water, and fermented manure. The equipment used included a pH–TDS–EC–Temperature meter, measuring instruments, and polybags (20 × 20 cm).

Testing the effectiveness of moringa leaf BOF using a Non-Factorial Completely Randomized Design (CRD) with 5 treatments consisting of P1 (10% moringa leaves = 100 g L-1); P2 (15% moringa leaves = 150 g L-1); P3 (20% moringa leaves = 200 g L-1); K- (0% moringa leaves); and K+ (moringa-LOF commercial fertilizer).

2.1. Research Stage

2.1.1. Subculture and Inoculant Preparation of Azotobacter chroococcum)

The medium used for the growth of nitrogen-fixing bacteria is Nitrogen Free Bromthymol Blue (NFB) made from 20 g agar; 5 g malic acid; 0.5 g K2HPO4; 0.2 g MgSO4. 7H2O; 0.1 g NaCl; 0.002 g CaCl2; 2 mL BTB (0.5%) (0.5 g) in NaOH; 4 mL Fe EDTA 1.64%; 4 g KOH; 2 mL microelement (0.4 g CuSO4; 0.12 ZnSO4.7H2O; 1.4 g H3BO3; 1.5 g Na2MoO4.2H2O; and 1.5 MnSO4.H2O dissolved in 100 mL distilled water).

All ingredients were dissolved in 1 L of distilled water, set the pH to 6.5, and then sterilized in an autoclave at 121 °C for 30 minutes (Baldani et *al.*, 2014). The bacterial subculture process was carried out on Nutrient Agar (NA) tilted media aseptically, then incubated at room temperature for 24 hours. The inoculum was prepared by inoculating 1% of *A. chroococcum* culture into 200 mL of liquid NFB medium in an Erlenmeyer flask and shaking at room temperature for three days (Hindersah et *al.*, 2021).

2.1.2. Preparation of Moringa Leaf BOF

Fresh moringa leaves were washed with running water. Each treatment was fermented in a volume of 2.5 L. The P1 formulation consisted of 250 grams of ground moringa leaves, mixed with 100 mL of molasses, 100 mL of EM4, 1.5 L of rice washing water, 150 grams of fermented manure, 200 mL of *Azotobacter chroococcum* inoculant, and clean water to reach the specified volume. Treatments P2 used 375 grams of moringa leaves, and P3 used 500 grams of moringa leaves, with the same additional ingredients. The negative control (K−) excluded moringa leaves but used the same quantities of other ingredients. All mixtures were sealed and fermented for 14 days.

2.1.3. Sowing of Green Spinach Seeds

Maestro F1 green spinach seeds were sown in trays 1 cm depth with three seeds per hole, and then covered with soil. The trays were covered with clear plastic for 2 days and watered sufficiently to keep it moist. Spinach seedlings that were 7 DAP (Days After Planting) and had 4 leaves were transferred into polybags measuring 20 cm x 20 cm. Each polybag contained 1 spinach plant.

The concentrated BOF (10 mL) was diluted in 1 L of water (1:100) and applied once a week by drenching 100 mL around the root area in the morning (Onyia et *al.*, 2020). No additional watering was conducted immediately after fertilization. Plants were watered daily in the morning and weeds were removed regularly.

2.1.4. Application of Moringa Leaf BOF and Plant Maintenance

A total of 10 mL of concentrated liquid BOF was diluted in 1 L of water (1:100) and applied by drenching around the root zone (Onyia et *al.*, 2020). The fertilizer was applied once a week at a dose of 100 mL per plant in the morning when the temperature was relatively cool and humidity was high to minimize evaporation losses. No additional watering was carried out immediately after fertilization. Plant maintenance included daily watering in the morning to maintain soil moisture and periodic removal of weeds to reduce competition for nutrients, water, and light between plants.

