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Germination and Early Seedling Growth of Three Arabica Coffee Varieties at Four Seed Soaking Water Temperatures

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Abstract

It takes three weeks to analyze the germination percentage of Arabica coffee seeds germinated using paper and a three-day water-soaking method. This 3-week period is considered too long for seed distribution to remote areas. Thus, we need to modify this germination test to have a shorter test time. Temperature treatment is one method to break the seed dormancy period for faster germination. This study aimed to obtain a faster and more precise method of germination test on Arabica coffee seeds. We employed a 3 x 4 factorial complete randomized block design with three replications in which Arabica coffee varieties of Gayo-1, Kartika-1, and Sigararutang as the first factor and the temperature of the soaking water of the seeds (25 ^{0}C, 50 ^{0}C, 75 ^{0}C, and 90 ^{0}C) as the second factor. The research was conducted at the Plant Breeding Laboratory, Indonesian Coffee and Cocoa Research Institute (ICCRI), for four months. Findings showed that the interaction between treatments was only found in seed germination percentage. Soaking in room temperature water (control) for three days was better than using water at 50 ^{0}C, 75 ^{0}C, and 90 ^{0}C on the germination percentage, sprout length, and vigor index. Observations of Arabica seed germination could be shortened to 14 days compared to the standard 21-day observation. During the seedling phase, the shoot growth and root growth of the Arabica coffee seeds soaked in water at 50 ^{0}C showed no significant difference from the control. Soaking at 75 ^{0}C and 90 ^{0}C damaged the embryo, and the seeds rotted. Different varieties led to different germination percentages, sprout lengths, and fresh weight of seedling shoots. The method of soaking at 50 ^{0}C for 30 minutes can become an alternative in germination test of Arabica coffee seeds because it regulated small negative effect on germinated seed and seedling quality, but it shortens three days of testing time.

Keywords: *Coffea arabica*, quality, seed viability, seedling emergence

INTRODUCTION

Arabica coffee has been an essential commodity for the beverage industry nationally and internationally (Huang *et al*., 2014). Indonesia's coffee production ranks fourth globally after Brazil, Vietnam, and Columbia (Ditjenbun, 2021). Efforts to increase coffee production have been made, including distribution of superior Arabica coffee seeds. Arabica coffee cultivation and development centers include Sumatera, Bali, Java, Sulawesi, and Papua islands. Arabica propagation is mostly done generatively using seeds, unlike Robusta, which is mostly vegetative. In addition to being easy to produce, generative propagation

makes it possible to reach remote areas where Arabica coffee is planted, mostly in mountainous areas. The coffee seeds must have good genetic, physiological, and physical qualities to grow well. The government of Indonesia has regulated the distribution of certified seeds to guarantee seed quality. For coffee, the government of Indonesia has set a minimum standard of 80% viability for seeds to be labelled as certified ones (Kepmentan, 2021).

A germination test is a method of early detection of the ability of a seed lot to grow in a field to ensure uniformity in the growth of the lot (Sudrajat *et al*., 2017). It takes 3-4 weeks for a germination test to be done on coffee seeds (Guimarães *et al*., 2013; Wibowo *et al.*, 2020; Penido *et al*., 2021) because coffee seeds are intermediate seeds (water content of 30-40%) and coffee plants are forest plants (Sudrajat *et al*., 2017). The germination test is considered too long for seed producers since coffee seeds have a relatively short shelf life (Abreu *et al*., 2014) yet fast seed deterioration; this leads to a shorter time for seed distribution and narrower distribution areas. Germination tests can be made faster with tetrazolium, yet the method is expensive.

