

## Growth Response of Robusta Coffee (*Coffea canephora* Pierre ex A. Froehner) Seedlings to the Application of Golden Apple Snail

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### ABSTRACT

One type of coffee plant widely cultivated in Indonesia is robusta coffee. During cultivation, nursery practices are crucial for improving coffee quality and productivity. To obtain good Robusta coffee seedlings, fertilization is essential. The recommended fertilizer is organic, which is more environmentally friendly. Fertilizing with fermented golden apple snail extract supports sustainable agriculture. Therefore, the purpose of this study is to determine the concentration, frequency of treatment, and interaction on the growth of hybrid robusta coffee seedlings prolegitim (BP 42 x BP 358). The study was conducted in the field laboratory of Politeknik Negeri Jember for 5 months. This study used a non-factorial RBD with 7 treatments and 6 replications. K0 (Control-0% concentration); K1 (2.5% concentration + application every 4 weeks); K2 (5% concentration + application every 4 weeks); K3 (2.5% concentration + application every 2 weeks); K4 (7.5% concentration + application every 4 weeks); K5 (5% concentration + application every 2 weeks); K6 (7.5% concentration + application every 2 weeks). The observed variables include: Number of Leaves (pairs), Leaf Area Index, Stem Height, and Root Length. The experimental data were analyzed using ANOVA followed by the LSD test at the 5% significance level. The study found that the K2 treatment (5% concentration applied every 2 weeks) produced the optimal growth response, particularly in leaf area, seedling height, and root length.

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## 1. Introduction

Indonesia is a major coffee-producing country and currently ranks fourth globally in coffee bean production after Brazil, Vietnam, and Colombia (Direktorat Jendral Perkebunan, 2024). In 2023, the national coffee plantation area covered 1,268,905 ha with a production of 760,192 tons, while in 2024, the plantation area slightly declined to 1,262,969 ha, but production increased to 775,950 tons. This trend indicates a continuous rise in coffee productivity alongside increasing domestic demand and consumption. To sustain and enhance Robusta coffee production, the use of high-quality seedlings is essential, as seedling quality strongly determines subsequent plant growth, productivity, and yield quality. Therefore,

nursery management and seedling maintenance are critical stages in coffee cultivation systems and should be treated as integrated components of sustainable coffee production (Pranata & Zakariyya, 2021).

According to (Dewantara *et al.*, 2017), in coffee cultivation, the production of superior seedlings largely depends on the quality of the planting medium and fertilization strategies, both of which work synergistically to promote optimal plant growth. The application of nutrient and growth-promoting supplements is therefore a critical factor, particularly during the seedling stage (Marziah *et al.*, 2019). The use of organic inputs represents an important strategy for environmentally sustainable agriculture, offering multiple benefits while reducing dependence on inorganic (Kalay *et al.*, 2021). One organic resource with considerable potential to supply nutrients, amino acid supplements, and phytohormones is the golden apple snail (*Pomacea canaliculata*) (Asmono *et al.*, 2023). Although this species is a major pest in rice cultivation and is generally underutilized by farmers, it possesses valuable agronomic potential. As stated by (Sulfianti *et al.*, 2018,) golden apple snails contain beneficial local microorganisms that can enhance soil fertility, while liquid organic fertilizer derived from this organism can increase nutrient availability—particularly nitrogen—through its chitin content. In addition, golden apple snails contain carbohydrates, proteins, lipids, potassium, sodium, riboflavin, calcium, niacin, copper, manganese, vitamin C, zinc, and essential amino acids such as histidine, arginine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Notably, tryptophan serves as a precursor for indole-3-acetic acid (IAA), an auxin phytohormone that plays a key role in regulating plant growth (Madusari *et al.*, 2021). This finding is further supported by (Andriani, 2018), who reported that golden apple snail-based formulations enriched with local microorganisms can significantly enhance plant growth and yield performance.