2.2. Parameter Observation

Fertilizer characteristics (pH, temperature, and color) were observed on days 0, 7, and 14 of fermentation. pH and temperature were measured using a pH–TDS–EC–Temp meter, while color was observed visually (Tsaniya et *al.*, 2021). The effectiveness of moringa leaf BOF was evaluated by measuring plant height and number of leaves of green spinach at 7, 12, 17, 22, 27, 32, and 37 days after planting (DAP).

2.3. Data Analysis

BOF characterization data were analyzed descriptively in accordance with Indonesian National Standards (INS) and credible journal articles. Plant height growth data were analyzed using Analysis of Covariance (ANACOVA), while the number of leaves using one way Analysis of Variance (ANOVA) with a significance level of 5%, followed by LSD and Duncan's Multiple Range Test (DMRT). All data analysis of this study used IBM SPSS Statistics 27.0 software.

3. Results and Discussion

3.1. Degree of Acidity (pH) of Moringa Leaf Bio Organic Fertilizer

Degree of acidity (pH) is an important factor that affects the activity of microorganisms to decompose organic matter. The graph of changes in the pH of moringa leaf BOF during the fermentation process can be seen in

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graph 1.

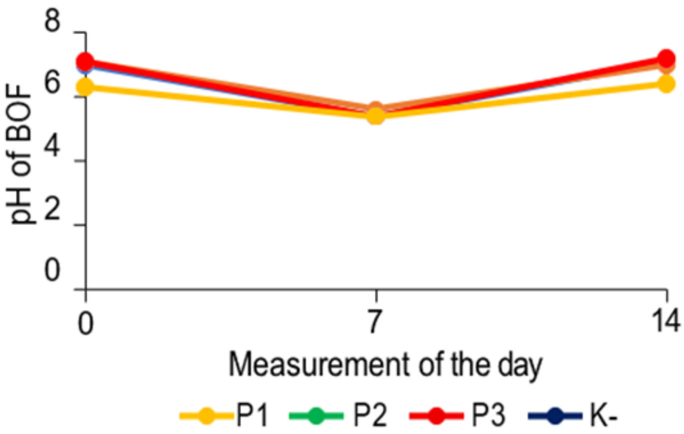

Figure 1. Changes in pH of moringa Leaf BOF

Based on Figure 1, the pH of the fertilizer before fermentation was in the neutral range (6–7). The pH of the fertilizer before fermentation was within the neutral range (6–7). On day 0, treatment P3 exhibited the highest initial pH value (7.07), whereas the control (K–) had the lowest (6.23). During the first week of fermentation, the pH of all treatments decreased to approximately 5, indicating active microbial decomposition of organic matter. In the second week, the pH gradually increased to the neutral range (6–7). After 14 days, treatment P3 recorded the highest pH (7.13), while K– remained the lowest (6.36).

The decrease in pH during the early fermentation phase indicated microbial activity in decomposing complex organic compounds into simpler organic acids, such as acetic, propionic, and butyric acids (Sarah et *al.*, 2023; Azara et al., 2021). This acidic condition indicated an active anaerobic fermentation process, which generally proceeds optimally at pH 6.5–7.5 (Sarah et al., 2023).

From day 8 to 14, the pH increased due to the release of ammonia resulting from microbial metabolism during organic matter degradation (Allaily et al., 2022; Yao et al., 2024). The rising pH created a more favorable environment for microbial proliferation, particularly for *Azotobacter chroococcum*, which thrives under near-neutral conditions. After 14 days of fermentation, the final pH (6–7) indicated that the environment remained suitable for the survival of *A. chroococcum* in the bio-organic fertilizer. According to Aasfar et al. (2021), *A. chroococcum* grows optimally at pH 7–7.5, supporting its physiological and metabolic activities. Fertilizers with excessively low pH values may inhibit microbial growth, while highly alkaline conditions can reduce the rate of organic matter decomposition (Hernández-Fernández et al., 2021; Wang et al., 2022).

