**Bioscientist: Jurnal Ilmiah Biologi**
https://e-journal.undikma.ac.id/index.php/bioscientist

March 2026 Vol. 14, No. 1
e-ISSN: 2654-4571
pp. 133-143

# Comparison of the Growth and Development of Green Spinach (*Amaranthus hybridus* L.) under Soil Conditions from the Java and Kalimantan Regions

**[1]Riannisa'a Shafira, [2]Fitria Alfiyah Hastuari, [3]Anindya Aulya Andayani, [4]Rofina Mbale Role, [5*]Meti Indrowati**
[1,2,3,4,5]Department of Biology Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia.
*Corresponding Author email: metiindrowati@staff.uns.ac.id
Received: January 2026; Revised: February 2026; Accepted: March 2026; Published: March 2026

**Abstract:** This study aimed to compare the growth of green spinach (*Amaranthus hybridus* L.) cultivated in two different soil types originating from Java and Kalimantan, and to examine the effect of soil pH on plant height. The experiment was conducted over a 21-day period (3–24 November 2025) using a comparative experimental design with a total of eight samples, consisting of four plants in each treatment group. The parameters observed included soil pH, plant height, number of leaves, leaf width, and leaf color. Environmental variables—such as light intensity, water volume, pot size, and seed quantity—were controlled to ensure consistent experimental conditions. The data were analyzed using statistical assumption tests, including the Shapiro–Wilk normality test and Levene's homogeneity test, followed by linear regression analysis and analysis of covariance (ANCOVA). The results indicated that the data were normally distributed ($p = 0.328$) and homogeneous ($p = 0.575$). Regression analysis showed that soil pH had a significant effect on plant height ($p = 0.026$), whereas soil type did not have a significant effect after controlling for soil pH (ANCOVA, $p = 0.089$). The mean difference in plant height between soils from Java and Kalimantan was 2.90 cm; however, this difference was not statistically significant. These findings suggest that the growth of green spinach—particularly plant height—is more strongly influenced by environmental factors, especially soil pH, than by differences in soil origin.
**Keywords**: Growth; development; green spinach; Java Soil; Kalimantan Soil

**How to Cite**: Shafira, R., Hastuari, F. A., Andayani, A. A., Role, R. M., & Indrowati, M. (2026). Comparison of the Growth and Development of Green Spinach (Amaranthus hybridus L.) under Soil Conditions from the Java and Kalimantan Regions. *Bioscientist: Jurnal Ilmiah Biologi*, *14*(1), 133–143. https://doi.org/10.33394/bioscientist.v14i1.19533

https://doi.org/10.33394/bioscientist.v14i1.19533



## INTRODUCTION

Indonesia is widely recognized as an agrarian country with substantial potential in natural resources and biodiversity, particularly in the agricultural and horticultural sectors. The geographical characteristics of Indonesia, which consists of thousands of islands with diverse environmental conditions, have led to the formation of a wide range of agroecosystems in terms of climate, soil types, and levels of land fertility (FAO, 2021; Timikasari et al., 2022). This environmental diversity provides significant opportunities for the development of various food and horticultural commodities. However, differences in agroecosystem conditions also require the application of appropriate cultivation techniques to ensure that crops can grow and produce optimally in different environments (Lal, 2020).

One horticultural commodity with high nutritional value and widely consumed by the community is green spinach (*Amaranthus hybridus* L.). This plant is known as a rich source of vitamin A, vitamin C, iron, calcium, and various antioxidant compounds that are essential for human health (Gupta et al., 2018; Taufik et al., 2025). In addition to its high nutritional content, spinach is a leafy vegetable with a relatively short growth cycle and simple cultivation techniques. Therefore, it is widely cultivated both by smallscale farmers and at the household level (Sarker & Oba, 2019). Along with the increasing population and growing public awareness of the importance of consuming nutritious food, the demand for leafy vegetables such as spinach continues to rise. This situation makes the development of spinach cultivation an important strategy in supporting food security and fulfilling the nutritional needs of the population (FAO, 2021).

The growth and productivity of spinach plants are strongly influenced by environmental conditions, particularly soil quality as the growing medium. Soil functions as a provider of nutrients, water, and physical space for the development of plant root systems (Brady & Weil, 2017; Simbolon et al., 2022). Several soil factors that influence the growth of spinach include soil pH, nutrient content, soil structure, and the availability of organic matter (Farintosh et al., 2019). Among these factors, soil pH is a crucial parameter because it affects both nutrient availability and soil microbial activity. Spinach generally grows optimally in soils with a pH range of 6 to 7, as under these conditions both macro- and micronutrients are present at levels that are most readily absorbed by plants (Havlin et al., 2014).