Previous studies have demonstrated the potential of golden apple snail-based organic inputs to enhance plant growth. (Asmono *et al.*, 2023) reported that the application of liquid organic fertilizer (LOF) derived from golden apple snails at a concentration of 10 mL, applied biweekly, significantly improved the growth of Robusta coffee cuttings. Similarly, (Madusari *et al.*, 2021) found that the application of local microorganism (LM) formulations derived from golden apple snails had a significant positive effect on oil palm seedling growth, with the 10 mL concentration producing statistically superior results. In contrast, (Wardana *et al.*, 2023) reported that a higher concentration (20 mL) of golden apple snail-based LOF resulted in significant growth improvements in black potato plants. Based on the background described above and previous studies on the role of golden apple snail in stimulating plant growth, further research is required to explore the use of snail extract during the nursery stage of robusta coffee plants, with different extract concentrations and application frequencies. This study aims to evaluate the effect of golden apple snail extract on the nursery phase of hybrid propelegitim robusta coffee (BP 42 × BP 358).

## 2. Methodology

This study was conducted at the Agricultural Production Field Laboratory, Politeknik Negeri Jember, located at an altitude of 110 m above sea level (−8.159802, 113.723151). The experiment was carried out over a five-month period. The equipment used included 200 mL and 1,000 mL graduated cylinders, 20 × 30 cm polybags, 50% shade netting, a digital balance, plastic covers, wire, an oven, stationery, watering cans, and a hoe. The plant materials consisted of two-month-old hybrid Robusta coffee seedlings (*Coffea canephora*) of

propelegitim origin (BP 42 × BP 358). The growing media comprised topsoil and sand, while the treatment material was a golden apple snail extract fermented for 21 days.

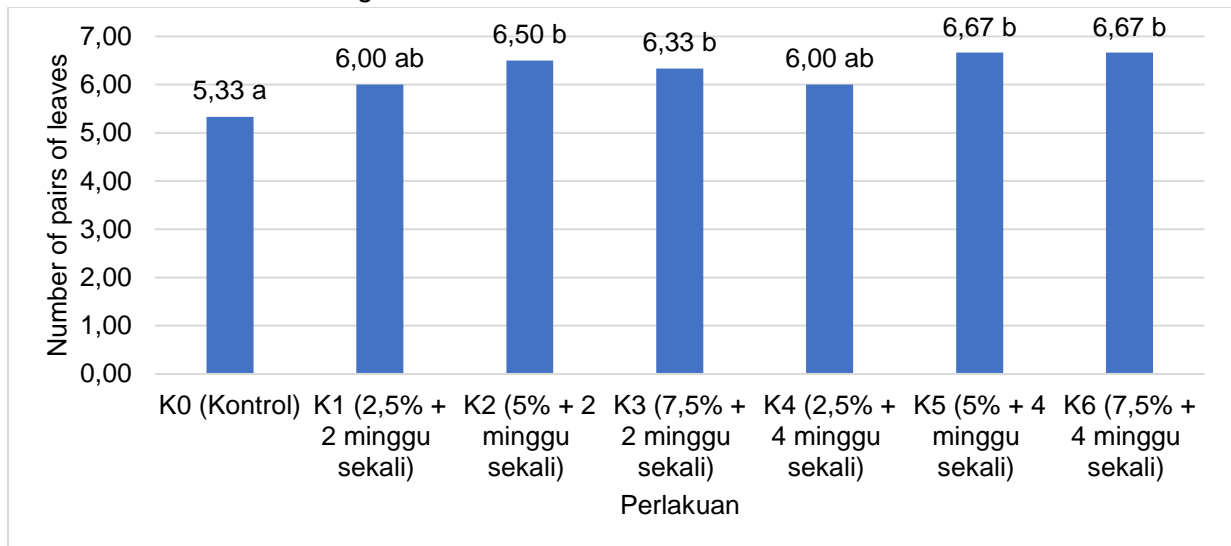
The experiment was arranged in a randomized complete block design (RCBD) with a non-factorial treatment structure. A total of seven treatments were evaluated with six replications. The treatments consisted of K0 (control, 0% concentration); K1 (2.5% concentration + every 4 week); K2 (5% concentration + every 4 week); K3 (2.5% concentration + every 2 week); K4 (7.5% concentration + every 4 week); K5 (5% concentration + every 2 week); and K6 (7.5% concentration + every 2 week). The golden apple snail extract was applied to Robusta coffee seedlings by soil drenching at the assigned concentration, at a rate of 200 mL per polybag.

