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Comparative study on seed treatment methods on local variety of okra (*Abelmoschus esculentus* L. Moench) and rosselle (*Hibiscus sabdariffa* L.)

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Abstract

Abelmoschus esculentus L. Moench and *Hibiscus sabdariffa* L. are two economically important crops in developed and developing countries, Nigeria inclusive. Seed germination and growth are crucial phenological stages that are essential to the entire life of the plant. One of the most significant factors influencing agricultural output in the Southern Guinea Savanna is seedling failure. Survival and development of seeds of many plant species depend on their germination under harsh circumstances. The purpose of this study was to determine how various seed treatment techniques affected the germination of *Hibiscus sabdariffa* L. and *Abelmoschus esculentus* L Moench. The study comprised two lab experiments in a completely randomized design (CRD) with three replications, set up as factorial treatments. To break seed dormancy were used two techniques: acid scarification and water soaking. The best results in most of the viability criteria that were tested, and the highest rate of germination for okra seeds were achieved at acid scarification for three minutes at 60% H_2SO_4 concentration. The findings of this study revealed that the most successful technique for increased germination of roselle was the treatment with hot water for 5 minutes at 80°C. This approach provided the highest daily germination, peak value, and germination percentage. According to the research findings, okra and roselle growers can break dormancy by soaking in 60% H_2SO_4 for three minutes and at 80°C for five minutes, respectively.

Keywords: Abelmoschus *esculentus* L. Moench, *Hibiscus sabdariffa* L., germination, seed treatment

INTRODUCTION

Seed viability testing is a crucial aspect of seed quality assessment, especially for agricultural crops. Seed viability determines the potential for successful germination and subsequent crop establishment. Various seed treatments are employed to enhance seed viability and germination rates. Seeds must be highly viable at the beginning of storage and remain so for the duration of storage (Baskin & Baskin, 2019). According to Roberts & Ellis (2018), at first seed viability decreases gradually and after that accelerate as seeds get older. It is crucial to identify when this decline takes place so that high-viability seeds can be used to replace the outgoing seeds and replenish the accession.

Okra (*Abelmoschus esculentus* L. Moench), belongs to the *Malvaceae* family, is a vegetable crop that has gained significant popularity during the past century (Modi et al., 2016). It is cultivated in nearly every country globally and serves as a significant horticultural crop in Zimbabwe, where it is planted in fields, greenhouses, and backyard gardens. The crop exhibits tolerance to mid-season dry conditions in Zimbabwe, and its connection to indigenous cuisine across many regions generates substantial and consistent demand. It can be consumed post-cooking as green pods and also the entire pod in its dehydrated form can be utilized. Baskin et al. (2021) assert that, in addition to its palatability, okra is an excellent source of vitamins A and C, which are essential for bone growth, cell division, and differentiation, as well as for the synthesis of collagen, a protein that provides structure to bones, cartilage, muscles, and blood vessels.

Okra plants are mostly propagated through seeds. Keller & Kollmann (2019) indicated that germination is a pivotal phase in the life cycle of both weeds and crop plants, frequently influencing population dynamics with significant practical consequences. Nevertheless, the rigid seed coat of okra can lead to sluggish and inconsistent germination and emergence, particularly under sub-optimal conditions (Demir, 2021). Suboptimal and protracted seed germination resulting from dormancy is a significant barrier in the propagation of this crop. Mohammadi et al. (2022) assert that the okra crop possesses seed hardness, which complicates its management and adversely affects seed germination, weed control, harvesting, and other management aspects. The germination rate of okra seeds is relatively low, attributed to the presence of seed hardness in this species (Luis-Felipe et al., 2020).