Soil characteristics in Indonesia vary considerably across regions. Java Island is generally dominated by Andisols, which are formed from volcanic materials produced by volcanic activity. Andisols are known for their high organic matter content, good soil structure, and high water-holding capacity, making them highly supportive of agricultural cultivation (Juarti, 2024; Soil Survey Staff, 2014). In contrast, much of Kalimantan is dominated by peat soils, which possess distinct physical and chemical properties. Peat soils generally exhibit high acidity, contain large amounts of incompletely decomposed organic matter, and have relatively low nutrient availability (Astuti et al., 2020; Page et al., 2011). These differences in soil characteristics may result in varying effects on the growth and development of green spinach (*Amaranthus hybridus*) (Khoirurrozzikin et al., 2023).

Several previous studies have examined the influence of various soil factors on spinach growth, such as soil pH, nutrient content, and types of growing media (Sarker & Oba, 2019; Farintosh et al., 2019). However, most of these studies were conducted using a single soil type or within a specific region. Consequently, information regarding the growth response of spinach in two soil types with markedly different characteristics remains relatively limited. In other words, previous research has tended to examine soil factors separately without directly comparing dominant soil types from different regions.

Based on this condition, a research gap remains in the form of the absence of experimental studies that directly compare the growth response of *Amaranthus hybridus* on two contrasting soil types—namely Andisol soil from Java and peat soil from Kalimantan—using the same growth parameters under controlled treatment conditions. Such a comparative study is important to obtain a more comprehensive understanding of the extent to which differences in soil characteristics quantitatively influence the growth of spinach plants.

Based on this background, this study was formulated around the research question of whether differences in the characteristics of Andisol and peat soils significantly influence the growth and development of *Amaranthus hybridus*. Therefore, this study aims to analyze and quantitatively compare the growth of green spinach cultivated in Andisol and peat soil media through the measurement of several plant growth parameters. The results of this study are expected to provide a scientific contribution in the form of empirical data regarding the growth response of green spinach to two major soil types in Indonesia. Furthermore, the findings are expected to serve as a basis for technical recommendations in selecting appropriate growing media and soil management strategies to improve spinach productivity in regions with different soil characteristics.

## METHOD

### Study Location and Time

The study was conducted from 3 to 24 November 2025. Although the soil used in this study originated from two different regions—Solo City (Java Island) and Kalimantan—all planting and observation activities were carried out at a single experimental site under uniform environmental conditions. Soil from each region was collected directly from its original field location and then transported to the research site to be used as the planting medium.

This study did not involve cultivating plants in two separate locations; rather, it utilized two different soil types as treatments within the same controlled growing environment. All plants were placed in an area receiving relatively similar light intensity, temperature, and watering conditions in order to minimize the influence of environmental variables other than soil type. This approach was intended to ensure that any observed differences in the growth and development of green spinach (*Amaranthus hybridus* L.) were primarily attributable to differences in soil characteristics, rather than variations in climate or environmental conditions between regions.

### Tools and Materials

The tools and materials used in this study included uniform-sized pots or polybags, soil from Java and Kalimantan, green spinach seeds, a measuring cylinder to determine watering volume, a soil pH meter or pH indicator paper to measure soil acidity, and measuring tools such as a ruler to determine plant height and leaf width. Observation sheets were prepared to record leaf number and leaf color, while a checklist was used to ensure that plant maintenance procedures were carried out according to standardized protocols.

### Research Procedure

The experiment lasted 21 days, and the entire experimental process was conducted at the same location to ensure that environmental growing conditions remained controlled and uniform across all treatments. The planting media were prepared by sieving the soil to remove gravel and coarse organic debris. The soil was then subjected to air-drying at room temperature until the moisture content naturally decreased. This drying process aimed to standardize the physical condition of the soil before use as a planting medium, rather than to eliminate or reduce specific microorganisms.

