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The Effectiveness of Rorak in Increasing Arabica Coffee (*Coffea arabica* L.) Growth and Productivity in the Gayo Highlands Bener Meriah Regency

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Abstract

Arabica coffee plants can only grow optimally at altitudes above 1,000 meters above sea level. This research aims to compare the growth and yield of Arabica coffee plants (*Coffea arabica*) on land with and without Rorak at the Testing and Implementation Installation of Standard Agricultural Instruments (IP2SIP) in Gayo Regency, Aceh. The study uses a descriptive quantitative method with purposive sampling, involving 50 plant samples from two gardens. Growth parameters observed include stem diameter and leaf area, while yield parameters include fruit diameter and fruit weight. The results show that plants grown on land with Rorak exhibit significantly different growth compared to those on land without Rorak. Stem diameter and leaf area are larger on land with Rorak, indicating more optimal physiological conditions and vegetative development. Regarding yield parameters, fruit diameter and fruit weight are also higher on land with Rorak, reflecting better seed formation and more complete fruit filling. Overall, the implementation of Rorak in Arabica coffee plantations has the potential to enhance vegetative growth and plant productivity, making it an effective practice for sustainable cultivation systems in highland areas. Reason: The text was revised to correct grammar, punctuation, and spelling errors, improve sentence structure, and enhance clarity and technical accuracy. The vocabulary was refined to convey the research objectives, methods, and findings more effectively, ensuring the text is coherent and professional for an academic audience.

Keywords: Conservation, Cultivation Sustainable, Diameter Stem, Leaf Area, Weight Fruit

1. Introduction

Arabica coffee (*Coffea arabica*) is a key plantation commodity that contributes to foreign exchange earnings and supports the Indonesian economy. Arabica coffee is typically traded as green beans. It is more in demand in both the Indonesian and international markets due to its sweeter and smoother taste, compared to Robusta coffee, which has a stronger, more bitter flavour. The average price of Arabica coffee on the international market is $4.25 per kilogram, which is higher than the price of Robusta coffee, at $1.89 per kilogram (Sekjentan, 2023).

Indonesian Arabica coffee production reached 206,960 tons in 2020, supported by 329,815 hectares of Arabica coffee plantations. Aceh Province was the largest producer of Arabica coffee in Indonesia that year, producing 66,050 tons. Notably, 96.82% of this production came from only two districts. The most dominant was the Central Aceh District, which contributed 52.98% of the production, equivalent to 35,260 tons. The second was Bener Meriah Regency, accounting for 43.84% or 29.17 thousand tons. Together, these two regencies had a total Arabica coffee plantation area of 50.34 thousand hectares. (Directorate General of Plantations, 2024) .

Arabica coffee plants can only grow well on land with an altitude of 1,000-2,000 meters above sea level, an air temperature of 15-25 °C, and rainfall of 1,500-2,500 mm per year. Locations above 1000 meters above sea level generally have high rainfall with an average of 2000 mm per year. In addition, the research location features an area with a slope of up to 30%, necessitating the application of

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effective cultivation techniques, including land management, planting shade plants, and caring for Arabica coffee plants in accordance with Good Agricultural *Practice* (GAP). One of them is the creation of Rorak to reduce the occurrence of waterlogging during rainfall (Wardana, 2023). Rorak is also known to reduce the amount of surface flow and erosion by 2.07% compared to land without Rorak. Rorak functions as a place to collect sediment, allowing it to be easily returned to agricultural land, and also as a storage site for organic material, serving as a source of plant nutrients (Pratiwi & Salim, 2013; Hutasoit & Hanum, 2015).

Satibi *et al.* (2019) stated that Arabica coffee plantations that use Rorak and N-total content of 0.32%, P 25.52 ppm, and K-dd 0.62 me/100 g are taller compared to those with land without Rorak, where N-total is 0.27%, P 23.01 ppm and K-dd 0.53 me/100 g. Rorak can increase cherry productivity by 34.72% compared with land without Rorak. The circumference of the stem is bigger; however, the cherry weighs smaller.

The presence of Rorak, at a density of 250 pieces per hectare in rubber plantations, can increase the annual stem circumference growth by 13.80 cm, which is higher than in plantations without Rorak, where the stem circumference increases by only 8.7 cm per year. Additionally, Rorak can increase production by an average of 17.95 kg per tree per year, compared to 15.54 kg per tree per year in plantations without Rorak (Nugroho, 2017).

