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Composition Treatment of Planting Media by Using Coffee Leather Waste Compost on The Growth of Arabic Coffee (Coffea Arabica) Seeds

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ABSTRACT

Coffee (Coffea sp.) plays a crucial role in the Indonesian economy as a significant plantation commodity. However, the high production of coffee leads to an increase in coffee skin waste generated during post-harvest processing. Utilizing this waste as compost material can help sustain agricultural land, particularly coffee plantations. This study aimed to examine how different planting media compositions, enhanced with coffee skin waste compost, affect the germination of Arabica coffee seeds. The experiment employed a Factorial Randomized Complete Block Design (CRD) with two factors. Factor I involved seed maturity levels: T1 for mature seeds and T2 for immature (green) seeds. Factor II focused on planting media composition, with four variations: M0 (soil: compost: sand at a ratio of 1:0:1), M1 (1:1:1), M2 (1:2:1), and M3 (1:3:1). Observations covered germination rate, root length, hypocotyl length, plant height, and leaf count. Data analysis was conducted using variance analysis, and significant differences were further examined with Duncan's multiple range test at a 5% significance level. The combination of mature seed treatment (T1) and the planting medium composition M0 (soil: compost: sand at 1:0:1) yielded the best results. Overall, mature seed treatment (T1) was most effective. However, the addition of coffee skin waste compost to the planting media did not significantly affect any observed variables. These findings suggest that while mature seeds are crucial for optimal growth, the composting of coffee skin waste in the planting medium does not significantly influence the germination and early growth stages of Arabica coffee seeds.

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INTRODUCTION

Coffee (*coffea sp*.) is one of the plantation commodities that has an important role in the Indonesian economy and is able to contribute considerable foreign exchange. Bondowoso Regency is the leading coffee-producing area in East Java, with extensive plantations cultivated by both smallholder farmers and state-owned enterprises, significantly contributing to regional coffee production and economic development. This can be seen from the coffee plantation area in Bondowoso Regency in 2023 which amounted to 7,054 hectares with an altitude between 1100-1550 meters above sea level. With this area, coffee production can reach 4,135 tons (Bondowoso Central Bureau of Statistics, 2023).

The high production of coffee is directly proportional to the high production of coffee skin waste produced due to the post-harvest processing of coffee. Consequently, the abundant coffee skin waste generated during post-harvest processing poses significant environmental challenges if not managed effectively, emphasizing the importance of exploring sustainable utilization strategies, such as composting, to mitigate potential environmental impacts (Novita et al., 2021). The use of coffee skin waste as compost material can maintain agricultural land, especially coffee plantations, so that it can be sustainable. Coffee skin waste contains potassium, nitrogen, phosphorus, and carbon. The benefits of coffee skin waste as compost fertilizer can increase plant growth. The application of organic fertilizer derived from coffee skin waste has the potential to significantly enhance plant growth, particularly in increasing plant height and leaf area, thus representing an environmentally sustainable solution to coffee waste management and contributing positively to the productivity of coffee cultivation (Ansiska et al., 2022).

Coffee seed germination is often a problem when propagating generatively, namely the hardness of the seed coat which causes seed germination to be slow. Hard seed coat requires a long time in the germination process. Giving the composition of planting media in the form of soil with manure or husk charcoal can increase the germination speed index compared to the media in the form of soil without mixture (Nabilah et al., 2021).

Planting media is one of the factors that greatly affects seed germination. According to (Rezki et al., 2024) that a good planting medium for seed germination is the provision of organic materials such as compost, manure or other organic materials such as husk charcoal, as well as the opinion of coffee farmers that the position of good planting media for coffee seed germination is sand: compost: soil (1: 1: 1). Planting media must produce an appropriate structure because each type of planting media has a different effect on plants. According to (Taryana et al., 2019) the optimum composition of planting media for coffee seed germination is a mixture of soil: manure: husk charcoal

(1:1:1) where the three planting media contain elements that support the growth and development of coffee seed germination, so that coffee seeds can germinate faster.