Data were collected at the end of the experiment when plants were 16 weeks after treatment. The observed parameters included the number of leaves (pairs), leaf area index, stem height (cm), and root length (cm). Experimental data were subjected to analysis of variance (ANOVA), and if the treatment effects were significant, mean comparisons were carried out using the Least Significant Difference (LSD) test at the 5% significance level.

### 3. Results and Discussion

#### 3.1. Number of Leaves

The analysis of variance (ANOVA) indicated a significant effect of golden apple snail extract application on the number of leaves at 16 weeks after treatment. Further analysis using the Least Significant Difference test at the 5% significance level revealed significant differences among treatments. The mean number of leaves per treatment at 16 weeks after treatment is shown in the figure below.



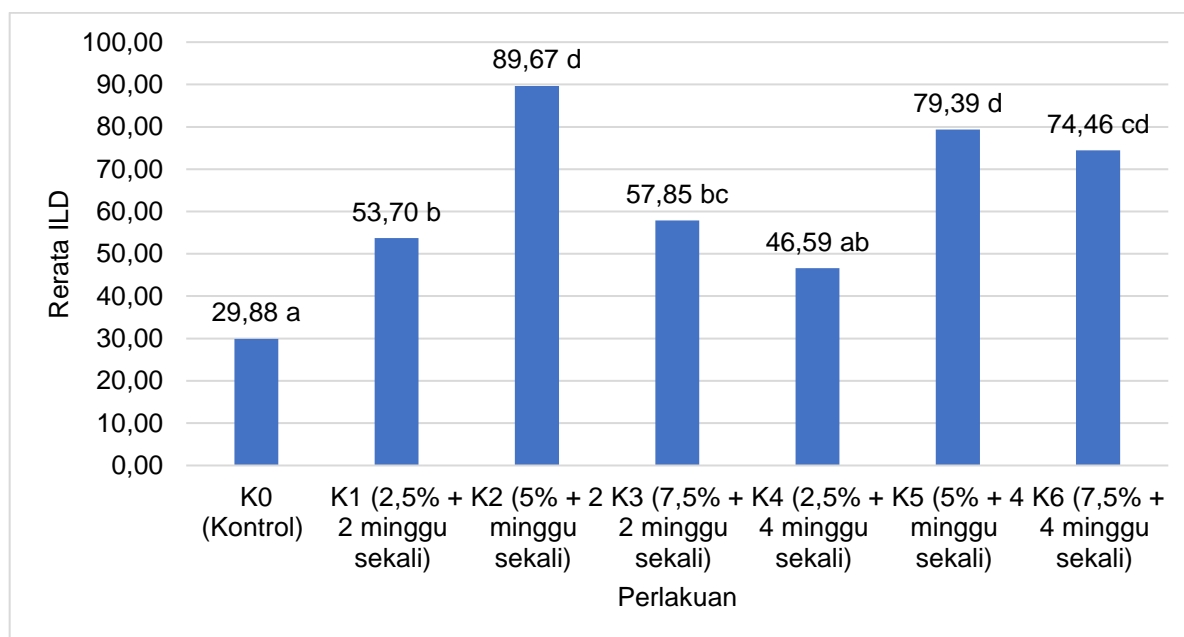
**Figure 1.** Mean Number of Leaves (Pairs) of Robusta Coffee Seedlings

Based on the results of the LSD post hoc test presented in Figure 1, a significant difference in the number of leaves was observed in the control treatment (K0). In contrast, treatments K1–K6 showed no significant differences in the number of leaves parameter. The application of golden apple snail extract, which contains essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), and amino acids (Asmono *et al.*, 2023), likely promoted leaf growth. This finding is consistent with (Madusari *et al.*, 2021), who reported that nitrogen

plays a key role in cell division and tissue formation during the vegetative growth phase, thereby enhancing leaf development.