The next step involved planting spinach seeds in each pot at a depth of 1–2 cm, with one seed per pot. All pots were placed in the same area to obtain relatively uniform light intensity. Temperature control was achieved by placing the plants in a semi-open environment protected from direct rainfall and excessive heat, thereby minimizing extreme temperature fluctuations. Ambient temperature was monitored periodically to ensure that conditions remained within the optimal temperature range for spinach growth. Watering was carried out every morning using the same volume of water for each pot in order to maintain relatively consistent soil moisture across treatments.

Soil pH measurements were conducted at the beginning of the study as baseline data and were repeated at the end of the experiment to observe changes in the planting medium. Observations of plant height, leaf width, leaf number, and leaf color were conducted every three days at the same time of day to avoid the influence of daily physiological fluctuations that might affect measurement results. With this design, environmental variables such as light, temperature, and watering were maintained as consistently as possible, allowing differences in plant growth to more accurately reflect the effect of soil type.

**Observation Parameters**

This study employed a quantitative approach with a comparative experimental design to examine the effect of soil conditions from Java and Kalimantan on the vegetative growth of green spinach (*Amaranthus hybridus* L.). This design was selected to compare two treatment groups under controlled conditions in order to determine the extent to which soil conditions influence plant growth parameters.

The research subjects consisted of four spinach plants randomly selected and divided into two treatment groups, each consisting of two plants. The first group used soil originating from Java as the planting medium, while the second group used soil originating from Kalimantan. This grouping aimed to identify potential significant differences in the dependent variables related to soil chemical and physical characteristics, including soil pH, organic carbon (C-organic) content, macronutrient elements (N, P, and K), and soil texture, in addition to plant growth parameters such as plant height, leaf width, leaf number, and leaf color.

The independent variable in this study was soil type, categorized as Kalimantan soil (A) and Java soil (B). The dependent variables included five plant growth parameters: soil pH, measured at the beginning and end of the study; plant height, observed periodically; leaf width, measured using a ruler; leaf number, counted during each observation period; and leaf color, assessed visually using a color chart to ensure consistency in evaluation. All control variables—including light exposure, watering frequency, environmental temperature, pot size, planting medium volume, and the number of seeds per pot—were maintained consistently to prevent them from influencing differences in results between the two treatment groups.

**Data Analysis**

Data on spinach plant height were analyzed using Linear Regression and Analysis of Covariance (ANCOVA). Linear regression was used to determine the weekly growth pattern of the plants and to calculate the growth rate for each regional soil group, namely Java and Kalimantan. Through this regression model, the slope of the growth line was obtained, representing the rate at which plant height increased each week. This analysis was selected because the data formed a time series and exhibited a generally linear relationship between time and plant height (Khammar et al., 2020).

Subsequently, ANCOVA was applied to determine whether the plant growth rates between the two regions differed significantly. This technique was used to test differences in group means while accounting for the covariate variable, namely the week of observation. ANCOVA enabled the researchers to assess whether the regression lines for the Java and Kalimantan groups differed in slope or remained parallel (Ludtke & Robitzsch, 2025).

## RESULTS AND DISCUSSION

This section presents the development of spinach plant growth cultivated in soils originating from Java and Kalimantan during four weeks of observation, serving as a basis for comparison under similar cultivation conditions. The parameters observed included soil pH, plant height, leaf size (width and length), and changes in leaf color as indicators of plant health. Plant height was measured from the base of the stem to the highest leaf tip by gently folding the leaves, following the method described by Fajri & Suparti (2022).

**Description of Soil pH and Plant Height Growth in Kalimantan Soil Media**

The results of four weeks of observation on the vegetative growth of spinach plants grown in Kalimantan soil media are presented in Table 1.

**Table 1.** Observation data of spinach growth in Kalimantan soil

| Week | Soil pH | Plant Height (cm) | Leaf Width (cm) | Leaf Length (cm) | Leaf Color |
|---|---|---|---|---|---|
| 1 | 6,9 | 0,5 | 0,3 | 0,4 | Green |
| 2 | 6,9 | 3,2 | 0,5 | 0,7 | Green |
| 3 | 6,9 | 5,6 | 0,5 | 1,0 | Green |
| 4 | 6,9 | 7,4 | 0,5 | 1,3 | Green |

Based on the data presented in Table 2, plant height increased from 0.5 cm in the first week to 7.4 cm in the fourth week. The regression growth rate of 2.31 cm per week indicates stable growth comparable to that observed in the Java soil media. Meanwhile, the pH of the Kalimantan soil remained stable at 6.9 throughout the four-week observation period. This stability indicates relatively neutral soil chemical conditions that support nutrient availability, thereby allowing optimal plant growth.