Based on the above considerations, it is necessary to conduct research on the germination of Arabica coffee seeds with the composition of planting media and different seed maturity levels to determine the interaction between the composition of planting media and seed maturity levels in Arabica coffee seeds, To determine the effect of planting media composition treatment with the provision of coffee skin waste compost on the germination of Arabica coffee seeds, to determine the effect of seed maturity level treatment on the germination of Arabica coffee seeds.

MATERIAL and METHOD

The present study was conducted at Green House, Bondowoso Regency, and the Soil Science Laboratory, Faculty of Agriculture, University of Jember, from March to August 2024. The materials and tools employed in this research encompass a range of instruments, including sacks, stationery, a camera, a hoe, a ruler, a dipper, a sieve, and a paddle. The coffee seeds utilised in this experiment were meticulously selected based on rigorous quality and uniformity criteria, ensuring optimal performance and consistency in the experimental design. The initial sorting of the seeds was conducted manually, with a focus on ensuring uniformity in physical attributes such as size, shape, and weight. Seeds of a similar size (approximately 8-10 mm in diameter), consistent weight (approximately 0.15–0.20 grams per seed), and regular elliptical shape were selected for further analysis. Furthermore, a meticulous examination of the selected seeds revealed no visible defects, including indications of disease, insect damage, physical injuries, discolouration, or deformities. The objective of this meticulous selection process was to eradicate variability associated with seed quality and condition, thereby ensuring consistent germination and uniform growth performance throughout the study period. The experiment incorporated coffee skin waste, EM 4 solution, bran, cow dung, molasses, water, and polybags measuring 15 cm x 15 cm.The implementation of this research experiment entailed the fabrication of coffee skin waste compost as a planting medium. The first step was to pour 1 bottle cap of EM-4 Bioactivator and molasses into 1 litre of water, then fill the composter container with 80% coffee husk waste, 10% cow manure and 10% bran/chaff, mixed well. Subsequently, the mixture was irrigated with a blend of EM-4, water, and molasses that had been prepared earlier. The mixture was then stirred to form a homogeneous mixture. The composter is then closed tightly and the mixture is turned over once a week. If the mixture is very dry, it is watered with water. Following a period of 3-4 weeks, the compost is deemed ready for harvesting. The results of the composting process demonstrate that the resulting compost meets the specified criteria, with a black colour, a loose texture, and an absence of unpleasant odours. The colour of the mature compost is blackish brown, the texture is loosely cohesive and it

is easily crushed in the hand, and the temperature of the mature compost does not feel hot (Deni et. al., 2020). The maturity of compost derived from coffee leather waste was quantitatively confirmed through laboratory analysis. The results obtained indicated that the compost contained an organic carbon (C-organic) content of 25.81%, which exceeded the minimum standard stipulated by the Indonesian Ministry of Agriculture. Furthermore, the C/N ratio was measured at 17.32, thereby exceeding the minimum quality standard, while the moisture content was determined at 5.95%, a figure well within the acceptable limits. While these parameters demonstrated compost maturity, it was decided that specific analyses of pH and microbial activity would be conducted separately.

The seed sowing procedure was executed within a greenhouse, which was fabricated using netting to prevent direct entry of rainwater or sunlight into the nursery. A 15 cm x 15 cm polybag filled with sand, compost, and soil was utilised for the cultivation of Arabica coffee seeds. The coffee seeds are sown by placing the flat surface of the seed facing downward on the soil surface, followed by covering the seed with a layer of soil. Maintenance practices entail the provision of hydration and the management of plant pest organisms (OPT) (Armalia, 2023). The observed research variables are as follows:

Germination Rate Measurement (days)

According to Lesilolo et al. (2012) the measurement of germination rate is done by counting the total days required for seeds to germinate. Observation of germination rate is done at a certain amount of time.

$$\text{Sprout Growth Rate} = \frac{N1T1 + N2T2 + \ldots + NXTX}{\text{Number of seeds that germinate}}$$

N: Number of seeds germinated each day, T: The amount of time between the beginning of observation and the end of the interval (Purba et al., 2014).