Leaf number is a key indicator of vegetative growth and is highly dependent on the availability of essential nutrients, particularly nitrogen and calcium. These results indicate that the nutrients contained in golden apple snail extract were effectively utilized by the plants in accordance with their physiological requirements. The control treatment had the lowest mean leaf number, suggesting that the absence of nutrient supplementation—especially nitrogen—limited vegetative growth and reduced leaf development in coffee seedlings. This finding is consistent with (Asmono *et al.*, 2023), who reported that insufficient application rates slow plant growth, whereas excessive concentrations may cause phytotoxic effects, inhibit growth, and ultimately lead to plant mortality. Furthermore, the amino acids present in golden apple snail-based liquid organic fertilizer serve as precursors for auxin biosynthesis, which plays a critical role in stimulating root and shoot development, as well as cell division, in coffee seedlings. Similarly, Angelina (2019) reported that amino acids derived from golden apple snails had significant positive effects on plant height, stem diameter, leaf number, and overall seedling quality.

The analysis of variance (ANOVA) showed that the application of golden apple snail extract had a highly significant effect on the leaf area index (LAI). Further mean separation using the Least Significant Difference (LSD) test at the 5% significance level revealed significant differences among treatments. The LAI values at 16 weeks after treatment are presented in the following figure.



**Figure 2.** Mean Leaf Area Index (LAI) of Robusta Coffee Seedlings

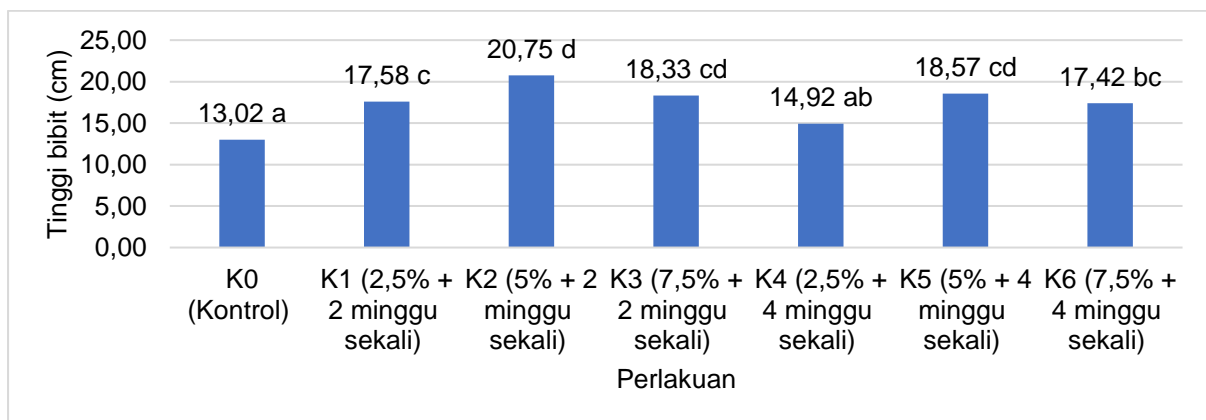
As shown in Figure 2, the application of fermented golden apple snail extract at different concentrations had a highly significant effect on the leaf area index (LAI) at 16 weeks after treatment. Treatment K2 (5% concentration applied at a 2-week interval) produced the highest mean LAI value (89.67), which was significantly higher than that of the control treatment (K0), which exhibited the lowest mean LAI (29.98) according to the LSD test at the 5% significance

level. The inferior performance of the control treatment can be attributed to insufficient nutrient supply, particularly nitrogen, which is essential for leaf formation and expansion. Nitrogen deficiency limits chlorophyll synthesis and photosynthetic activity, thereby restricting leaf development and overall vegetative growth.

