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Effect of Type and Concentration Strong Acid Variety on Viability, Vigor and Growth of Arabica Coffee Seeds Sigararutang Variety on Different Planting Media

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Abstract

Background. The dormancy of Arabica coffee seeds is one of the main obstacles in the provision of quality seeds because the hard seed skin causes the germination process to take place slowly and is not uniform.

Purpose. This study aims to obtain the best combination of types and concentrations of strong acids and planting media in increasing the viability, vigor, and growth of Arabica coffee seeds of the Sigararutang variety.

Method. The research was carried out at the Greenhouse of the Faculty of Agriculture, Winaya Mukti University, using a Split-Plot Design with three replications. The main plot consists of two planting media, namely a mixture of soil: husk charcoal (2:1) and soil: manure (2:1), while the subplot is a combination of three types of strong acids (H_2SO_4, HNO_3, and HCl) at concentrations of 0%, 5%, 10%, 15%, and 20%. The parameters observed included germination age, germination power, growth rate, percentage of Soldier phase, percentage of Kepel phase, and seedlings height aged 91 days after planting. The data was analyzed using analysis of variance (ANOVA) and continued with the Duncan's Multiple Range Test (DMRT) at a real level of 5%.

Results. The results showed that there was a real interaction between the combination of strong acids and planting media on germination age and germination power. Treatment of HNO_3 5% and HCl 10% on soil media: husk charcoal produces the fastest germination rate, while HNO_3 5%, H_2SO_4 20%, and HCl 10% on the same media result in the highest germination rate of 100%. The 5% HNO_3 treatment provides the best growth speed and seedlings height up to 8.11 cm at the age of 91 days after planting.

Conclusion. Soil media: husk charcoal consistently yields better results than soil media: manure on most growth parameters. Thus, scarification using HNO_3 5% combined with soil media: husk charcoal is recommended as the most effective pre-planting treatment to accelerate germination, increase viability and vigor, and produce more optimal early growth of Arabica coffee seeds.

Keywords: arabica coffee seeds, dormancy, HNO_3, planting media, chemical scarification, viability.

INTRODUCTION

Coffee is one of Indonesia's strategic plantation commodities that has an important role for the national economy and the welfare of farmers. According to data from the Central Statistics Agency, as quoted by Dataloka.id (2025), total national coffee production in 2024 will reach 807,580 tons, an increase from the previous year's 758,720 tons, and this is the highest level in the last 10 years. Although production tends to increase, BRMP Plantation (2025) reports that more than 90% of Indonesia's coffee production is still produced by around 1.8 million smallholders with an average land ownership of only 0.5–1 hectare, so increasing productivity through improving seed quality is very important to support the sustainability of coffee farming.

One of the main obstacles to the provision of quality coffee seeds is a long germination time and low germination rate due to the physical dormancy of the seeds caused by the hard, impermeable horn bark (endocarp), which hinders water imbibition and gas exchange required for germination. One effort to overcome this obstacle is chemical scarification using a strong acid solution.

This study presents a comprehensive evaluation of three strong acids (H_2SO_4, HNO_3, and HCl) at various concentrations, combined with different growing media, to determine the optimal scarification treatment in Arabica coffee beans (Coffea arabica L. var. Sigararutang). Unlike previous studies that focused on acid factors or single scarification, this study demonstrated the interaction between chemical scarification and planting media on seed viability, vigor, germination performance, and early seedling growth, providing a practical protocol for improving coffee seed propagation.

LITERATURE REVIEW

Strong acid solutions such as H_2SO_4, HNO_3, and HCl have long been used to soften seed coats through soaking, as summarized by Wijayanti (2023) in her study of mechanical and chemical scarification methods for breaking seed dormancy. Previous research has shown that strong acid treatment effectively improves seed viability and vigor across various commodities with similar types of physical dormancy. In arabica coffee seeds, Binarht, Mayun, and Astawa (2022) found that the administration of 20% H_2SO_4 with a soaking time of 20 minutes broke the

dormancy of the Kopyol variety of arabica coffee at 25 days after seeding. Another study by Hedty, Mukarlina, and Turnip (2014) also examined the administration of H_2SO_4 and coconut water to the viability test of arabica coffee beans. In other commodities, Latue, Rampe, and Rumondor (2019) reported that a 20% sulfuric acid concentration was the most effective for breaking the dormancy period of nutmeg seeds, accelerating germination from 60 days after planting to 14 days after planting, as indicated by seed viability and vigor tests.