Root Length Measurement (cm)

Root length measurements were taken at the end of the observation. Based on research conducted by Clarita, (2020) root length is measured from the base of the root to the longest root tip using a ruler.

Hypocotyl Length Measurement (cm)

Hypocotyl length measurements were taken at the end of the observation. Based on Yuliantina's research, (2019) hypocotyl length is measured from the bottom of the cotyledons to the base of the sprout roots using a ruler.

Plant Height Measurement (cm)

Plant height is done at the end of observation. Based on Reni's research, (2023) Plant height is measured from the tip of the root to the tip of the coffee plant leaves using a ruler.

Number of Leaves (blade)

The number of leaves is done at the end of the observation. Based on Reni's research, (2023) the observation of the number of leaves was carried out at the end of the observation by counting the number of leaves that had opened completely

Statistical Analysis

This study used a completely randomized design (CRD) consisting of 2 factors and 3 replications. The factors used in this study are the maturity level of Arabica coffee seeds and the composition of different planting media. The first factor is the maturity level of Arabica coffee seeds consisting of 2 levels, T1: Ripe coffee seeds (red), T2: Immature coffee seeds (green). These maturity stages were selected because they represent distinct physiological conditions commonly encountered in coffee farming practices. Results indicated significant differences in seedling growth, with ripe seeds generally exhibiting superior growth characteristics compared to immature seeds. The second factor is the composition of different planting media consisting of 4 levels, M0: soil (1): compost (0): sand (1), M1: soil (1): compost (1): sand (1), M2: soil (1): compost (2): sand (1), M3: soil (1): compost (3): sand (1). The data obtained were carried out using analysis of variance with a confidence level of 95% and if there were significant differences between treatments, further tests were carried out using Duncan's multiple range test at the 5% error level.

Analysis of research data using Analysis of Variance, if the data showed significant differences between treatments, then further tests were carried out using Duncan's Multiple Range Test at the 5% level.

RESULTS and DISCUSSION

The results of the analysis in Table 1 show that the interaction between the level of seed maturity and the composition of the growing media has a significant effect on the hypocotyl length parameter. The average test results of the interaction effect of seed maturity level and the composition of planting media on hypocotyl length parameters using Duncan's distance test at the 5% level.

It can be seen in Table 1 that the hypocotyl length is found in the interaction of seed maturity level treatment at the same level T1 (mature) which shows the combination of mature seed maturity level treatment and planting media composition (Soil (1):

Compost (1): Sand (1)) (T1M1) has an average value of hypocotyl length of 8.7 cm which is not significantly different from the treatment combination of the level of maturity of mature seeds and the composition of planting media (Soil (1): Compost (0): Sand (1)) (T1M0).

Table 1. Duncan's distance test results 5% of the effect of seed maturity level (T) and the composition of planting media (M) on hypocotyl length parameters (cm)

Seed maturity level	Growing media composition			
	M_0 (1: 0:1)	M_1 (1: 1: 1)	M_2 (1: 2: 1)	M_3 (1: 3: 1)
T_1 (mature)	6,9(a)	8,7(a)	5,0(a)	6,0(a)
	A	A	B	AB
T_2 (immature)	5,0(b)	5,0(b)	5,2(a)	5,2(a)
	A	A	A	A

Numbers followed by the same uppercase (horizontal) letters, comparing the simple effect of the planting media composition factor (M) at the same level of seed maturity (T). Numbers followed by the same lowercase letters (vertical), comparing the simple effect of the seed maturity level factor (T) at the same level of planting media composition (M).