The application of golden apple snail extract in treatment K2 (5% concentration applied at a 2-week interval) effectively promoted leaf area development, resulting in the highest mean LAI. This response can be attributed to the nutrient composition of the extract, particularly nitrogen (N), phosphorus (P), and potassium (K), which are readily absorbed by plant roots and support the growth and development of coffee seedlings. Nitrogen plays a pivotal role in vegetative growth, including leaf initiation and expansion (Syifa *et al.*, 2020). Adequate nitrogen availability accelerates leaf growth and increases leaf size, thereby enhancing photosynthetic capacity. This finding is consistent with (Sarif *et al.*, 2015), who reported that nitrogen is essential for vegetative development, including shoot, stem, and leaf formation. When nutrient requirements are met, leaf surface area increases, enabling more efficient photosynthesis.

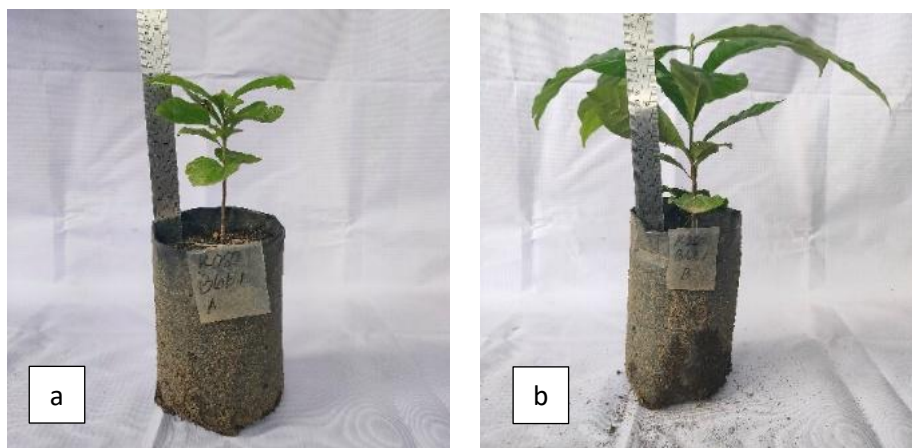
### 3.2 Seedling Height

The analysis of variance (ANOVA) revealed a highly significant effect of golden apple snail extract application on seedling height at 16 weeks after treatment. Subsequent analysis using the Least Significant Difference (LSD) test at a 5% significance level demonstrated significant variation among treatments. The seedling height responses at 16 weeks after treatment are presented in the following figure.



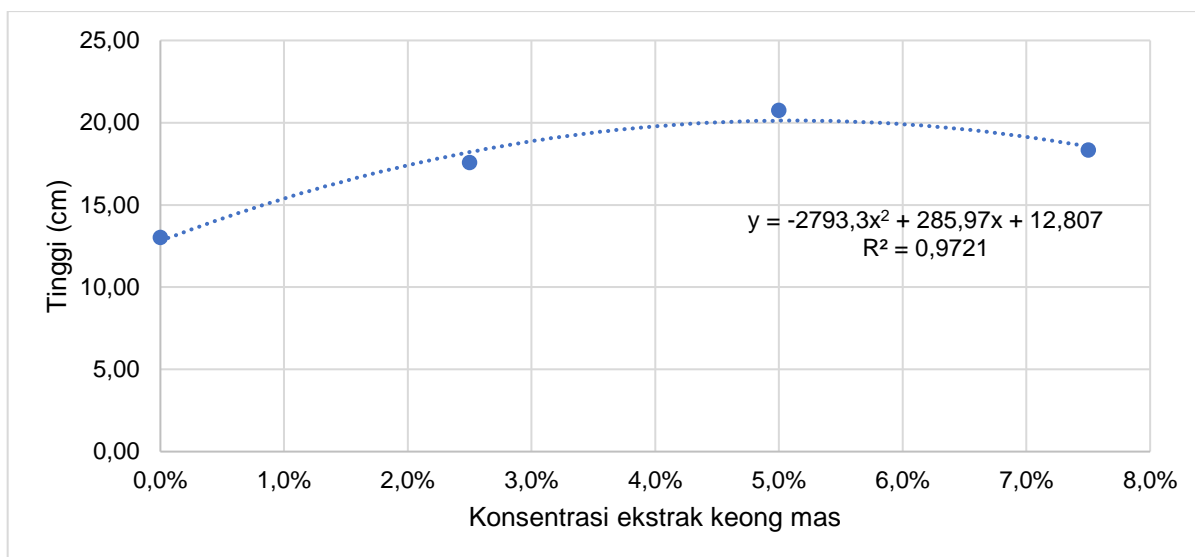
**Figure 3.** Mean Seedling Height (cm) Of Robusta Coffee