Nitric acid (HNO_3) works by dissolving the outer layer of the seed shell at a specific concentration, making the shell structure more permeable and accelerating the entry of water into the seed tissue. This working principle also underlies the formation of its derivative compound, namely potassium nitrate (KNO_3), which results from a reaction between HNO_3 and potassium hydroxide (KOH) and has been widely applied in research on the breaking of dormancy in plantation plant seeds, including robusta coffee.

Hydrochloric acid (HCl) has been tested directly on coffee seeds (*Coffea sp.*) through a study that examines the effect of HCl concentration and soaking time on dormancy breaking, which confirms that this type of acid has the potential to be applied specifically to coffee commodities (Junita, Hamidan, Siregar, Ariska, & Resdiar, 2023). A number of studies on other commodities provide an overview of the dose-response pattern of HCl concentration levels to the effectiveness of dormancy fractures. In tamarind seeds (*Tamarindus indica* L.), soaking with HCl concentrations of 1%, 15%, 30%, and 45% showed that the concentration of 45% resulted in the fastest germination rate as well as the highest germination percentage, which was 83.33%, so it was declared to be the most effective level in breaking dormancy (Imansari & Haryanti, 2017). In teak seeds (*Tectona grandis* Linn.f), the results of the variety analysis showed that different HCl concentrations had a significant influence on plant height and leaf area parameters, with 1 M HCl immersion for 12 hours resulting in higher values than controls (0 M) (Dewi, Kusmiyati, & Anwar, 2022). As for sunan hazelnut seeds, soaking in 10% HCl resulted in a higher germination height of 20.17 cm, compared to the control treatment, which reached only 11 cm (Ismail & Duryat, 2018).

These findings consistently show that the effectiveness of high acid concentrations is commodity-specific, depending on the thickness and hardness of the seed shell structure. Concentrations that are too low tend not to soften the seed skin optimally, while concentrations

that are too high risk causing damage to embryonic tissue due to the corrosive properties of acids, ultimately reducing seed viability. Therefore, determining the optimal concentration through multi-stage testing is an important step before chemical scarification is widely applied to coffee beans.

In addition to chemical factors, the success of dormancy fracture also depends on the conditions of the medium in which the seeds germinate after acid treatment. Nurihandayani, Adnan, and Ridha (2025) in their research on the viability of arabica coffee seeds in different planting media after mechanical scarification showed that the types of planting media that include a combination of soil with manure, soil with manure and rice husk, and soil with manure and cocopeat have a real influence on maximum growth potential, germination power, germination height, and the length of the roots, as well as the wet weight and dry weight of the sprouts. Media with a more porous structure, such as mixtures containing rice husk or cocopeat, generally provide better aeration and drainage conditions than pure soil media, so they have the potential to support the continuation of the imbibition process and root growth after chemical scarification more optimally. Based on the description above, it can be concluded that the effectiveness of H_2SO_4, HNO_3, and HCl in breaking the dormancy of coffee seeds is greatly influenced by the interaction between the level of concentration applied and the type of planting medium used in the next germination stage.