The application of Rorak on land with volcanic soil characteristics—specifically, an organic matter content (humus) exceeding 5%, an effective depth greater than 100 cm, and a soil pH ranging from 5.5 to 6.5—differs from previous research, which was generally conducted on low-fertility soils. This study provides new insights into the effectiveness of Rorak on relatively fertile soils and its potential to enhance Arabica coffee productivity.

2. Material and Methods

The research method used is a descriptive quantitative approach with purposive sampling, namely sampling with specific objectives and a certain focus. The total population of Garden 1 consists of 100 plants, and there is no treatment for making Rorak. In contrast, Garden 2 has a total of 100 plants, and each plant receives a treatment of making Rorak. Rorak is constructed under the canopy of the plant, measuring 100 cm in length, 30 cm in width, and 30 cm in depth. Samples were taken from Garden 1 and Garden 2, with each garden containing 50 samples. The formula used to obtain the sample uses the Slovin formula with a 10% error rate.

2.1. Variables observation

2.1.1. Measuring the stem diameter

The plant stem was measured using a Vernier calliper. Measurements were taken at two points. Different gardens , namely the garden with Rorak (with 50 samples) and the garden without Rorak (with 50 samples). The results of the next measurement were processed using SPSS with a T-Test.

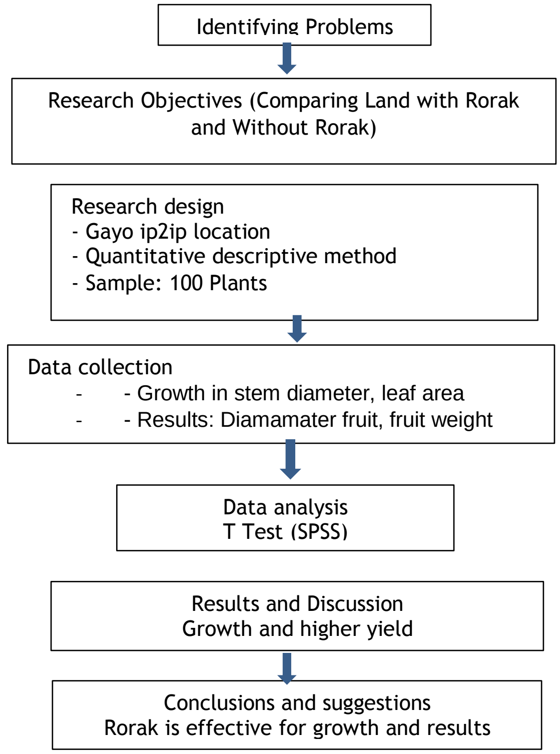

Figure 1. Flowchart study

Table 1. Retrieval sample coffee plants

No	Location	Land area	Number of Plants
1	Garden 1	625 M²	50
2	Garden 2	625 M²	50

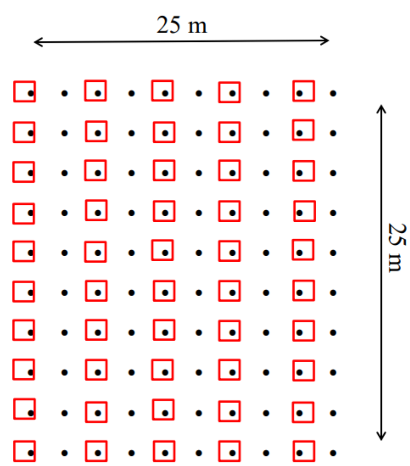

Figure 2. Point Retrieval sample. ☐ = Arabica Coffee Sample Plant

2.1.2. Leaf Sampling

Eight Arabica coffee leaves were taken from each sample plant. The leaves were photographed and then imported into ImageJ software to determine their leaf area and calculate the average. The average leaf area was then processed using SPSS using a T-test.

Figure 3. Measurement of stem diameter

Figure 4. Retrieval sample coffee leaves

2.1.3. Measuring Fruit Diameter

20 Arabica coffee fruits were taken from each sample plant in each garden and then measured using a calliper. The sample plants were the same plants used for measuring stem diameter and leaf area. The results were then processed with *SPSS* using the T-test.

