Effects of Drying Method and Seed Priming Duration on Coffee Seed and Seedling Quality

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Abstract

Coffee is an economically important cash crop in Ethiopia. However, the conditions under which coffee seeds are dried and processed significantly affect the seedling quality and productivity. The objective of this study was to evaluate the effect of pre-sowing treatments and drying methods on the physiological quality of coffee seeds and seedlings. The study included two coffee varieties (74110, 75227), two drying conditions (under-shade drying room, open sun), and five durations of seed hydropriming (6, 8, 18, 24 hours, and an untreated control). A factorial combination of the three factors were laid out in a Completely Randomized Design of three replications. Results indicated that the highest germination percentage (91%), emergence rate (90%), and seedling vigor index-I (2236 cm.%) were recorded for seeds dried under-shade drying room. In contrast, the lowest values of germination percentage, emergence rate, and vigor index were observed for seeds dried under open sun. There was a significant difference in seed germination based on hydropriming time, with the highest germination percentage (83%) recorded for seeds soaked for 6 hours, followed by 24 hours (83%). The lowest germination percentage (77%) was recorded for un-soaked seeds. In conclusion, drying seeds under shade is better for coffee seed quality, and hydropriming has improved seedling vigor. However, further investigation into seed priming methods and preservation techniques for primed seeds is necessary to improve coffee seed quality.

Keywords: Coffee; Seed drying; Germination**;** Seed; Seed priming; Seed longevity

Introduction

Coffee (*Coffea arabica* L.) is one of the most important agricultural products in the international market and many countries are involved in its production, trade and consumption (Daviron and Ponte, 2005). Coffee accounts for 4–5% of the GDP, 10% of the total agriculture production, 40% of total exports, 10% of total government revenue, and 25–30% of total export earnings in Ethiopia (Worku, 2019). Coffee industry is a major driver of the country's economic well-being. Recently, coffee exports brought Ethiopia $1.43 billion in revenue during the 2023/24 Ethiopian fiscal year (XINHUA, 2024). Coffee provides a livelihood for a large portion of the population. Over 25% of Ethiopians are directly or indirectly engaged in the production, processing, and trading of coffee (EBI, 2014; Feleke, 2018).

Despite the existence of enormous genetic diversity and its importance in the

country's economy, the national average productivity of the crop remains very low (646 kg ha^{-1}) (CSA, 2019). Several factors are contributing to the low productivity of the crop. Among which limited use of improved coffee varieties, improper establishment and management of the coffee plant during the early stage of establishment in the field, and the use of poor-quality seedlings for field planting. Low quality coffee seedlings are mostly the result of poor seed preparation and handling, the use of deteriorated seeds and growing media not suitable for germination and seedling growth, and improper depth of seed sowing and pre-germination (Netsere *et al*., 2008). Similarly, Kufa *et al.* (2011) reported the detrimental impact of poor seed preparation and handling in reducing coffee production and productivity.

Among the seed preparation and handling practices, drying methods and condition of processing are the major factors influencing coffee seed quality (Netsere *et al*., 2006). Drying coffee seeds in a well aerated, cool and shaded condition till they attained the desired moisture level before sowing recorded higher germination percentage (Netsere *et al*., 2006). Coffee seed dried under corrugated iron show good germination percentage than those dried under *albizzia* and in open sun (Netsere *et al*., 2008). Pre-sowing seed treatment practices have been tested aiming at improving the viability and germination of seeds and production of quality coffee seedlings with limited scope and coffee varieties. A study on coffee seed system in south western Ethiopian revealed that, some farmers prepared coffee seed by directly exposing to sun drying (Taju M., 2023, unpublished data). However they did not consider the effect of this drying method on coffee seed and seedling quality. The objective of this study was to evaluate the effect of pre-sowing treatment and drying methods on seed and seedling quality of coffee.

Materials and Methods

Description of the Study Site

The study was conducted at Jimma Agricultural Research Center (JARC), Southwestern Ethiopia. The JARC lies 365 km from the capital city, Addis Ababa, at an altitude of 1750 meters above sea level. The center's location falls within the sub humid tropical belt at 7^0 46" N, latitude, and $36^0$47" E longitude. Average annual rain fall of the area is 1594 mm with 67% mean relative humidity. The mean minimum and maximum temperatures are 11.6^0C and 26.3^0C respectively.

Experimental materials and procedures

Two widely adapted coffee varieties (74110 and 75227) were used in the experiment. The varieties were resistant to coffee berry disease, widely adapted, and high yielders (Teferi *et al* 2008).