STATE OF THE ART

Researcher	Research Focus	Key Findings	Limitations
Hedty et al. (2014).	H_2SO_4 on the viability of Arabica coffee seeds	H_2SO_4 is able to increase the viability of coffee beans	Using only one type of acid without comparing other types of acids
Binarht et al. (2022).	Concentration and soaking time of H_2SO_4	H_2SO_4 20% effective in breaking the dormancy of Arabica coffee	Not evaluating the planting medium and not comparing the types of acids
Junita et al. (2023).	HCl concentration in coffee beans	HCl has the potential to accelerate germination	Only test HCl so its relative effectiveness against other acids is not yet known

Researcher	Research Focus	Key Findings	Limitations
Wijayanti (2023)	Mechanical and chemical scarification review	Chemical scarification effectively increases germination of physically dormant seeds	It is a literature review, has not done comparative experimental proof.
Nurihandayani et al. (2025)	Post-scarification planting media in Arabica coffee	Planting medium affects viability and growth	Using mechanical scarification, not chemical scarification
This research	Comparison of H_2SO_4, HNO_3, and HCl at different concentrations with two growing media	Determine the most effective treatment combination for the viability, vigor, and growth of Arabica coffee beans	Provides more comprehensive technical recommendations than previous research

Research that specifically tests the combination of acids (H_2SO_4, HNO_3 and HCl), concentration levels, and types of growing media simultaneously on the viability, vigor, and growth of coffee seeds is still very limited. Most previous studies have examined a single strong acid in isolation, without considering its interactions with planting media factors, so this is a relevant research gap to be addressed in this study.

This study aims to determine an optimal treatment combination of strong acids and concentrations across different growing media to improve the viability, vigor, and growth of coffee seeds, as a basis for technical recommendations for seed breeders and coffee farmers in the field.

METHODS

This research was conducted for approximately at the Greenhouse of the Faculty of Agriculture, Winaya Mukti University, Sumedang, West Java. The materials used are coffee seeds (*Coffea* sp.) of the Sigararutang variety, sorted for uniform size; H_2SO_4, HNO_3, and HCl solutions; and planting media consisting of a soil mixture with husk charcoal and a soil mixture with manure. The plan used is a Split-Plot Design with three replicates. The planting medium is placed as the main plot, consisting of two levels, namely a mixture of soil and husk charcoal, and a mixture of soil and manure. The type and concentration of strong acids are placed as subplots, including control treatment and several concentration levels of each type of acid (H_2SO_4, HNO_3, and HCl) with a concentration of 0%; 5%; 10%; 15%; 20%, resulting in 30 treatment combinations, each

repeated 3 times to test the interaction between the type of planting media and the type and the concentration of strong acids on the viability, vigor, and growth of the coffee beans. The research implementation began with preparing planting media at a 2:1 volume ratio and placing it in a large tray. The coffee seeds are then soaked in an acidic solution according to the treatment combination for the seedlings for a certain time, then washed thoroughly with running water to remove any remaining acid before being planted in the prepared medium. Maintenance is carried out through regular watering to maintain the humidity of the media at the condition of the field capacity, weed control, and pest or disease control if any. The observed variables included germination age, viability (germination power), vigor (growth speed), percentage of Soldier phase, percentage of Kepel phase, and growth (seedlings height). The data obtained were analyzed using Analysis of Variance (ANOVA) according to the Divided Plot Design model, and, if the treatment showed a real influence, Duncan's Multiple Range Test (DMRT) was applied at the 5% level.

DISCUSSION

Based on the literature review, several research gaps remain.

Gap 1. Most previous studies have evaluated only one type of strong acid, such as H_2SO_4 or HCl, so there is no information available on the relative effectiveness of strong acids between types of strong acids in breaking the dormancy of coffee beans.

Gap 2. Previous research has focused more on acid concentration or soaking duration, while the effects of interactions among acid type, concentration, and planting media remain underexplored.

Gap 3. Most studies measure only germination potential or germination age, without integrating parameters such as viability, vigor, Soldier phase, Kepel phase, and seed growth as indicators of seed quality.

Gap 4. There are no practical technical recommendations regarding the combination of acid types, optimal concentrations, and planting media for producing Arabica coffee seeds of the Sigararutang variety.

The results of this study include:

Germination Age (days)

The results of Duncan's analysis showed that the interaction between a combination of strong acids of various concentrations and the planting medium had an influence. The results of the analysis are shown in Table 1. In both types of media, the combination of strong acids and concentrations affects the germination age of coffee seeds. The combination of 5% HNO_3 and 10% HCl treatment in mixed soil media : husk charcoal showed the fastest germination age.