Figure 5. Measuring the diameter of coffee

2.1.4. Fruit Weight Measurement

The Arabica coffee cherries used were those used to measure their diameter. They were weighed individually and then processed using SPSS using a T-test.

Figure 6. Measurement heavy fruit (cherry)

3. Results and Discussion

3.1. Stem Diameter

The results of the t-test indicate a significant difference in the stem diameter of Arabica coffee plants grown on land with and without Rorak, as illustrated in the following figure.

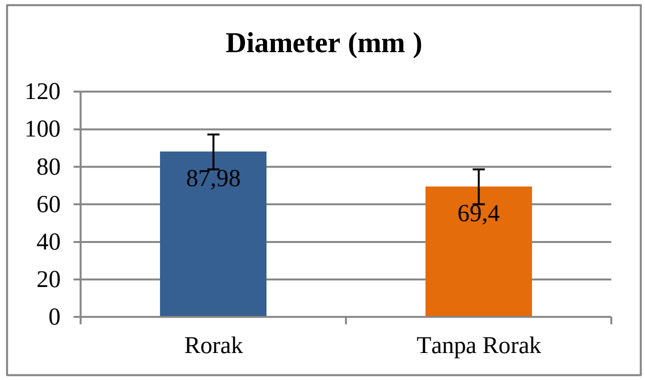

Figure 7. Diameter Stem Rorak and Without Rorak

The average diameter of Arabica coffee stems exhibits a significant difference, specifically in the diameter of Arabica coffee stems grown on land that uses Rorak. diameter 87.98 mm and larger compared to the diameter of the stem of the Arabica coffee plant that does not use Rorak, the diameter of which is only 69.4 mm.

This finding aligns with research by Susilo et al. (2021), which states that the use of Rorak can increase the growth of Arabica coffee plant stems because Rorak can accommodate organic materials and nutrients on the surface of the soil that are carried away when it rains, so that the plant's nutrient needs are met.

3.2. Plant Leaf Area (cm)

The results of the t-test indicate a significant difference in the leaf area of Arabica coffee plants on land with and without Rorak, as illustrated in the picture below.

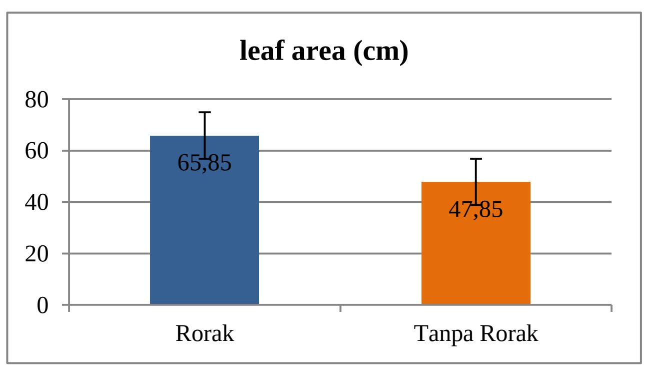

Figure 8. Coffee leaf area with Rorak and without Rorak

The average leaf area of Arabica coffee plants shows a significant difference, where Arabica coffee plants using Rorak have an area of 65.85 cm², larger than the area of leaves that do not use Rorak, which is 47.84 cm².

According to Fauzi *et al.* (2021), high N content in the soil, absorbed by plants, significantly increases leaf area, leaf color, and leaf number. A high nitrogen content also increases leaf cell division, thereby increasing leaf area. This increased leaf area also helps enhance plant photosynthesis. Nitrogen plays a crucial role not only in leaf development but also in the uptake of other essential nutrients, such as phosphorus and potassium, which both aid in the formation of new leaves (Seno *et al.* 2023).