Visual documentation of spinach growth in Kalimantan soil media is presented in Figure 1.

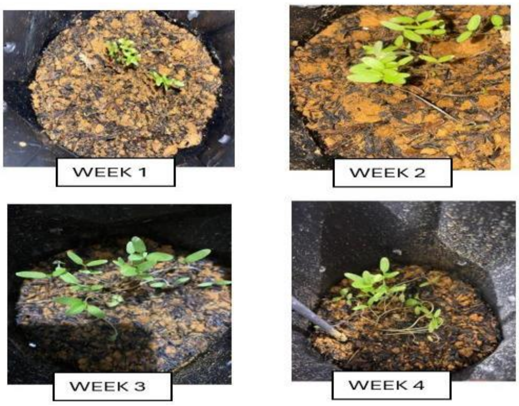


**Figure 1.** *Amaranthus hybridus* grown in Kalimantan soil conditions

**Description of Soil pH and Plant Height Growth in Java Soil Media**

The results of four weeks of observation on the vegetative growth of spinach plants grown in Java soil media are presented in Table 2.

**Table 2.** Observation data of spinach growth in Java soil

| Week | Soil pH | Plant Height (cm) | Leaf Width (cm) | Leaf Length (cm) | Leaf Color |
|---|---|---|---|---|---|
| 1 | 6,5 | 1,2 | 0,3 | 0,4 | Pale green |
| 2 | 6,4 | 2,8 | 0,5 | 0,7 | Light green |
| 3 | 6,3 | 5,4 | 0,8 | 1,2 | Green |
| 4 | 6,2 | 7,9 | 1,1 | 1,6 | Darker green |

Based on the data presented in Table 1, the pH of the Java soil gradually decreased from 6.5 to 6.2. However, this decline remained within the optimal range for spinach growth and did not significantly inhibit plant development. Vegetative growth over the four-week period in the Java soil media showed a consistent pattern. Plant height increased from an average of 1.2 cm in the first week to 7.9 cm in the fourth week, indicating progressive growth responses each week. In addition to plant height, visual changes were observed in leaf color, which shifted from pale green to darker green by the end of the observation period. This change suggests an increase in chlorophyll accumulation associated with improved nutrient availability.

Visual documentation of spinach growth in Java soil media throughout the four-week observation period is presented in Figure 2.

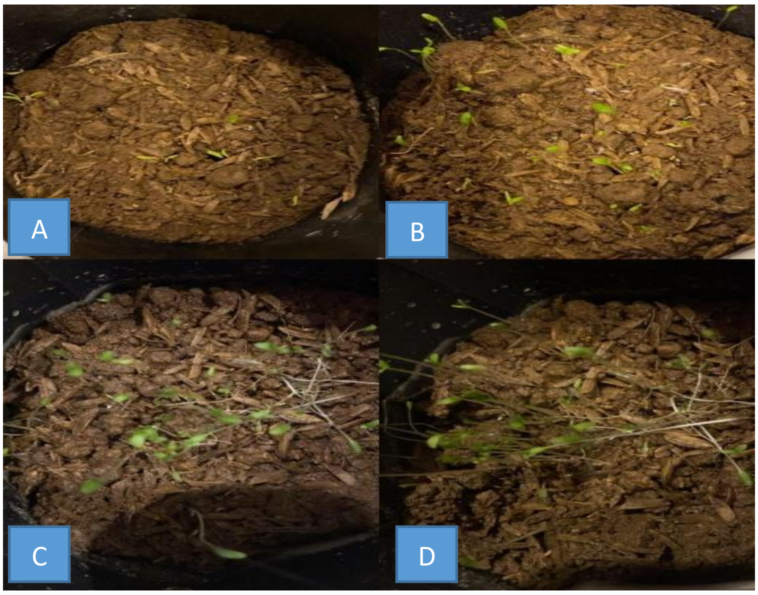


**Figure 2.** *Amaranthus hybridus* grown in Java soil conditions (A = Week 1, B = Week 2, C = Week 3, D = Week 4)

### Descriptive Analysis of Leaf Parameters (Number, Width, Length, and Color)

The results of four weeks of observation on vegetative growth (leaf parameters) of spinach plants grown in Java and Kalimantan soil media are presented in Table 3.