Ripe red cherries were harvested, following the conventional procedures widely applied in coffee seed preparation (Goodman, 1980). After harvesting, the cherries

were sorted and pulped. Then, the abnormal, the cracked, and the floater beans were sorted and discarded. Beans were washed thoroughly to remove the mucilage. The coffee seeds with parchment were placed at their respective drying areas, and treated with wood ash.

The extracted coffee seeds were dried by two methods: under-shade drying room, and open sun drying, over raised bed in both cases. Drying continued until the moisture content reached 13%. Following drying, coffee seeds were hydro primed using pure tap water for duration's vis. 6, 12, 18 and 24 hours to promote imbibition. For comparison the un-primed (untreated) seed was used during the experiment as control.

A total of 20 treatment combinations, two coffee varieties (74110 and 75227), two seed drying methods (under shade and direct sun drying), and five priming durations (un-soaked, 6, 12, 18 and 24 hours) were randomly arranged in Completely Randomized Design (CRD) with three replications.

Data collected

Seed germination

Standard seed germination test was conducted following the International Seed Testing Association (ISTA) rules. A total of four hundred seeds were used in four replicates, with each replicate containing 100 seeds. The seeds were kept in Petri-dishes lined with filter paper (Whatman No.1) and moistened with distilled water and then placed over clean laboratory bench at room temperature (22-25^{o}C). The germinated seeds were visually observed for appearance of radicle and/or plumule and germination percent was calculated by the following formula:

$$Germination\ (\%) = \frac{\text{Number } of\ germinated\ seeds}{\text{Total number of planted seeds}} * 100$$

Seedling emergence

Following the seedling emergence, the number of seedlings that emerged above the soil surface was counted and recorded (Coste, 1992). Thus, based on the records the percentage of Emergence seedlings (%) was determined as follows.

$$Seedling\ Emergence = \frac{number\ of\ emerged\ seedlings}{total\ number\ of\ seeds\ sown} x100$$

Seedling growth parameters and vigor tests

The seedling plant height, seedling root length, girth diameter, seedling dry weight and seedling vigor were recorded. Ten normal seedlings were randomly selected from each sample for the seedling vigor test. The seedling shoot and root length were measured from the point of attachment of the cotyledon to the seedling tip,

and the root length was measured from the point of attachment of the cotyledon to the root tip. The average shoot and root lengths were determined following a formula by Fiala (1987). Seedling dry weight was measured after the final count of seedling emergence germination. The selected seedlings from each replicate were dried in an oven at 80ºC for 24 hours. The dried seedlings were weighed on a sensitive balance. The seedling vigor index was calculated by using the below formula as suggested by Abdul-Baki and Anderson (1973).

$$Vigor\ Index\ I\ (VI) = Germination\ (\%) * seedling\ length(cm)$$
$$Vigor\ Index\ II\ (VII) = Germination\ (\%) * seedling\ dry\ weight\ (gm)$$

Data analysis

The data were subjected to analysis of variances using SAS 9.3 Version and treatment means were separated using Least Significance Difference (LSD) test.

Results and Discussion

Seed germination

The ANOVA results indicated a highly significant difference in seed germination among the drying methods (Table 1). The seed germination percentage for the under-shade drying method was significantly better than that of the open sun drying method (Table 2). Seed germination percentage was also significantly influenced by the hydropriming time. Seeds soaked for 6 hours had the highest germination percentage while the lowest germination percentage was recorded for unprimed seeds (Table 3). However, there was no statistically significant difference in germination among the different varieties and treatment combinations.

Table 1. Summary of ANOVA for the effect soaking time and drying method on coffee seed and seedling quality parameters

Source of variation	DF	Mean square							
		Germination (%)	Seedling emergence (%)	Vigor index-I (cm.%)	Vigor index-II (g.%)	Girth diameter (mm)	Plant height (cm)	Root length (cm)	Total dry matter (g)
Model	19	338.2**	429.3**	657232 **	52985.4**	0.4	38.1**	6.3	3.2**
Variety (A)	1	0.4	77.1	21233	29614.8	0.8	16.2	1.7	0.0
Draying method (B)	1	6262.8**	7661.4**	11105441 **	651333**	4.4**	585.3**	82.7**	45.4**
Soaking time(C)	4	21.6*	28.9	37419*	39881.2*	0.0	1.2	2.5	1.0
B*C	4	1.8	18.4	78923	7180.6	0.1	13.0	1.5	0.8
A*B*C	9	7.7	25.4	99485	15280.8	0.3	7.3	2.2	0.9
Error	40	6.9	31.5	68060	25727.6	0.2	6.6	2.2	0.8