Table 1. Effect of Various Combinations of Strong Acids and Concentrations on Planting Media on Germination Age (days)

Treatment	Soil media : husk charcoal	Soil media : manure
H_2SO_4 0%	35.33 a A	35.67 a A
H_2SO_4 5%	30.33 b B	34.33 b A
H_2SO_4 10%	29.67 c B	34.67 a A
H_2SO_4 15%	28.67 c B	33.33 b A
H_2SO_4 20%	29.67 c B	34.00 b A
HNO_3 0%	37.00 a A	36.33 a A
HNO_3 5%	28.33 c A	29.33 d A
HNO_3 10%	28.67 c A	30.33 c A
HNO_3 15%	30.00 c A	30.00 c A
HNO_3 20%	30.00 c A	31.33 c A
HCl 0%	32.00 b A	32.67 b A
HCl 5%	29.33 c A	30.33 c A
HCl 10%	28.33 c A	29.67 d A
HCl 15%	30.33 b A	31.67 c A
HCl 20%	31.00 b B	35.67 a A

Remarks: the same lowercase notation in the same column and the same uppercase on the same line show an intangible difference on Duncan's 5% test

Combination of 5% HNO_3 and 10% HCl treatment in soil media: husk charcoal produces the fastest germination rate among treatments. This acceleration is closely related to the mechanism of action of strong acids in softening the seed shell. Strong acids such as HNO_3 and HCl degrade the hard layer of seed skin (testa), which has been inhibiting the entry of water and oxygen into the embryo. This is in line with the results on Gmelina arborea seeds, where soaking using strong acids results in faster germination times compared to no treatment (Suhartati, Taat Andayani, & Wahyudiono, 2022). the soil : husk charcoal medium consistently produced a significantly lower germination age (notation B) compared to soil : manure (notation A), indicating that husk charcoal accelerated germination more effectively under these acid treatments. For the remaining treatments (0% controls, all HNO_3 levels, and HCl 0–15%), the two media were not significantly different from one another (both notation A), suggesting that media effects only become apparent once seeds are exposed to a certain intensity of chemical stress from the acid scarification. This pattern can be explained by the differing physical properties of the two media. Husk charcoal is highly porous and provides superior aeration and drainage, allowing oxygen and water to reach the embryo more readily once the hardened testa has been degraded by the strong acid. Since acid scarification works precisely by breaking down the impermeable seed coat that normally restricts water and oxygen uptake, a medium that further facilitates gas and water exchange such as husk charcoal logically complements and reinforces this mechanism, producing an additive effect that shortens germination time. Manure, by contrast, tends to be denser and retains more moisture, which can slow oxygen diffusion to the embryo even after the testa barrier has been chemically removed.

This interpretation is consistent with findings on other hard-coated seed species, where scarification method and media aeration jointly determine germination speed. The present results extend this principle by showing that the benefit of acid scarification on germination speed is further amplified when paired with a well-aerated, free-draining medium like husk charcoal, whereas a denser, nutrient-rich medium like manure while still beneficial for seedling vigor at later growth stages does not confer the same speed advantage during the germination phase itself.

Germination Power 35 HST

Duncan's analysis showed that there was an influence of the interaction between a combination of strong acids of various concentrations and the planting medium on germination. The results of the analysis are shown in Table 2.