The level of maturity of coffee seeds can affect plant growth, where mature coffee seeds have fast growth compared to young coffee seeds. So that it can affect the parameters tested. seeds *(Rohaeni, 2019).* So that the recommendations given to get the highest hypocotyl length yield value, it should be given a combination of seed maturity level treatment T1 (mature) and planting media composition M1 (Soil (1): Compost(1): Sand(1)) (T1M1) and can also be with a combination of seed maturity level T1 (mature) and the composition of planting media M0 (Soil(1): Compost(0): Sand(1)) (T1M0) provided the soil is fertile and has sufficient nutrients for the plants. The use of soil and sand planting media without compost can be applied with fertile soil criteria. Soil fertility is the ability of a soil to provide nutrients, at a certain rate and balance on an ongoing basis, fertile soil has sufficient nutrient availability and there are no limiting factors in the soil for plant growth. The requirements for fertile soil are having a pH of around 6.0-6.8 which can help absorb nutrients and maintain soil balance, having a high C-organic content of around 2.20%, containing nutrients such as nitrogen, phosphorus, and potassium, fertile soil has a blackish brown color, and has a good soil physical structure (Fista et al., 2022). The observed lack of significant growth variation in immature seeds (T2) across different media compositions (Table 1) is likely due to their inherent physiological immaturity. Immature seeds possess less developed embryo structures and exhibit lower metabolic activity, making them less responsive to variations in nutrient availability provided by different media. In contrast, mature seeds (T1), having fully developed embryos and higher metabolic capacities, clearly respond to changes in media composition, highlighting their greater sensitivity to

nutrient conditions during early growth stages (Rahimi et al., 2024). Seed maturity significantly influences seedling growth responses, including hypocotyl length, because mature seeds generally have better-developed reserves and vigor, enabling more efficient utilization of nutrients from the planting media. Consequently, when planted in media with varying compositions, mature seeds can effectively harness enhanced nutrient availability and moisture conditions offered by optimal mixtures of coffee leather waste, leading to greater hypocotyl elongation. In contrast, less mature seeds may show limited responsiveness due to insufficient nutrient reserves, even in favorable media compositions. Thus, the interplay between seed maturity and media composition becomes critical, emphasizing that both factors collectively determine the optimal hypocotyl growth performance in Arabica coffee seedlings (Groot, 2022).

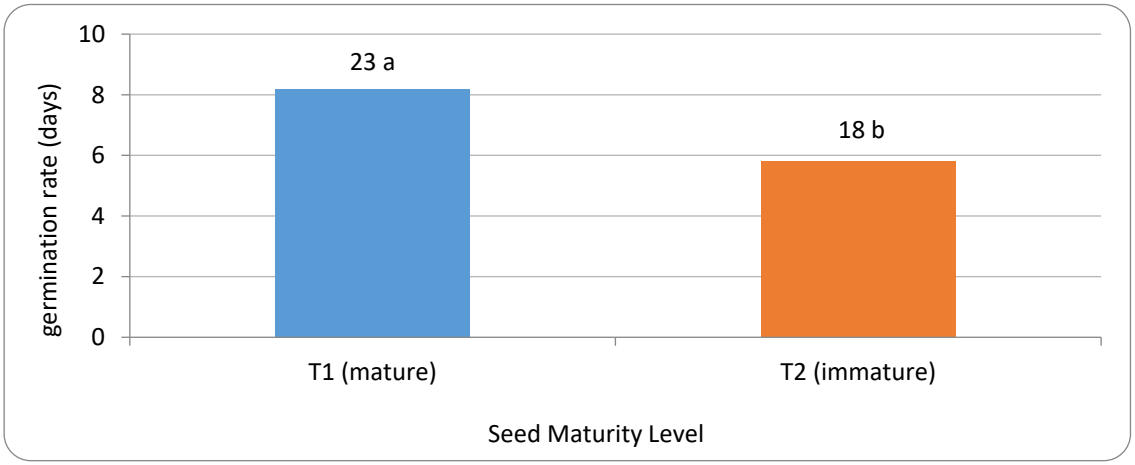

Figure 1. Results of Duncan's further test at the 5% level of the effect of seed maturity level (T) on germination rate (days) in Arabica coffee seeds