Roselle belongs to the genus *Hibiscus*, with species such as *Hibiscus cannabinus* L. and *Hibiscus sabdariffa* L. being particularly prevalent in Indonesia, and used for obtaining natural fibers. *Hibiscus sabdariffa* L. is a species of rosella with potential applications in functional food, due to its content of antioxidants, antibacterial agents, natural colors, and health benefits (Abdallah, 2015; Chang et al., 2014). Regarding plant morphology, various parts of the plant can be utilized, especially the flower petals (Simon & Wu, 2016). The plant leaves, stems, and flowers are abundant in natural phytochemicals, including phenolic compounds, alkaloids, tannins, flavonoids, saponins, organic acids, anthocyanins, and polysaccharides (Mungole & Charturvedi, 2021).

The viability of seeds can be affected by various factors, including genetic characteristics, environmental conditions, and seed treatments. In the production of Okra (*Abelmoschus esculentus* L. Moench) and Roselle (*Hibiscus sabdariffa* L.), ensuring high seed viability is essential for optimal crop performance. Despite the importance of seed viability, there is limited research comparing the effectiveness of different seed treatments in enhancing the viability of okra and roselle seeds. Thus, the overarching problem addressed by this research is the lack of comprehensive comparative analysis of seed viability tests for okra and roselle seeds using different seed treatments. The main objective of this research is to conduct a comparative analysis of seed viability tests for okra and roselle seeds using different seed treatments. The specific objectives of this study are to: (i) compare the germination percentage of okra and roselle seeds subjected to different seed treatments, (ii) compare the most effective seed treatment for enhancing seed viability in okra and roselle.

MATERIALS AND METHODS

This study was carried out in the Laboratory of Biology Department, Ibrahim Badamasi Babangida University, Lapai, Niger State. The materials used for the experiment include: Petri dish, tissue paper, watering bottle, measuring tape. Okra and roselle seeds were collected from local sources which provide quality seeds. The study applied a factorial treatment structure in a Completely Randomised Design (CRD). Each treatment of the experiment was replicated thrice. Each replicate consisted of 100 seeds. The seed treatments employed for this research was according to Baskin & Baskin (2014), and is explained as follow.

Control (No Treatment)

Prior to the germination test the untreated seed were rinsed with distilled water for debris and dirt removal.

Priming with Water

The seeds of okra and roselle underwent priming with hot water, influenced by two variables: water temperature and soaking period given by Baskin & Baskin (2014). The temperature was set on two levels (60°C and 80°C), while the soaking was done either for 3 or 5 minutes. For each treatment combination, 30 seeds were immersed in 100 ml beakers containing water at a constant temperature in a controlled water bath. After corresponding treatment, the seeds were removed from the water and allowed to air dry. Seeds were air-dried for 5 hours before initiating the germination test.

Acid Scarification

The seeds of okra and roselle were scarified using sulfuric acid (H_2SO_4) as given by Baskin et al. (2019). Two parameters, acid concentration and duration of exposure, were studied. The concentration of H_2SO_4 was 60% and 80%, and the exposure period was set at two levels (3 or 5 minutes). For each treatment combination, 30 seeds were planted in beakers, and varying amounts of the acid were added. A stopwatch was utilized to quantify the duration of exposure to H_2SO_4. The seeds were extracted instantly and washed extensively in water to neutralize acid completely. Subsequent to treatment and comprehensive washing, the seeds were desiccated and preserved in anticipation of germination tests.

Germination Test

Seeds from each treatment group was subjected to a standard germination test under controlled conditions of temperature and moisture. Germination percentage, germination speed, and different characteristics was recorded.

Data Collection

Observations were made on number of days for germination required for the first count, germination speed, mean germination time, germination percentage, peak value, mean daily germination and germination value.

Daily and Cumulative Germination Count

The seeds with radicle growth were observed and counted as germinated seeds. The primary data on seed germination were collected on a daily basis. The final germination percentage was calculated from the total seeds that germinated. Daily germination percentages were summed up to obtain cumulative germination percentage for each treatment.