Coffee seeds are intermediate seeds sensitive to drying. One cause of the decrease in the germination percentage of coffee seeds is the decrease in water content due to drying after harvest. Drying can increase the levels of reactive oxygen species (ROS) as a result of physiological stress (Santos *et al*., 2014). This can stimulate the activation of the catalase enzyme that inhibits seed germination. Abreu *et al.* (2014) mentioned that the increase in catalase enzyme activity is inversely related to seed viability—the higher the activity of the catalase enzyme, the higher the viability loss making it difficult for seeds to germinate. Coffee seeds that have been stored will undoubtedly experience a period of seed dormancy; a method is needed to break the dormancy after storage to activate enzymes that stimulate germination. The use of inappropriate germination methods will reduce the success rate of coffee seed germination.

Current seed germination tests are done by stripping the parchment and soaking the seed in water for three days to accelerate germination (Kepmentan, 2021; Wibowo, 2021). Arabica coffee seeds germinated without stripping the parchment need longer germination time of more than 50 days in seedling beds (Rahardjo, 2012). Several germination methods have been reported, including 48-hours soaking in water, 48-hours soaking in distilled water, 6-hours soaking in running water, and 5-hours soaking in water of 40-45 ^{0}C (Rahardjo, 2012). The fastest germination time happens to the treatment using distilled water and running water, which are 35-40 days; yet, the time is considered too long for certified seeds. Companies producing seeds need a shorter germination time (Caldeira *et al*., 2015) for a faster marketing cycle. Thus, a modified method that can shorten the process is needed for faster distribution of seeds. This study aimed to investigate an accurate and faster method for germinating Arabica coffee seeds. The finding is expected to become a new reference for germination tests of coffee seeds in laboratories.

MATERIALS AND METHODS

Plant Materials

Viability testing in this study employed three varieties of Arabica coffee with four different treatments. We used a Factorial Randomized Complete Block Design with two factors. The first factor was the Arabica coffee varieties with three treatment levels, namely Gayo-1, Kartika-1, and Sigararutang. The second factor was the temperature of

the soaking water, with four treatment levels, namely 25 ^{0}C (unheated water temperature) as a control, 50 ^{0}C, 75 ^{0}C and 90 ^{0}C. The standard coffee seed testing method is soaking the seeds in water at 25 ^{0}C for three days (S1). Soaking the seeds in water at 50 ^{0}C, 75 ^{0}C, and 90 ^{0}C was carried out for 30 minutes. Choices of temperature for coffee seed soaking were based on previous study (Rahardjo, 2012), which used a temperature range of 40-45 ^{0}C, yet the results obtained were not optimal. Putra *et al.* (2012) report that soaking coffee seeds for seven days in a water temperature of 90 ^{0}C brings a good effect on the germination percentage of the seeds. The two temperatures became our reference in making a range of soaking temperature as a treatment level. The combination of soaking temperatures and varieties resulted in 12 treatment combinations, and each treatment unit was replicated three times. Each replication in each unit used 25 coffee seeds. The seeds were stored for about two months after harvest. Arabica coffee harvesting happens about three months from July to September. The research was conducted at the laboratories and greenhouse of Plant Breeding Laboratory, Indonesian Coffee and Cocoa Research Institute (ICCRI). The study site is located about 45 m asl. The average room temperature of the study site is 25-28 ^{0}C.

Seed Germination Test

The 25 coffee seeds for each experimental unit (Sudrajat *et al.*, 2017) were manually hulled to remove the parchment. Each seed was then treated according to the design or treatment levels: (i) seeds were soaked in room temperature water (25 ^{0}C) for three days—this is the standard method for coffee seed germination testing as instructed by Kepmentan (2021); (ii) seeds were soaked in water at 50 ^{0}C for 30 minutes; (iii) seeds were soaked in water at 75 ^{0}C for 30 minutes; and (iv) seeds were soaked in water at 90 ^{0}C for 30 minutes (Putra *et al.*, 2012). After the treatments, the seeds were drained and tested for viability using the method of between-paper test or towel test for seeds. It is a method done using rolled paper method set up on a plastic sheet. (Sudrajat *et al*., 2017) for 21 days of the germination phase. The observed characteristics are germination percentage, sprout length, and vigor index calculated using the following formulas:

Germination percentage = $\frac{nKN}{N} \times 100\%$

In which n KN is the number of seeds that sprout on the last day of observation; N is the total number of seeds tested (Sudrajat *et al*., 2017; Wibowo *et al*., 2020).