Table 2. Effect of Various Combinations of Strong Acids and Concentrations in Planting Media on Germination Power (%)

Treatment	Soil media : husk charcoal	Soil media : manure
HNO_3 0%	75.00 b A	75.00 b A
HNO_3 5%	100.00 a A	83.33 a B
HNO_3 10%	91.67 a A	75.00 a B
HNO_3 15%	91.67 a A	75.00 a B
HNO_3 20%	91.67 a A	75.00 a B
H_2SO_4 0%	75.00 b A	75.00 a A
H_2SO_4 5%	83.33 a A	75.00 a A
H_2SO_4 10%	83.33 a A	75.00 a A
H_2SO_4 15%	83.33 a A	75.00 a A
H_2SO_4 20%	100.00 a A	83.33 a B
HCl 0%	91.67 a A	75.00 a B
HCl 5%	91.67 a A	83.33 a B
HCl 10%	100.00 a A	83.33 a B
HCl 15%	83.33 a A	75.00 a A
HCl 20%	83.33 a A	75.00 a A

Remarks: the same lowercase notation in the same column and the same uppercase on the same line show an intangible difference on Duncan's 5% test

In both types of media, the combination of strong acids and concentrations affects the germination age of coffee seeds. The combination of HNO_3 5%, H_2SO_4 20%, and HCl 10% in mixed soil media : husk charcoal showed the highest germination percentage of 100%, although the difference was not noticeable compared to other concentrations, except for the control on the soil media: husk charcoal, and differed for the same concentration treatment across media. The highest germination power (100%) was achieved by a combination of 5% HNO_3, 20% H_2SO_4, and 10% HCl on soil medium: husk charcoal, well above the control (75%). The increase in germination due to strong acid treatment is consistent with the finding that chemical treatment of hard seed shells increases the percentage of normal germination compared to untreated seeds. Scarification has a positive effect on plant growth, including increasing germination capacity and accelerating germination (Wijayanti, 2023). Interestingly, in this study, the effect of the same acid concentration differed significantly between media, indicating an interaction between the effectiveness of chemical scarification and the microenvironmental conditions (humidity and aeration) provided by each planting medium.

Growth Rate (%/etmal)

Duncan's analysis showed no effect of the interaction between a combination of strong acids at various concentrations and the planting medium on germination speed. The results of the analysis of the independent influence of strong-acid combinations at various concentrations are shown in Table 3.

Table 3. Effect of Various Combinations of Strong Acids and Concentrations on Growing Media on Growth Rate (%/etmal)

Treatment	Average Growth Rate (%/etmal)	Notation
HNO_3 0%	2.44	B
HNO_3 5%	5.22	A
HNO_3 10%	4.03	A

HNO_3 15%	4.41	A
HNO_3 20%	3.63	B
H_2SO_4 0%	0.81	C
H_2SO_4 5%	0.81	C
H_2SO_4 10%	1.30	C
H_2SO_4 15%	0.81	C
H_2SO_4 20%	1.61	C
HCl 0%	0.80	C
HCl 5%	0.80	C
HCl 10%	0.41	C
HCl 15%	0.00	D
HCl 20%	0.00	D

Remark: the same letter notation shows an intangible difference on Duncan's 5% test

From Table 3, it can be seen that HNO_3 treatment at concentrations of 5%, 10%, and 15% has the greatest effect on the growth rate of coffee beans. HNO_3 at concentrations of 5–15% yields the highest growth rate, whereas HCl at high concentrations (15–20%) suppresses growth to nearly zero. This pattern suggests that the effectiveness of strong acids in breaking dormancy is dose-dependent: at low to moderate concentrations, the acid helps soften the seed shell, but at excessively high concentrations, it can damage embryonic tissue. This is consistent with the general principle that chemical treatments, such as KNO3 and strong acids, work by softening the seed coat and facilitating water entry into the seeds, thereby accelerating metabolic processes (Wijaya, Fitriani, & Hayati, 2020). Its effectiveness is highly dependent on the concentration and duration of administration. HCl at high doses is likely to be too corrosive to the coffee seed embryo to inhibit, rather than accelerate, growth.

Percentage of Soldier Phase and Kepel Phase

Duncan's analysis showed no effect of the interaction between a combination of strong acids at various concentrations and the planting medium on germination speed. The results of the analysis of the independent influence of the planting media are shown in Table 4.