As shown in Figure 3, the concentration of fermented golden apple snail extract and the application frequency significantly influenced seedling height at 16 weeks after treatment. Treatment K2 (5% concentration + every 2 weeks) resulted in the greatest mean seedling height (20.75 cm), which was significantly higher than that of the control treatment (K0), which exhibited the lowest mean height (13.02 cm).



**Figure 4.** Stem Height of Robusta Coffee Seedlings: (a) Control (K0) And (b) K2 Treatment (5% Concentration + Every 2 Week)

Seedling height growth was influenced by increased nutrient availability resulting from the application of golden apple snail extract. The application of the extract at 5% concentration every 2 weeks (K2) was the most optimal treatment for promoting stem elongation in Robusta coffee seedlings. Furthermore, this optimal concentration was supported by regression analysis comparing several extracts, 5% concentrations applied every 2 weeks, as illustrated in Figure 5.



**Figure 5.** Regression Relationship Between Golden Apple Snail Extract Concentration And Seedling Height Of Robusta Coffee.

The regression analysis presented in Figure 5 indicated that seedling height response to increasing concentrations of golden apple snail extract followed a quadratic pattern, described by the equation  $y = -2793.3x^2 + 285.97x + 12.807$  ( $R^2 = 0.9721$ ). This model suggests that the maximum predicted seedling height was achieved at an optimal extract concentration of 5.12%. This result is consistent with the findings of (Asmono *et al.*, 2023), who reported that a 5% concentration of a golden apple snail-based liquid organic fertilizer

produced the greatest enhancement in stem height in coffee cuttings. Similarly, (Madusari *et al.*, 2021) demonstrated that the application of golden apple snail-derived liquid organic fertilizer significantly increased stem diameter, plant height, and leaf area. The primary nutrients contained in organic-based liquid fertilizers, particularly nitrogen (N), phosphorus (P), and potassium (K), contribute to improved plant health and overall growth. These nutrients help fulfill plant nutritional requirements, thereby promoting stem elongation and vegetative development (Humaida *et al.*, 2023).

3.2.3 Reliability Test

Reliability testing ensures that the indicators within a construct are consistent and reliable. The construct is considered reliable if the Cronbach's alpha value and composite reliability meet the criteria (>0.7), as shown in Table 5.

3.3. Root Length

The analysis of variance (ANOVA) revealed a highly significant effect of golden apple snail extract application on root length at 16 weeks after treatment. Further mean separation using the Least Significant Difference (LSD) test at the 5% significance level demonstrated significant differences among treatments. Root length responses at 16 weeks after treatment are shown in the following figure.