DF= Degrees of freedom; **, * Significant at ($P \leq 0.01$ and $P<0.05$), respectively

The results indicated that the drying methods significantly affects seed germination. Similar findings were reported by Netsere *et al*. (2015), who noted that drying methods and processing conditions impact coffee seed quality. Netsere *et al*. (2008) also found that drying coffee under shade results in a higher germination percentage. Vieira *et al.* (2022) emphasized the importance of harvesting, processing, and drying methods and conditions for fungal development. In southwestern Ethiopia, some farmers dry coffee seeds under direct sunlight (Author, unpublished data). The present study showed that, drying coffee seeds under direct sunlight negatively influences germination. This adverse effect is likely due to the rapid reduction in moisture content, causing sudden and abrupt physical and physiological changes in the seeds, leading to poor germination and the production of more abnormal seedlings with a low vigor index. Additionally, open sun drying can directly damage the seed embryo, reducing seed and seedling quality. Therefore, coffee seeds require special care during drying to reduce seed deterioration and maintain seed quality.

Table 2. Effect of drying method and coffee varieties on germination, seedling emergence and vigor

Seed drying methods	Germination (%) *	Seedling emergence (%)	Vigor index-I (cm.%)	Vigor index-II (g.%)
Shade dried	91.5[a]	90.2[a]	2236.3[a]	541.4[a]
Sun dried	70.5[b]	68.4[b]	1378.2[b]	366.8[b]
Coffee Varieties				
74110	81.6[a]	81.1[a]	1845.6[a]	424.7[a]
75227	81.4[a]	78. 7[a]	1813.4[a]	489.0[a]
CV (%)	2.9	7.2	16.2	39.0
LSD (0.05)	1.5	3.7	190.5	115.4

*Means within the same column followed by different letter (s) are significantly different at 5% level of significance.
LSD=Least significant difference; CV= coefficient of variation.

Seedling emergence

Seedling emergence rate was significantly influenced by the coffee seed drying methods. Seedlings from seeds dried under-shade had significantly better emergence rate compared to that of seeds dried in open sun (Table 2). Additionally, significant differences were observed in seedling emergence based on hydropriming time. The highest seedling emergence was recorded for seeds soaked for 12 hours, followed by seeds soaked for 24 hours. Unprimed seeds demonstrated the lowest seedling emergence rate (Table 3).

Table 3. Effect of soaking time on seed germination, seedling emergence and vigor

Seed Soaking time (in hours)	Germination (%) *	Seedling emergence (%)	Vigor index-I (cm.%)	Vigor index-II (g.%)
Control (un-soaked)	76.9^{b}	75.0^{b}	1590.8^{b}	349.6^{b}
6	83.3^{a}	78.0^{ab}	1929.1^{a}	443.0^{ba}
12	83.0^{a}	83.0^{a}	1861.1^{ba}	424.6^{ba}
18	81.3^{a}	80.5^{ab}	1880.0^{ba}	571.7^{a}
24	83.1^{a}	82.6^{a}	1882.5^{ba}	503.4^{ba}
CV (%)	2.9	7.2	16.2	39.0
LSD(0.05)	2.4	5.8	300.8	182.3

Means with different letter (s) along columns are significant difference (P<0.05); LSD=Least significant difference, CV= coefficient of variation.

Pre-sowing seed treatment practices aim to improve seed viability, germination, and the production of quality coffee seedlings. These practices include seed preparation and handling, pre-sowing seed treatment, and pre-germination techniques. Various research findings and techniques have been generated in this regard. In the current study, soaking coffee seeds before sowing promoted seed germination and emergence to some extent. Kufa and Yilma (2007) reported that, soaking coffee seeds in cold pure water for 24 hours before sowing improved the rate of emergence, especially in the early stages after sowing. They also indicated that removing the parchment and soaking the seeds enhanced seedling growth and shortened the nursery period by about four weeks. However, in the present study, seedling growth parameters did not vary significantly based on soaking time.

Seedling vigor

Drying methods posed significant effect on the seedling vigor indices (Table 1). Coffee seed dried under-shade demonstrated higher vigor index I compared to the open sun drying method. Vigor index II was also significantly better coffee seeds dried using the under-shed method (Table 2). Hydropriming also significantly influenced seedling vigor indices. The highest seedling vigor indices were recorded for priming durations of 6 and 18 hours while vigor indices were the lowest for unprimed seeds (Table 3).