The results showed that the pH value of this BOF was within the normal range and safe to apply to plants. The pH value of the Moringa leaf-based BOF remained within the safe range (6–7), aligning with the Minimum Technical Requirements for Organic Fertilizers, Biofertilizers, and Soil Improvers established by the Ministry of Agriculture (Kementan, 2019), which specify a pH range of 4–9. Therefore, the produced BOF met the standard requirements for field application.

3.2. Temperature of Moringa Leaf Bio-Organic Fertilizer

Temperature is an important environmental factor for the survival of microorganisms. The changes in the temperature of moringa leaf BOF during14 days of fermentation can be seen in Figure 2.

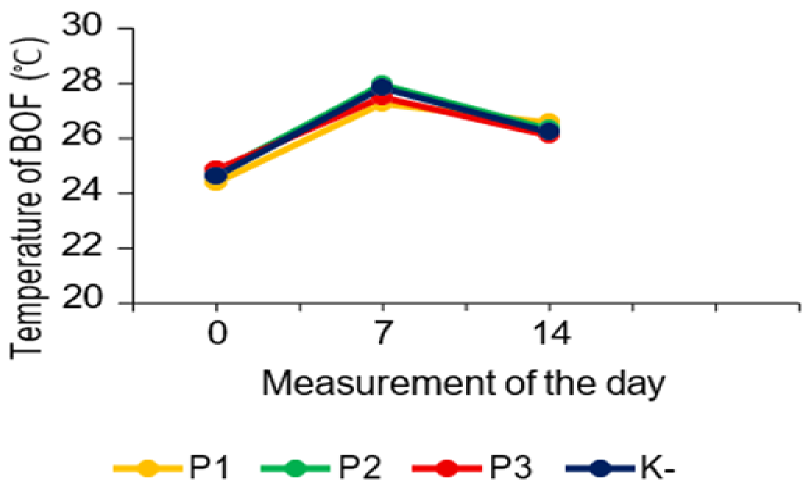

Figure 2. Changes in Temperature of Moringa Leaf BOF

Based on the research results in Figure 2, the temperature at the beginning of fermentation was recorded at 24 °C, which is slightly below the optimal range for organic matter fermentation (25–55 °C) (Arifan et al., 2022). This relatively low temperature was likely influenced by ambient room conditions. However, it remained within the range that supports the survival of *Azotobacter chroococcum*. According to Aasfar et al. (2021), Azotobacter species grow well at 25–30 °C, which supports their physiological and metabolic activities.

Entering the second week, the temperature decreased to 26 °C. Observation results for 14 days showed that P1 had the highest temperature of 26.5 °C while P3 showed the lowest temperature of 26 °C. The observation results on day 0, the initial temperature of the fertilizer was recorded at around 24 °C. This temperature is lower than the optimal range of fermentation which is 25-55 °C (Arifan et al., 2022), which is likely influenced by room temperature and by Abidin et al. (2024) were also reported that there was an increase in temperature during the fermentation process from 25.9 °C to 29.1 °C as a result of the biochemical reactions that occurred. The study conducted by Afa et al. (2024) explained that there was no increase in temperature during the fermentation process.

The results of observations in the second week, namely on days 8 to 14, the temperature decreased from 27 °C to 26 °C. This decrease indicates that microbial activity has decreased due to the reduction of organic matter as a source of metabolism. A decrease in temperature will occur along with the decomposition of most organic matter (Napoleon & Sulistiyani, 2023). However, the resulting final temperature of 26 °C is within the range that supports the survival of A. chroococcum. According to Aasfar et al. (2021), Azotobacter can grow well at a temperature of 25-30 °C which supports its physiological activities.

3.3. Colors of Mooringa Leaf Bio-Organic Fertilizer

Color acts as one of the important indicators in identifying the maturity of fertilizer. Changes in the color of the fertilizer during the fermentation process for 14 days are presented in Table 1.