Germination Speed

Germination speed was calculated using the formula described by Aldhous (1972) and Djavanshir & Pourbeik (1976):

$$\text{Germination Speed} = \frac{\text{Final Germination Percentage}}{\text{Days of Completion of Germination}}$$

Mean Germination Time (MGT) = Mean germination time was calculated by the formula given by Ellis & Roberts (1981)

$$\text{MGT} = \frac{(\text{n1} \times \text{d1}) + (\text{n2} \times \text{d2}) + (\text{n3} \times \text{d3})}{\text{Total Number of Germinated Seeds}}$$

Where: n= number of germinated seed and d = number of days

Mean daily germination (MDG): The Mean daily germination was calculated by the formula given by Czabator (1962)

$$\text{MDG} = \frac{\text{Total Number of Germinated Seeds}}{\text{Total Number of Days}}$$

Peak Value (PV): Peak value was calculated by the formula given by Czabator (1962)

$$PV = \frac{\text{Highest Seed Germinated}}{\text{Number of Days}}$$

Germination Value (GV): Germination value was calculated by the formula given by Czabator (1962)

$$GV = PV \times MDG$$

Data Analysis

Analysis of variance (ANOVA) was used to determine significant differences among treatments. Post-hoc comparison tests such as Least Significant Difference (LSD) was used to identify specific treatment effects.

RESULTS AND DISCUSSION

The aim of this research was to examine the effect of different seed treatment methods on the viability of okra and roselle seeds. Different concentrations of sulfuric acid and water with different temperatures were used to treat okra and roselle seeds; germination, seedling growth and different characteristics were determined.

Effect of different seed treatments on the Mean Germination time of okra (Abelmoschus esculentus L. Moench) and roselle (Hibiscus sabdariffa L.)

The germination of *Abelmoschus esculentus* L. Moench seeds commenced on the first and second days' post-treatment in pretreatments (T1, T2, T3, T4, T5, and T8) and (T0, T6, and T7) correspondingly. The mean germination time (MGT) for *Abelmoschus esculentus* L. Moench seeds was approximately 2 days across all pre-sowing conditions. Furthermore, there were significant differences ($p < 0.05$) in MGT among the treatments. The mean germination time of *Hibiscus sabdariffa* seeds is presented in Table 1. The result showed that T6 (soaking seeds in 60% H_2SO_4 for 5 min) had the lowest mean germination time, it took approximately 3 days for a seed to germinate, while T2 had the fastest mean germination time, that seeds in this treatment germinated in just a day after the treatment. Moreover, there were significant differences ($p < 0.05$) in MGT between the treatments.

Effect of different seed treatments on Germination percentage of okra (Abelmoschus esculentus L. Moench) and roselle (Hibiscus sabdariffa L.)

The cumulative germination percentage (GP) of *Abelmoschus esculentus* L. Moench seeds is shown in Table 1. The results indicated a substantial variation in germination percentage (GP) among the pretreatment seeds, with the highest GP (86.67%) achieved in seeds subjected to T5 (H_2SO_4 (60%) for 3 min), exhibiting less non-germinated seeds relative to the majority of the treatments. The control, T3, T4, T7, and T8 exhibited a germination rate of 80%, surpassing the treatments that recorded less than 50% germination. T6 (H2SO4 (60%) for 5 min) had the lowest germination percentage. Nonetheless, no significant variation in GP was observed between T0, T1, T3, T4, T5, T7, and T8 at the 5% probability level. Percent germination in *Hibiscus sabdariffa* L. seeds has been presented in Table 1. Maximum percentage of germination (80%) was recorded at T4 (soaking seeds in 80°C water for 5 min) followed by T3 and T4. Germination percentage further declined to 66.67%, 46.67% and 40% in T8, T1 and T0 treatments respectively. However, there were no significant ($p < 0.05$) differences in the germination percent of seeds in T3, T4, T5 and T8 as well as T0, T2, T1 and T7 while T6 had the least germination percent of *Hibiscus sabdariffa* L. seeds.

Effect of different seed treatments on Peak value of okra (Abelmoschus esculentus L. Moench) and roselle (Hibiscus sabdariffa L.)