Sprout length = $\frac{\sum_{i=1}^{n} SL}{n}$

In which SL (Sprout Length) refers to the length of each sprout (cm); n is the number of sprouts (Silva *et al*., 2019).

Vigor index (%) = $\frac{\sum KN \text{ on } first \text{ } count}{\sum GS} \times 100\%$

In which KN is the number of seeds that sprout normally on day-i; GS is the total number of seeds tested (Tefa, 2017).

Seedlings Quality Evaluation

After the seeds were evaluated for germination, they were moved to a 12 cm x 20 cm polybag. The planting medium was a mix of soil and organic fertilizer at a ratio of 1:1. The seedlings were taken care of for three months after sowing. Their growth was evaluated, including the height, stem diameter, number of leaves, leaf area, root length, fresh weight of shoots and roots, dry weight of shoots and roots, and root-to-shoot ratio.

Data Analysis

Data were analyzed using analysis of variance (ANOVA) and Duncan's multiple range test with a 95% confidence level in SAS 9.0 software.

RESULTS AND DISCUSSION

Seed Germination

The analysis of variance showed that at the germination phase, the difference in seed soaking temperatures significantly affected germination percentage, sprout lengths, and vigor index, while Arabica coffee varieties significantly affected germination percentage and rate (Table 1). The interaction between seed soaking water temperatures and Arabica coffee varieties occurs in germination percentage.

During the seedling growth phase, soaking water temperature significantly affected seedling height, stem diameter, number of leaves, leaf area, root length, fresh weight of shoots and roots, dry weight of shoots and roots, and root-to-shoot ratio. Arabica coffee varieties only significantly affected seedling height (Table 1). During the seedling growth phase, there was no interaction between soaking water temperatures and varieties.

Sprouting of Arabica coffee seeds was done for 21 days and was observed every day until no sprouting was noticed. The standard for germination tests of Arabica coffee seeds in Indonesia is 21-day observations (Rahardjo, 1988; Kepmentan, 2021). That 21-day observation is considered too long if the seeds must be immediately distributed to many places in Indonesia. Based on the observations, germination tests could be shortened to 14-day observation. This was proven by the sprouting of three varieties of Arabica coffee seeds used in this study (Gayo-1, Kartika-1, and Sigararutang) that no more sprouted on day 12 and 15 (Figure 1). Seeds soaked in room temperature water for three days and in water at 50 ^{0}C for 30 minutes would stop sprouting on day 15; Guimarães *et al.* (2013) reveal the same result on the germination test of Arabica coffee seeds for 30 days. The number of germinating seeds (sprouts) of the Arabica coffee on day 14 and 16 of the observations was not significantly dif- ferent from the number of germinating seeds on day 30. For urgent needs, germination tests of Arabica coffee seeds can be finished to 14 days; germination tests for Arabica coffee may differ from those of Robusta and Liberica coffee.

The treatment of soaking seeds in water at 50 ^{0}C for 30 minutes has been proven to accelerate the sprouting of Arabica coffee seeds. Soaking with heated water will soften the seed endosperm so that imbibition can start immediately. Soaking with high-temperature water can break the seed dormancy (Statton *et al*., 2017), accelerating the activation of enzymes that contribute to seed germination during imbibition process (Khaeim *et al*., 2022). At higher temperatures (75 ^{0}C and 90 ^{0}C)

Table 1. Variation analysis of the effect of soaking temperature, variety and their interaction on germination and seedling performance of Arabica coffee

Parameter	Soaking water temperature	Variety	Interaction
Germination percentage	**	**	*
Sprout length	**	ns	ns
Vigor index	**	ns	ns
Seedling height	**	*	ns
Stem diameter	**	ns	ns
Number of leaves	**	ns	ns
Leaf area	**	ns	ns
Root length	**	ns	ns
Shoot fresh weight	**	ns	ns
Shoot dry weight	**	ns	ns
Root fresh weight	**	ns	ns
Root dry weight	**	ns	ns

Notes: ns = not significantly different; (*) = significant at $\alpha = 0.05$; (**) = significant at $\alpha = 0.01$.