3.3. Arabica Coffee Fruit Diameter (g)

The results of the t-test show that there is a significant difference in the diameter of the fruit of Arabica coffee plants on land with and without Rorak, as illustrated in the picture. following

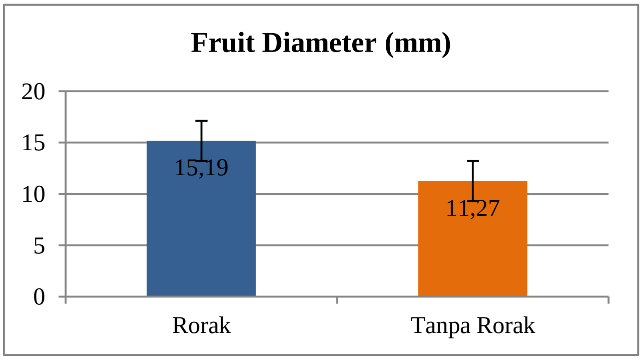

Figure 9. Diameter Fruit with Rorak and without Rorak

The average diameter of Arabica coffee fruit using Rorak is larger than that of those who don't use Rorak, with a diameter of 15.19 mm with Rorak, compared to 11.27 mm without Rorak.

Based on field observations and nutrient analysis, the soil of the area using Rorak has higher levels of N, P, K, and organic carbon. This finding enhances the plant's nutrient uptake, facilitating the formation and development of Arabica coffee fruit. This finding aligns with the results of Harahap et al. (2019), who demonstrated that P and K play a crucial role in fruit growth and development. P plays a role in the formation of fruit and flowers. K plays a role in enhancing the quality of the fruit, as well as the weight and size of the Arabica coffee fruit.

3.4. Weight of Arabica Coffee Fruit (g).

The results of the t-test indicate a significant difference in the diameter of the fruit of Arabica coffee plants on land with and without Rorak, as illustrated in the picture below.

The average weight of Arabica coffee fruit treated with Rorak is 2.48 g, which is significantly higher than the weight of the fruit that does not use Rorak, at 1.47 g.

The higher potassium (K) content in soil with Rorak can play a role in enhancing fruit enlargement and regulating the transport of photosynthetic products (sugars) from leaves to fruit. Additionally, a high phosphorus (P) content contributes to the formation of energy required for cell division and fruit development, thereby accelerating the fruit ripening process (Susilo *et al.* 2021).

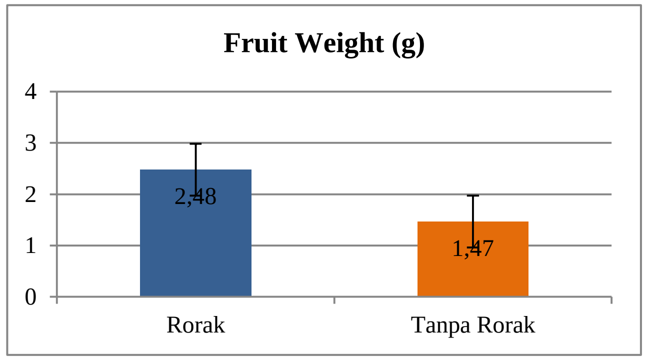

Figure 10. Weight fruit with Rorak and without Rorak

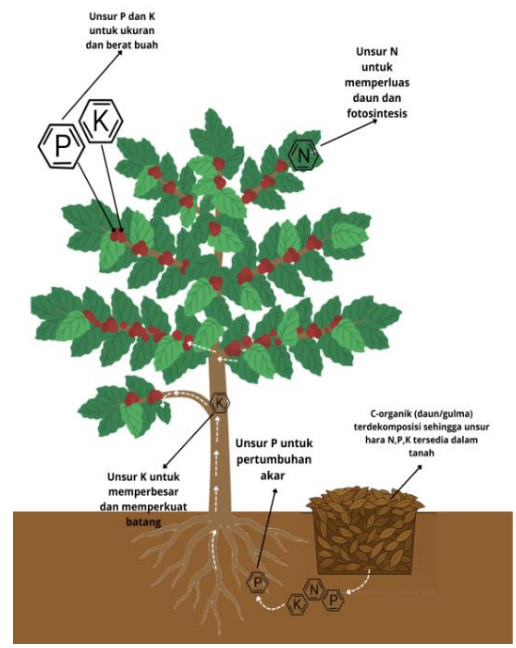

Figure 11. Benefits of Rorak for coffee plants

4. Conclusion

The application of Rorak to Arabica coffee plantations significantly influences vegetative growth (stem diameter, leaf area) and generative growth (fruit weight, fruit diameter) compared to land without it. Rorak is recommended as a soil conservation technique and as a means to increase Arabica coffee productivity, making it suitable for widespread adoption by farmers with similar land conditions.

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