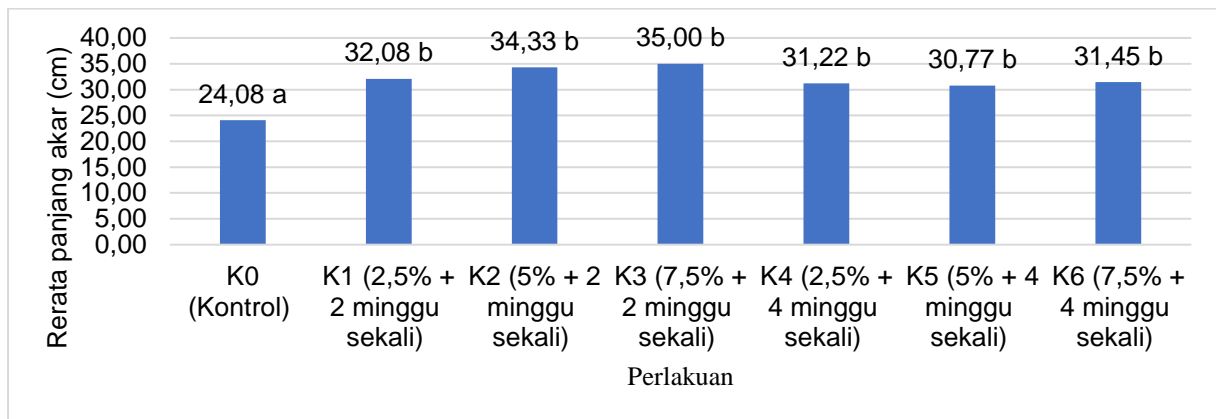


Figure 6. Mean Root Length (cm) of Robusta Coffee Seedlings

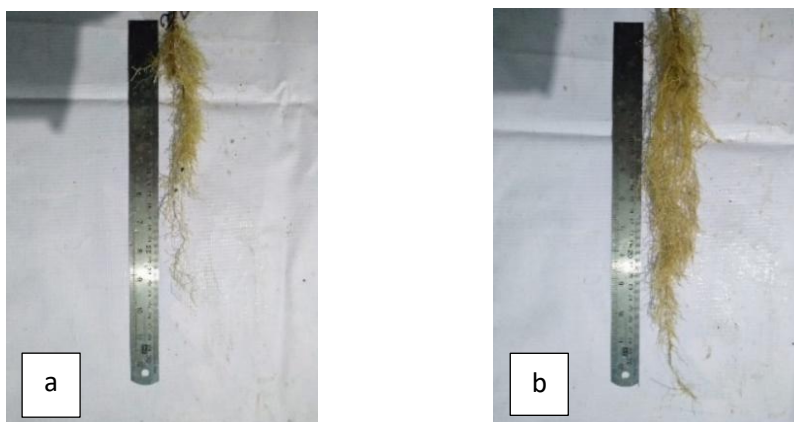


Figure 7. Root length of Robusta Coffee Seedlings: (a) control (K0) and (b) K2 treatment (5% concentration applied every 2 week).

Significant differences in root length were observed between seedlings treated with golden apple snail extract and the untreated control (Figures 6 and 7). However, no significant differences were detected among the extract-treated treatments (K1–K6). The application of fermented golden apple snail extracts enhanced root growth in coffee seedlings, indicating that the nutrients supplied through the extract effectively supported root development. Phosphorus plays a crucial role in stimulating root growth, particularly in young plants (Rinekso *et al.*, 2020). The phosphorus (P) contained in golden apple snail–based liquid organic fertilizer functions as a component of enzymes and adenosine triphosphate (ATP), thereby facilitating energy transfer processes that support cell division, enlargement, and differentiation in root tissues. Similarly, Ramadhan *et al.* (2018) emphasized that phosphorus is an essential macronutrient that accelerates root growth and the development of meristematic tissues.

In addition to phosphorus, root elongation is also promoted by nitrogen, which serves as a structural component of essential compounds such as amino acids and proteins involved in vegetative growth, including roots, stems, and leaves. Nitrogen availability supports cellular division, expansion, and elongation by contributing to amino acid and protein synthesis (Jatsiyah *et al.*, 2020).

#### 4. Conclusion

The results of this study indicate that:

1. Golden apple snail extract affects coffee plants during the nursery stage.
2. Treatment K2 (5% concentration + every 2 weeks) had a highly significant effect on leaf area index, seedling height, and root length.

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