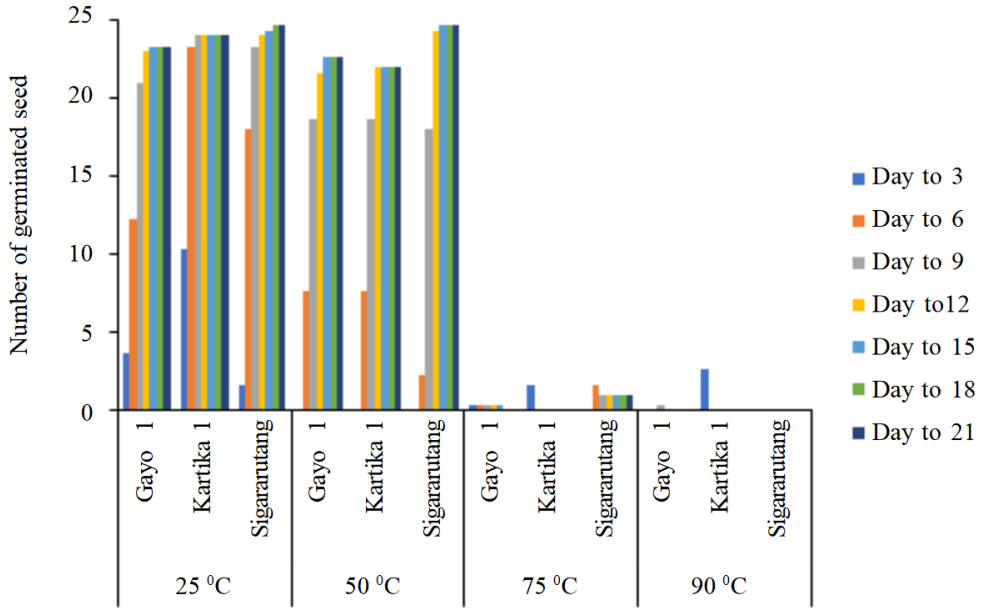

Figure 1. Effect of soaking temperature and variety of Arabica coffee on number of germinated seeds during the first 21 days

with the same length of time, seeds started to sprout on day three, yet the sprouts then rotted due to damage caused by too high temperature during soaking. However, Putra *et al*. (2012) reported differently—that soaking in water at 90 ^{0}C for 30 minutes could increase the viability and vigor index of Arabica coffee seeds. Each seed type has different tolerance levels to soaking to break seed dormancy. Coffee seeds are only tolerant to the soaking temperature of 50 ^{0}C to stimulate sprouting; it is different from other seeds of *Senegalia galpinii* and *Vachellia robusta* that can stand a boiling water temperature to stimulate sprouting (Botumile *et al*., 2020) and sunflower seeds that effectively germinate if soaked in water at 80 ^{0}C (Uddin *et al*., 2015). Effective soaking temperatures on germination or sprouting depend on the types and components that make up the seeds.

Germination Performance

Germination tests are essential to reveal the viability of the seed lot. Germination tests help us determine the maximum number of seeds that can grow into normal seedlings (Bhuker *et al*., 2020). Results of germination tests can also assist in the early prediction of the number of seeds needed. Germination tests of coffee seeds on soil are longer, around 50-60 days after sowing (Eira *et al*., 2006).