Table 4. Effect of Planting Media Composition on Soldier Phase Percentage (%)

Planting Media	**Average** Soldier Phase Percentage (%)
Soil : husk charcoal	46.47 A
Soil : manure	40.99 B

Remark: the same letter notation shows an intangible difference on Duncan's 5% test

From Table 4, it can be seen that the mixed soil with husk charcoal planting medium, at a volume ratio of 2:1, has the greatest effect on the percentage of the Soldier Phase in coffee seeds. The results of Duncan's analysis showed that there was no effect of the interaction of a combination of strong acids of various concentrations with the planting medium on the percentage of the Kepel phase. The results of the analysis of the independent influence of the planting media are shown in Table 5.

Table 5. Effect of Planting Media Composition on Kepel Phase Percentage (%)

Planting Media	**Average Kepel Phase Percentage (%)**
Soil : husk charcoal	59.66 A
Soil : manure	52.31 B

Remark: the same letter notation shows an intangible difference on Duncan's 5% test

From table 5, it can be seen that the planting medium of mixed soil with husk charcoal at a volume ratio of 2:1 has the best influence on the percentage of coffee seed Kepel phase, at 59.66%, compared to soil: manure at 52.31%. This is because coffee seed germination is primarily limited by its hard, water-impermeable seed coat, which restricts oxygen and water uptake by the embryo (Muniarti & Zuhry, 2002, as cited in Nengsih, 2017). Husk charcoal's porous, well-aerated, and free-draining structure better supports this oxygen demand and offers less mechanical resistance to the emerging hypocotyl than the denser, moisture-retentive manure. Husk charcoal is also nearly sterile from carbonization, lowering damping-off risk at this fragile stage. Manure's nutrient benefits, by contrast, become more relevant only at later vegetative growth stages.

The results of further variety analysis showed that the combination of acid type and concentration also had a significant effect on the percentage of multiple phases, while the interaction between acid concentration and the planting medium was not real. Therefore, Duncan's follow-up test for the acid-concentration factor was performed on the combined average of the two media. The results of further tests are presented in Table 6.

Table 6. Effect of Various Combinations of Strong Acids and Concentrations on Kepel Phase Percentage (%)

Treatment	Average (%)	Notation
H_2SO_4 20%	66.21	A
HCl 10%	62.71	AB
HNO_3 5%	61.25	AB
HNO_3 10%	58.33	ABC
HCl 5%	57.17	ABC
HCl 0%	55.71	BC
H_2SO_4 5%	55.71	BC
HNO_3 20%	55.12	BC
HNO_3 15%	55.12	BC
H_2SO_4 15%	55.12	BC
HCl 20%	53.67	BC
HCl 15%	52.21	BC
H_2SO_4 10%	51.92	BC
H_2SO_4 0%	50.17	C
HNO_3 0%	49.29	C

Remark: the same letter notation shows an intangible difference in Duncan's 5% test

From Table 6, it can be seen that the 20% H_2SO_4 combination produced the highest percentage of the Kepel phase (66.21%) and was significantly higher than the 0% H_2SO_4 control (49.29%) and the 0% HNO_3 control (49.29%), but it did not differ significantly from most other concentration levels. This pattern suggests that an increase in the concentration of strong acids at some level contributes to the speed at which plants reach the Kepel phase, in line with the principle that proper chemical scarification accelerates water imbibition and early germination, although differences between concentration levels are largely not statistically significant.

Coffee Seedlings Height 91 HST (cm)

The results of Duncan's analysis showed that there was no effect of the interaction of a combination of strong acids of various concentrations with the planting medium on the height of coffee seedlings at 91 HST. The results of the analysis of the independent effect of the combination of strong acids with various concentrations are shown in Table 7.