Figure 1 shows that the main effect of seed maturity level on germination rate shows the effect of Arabica coffee seed maturity level on treatment T1 (mature) produces an average germination rate of 23 days which is significantly different from treatment T2 (immature) which is 18 days, so the recommendations given to determine the highest growth rate, then it should be given the treatment of Arabica coffee seed maturity level T1 (mature). This is due to the factor that the maturity level of the coffee seeds tested can affect the results of sprout growth. This is in line with research (Junaidi, 2021) where the low germination of seeds is thought to be due to the seeds used that are not physiologically ripe, the seeds used are not physiologically ripe (green) do not have sufficient food reserves and the state of the embryo is not perfect, while the physiologically ripe (red) embryo has been formed perfectly and already has sufficient food reserves. Not only that, the seed germination process can also be influenced by several factors including seed dormancy. Dormancy is a condition of seeds that experience a resting period and are difficult to germinate even in an environment that allows them to grow. One way to break seed dormancy is to soak the seeds with

different types of water, namely coconut water, aquadest and 60℃ hot water (Suhendra et al., 2021). Based on the research, the coffee seeds to be sown have been soaked with 60℃ hot water to break seed dormancy.

The observation that immature seeds germinated faster (18 days) compared to mature seeds (23 days) could be attributed to differences in dormancy and metabolic activity. Immature seeds likely have underdeveloped physiological dormancy mechanisms, resulting in earlier water uptake and quicker initiation of germination. However, despite this initial advantage, immature seeds ultimately exhibit poorer growth due to their limited metabolic reserves, reduced vigor, and incomplete development of essential tissues. In contrast, mature seeds, although requiring slightly longer periods for dormancy breaking and germination initiation, possess fully developed nutrient reserves and metabolic pathways, enabling stronger and sustained seedling growth post-germination. This explains the paradoxical finding of rapid germination in immature seeds followed by inferior overall growth performance compared to mature seeds (Chandra et al., 2024).

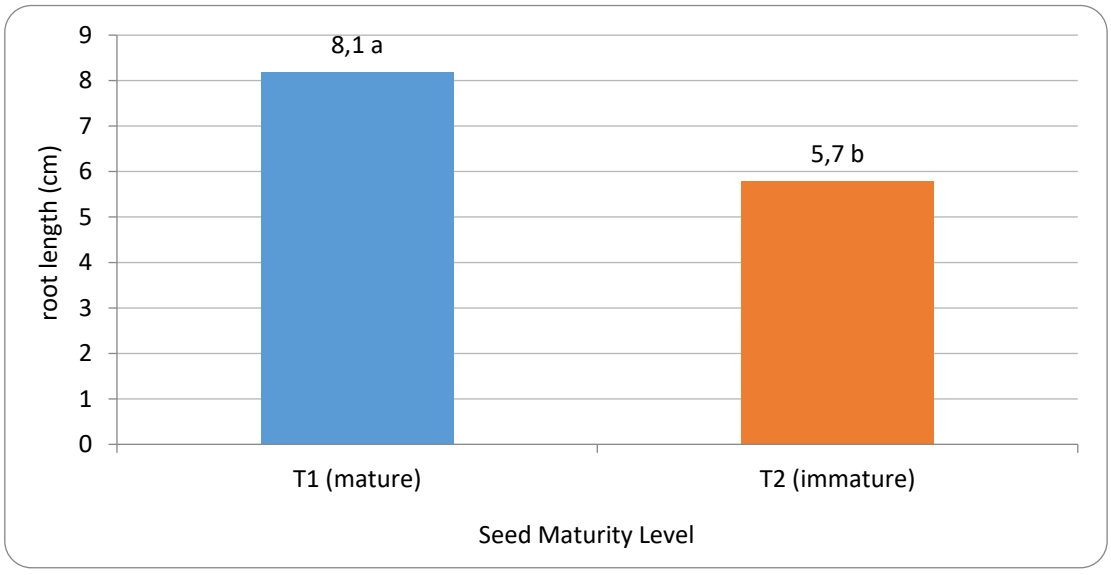

Figure 2. Results of Duncan's further test at the 5% level of the effect of seed maturity level (T) on root length (cm) in Arabica coffee seeds