**Table 3.** Vegetative growth data (leaf parameters)

| Parameter | Java Soil | Kalimantan Soil | Interpretation |
|---|---|---|---|
| Final leaf width | 1.1 cm | 0.5 cm | Wider in Java soil |
| Final leaf length | 1.6 cm | 1.3 cm | Slightly longer in Java soil |
| Color change | Pale green → dark green | Consistently green | Indicator of good chlorophyll development |
| General pattern | Progressive leaf growth | Increasing leaf length | Moderate differences |

Based on the data in Table 3, in the Java soil media, leaf width increased from 0.3 cm to 1.1 cm, while leaf length increased from 0.4 cm to 1.6 cm. Leaf color gradually changed from pale green to darker green. In contrast, in the Kalimantan soil media, leaf width remained relatively stable within the range of 0.3–0.5 cm, while leaf length increased from 0.4 cm to 1.3 cm. Leaf color remained consistently green throughout the observation period. In summary, the final leaf size in the Java soil media tended to be slightly larger than that in the Kalimantan soil media, although these differences were not statistically tested in the main model.

### Results of Statistical Assumption Tests

Before performing parametric analysis, tests of normality and homogeneity of variance were conducted. The homogeneity test produced a value of $p = 0.575$ (>

0.05), indicating that the variances between groups were homogeneous. Furthermore, the Shapiro–Wilk normality test yielded p = 0.328 (> 0.05), indicating that the data were normally distributed. The visualization of residual normality is shown in Figure 3.

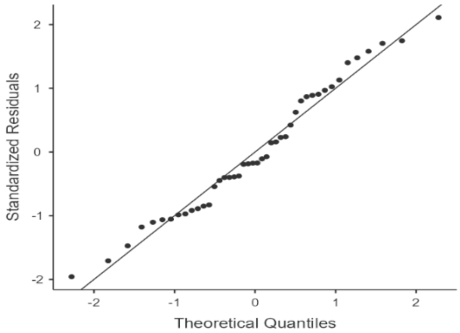


**Figure 3.** Q–Q plot of residual distribution

## Results of ANCOVA and Regression Analysis

ANCOVA analysis was used to determine differences in mean plant height between the Java soil and Kalimantan soil treatment groups. The results are presented in Table 4.

**Table 4**. Results of ANCOVA analysis

| | **Sum of Squares** | **df** | **Mean Square** | **F** | **p** | **$\eta^2$** | **$\eta^2p$** | **$\omega^2$** |
|---|---|---|---|---|---|---|---|---|
| Total Treatment | 239.4 | 2 | 119.7 | 3.40 | 0.043 | | | |
| Soil Type | 86.5 | 1 | 86.5 | 3.03 | 0.089 | 0.061 | 0.069 | 0.040 |
| pH | 152.8 | 1 | 152.8 | 5.36 | 0.026 | 0.109 | 0.116 | 0.087 |
| Residuals | 1169.3 | 41 | 28.5 | | | | | |

The analysis results in Table 4 indicate that the overall treatment model significantly affected plant height (F = 3.40; p = 0.043 < 0.05). However, partially, soil type did not significantly affect plant height (p = 0.089 > 0.05), whereas soil pH had a significant effect (p = 0.026). The partial eta-squared ($\eta^2p$) values indicate that pH contributed more strongly (0.116) to plant height variation than soil type (0.069).

Subsequently, a linear regression analysis was conducted to examine the relationship and influence of soil characteristics (X) on the growth and development of spinach plants (Y). The results are presented in Table 5.

**Table 5.** Results of linear regression analysis

| **Model** | **R** | **$R^2$** |
|---|---|---|
| **X-Y** | 0.377 | 0.142 |

The results in Table 5 indicate an $R^2$ value of 0.142, meaning that 14.2% of the variation in spinach growth and development (plant height) was explained by soil characteristics, while the remaining variation was influenced by other factors not included in this study.

The findings showing that soil type did not significantly affect spinach plant height after controlling for soil pH (p = 0.089) suggest that differences in soil origin between Java and Kalimantan are not the primary determinants of plant growth when environmental conditions such as light, temperature, and watering are controlled within the same location. This result indicates that spinach possesses relatively good physiological plasticity toward variations in growing media, provided that key chemical factors remain within optimal ranges (Rahayu et al., 2024).