Table 1. Average Number of Green Spinach Leaves

Treatments	Colors (Day-Observation)		
	0	**7**	**14**
0% Moringa (-K)	Brown	Brown	Dark Brown
10% Moringa Leaves (P1)	Greenish Brown	Dark Brown	Dark Brown
15% Moringa Leaves (P2)	Greenish Brown	Dark Brown	Dark Brown
20% Moringa Leaves (P3)	Greenish Brown	Brown	Blacklish Brown

Visual observation of fertilizer color as shown in Table 1 shows a color change from greenish brown to dark brown to blackish brown. On day 0, treatments P1, P2, and P3 were dominated by greenish brown color, while K- showed brown color. Entering the first week of fermentation, the color changed to brown to dark brown, indicating that organic matter decomposition had occurred. At the end of the fermentation process, the color of the fertilizer became more intense to dark brown to blackish brown.

The initial color of fertilizer before fermentation is greenish brown which is influenced by the composition of the basic ingredients (Apriani & Asngad, 2023). The brown color comes from ingredients such as molasses, EM4, and manure, while the greenish color is the natural color of moringa leaves that have not been decomposed.

Color changes that occur during the fermentation process are due to the activity of microorganisms in decomposing organic matter in fertilizers. As the process progresses, organic matter undergoes an oxidation reaction which results in a darker color. In accordance with the study of Kartini et al. (2023) which shows that the activity of microorganisms causes changes in the particle size of organic matter to become smaller and then followed by a change in color to darker. P3 treatment produces a blackish brown final color. This is because Moringa leaves have phenolic compounds that can potentially produce dark pigments. Studies conducted by Gomes et al. (2014) stated that phenol compounds in the substrate can be oxidized by the enzyme polyphenol oxidase (PPO) into dark quinone compounds. This oxidation process is likely to occur when the container is open so that outside air can react directly with the material. The observation results for 14 days of fermentation showed the dominance of dark brown to blackish color. This condition has reached optimal fertilizer maturity, as described by Afa et al. (2024), which states that the dark color indicates that most of the organic matter has been decomposed so that fertilizers containing nutrients can be directly absorbed by plants.

3.4. Green Spinach Plant Height

Observation data on the height of green spinach plants during 37 weeks of planting overall showed that the provision of moringa leaf BOF gave significant influence and difference on the growth of green spinach plant height. BOF P3 gave the highest result of 26.57 ± 1.27 but was not significantly different from K+ and P2, while K- gave the lowest result of 19.25 ± 1.27.

The results of the analysis of the average height of green spinach plants are in Table 2.

Table 2. Average Height of Green Spinach

Treatments	AverageHeight to Spinach (cm)
0% Moringa Leaves (-K)	19.25 ±1.27ab
P1 (10% Moringa Leaves)	21.17±1.37b
P2(15% Moringa Leaves)	23.35±1.29bc
P3 (20% Moringa Leaves)	24.84±1.26bc
Commercial Fertilizer (K+)	26.57±1.27bc

Note: In columns with the same letter above the number, the value is not significantly different based on Duncan's test at the 5% significance level (n=5; mean ± SD.

In general, the development of the average height of spinach plants is presented in Figure 3, which illustrates the plant's growth from 7 to 37 WAP (Week After Planting).