Figure 2 shows that the main effect of seed maturity level on root length shows the effect of Arabica coffee seed maturity level on treatment T1 (mature) produces a higher average root length of 8.1 cm which is significantly different from treatment T2 (immature) which is 5.7 cm, so the recommendations given to determine the highest root length, then it should be given the treatment of Arabica coffee seed maturity level T1 (mature). This aligns with findings from previous studies (Farida, 2018) that the level of seed maturity can affect root length, physiologically mature seeds will have good and fast root growth because physiologically mature seeds have the best quality

to be used as seeds compared to seeds that are not physiologically mature. Seed germination is a process of seed development into new plants starting from root growth, the stages that occur during germination until root development, namely starting with cell division and enlargement in the seed, then plant metabolic enzymes become active so that the seed coat breaks, and the roots begin to develop so that the roots begin to absorb water and nutrients in the soil or planting media mixture.

Based on Figure 2, it can be seen that the red coffee seeds have a perfect level of physiological maturity. Physiologically mature fruits have maximum food reserves and sufficient water content for germination and growth of coffee seeds. Besides being influenced by the factor of seed maturity, of course, it can also be influenced by the planting media used. According to (Junaidi, 2021) in his research said that root length shows root activity in absorbing nutrients. Therefore, the amount of nutrients contained in the planting media can affect root elongation. Besides being influenced by planting media factors, the maturity level of coffee seeds can also affect root length.

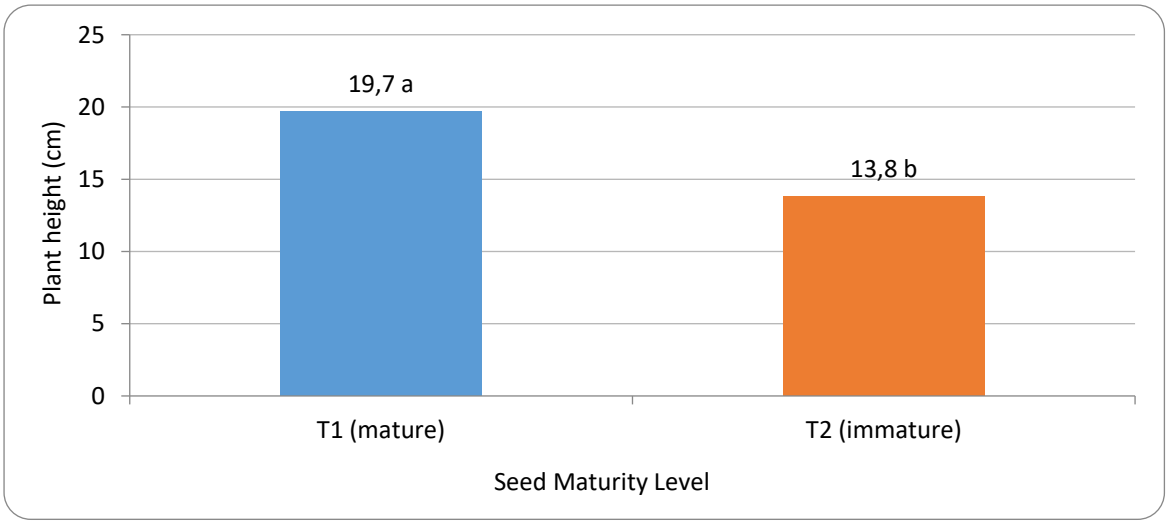

Figure 3. Results of Duncan's further test at the 5% level of the effect of seed maturity level (T) on plant height (cm) in arabica coffee seeds

Figure 3 shows that the main effect of the level of seed maturity on plant height shows the effect of the level of maturity of arabica coffee seeds on the T1 (mature) treatment produces the highest average plant height of 19.7 cm which is significantly different from the T2 (immature) treatment of 13.8 cm, so the recommendations given to determine the highest plant height, it is better to give the treatment of the level of maturity of T1 (mature) arabica coffee seeds. This is in accordance with (Rohaeni, 2019) that seeds harvested before physiological maturity have low viability, because they do not have sufficient food reserves and embryo formation is not yet complete.