Additionally, the chemical characteristics of the two soils used in this study may not have been highly contrasting after undergoing air-drying and pot placement, thereby reducing the natural differences typically observed under field conditions (Fauziah et al., 2025). Although statistically non-significant, the effect size ($\eta^2p = 0.069$) indicates a small to moderate practical contribution. This suggests that soil type still exerts some influence, although its strength is relatively weak in the present model. With a larger sample size, the effect might become clearer and potentially statistically significant.

Conversely, soil pH showed a significant effect on plant height ($p = 0.026$) with a partial eta-squared value of 0.116, which falls within the moderate effect size category. This indicates that approximately 11.6% of the variation in plant height can be explained by differences in soil pH. Physiologically, soil pH plays a direct role in determining the availability of macronutrients such as nitrogen, phosphorus, and potassium, which are essential during the vegetative growth phase (Elly & Maitimu, 2025). Within the neutral pH range (6–7), nutrients are present in more available forms and can be absorbed more easily by plant roots, thereby supporting optimal stem elongation and leaf formation (Alpandari & Prakoso, 2024). Thus, these findings reinforce that soil chemical factors, particularly pH, are more influential than mere geographical differences in soil origin.

An interesting finding in this study is the Kalimantan soil pH value of 6.9 (neutral), which theoretically contrasts with the common assumption that Kalimantan soils are predominantly acidic peat soils. However, this condition can be explained by the specific characteristics of the sampled soil. It is possible that the collected soil represented mineral topsoil rather than deep peat, or peat soil that had undergone advanced decomposition, resulting in reduced acidity (Aprillia et al., 2021). Furthermore, not all regions of Kalimantan are dominated by pure peat soils; some areas contain alluvial and mineral soils with more neutral pH values (Muslim & Ritung, 2022). Therefore, the findings of this study do not contradict existing theory but rather highlight that soil characteristics depend strongly on the specific sampling location.

Based on the regression coefficient of determination ($R^2 = 0.142$), the model explained only 14.2% of the variation in plant height, indicating that most growth variation was influenced by other factors outside the model. These factors may include micronutrient content, soil organic carbon levels, soil texture, microbial activity, and plant physiological factors (Mujizat et al., 2023). Therefore, although soil pH was found to be significant, its influence alone cannot fully explain the overall variation in plant growth.

This study has several limitations that should be considered when interpreting the results. The main limitation is the very small sample size, consisting of only four plants per treatment group. Small sample sizes can reduce statistical power and increase the risk of Type II errors, where real effects remain undetected (Lestari & Aldini, 2025). In addition, the 21-day research duration does not represent the complete growth cycle of spinach plants, particularly the generative phase. Another limitation is the absence of quantitative laboratory analysis of soil organic carbon, micronutrient content, and soil texture, which limits the interpretation of growing media effects to pH parameters and morphological observations (Yuliani et al., 2020).

From a practical perspective, the findings of this study provide important implications for spinach cultivation. Soil pH management appears to be more crucial than soil origin alone. In agricultural practice, farmers can modify soil pH through liming, application of organic matter, or other soil ameliorants to achieve the optimal range. Therefore, optimizing soil chemical properties—particularly soil pH—may represent a more effective and realistic strategy than focusing solely on differences in soil type based on geographic origin.

## CONCLUSION

Based on the results of the research analysis, it can be concluded that differences in soil types—namely Andisol soil originating from Java and soil originating from Kalimantan—did not have a significant effect on the plant height of green spinach (*Amaranthus hybridus* L.) after controlling for the soil pH variable ($p$ = 0.089). Therefore, the alternative hypothesis stating that there is a difference in growth between the two soil types was not supported for the plant height parameter. These findings indicate that differences in the geographical origin of soil are not the primary factor determining vegetative growth when environmental conditions such as light, temperature, and watering are uniformly controlled. In contrast, soil pH was shown to have a significant effect on plant height ($p$ = 0.026) with a moderate effect size ($\eta^2 p$ = 0.116), indicating that soil chemical conditions—particularly the level of acidity—play a more important role in influencing the growth of green spinach than soil type in general. Leaf morphological parameters, such as leaf length and leaf width, only showed descriptive differences and were not analyzed inferentially within the ANCOVA model. Therefore, the statistical conclusions of this study are limited to the plant height parameter as the primary variable tested.