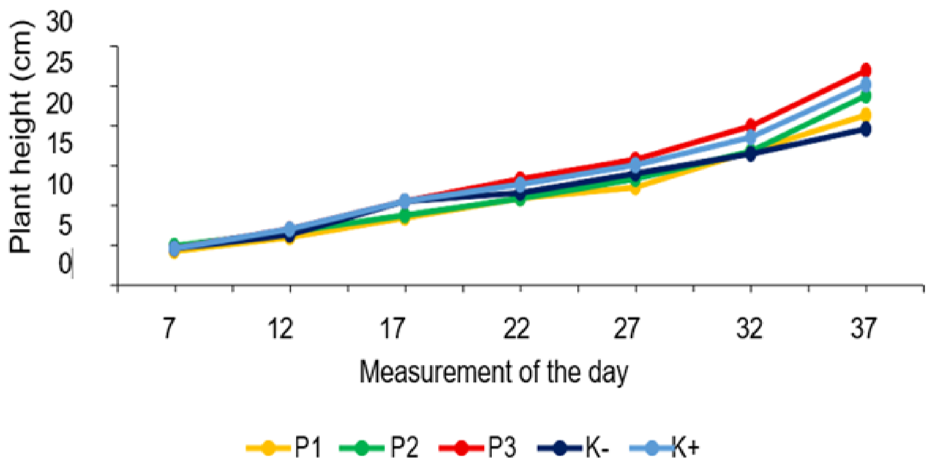

Figure 3. Height of green spinach

Based on the observation in Figure 3, P3 significantly increased the average plant height by 26.6 cm at 37 weeks after planting, while K- showed the lowest average of 19.3 cm. This indicates that P3 is the optimal dose in the growth of green spinach plants. Increasing the concentration of moringa leaves in fertilizer can provide nutrient availability. The P3 treatment showed more optimal results than the K^+ treatment, presumably related to the presence of A. chroococcum bacteria. Studies conducted by Aasfar et *al.* (2021), explained that Azotobacter bacteria are able to increase nitrogen availability and synthesize growth hormones such as cytokinins, IAA, and gibberellins.

The P3 variation showed a significant effect on the growth of green spinach plant height, indicating the potential of moringa leaves as fertilizer material. These results are in line with the study of Fiddaroini and Yulianti (2023) which reported that moringa leaf liquid organic fertilizer accelerated the growth rate of red spinach plant height up to 1.4 times faster than plants that were only watered with water with growth rates of 0.36 cm and 0.26 cm per day, respectively. Another study also proved that moringa fertilizer can increase the height of leek plants from 6.20 cm to 20.20 cm (Mare et *al.*, 2023).

Moringa leaves contain substances like phytohormones such as cytokinins zeatin, auxins, and gibberellins that play a role in regulating plant growth (Mashamaite et *al.*, 2022). Zeatin, which is dominant in moringa leaves, has an important role in cell division and enlargement in young tissues, as well as increasing the absorption and distribution of photosynthetic products (Yuniati et *al.*, 2022). This role is supported by auxins that stimulate cell elongation, stem growth, and lateral roots, as well as gibberellins that contribute to increasing plant height, leaf expansion, and photosynthetic efficiency (Mashamaite et *al.*, 2022). In addition to phytohormone content, Moringa leaves also contain macro nutrients such as Nitrogen (N), Phosphorus (P), and Potassium (K) which play an important role in supporting plant growth (Mare et *al.*, 2023).

Nitrogen functions in stimulating vegetative cell division, including stems so that plant growth can be influenced (Leghari et al., 2016). Other macro elements such as phosphorus contribute to increasing abiotic stress tolerance in plants, supporting growth, and strengthening roots and stems (Khan et al., 2023). Potassium also plays an active role in promoting plant growth by stimulating enzymes involved in photosynthesis, stomatal regulation, protein synthesis, and other metabolic processes (Chrysargyris & Tzortzakis, 2025).

3.5. Number of Green Spinach Leaves

Observation data on plants during 37 weeks of planting overall showed that the moringa leaf BOF gave significant influence increased the number of green spinach leaves.

The P3 treatment gave the highest result of 14.25 ± 0.95 but did not show a significant difference with K+ and P2, while the treatment with K- gave the lowest result of 10.50 ± 1.29 but did not differ significantly with P1 and P2. The results of the analysis of the average height of green spinach plants are presented in Table 3.

Table 3. Average Number of Green Spinach Leaves

Treatments	Average number of Spinach Leaves
0% Moringa Leaves (-K)	10.50 ±1.29ab
P1 (10% Moringa Leaves)	11.75±1.89b
P2(15% Moringa Leaves)	12.255±1.89bc
P3 (20% Moringa Leaves)	14.25±1.41bc
Commercial Fertilizer (K+)	13.00±1.41bc

Note : In colums with the same letter above the number, the value is not significantly different based on Duncan's test at the 5% significance level (n=5; mean ± SD).