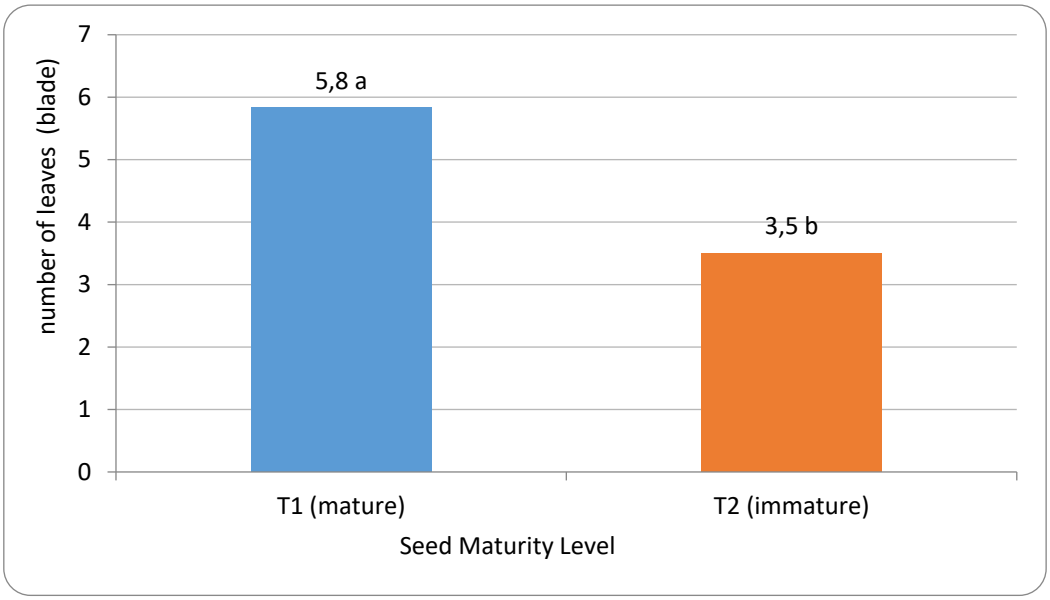

Figure 4. Results of Duncan's further test at the 5% level of the effect of seed maturity level (T) on the number of leaves (blade) on arabica coffee seeds

Figure 4 shows that the main effect of the level of seed maturity on the number of leaves shows the effect of the level of maturity of Arabica coffee seeds on the treatment of T1 (mature) produces an average number of leaves, namely 6 strands, which is significantly different from the treatment of T2 (immature), namely 4 leaves, so that the recommendations given to determine the number of leaves, then it should be given the treatment of the level of maturity of Arabica coffee seeds T1 (mature).

CONCLUSION and RECOMMENDATIONS

Based on the findings, the best treatment was identified as the combination of mature seeds (T1) with planting media composition M0 (soil: compost: sand = 1:0:1). Although the interaction between seed maturity levels and planting media composition was generally not statistically significant for most observed parameters, the treatment combination T1M0 consistently showed superior results in terms of hypocotyl length, plant height, germination rate, number of leaves, and root length compared to other treatments. This suggests that while incorporating coffee skin waste compost into the planting media provided minimal or non-significant growth enhancement, the maturity of coffee seeds had a clear and substantial impact on seedling performance. Therefore, future research should place greater emphasis on seed maturity factors, particularly by investigating physiological characteristics, metabolic reserves, and

dormancy mechanisms, to further optimize growth and performance of Arabica coffee seedlings.

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Conflict of Interest Statement

The authors have declared that there are no competing interests.

Authors Contribution

The authors contribute equally to the research

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