During germination, interactions between treatments, soaking temperatures, and Arabica coffee varieties only happened on germination percentage (Table 2). Soaking at room temperature for three days (control) still gave the best result on germination percentage, sprout length, and vigor index. However, soaking in water at 50 ^{0}C for 30 minutes can become an alternative to shorten the germination or sprouting time of Arabica coffee seeds. Soaking at higher temperatures (more than 50 ^{0}C) will only damage the germination process of Arabica coffee seeds; the same also applies to sprout length and vigor index. In other words, soaking in water at a temperature of more than 50 ^{0}C decreases the viability of Arabica coffee seeds (Suhendra *et al*., 2020). Seeds soaked in water at 75 ^{0}C and 90 ^{0}C rotted on day 21. Control treatments and soaking in water at

50 ^{0}C for 30 minutes showed a significantly different value on germination percentage, sprout length, and vigor index, yet the difference between the two treatments on the three germination parameters was not big enough. Soaking of seeds at high temperatures is often done to get uniform and simultaneous sprouting (Botumile *et al*., 2020). The benefit of this soaking method is often used for rapid germination tests of horticultural commodities. Our findings also confirmed that this soaking method could be applied to coffee germination tests.

Arabica Sigararutang showed the best germination percentage compared to Gayo-1 and Kartike-1; yet, results on sprout length and vigor index between the three varieties were not significantly different. Although Sigararutang had a different germination percentage than the other two varieties, the three tested Arabica coffee varieties showed the same growth and development of sprouts.

The Sigararutang variety showed the highest germination percentage on the seeds soaked in water for three days (control) and soaked in water at 50 ^{0}C. The three Arabica coffee varieties used in this study showed high germination percentage (more than 90%) on the two treatments, except Kartika-1 on the second treatment (Table 3). The sprout length of the three varieties also showed the best result on the seeds soaked in water for three days (control), although the result was not significantly different with the seeds soaked in water at 50 ^{0}C on Gayo-1 and Kartika-1. The control also showed the best vigor index, and the result was significantly different from seeds soaked in water at 50 ^{0}C of the three tested variables. The temperature of 50 ^{0}C is the highest temperature limit for soaking coffee seeds to accelerate germination.

During germination, significant differences happened due to differences in varieties. The three tested varieties (Gayo-1, Kartika-1, and

Table 2. Effect of soaking temperature and Arabica coffee varieties on several parameters on the germination stage

Treatment	Germination percentage (%)	Sprout length (cm)	Vigor index
Soaking Temperature			
25 ^{0}C (control)	96.00 a	5.97 a	573.44 a
50 ^{0}C	92.44 b	5.10 b	468.42 b
75 ^{0}C	0.44 c	0.00 c	0.00 c
90 ^{0}C	0.00 c	0.00 c	0.00 c
Variety			
Gayo-1	46.00 b	2.84 a	262.16 a
Kartika-1	46.00 b	2.88 a	264.47 a
Sigararutang	49.67 a	2.58 a	254.78 a
Interaction	(+)	(-)	(-)
CV (%)	5.30	16.96	16.88

Notes: Means of each variable with the same letter in the same column are not significantly different based on Duncan's multiple range test at α = 5%.

Table 3. Interaction between soaking temperatures and varieties on germination parameters of Arabica coffee sprouts

Soaking temperature	Variety								
	Germination percentage (%)			Sprout length (cm)			Vigor index		
	Gayo-1	Kartika-1	Sigar.	Gayo-1	Kartika-1	Sigar.	Gayo-1	Kartika-1	Sigar.
25 ^{0}C (control)	93.33 bc	96.00 ab	98.67 a	6.10 a	6.10 a	5.70 a	569.43 a	586.27 a	564.63 a
50 ^{0}C	90.67 cd	88.00 d	98.67 a	5.27 ab	5.40 ab	4.63 b	479.20 b	471.69 b	454.47 b
75 ^{0}C	0.00 e	0.00 e	1.33 e	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c
90 ^{0}C	0.00 e	0.00 e	0.00 e	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c	0.00 c

Notes: Means of each variable with the same letter in the same column are not significantly different based on Duncan's multiple range test at α = 5%.

Sigararutang) have different growth types. Gayo-1 is a tall type, Kartika-1 is a dwarf type, and Sigararutang is a semi-dwarf type (Hulupi, 2016). Significantly different results during growth due to differences in varieties are also reported by Wibowo *et al.* (2020).