In the table 3, showed that the P3 treatment gave the highest result of 14.25 ± 0.95 but did not show a significant difference with K+ and P2, while the treatment with K- gave the lowest result of 10.50 ± 1.29 but did not differ significantly with P1 and P2. Observation data for 37 weeks after planting showed that the provision of moringa leaf BOF had a significant effect on the increase in the number of green spinach leaves.

In general, the development of the average number of green spinach leaves is presented in Figure 4, which illustrates the plant's growth from 7 to 37 WAP (Week After Planting).

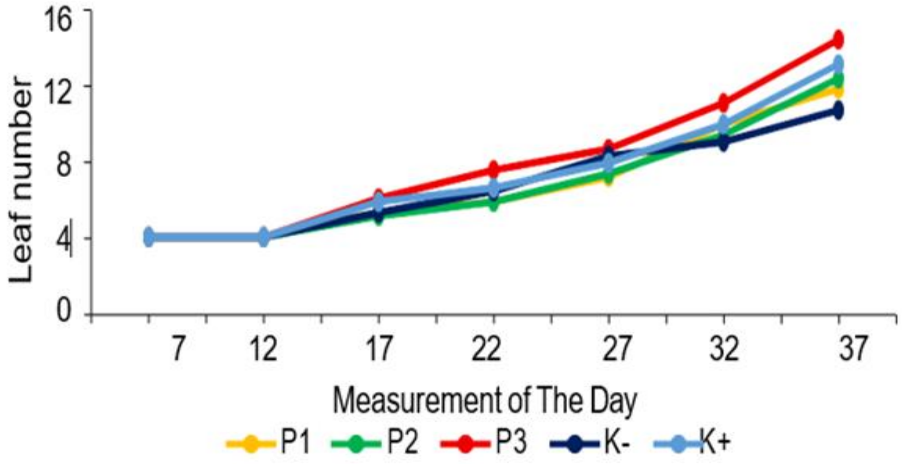

Figure 4. Number of green spinach leaves

The observation results presented in Figure 4 show the number of green spinach leaves has increased significantly. At 7 weeks of planting, all treatments had 4 leaves. After 37 weeks of planting, changes were seen, where P3 had the highest number of leaves, namely 14.25 leaves, while K- had the least with 10.5 leaves. It is suspected that P3 provides optimal results in meeting the nutritional needs of plants. In line with the research of Tomia and Pelia (2021) which reported an increase in the number of purple eggplant leaves with an average of 8.25 strands to 25.25 strands after being given moringa leaf liquid organic fertilizer. Another study also proved similar results in tomato plants with an average of 97.58 leaves at 21 HST (Noer, 2022).

Moringa leaves have a number of natural phytohormones such as auxins, cytokinins, and gibberellins that play an active role in leaf formation and development. Cytokinin contributes to enlarging mesophyll cells so that the leaf surface area increases, strengthening leaf structure by stimulating cell wall thickening in reinforcing tissues, and encouraging the formation of vascular tissue (Sosnowski et al., 2023). Auxin supports the growth of leaf number through cell elongation and enlargement in leaf meristem tissues, and regulates stomatal density (Mashamaite et al., 2022). Gibberellin also plays a role in cell elongation, leaf expansion, new leaf formation, and regulates leaf senescence (Ritonga et al., 2023). The interaction between the three phytohormones contributes significantly to increasing leaf quantity and quality.

4. Conclusion

Increasing the concentration of moringa leaves in Biological Organic Fertilizer (BOF) significantly affects plant growth parameters. Moringa leaf BOF with a concentration of 20% showed the most effective results on the height and number of leaves of green spinach plants. The characteristics of this moringa leaf BOF have met the standards of pH, temperature, and color of fertilizer quality. Thus, this moringa leaf BOF has the potential to be an effective fertilizer to increase plant growth It is necessary to further study the effective and efficient method of giving water to achieve high plant productivity.

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