As with GP, as compared to other sowing regimens, the seeds under T5 (about 7 seeds per day) had the highest PV values. *Abelmoschus* *esculentus* L. Moench seeds under T2, T3, T4, T6, T7, and T8 were statistically ($p < 0.05$) different from seeds in T1, whereas untreated seeds (T0) differed significantly from treated seeds at the 5% probability level. T0 also had the lowest peak value.

Table 1 presents the peak value of *Hibiscus sabdariffa* L. The highest PV were obtained in seeds under T3 and T4 (9 seeds/day) compared to other sowing treatments. Untreated seeds (T0) differed significantly at 5% probability level from treated seeds. There were no significant differences in the peak value of seeds in T3, T4 and T5, as well as seeds in T1, T2, T7 and T8. However, T6 had the lowest PV (0.75).

Effect of different seed treatments on Mean Daily Germination of okra (Abelmoschus esculentus L. Moench) and roselle (Hibiscus sabdariffa L.)

The highest Mean daily germination of *Abelmoschus esculentus* L. Moench seeds was obtained under T5 (Soaking in 60% H_2SO_4 for 3min) (1.44 seeds/day), while seeds soaked in 60% H_2SO_4 water for a period of 5 min (T6) had the least mean daily germination. There were no significant differences ($P < 0.05$) between the mean daily germination of seeds in T0, T1, T2, T3, T4, T5, T7 and T8. The highest Mean daily germination of *Hibiscus sabdariffa* L. seeds was obtained under T4 (soaking seeds in 80°C water for 5min) (1.33 seeds/day), while seeds soaked in 60% H_2SO_4 for a period of 5 min (T6) had the least mean daily germination. There were no significant ($p < 0.05$) difference between in the mean daily germination between T3, T4, T5 and T7 as well as T0, T1, T2, T6 and T8.

Effect of different seed treatments on Germination Value of Okra (Abelmoschus esculentus L. Moench) and Roselle (Hibiscus sabdariffa L.)

Germination value of *Abelmoschus esculentus* L. Moench was higher under T5 (soaking in 60% H_2SO_4 for 3 min) compared to other pre-treated and untreated seeds. The lowest GV was recorded in T6 (soaking in 60% H_2SO_4 for 5 min) followed by T1 (soaking in 60°C hot water for 3min) then untreated seeds (T0). However, there were no significant ($P<0.05$) difference between treatment T2, T3, T4, T5, T7 and T8.

Table 1 showed the germination value of *Hibiscus sabdariffa* L. seeds among treatments. The results showed that the final germination were significant. Germination value of *Hibiscus sabdariffa* L. was higher under T4 (soaking seeds in 80°C water for 5 min) compared to other pre-treated and untreated seeds. The lowest GV was recorded in T6 (soaking seeds in 60% H_2SO_4 for 5 min) followed by untreated seeds (T0). However, there were no significant ($p<0.05$) difference between treatments T3, T4 and T5.

Temperature significantly influences the growth and development of plants, and its impact on seed germination is intricate, as it affects each stage of the germination process differently and is interdependent with other factors (Mayer & Oljahoff-Mayber, 2018). The optimal temperature threshold for seed germination varies among species or cultivars (Reynolds & Thompson, 2017). Larcher (2015) indicated that tropical plants exhibit optimal germination at temperatures ranging from 15°C to 30°C, temperate plants from 8°C to 25°C, and alpine plants from 5°C to 30°C. While the seeds of *A. esculentus* and *Hibiscus sabdariffa* L. germinated throughout a broad temperature spectrum of 25 to 37°C, the germination analysis revealed that 30–35°C is the optimal temperature for seed germination.

Murthy and Reddy (2018) investigated the influence of varying temperatures on seed germination and seedling development in Ber (*Zizyphus mauritiana* Lam.), a species with habitat preferences middle to *A. esculentus* L. Moench and *Hibiscus sabdariffa* L.