The results of the current study indicate that there were significant influences the drying methods on seedling vigor indices. Seed quality is largely influenced by the drying methods. High temperatures, high relative humidity, and uneven drying can lower seed viability and vigor due to the differential rates of moisture loss (Copeland and McDonald, 2012). Drying coffee seeds under direct sunlight causes rapid moisture loss, disrupting the physiological drying process and harming seed quality. The rate at which seeds lose moisture depends on how quickly moisture migrates from the seed's interior to its surface and how fast surface moisture is released into the surrounding air. Rapid evaporation from the seed surface can cause moisture stress, damaging the embryo; therefore, seeds should be dried carefully to avoid heat stress damage (Philpot, 1976). Conversely, slow moisture elimination

can promote pathogen invasion (Chin and Hanson, 1997). Consequently, seeds dried in a shaded room lose moisture at an optimal rate, while those dried in direct sunlight lose moisture too quickly, potentially affecting seed germination, seedling emergence, and vigor.

Seedling growth

Drying methods posed significant influences on seedling growth parameters vis. girth diameter, plant height, root length, and dry matter of coffee seedling (Table 4). The girth diameter, plant height, root length, and total dry matter under-shade dried seeds were superior to that of open-sun dried seed. Duration of hydro priming improved seedling dry weight (Table 5) with a significantly better seedling dry weight recorded in seeds soaked for 24 hours compared to that of unprimed seeds.

Table 4. Effect of drying method and varieties on coffee seedling growth

Seed drying methods	Girth diameter (mm) *	Shoot length (cm)	Root length (cm)	Leaf dry matter (gm)	Root dry matter (gm)	Shoot dry matter (gm)	Total dry matter (gm)
Shade dried	4.0^{a}	24.5^{a}	21.6^{a}	3.2^{a}	1.5^{a}	1.2^{a}	5.9^{a}
Sun dried	3.6^{b}	18.5^{b}	19.5^{b}	2.1^{b}	1.2^{b}	1.0^{b}	4.4^{b}
Coffee Varieties							
74110	3.9^{a}	21.9^{a}	20.4^{a}	2.6^{a}	1.4^{a}	1.2^{a}	5.1^{a}
75227	3.7^{a}	21.5^{a}	20.9^{a}	2.7^{a}	1.4^{a}	1.1^{a}	5.2^{a}
CV (%)	14.2	12.4	7.6	21.7	23.2	16.7	17.6
LSD (0.05)	0.4	1.7	1.0	0.4	0.2	0.1	0.6

*Means in the same column followed with different letter (s) are significantly different at 5% level of significance; LSD=Least significant difference; CV= coefficient of variation.

Table 5. Effect of hydropriming duration (hours) on coffee seedling growth performance

Seed soaking time (in hours)	Girth diameter (mm)	Shoot length (cm)	Root length (cm)	Leaf dry matter (gm)	Root dry matter (gm)	Shoot dry matter (gm)	Total dry matter (gm)
Control (un soaked)	3.6^{a}	19.9^{a}	20.1^{a}	2.3^{b}	1.2^{b}	1.0^{b}	5.0^{b}
6	3.8^{a}	21.8^{a}	20.9^{a}	2.8^{ba}	1.2^{b}	1.2^{ba}	5.2^{ba}
12	3.8^{a}	22.2^{a}	20.6^{a}	2.6^{ba}	1.3^{b}	1.1^{ba}	5.0^{a}
18	3.9^{a}	22.0^{a}	20.3^{a}	2.6^{ba}	1.4^{ba}	1.1^{ba}	5.2^{ba}
24	3.9^{a}	22.3^{a}	21.3^{a}	3.1^{a}	1.6^{a}	1.3^{a}	6.0^{a}
CV (%)	14.2	12.4	7.6	21.7	23.2	16. 7	17.6
LSD (0.05)	0.6	2.7	2.0	0.6	0.3	0.2	0.9

*Means in the same column followed with different letter (s) are significantly different at 5% level of significance; LSD=Least significant difference; CV= coefficient of variation.

Conclusion

The drying method is a crucial operation after harvest to reduce the moisture content of seeds to a safe storage level and maintain their quality throughout the storage period. The results of this study demonstrated that drying coffee seeds under-shade is better for seed quality and seedling growth. Coffee seeds dried under open sun were significantly affected, leading to poor seed germination, seedling emergence, seedling vigor, and plant growth. Therefore, drying coffee seeds in a shaded room

is essential for achieving high germination rates, vigor, and well-performing seedlings. Though soaking seeds in water can be burdensome and impractical for mass seedling production, harvesting quality seeds, drying under an appropriate shaded room, implementing post-sowing amendments and, using suitable potted media while sowing is critical for maintaining seed quality. Additionally, it is important to investigate seed treatment methods and preservative techniques for treated seeds to further improve coffee seed quality.

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