## RECOMMENDATION

Future studies are recommended to expand the scope of the research by using a larger sample size and a longer observation period so that the entire plant growth cycle can be examined, including both vegetative and generative phases. In addition, soil characteristics should be analyzed more comprehensively through laboratory testing of soil physical and chemical properties, such as organic carbon (C-organic) content, macro- and micronutrient availability, soil texture, and cation exchange capacity. Such analyses would enable a deeper understanding of the influence of soil media on plant growth. Subsequent studies may also consider evaluating additional growth parameters, such as plant biomass, fresh and dry weight, and crop yield productivity, in order to obtain a more comprehensive understanding of the growth response of green spinach (*Amaranthus hybridus* L.) to variations in soil conditions and environmental factors.

## ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to all parties who provided support, assistance, and contributions to the implementation of this research, both directly and indirectly, enabling this study to be completed successfully.

## REFERENCES

Alpandari, H., & Prakoso, T. (2024). Respon pertumbuhan tanaman kangkung (*Ipomoea reptans* Poir) terhadap pemberian hara mikro melalui akar dan daun. *Pucuk: Jurnal Ilmu Tanaman, 4*(1), 1–8.

Aprillia, R., Mukhtar, W., Setiawati, S., & Asbanu, G. C. (2021). Karakteristik tanah bekas tambang bauksit dan tailing di Kabupaten Sanggau, Kalimantan Barat. *Jurnal Pendidikan Informatika dan Sains, 10*(2), 208–217.

Astuti, D., Rahman, A., & Pratama, H. (2020). Characteristics and management of peat soils for sustainable agriculture in Indonesia. *Journal of Tropical Soil Science, 25*(2), 95–104.

Astuti, Y., Astiani, D., & Herawatiningsih, R. (2020). Pengaruh pembakaran berulang pada lahan gambut terhadap beberapa karakteristik tanah di Desa Rasau Jaya Umum Kabupaten Kubu Raya Kalimantan Barat. *Jurnal Hutan Lestari, 8*(3).

Elly, S., & Maitimu, C. V. (2025). Karakteristik tanah berdasarkan kandungan unsur hara makro, C-organik, dan pH pada budidaya salak merah (*Salacca edulis* Reinw.) di Rumahsoal, Taniwel, Kabupaten Seram Bagian Barat. *JUSTE (Journal of Science and Technology), 5*(2), 151–161.

Fajri, A. N., & Suparti, S. (2022). Pertumbuhan tanaman bayam hijau (*Amaranthus hybridus* L.) secara hidroponik menggunakan ekstrak limbah bawang merah. In *Prosiding SNPBS (Seminar Nasional Pendidikan Biologi dan Saintek)* (pp. 232–237).

Farintosh, G., Riddle, R., & Van Acker, R. (2019). Growth and vegetable yield of *Amaranthus hybridus* L. as impacted by harvest methods in southern Ontario, Canada. *Canadian Journal of Plant Science, 100*(4), 365–371.

Fauziah, N. F., Titah, H. S., Tangahu, B. V., Yulikasari, A., Nurhayati, E., & Arliyani, I. (2025). Uji rentang dosis red mud sebagai amandemen tanah dengan kombinasi pupuk kandang terhadap pertumbuhan tanaman sawi (*Brassica juncea*). *Jurnal Purifikasi, 24*(1), 73–87.

Huda, M., Sulistiyowati, T. I., Primandiri, P. R., & Santoso, A. M. (2022). Kajian etnobotani tanaman obat di Desa Jugo Kecamatan Mojo Kabupaten Kediri. In *Prosiding Seminar Nasional Kesehatan, Sains dan Pembelajaran, 2*(1), 493–502.

Juarti, J. (2024). Analisis indeks kualitas tanah andisol pada berbagai penggunaan lahan di Desa Sumber Brantas Kota Batu. *Jurnal Pendidikan Geografi: Kajian, Teori, dan Praktek dalam Bidang Pendidikan dan Ilmu Geografi, 21*(2).

Khammar, A., Yarahmadi, M., & Madadizadeh, F. (2020). What is analysis of covariance (ANCOVA) and how to correctly report its results in medical research? *Iranian Journal of Public Health, 49*(5), 1016.

Khoirurrozzikin, M., Lestari, M. W., & Basit, A. (2023). Analisis pertumbuhan tanaman bayam (*Amaranthus tricolor* L.) akibat pemberian jenis dan dosis pupuk organik yang berbeda. *Agronisma, 11*(1).