Seedling Growth

During the seedling phase, there was no interaction between soaking temperatures and Arabica coffee varieties on all observed characteristics. There was no significant difference between the control and the treatment of soaking in water at 50 ^{0}C for seedling growth. There was a significant difference for the treatments of soaking in water at 75 ^{0}C and 90 ^{0}C (Table 4). Seeds soaked at high temperatures did not grow well in the nursery. The three tested Arabica varieties did not show significantly different results. However, Gayo-1 showed the best seedling growth because Gayo-1 has a different growth type than Kartika-1 and Sigararutang (Hulupi, 2016).

Seeds soaked in room temperature water (control) and soaked in water at 50 ^{0}C could produce many growing sprouts that were successfully grown into seedlings in the nursery. Meanwhile, soaking in water at 75 ^{0}C and 90 ^{0}C produced rotten seed sprouts at the end of the observation that they did not continue into the nursery phase. During the seedling phase, Gayo-1 and Sigararutang showed better seedling heights than Kartika-1 (Table 5). The same result is also reported by Wibowo (2021), that Gayo-1 has better plant height than the dwarf-type Arabica coffee in the nursery. The three tested varieties showed similar stem diameters during the seedling period, around 1.73-2.03 mm. The average number of leaves of Gayo-1 after three months of cultivation was around five leaves, while Kartika-1 and Sigararutang had six leaves. The three varieties will have 4-5 pairs of leaves 4-5 months after transplanting or replanting (Wibowo, 2021). The 4-5 pairs of leaves are the quality standard for seedlings from generative propagation to be ready to plant (Kepmentan, 2021).

Leaf growth of Sigararutang was better than Gayo-1 and Kartika-1, although the values of the leaf area were not significantly different. Sigararutang belongs to Arabica Catimor with a semi-dwarf growth type (Hulupi, 2016), making it possible for its leaves to grow better than Gayo-1, with a tall growth type. The shoot fresh and dry weight of Sigararutang was also better than Gayo-1 and Kartika-1.

Table 4. Influence of soaking temmperatue and variety on several growth parameters of the seedling stage of Arabica coffee

Treatment	SH	SD	NL	LA	RL	SFW	SDW	RFW	RDW
Soaking temperature									
25 ^{0}C (control)	11.33 a	1.86 a	5.78 a	12.57 a	11.07 a	1.37 a	0.29 a	0.20 a	0.06 a
50 ^{0}C	11.22 a	1.93 a	5.56 a	11.84 a	10.58 a	1.34 a	0.31 a	0.18 a	0.07 a
75 ^{0}C	0.10 b	0.02 b	0.00 b	0.21 b	0.08 b	0.01 b	0.00 b	0.00 b	0.00 b
90 ^{0}C	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
Variety									
Gayo-1	6.27 a	1.00 a	2.67 a	6.18 a	5.38 a	0.66 ab	0.14 a	0.09 a	0.03 a
Sigararutang	5.73 ab	0.91 a	2.92 a	6.62 a	5.60 a	0.73 a	0.17 a	0.08 a	0.02 a
Kartika-1	4.99 b	0.95 a	2.92 a	5.67 a	5.31 a	0.65 b	0.14 a	0.11 a	0.04 a
Interaction	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
CV (%)	17.51	19.21	11.08	21.94	24.03	13.64	20.92	19.797	18.86

Notes: Means of each variable with the same letter in the same column are not significantly different based on Duncan's multiple range test at α = 5%;. SH = Seedling height (cm); SD = Stem diameter (mm); NL = Number of leaves; LA = Leaf area (cm^2); RL = Root length (cm); SFW = Shoot fresh weight (g); SDW = Shoot dry weight (g); RFW = Root fresh weight (g); RDW = Root dry weight (g).