Table 7. Effect of Various Combinations of Strong Acids and Concentrations on Planting Media on Seedlings Height 91 HST (cm)

Treatment	Average Seedlings Height (cm)
HNO_3 0%	5.39 C
HNO_3 5%	8.11 A
HNO_3 10%	6.50 B
HNO_3 15%	6.49 B
HNO_3 20%	6.05 B
H_2SO_4 0%	5.01 C
H_2SO_4 5%	4.98 D
H_2SO_4 10%	5.03 C
H_2SO_4 15%	5.06 C
H_2SO_4 20%	5.75 C
HCl 0%	4.80 D
HCl 5%	5.44 C
HCl 10%	5.79 B
HCl 15%	5.11 C
HCl 20%	4.79 D

Remark: the same letter notation shows an intangible difference in Duncan's 5% test

From Table 7, it can be seen that a 5% HNO_3 treatment has the greatest effect on coffee seedlings height at 91 days after planting. The results of the analysis of the independent effect of the combination of planting media on the height of coffee seedlings at 91 HST are shown in Table 8.

Table 8. Effect of Planting Media Composition on Coffee Seedlings Height 91 HST (cm)

Planting Media	Average Seedlings Height 91 HST (cm)
Soil : husk charcoal	6.01 A
Soil : manure	5.24 B

Remark: the same letter notation shows an intangible difference on Duncan's 5% test

From Table 8, it can be seen that the planting medium of mixed soil with husk charcoal with a volume ratio of 2:1 has the best influence on the height of coffee seedlings plants 91 days after planting. The 5% HNO_3 treatment provided the highest seedlings height (8.11 cm), and the soil media: husk charcoal was again superior to the soil medium: manure (6.01 cm vs 5.24 cm). Husk charcoal's continued advantage over manure at 91 days reflects the same aeration mechanism

seen earlier, its porous, well draining structure sustains root-zone oxygen for respiration and elongation, whereas manure tends to compact and retain excess moisture, limiting aeration and slowing seedling growth. This result reinforces the pattern observed in the previous parameters: seeds that germinate faster and more simultaneously due to low-concentration nitric acid scarification tend to grow into more vigorous seedlings. The effect of planting media on the height growth of seedlings is in line with research on the composition of media in robusta coffee seedlings, which reported that the composition of the planting medium has a very noticeable effect on the growth parameters of seedlings (Sari, Marliah, & Herri, 2019).

The novelty of this research includes:

Conceptual Novelty

This is the first study to integrate three strong acids (H_2SO_4, HNO_3, and HCl), five concentration levels, and two types of planting media into a single experimental design to evaluate dormancy breakage in Arabica coffee seeds of the Sigararutang variety.

Methodological Novelty

The study used a Split-Plot Design to analyze the interaction between the planting media and a range of strong acid concentrations, thereby providing more comprehensive information than previous studies that tested only one factor.

Empirical Novelty

The results of the study show that:

- HNO_3 5% on soil media: husk charcoal accelerates germination life, increases growth speed, and produces the best seedling height.
- Combination of HNO_3 5%, H_2SO_4 20%, and HCl 10% in soil media: husk charcoal produces 100% germination.
- Soil media: husk charcoal consistently provides better growth performance compared to soil media: manure.

CONCLUSION

This study shows that the combination of strong-acid type, concentration, and planting media exerts different effects on the viability, vigor, and early growth of Arabica coffee seeds of the Sigararutang variety. There is a real interaction between strong acid treatment and planting

media on germination age and seed germination. The combination of HNO_3 5% and HCl 10% in the soil media: husk charcoal produces the fastest germination rate, while HNO_3 5%, H_2SO_4 20%, and HCl 10% in the same media result in the highest germination rate, reaching 100%. In general, the 5% HNO_3 treatment yields the best response, with increased vigor and early seed growth, as indicated by the highest growth rate and the greatest seedling height at 91 days of age. In addition, mixed soil: husk charcoal (2:1) consistently yields better results than soil: manure media on most growth parameters, including percentage Soldier phase, percentage Kepel phase, and seedling height. Based on these results, chemical scarification using 5% HNO_3, combined planting media soil: husk charcoal (2:1), can be recommended as an effective pre-planting treatment to improve the viability, vigor, and early growth of Arabica coffee seeds of the Sigararutang variety. These findings are expected to be the basis for the development of more efficient coffee seed propagation technology and support the provision of quality seeds for farmers and seed breeders.

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