Lestari, D., & Aldini, D. (2025). Kesalahan umum dalam analisis statistik dan cara menghindarinya. *Jurnal Intelek Insan Cendikia, 2*(5), 9492–9496.

Lüdtke, O., & Robitzsch, A. (2025). ANCOVA versus change scores for analyzing two-wave data. *Journal of Experimental Education, 93*(2), 363–395.

Mujizat, Y., Namriah, N., Leomo, S., Darwis, D., Alam, S., & Resman, R. (2023). Variabilitas kandungan C-organik pada tanah ultisol yang diberi berbagai jenis bahan organik untuk pertumbuhan tanaman sawi. *Jurnal Agroteknologi, 2*(2), 82–90.

Muslim, R. Q., & Ritung, S. (2021). Distribution of pyrite depth and soil properties in fresh water swampland in North Candi Laras Sub-district, South Kalimantan Province. In *IOP Conference Series: Earth and Environmental Science, 648*(1), 012041.

Nurjanah, A. P., Yanti, R., & Hotijah, S. (2025). Persebaran tanah dalam keanekaragaman hayati dan kearifan lokal di wilayah Indonesia. *Jurnal Pendidikan Sosial dan Humaniora, 4*(3), 4876–4882.

Pasaribu, M. M. A., Jaya, I. K. D., & Jayaputra, J. (2024). Pertumbuhan dan hasil tanaman bayam Brazil (*Alternanthera sissoo*) pada perlakuan beberapa jenis pupuk organik. *Agroteksos, 34*(2), 682–691.

Pogon, T. Y., Putra, D. P., & Rusmarini, U. K. (2023). Efektivitas serapan unsur hara nitrogen pada pembibitan tanaman tebu (*Saccharum officinarum* L.). *Agrisintech (Journal of Agribusiness and Agrotechnology), 4*(2), 53–57.

Rahayu, N. N., Firnia, D., Ritawati, S., & Sodiq, A. H. (2024). Pengaruh media tanam dan POC limbah sayuran terhadap pertumbuhan dan hasil tanaman sawi hijau (*Brassica juncea* L.). *Jurnal AgroSainTa, 8*(2), 53–64.

Ritonga, A., Saragih, E. L., Purba, G. A., Pandiangan, P. P. S., Damanik, R. N., & Al Azmi, F. (2025). Penerapan distribusi normal dalam pengukuran tinggi badan mahasiswa FMIPA Universitas Negeri Medan 2024. *Bilangan: Jurnal Ilmiah Matematika, Kebumian dan Angkasa, 3*(2), 39–53.

Rizkiyah, S., Rizqin, I. Z., Putri, M. A. B., Nasrudin, M., & Trimono, T. (2025). Pengaruh perubahan tahun terhadap produksi pertanian di Indonesia menggunakan pendekatan repeated measures MANOVA. *Ragam: Journal of Statistics & Its Application, 4*(1), 1–11.

Simbolon, V. A., Kinanti, R. P., & Erda, G. (2022). Efektivitas limbah tahu dengan aktivator kulit pisang kepok menjadi pupuk organik cair terhadap tanaman bayam hijau (*Amaranthus tricolor* L.). *Sulolipu: Media Komunikasi Sivitas Akademika dan Masyarakat, 22*(1), 80–87.

Susanty, W., Maulana, B., & Putri, A. (2025). Penerapan metode regresi linier dalam menganalisis faktor-faktor yang mempengaruhi tingkat melek huruf di Provinsi Sulawesi Tenggara. *Trigonometri: Journal Matematika dan Ilmu Pengetahuan Alam, 7*(1), 131–140.

Taufik, M., Ilyas, Y., & Arsela, P. (2025). Pemanfaatan ecoenzyme dalam meningkatkan hasil tanaman bayam (*Amaranthus hybridus* L.). *Proceedings Series on Physical & Formal Sciences, 8*, 144–148.

Timikasari, A. D., Shodiq, D. E., & Setiawan, I. (2022). Literatur review: sumber daya alam pangan pada sektor pertanian di Indonesia. *Jurnal Sains Edukatika Indonesia (JSEI), 4*(2).

Yuliana, E., Widyawati, N., & Sutrisno, A. J. (2020). Pengaruh komposisi media tanam terhadap pertumbuhan dan hasil tanaman bunga gladiol (*Gladiolus hybridus* L.). *Jurnal Teknik Pertanian Lampung, 9*(4), 353–360.