Table 5. Interaction between soaking temperatures and varieties on several parameters of Arabica coffee seedling growth

Soaking temperature	Variety								
	Seedling height (cm)			Stem diameter (mm)			Number of leaves		
	Gayo-1	Kartika-1	Sigar	Gayo-1	Kartika-1	Sigar	Gayo-1	Kartika-1	Sigar
25 ^{0}C (control)	13.00 a	9.53 c	11.47 ab	2.03 a	1.80 a	1.73 a	5.33 b	6.00 a	6.00 a
50 ^{0}C	12.07 ab	10.43 bc	11.17 bc	1.97 a	2.00 a	1.83 a	5.33 b	5.67 ab	5.67 ab
75 ^{0}C	0.00 d	0.00 d	0.00 d	0.00 b	0.00 b	0.07 b	0.00 c	0.00 c	0.00 c
90 ^{0}C	0.00 d	0.00 d	0.00 d	0.00 b	0.00 b	0.00 b	0.00 c	0.00 c	0.00 c
Soaking temperature	Leaf area (cm^2)			Root length (cm)			Shoot fresh weight (g)		
	Gayo-1	Kartika-1	Sigar	Gayo-1	Kartika-1	Sigar	Gayo-1	Kartika-1	Sigar
25 ^{0}C (control)	12.87 a	11.70 a	13.13 a	10.60 a	11.40 a	11.20 a	1.30 ab	1.33 ab	1.47 a
50 ^{0}C	11.87 a	10.97 a	12.70 a	10.93 a	9.83 a	10.97 a	1.33 ab	1.27 b	1.43 ab
75 ^{0}C	0.00 b	0.00 b	0.63 b	0.00 b	0.00 b	0.23 b	0.00 c	0.00 c	0.03 c
90 ^{0}C	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 c	0.00 c	0.00 c
Soaking temperature	Shoot dry weight (g)			Root fresh weight (g)			Root dry weight (g)		
	Gayo-1	Kartika-1	Sigar	Gayo-1	Kartika-1	Sigar	Gayo-1	Kartika-1	Sigar
25 ^{0}C (control)	0.27 b	0.27 b	0.33 a	0.17 a	0.27 a	0.17 a	0.07 a	0.07 a	0.03 a
50 ^{0}C	0.30 ab	0.30 ab	0.33 a	0.20 a	0.17 a	0.17 a	0.07 a	0.10 a	0.03 a
75 ^{0}C	0.00 c	0.00 c	0.00 c	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
90 ^{0}C	0.00 c	0.00 c	0.00 c	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b

Notes: Means of each variable with the same letter on the same column are not significantly different based on Duncan's multiple range test at $\alpha = 5\%$.

The root growth of Kartika-1 was better than Gayo-1 and Sigararutang on root length and root fresh and dry weight, although the value was not significantly different (Table 5).

In general, the growth of Arabica coffee seeds soaked in room temperature water for three days (control) and soaked in water at 50 ^{0}C for 30 minutes showed no significant difference. The latter treatment can become an alternative for germination tests of Arabica coffee seeds because it saves time (two days faster).

CONCLUSIONS

Observations of the sprouting of Arabica coffee seeds can be done until day 14 after sowing. During the germination phase, the control (seeds soaked in water at 25 ^{0}C for three days) showed the best results on germination percentage, sprout length, and vigor index. Meanwhile, during the seedling phase, the control and the seeds soaked in water at 50 ^{0}C for 30 minutes showed no significant differences in all observed characteristics. Soaking at higher temperatures damages seeds during sprouting and seedling. Soaking in water at 50 ^{0}C for 30 minutes can become an alternative to shorten the germination or sprouting time of Arabica coffee seeds. Germination tests on Arabica coffee seeds using the standard (control) method can be done until day 14 after sprouting.

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AUTHOR CONTRIBUTIONS

The first author proposed the research idea and contributed to data analysis, data

interpretation, and preparation of the manuscript publication. The second author contributed to the observation, data collection, and drafting of the publication. The third author contributed to providing guidance and supervision of research implementation.

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