Table 1. Effect of different seed treatments on the germination parameters of okra (*Abelmoschus esculentus* L. Moench) and roselle (*Hibiscus sabdariffa* L.)

Treatments	(MGT)(days)		(GP)(%)		(PV)(seeds/day)		(MDG)(seeds/day)		(GV)(number)	
	Okra	Roselle	Okra	Roselle	Okra	Roselle	Okra	Roselle	Okra	Roselle
T0	2.00^a	2.17^b	80.00^a	40.00^b	2.33^c	2.50^{bc}	1.33^a	0.67^b	3.10^c	1.67^{bc}
T1	1.78^a	1.86^b	73.33^a	46.67^b	4.50^b	3.00^b	1.22^a	0.78^b	5.49^b	2.33^b
T2	1.85^a	1.00^c	60.00^b	26.67^b	5.80^a	4.00^b	1.33^a	0.44^b	7.71^a	1.78^b
T3	1.67^a	1.18^c	80.00^a	73.33^a	6.00^a	9.00^a	1.33^a	1.22^a	7.98^a	11.00^a
T4	1.25^b	1.25^{ab}	80.00^a	80.00^a	6.00^a	9.00^a	1.33^a	1.33^a	7.98^a	12.00^a
T5	1.69^a	1.58^b	86.67^a	73.33^a	6.50^a	8.00^a	1.44^a	1.22^a	9.36^a	9.78^a
T6	1.00^b	3.22^a	20.00^c	20.00^c	6.00^a	0.75^c	0.33^b	0.43^b	1.98^d	0.32^c
T7	2.00^a	1.50^b	80.00^a	40.00^b	6.00^a	3.00^b	1.33^a	0.67^b	7.98^a	2.00^b
T8	1.92^a	1.80^b	80.00^a	66.67^a	6.00^a	4.00^b	1.33^a	1.11^a	7.98^a	4.44^b
SE±	0.115	0.233	6.849	7.351	0.431	1.020	0.113	0.117	0.844	1.525
LSD	0.391	0.794	23.33	25.041	1.468	3.476	4.116	0.399	2.875	5.196

legend: T0 (Control); T1 (HW (60°C, 3 min); T2 (HW (60°C 5min; T3 (HW 80°C ,3min); T4 (HW 80°C, 5min); T5 (H_2SO_4 (60%), 3 min); T6 (H_2SO_4 (60%), 5min); T7 (H_2SO_4 (80%), 3min) T8 (H_2SO_4 (80%), 5min). Means with same letters(s) along the column are not significantly different at 5% probability level using LSD.

They reported a significant increase in germination percentage with rising temperatures from 20°C to 30°C, peaking at 60.8% at 30°C, compared to a significantly lower rate of 14.4% at 20°C. The findings from the research showed that most treatments led to germination starting on the first or second day in okra seeds, except for okra seeds treated by soaking in 60% H_2SO_4 for 5 min, which accelerated the process, completing germination by the seventh day. This suggests that soaking okra seeds in 60% $H_2SO_4$for 5 min was highly effective in breaking dormancy and facilitating a rapid germination. The relatively short mean germination time (MGT) across all treatments indicated that the seeds responded positively to pre-sowing treatments, particularly to acid scarification. This finding aligns with existing literature that highlights the role of acid scarification in improving seed germination by enhancing water uptake and weakening seed coat hardness (Shaban, 2013). However, treating roselle seeds with hot water at 60°C for 5 min showed the fastest germination rate, with seeds germinating within a day after treatment. This suggests that a moderate heat application can effectively break dormancy in *Hibiscus sabdariffa* L. seeds, a finding consistent with earlier studies which recommended hot water treatments as a cost-effective and efficient method for seed germination (Ndubuaku et al., 2016).

The study found significant differences in germination percentage among the treatments for both okra and roselle seeds. The highest germination percentage for okra was observed in seeds soaked in 60% H_2SO_4 for 3 min, which suggests that short-term acid scarification can substantially improve seed viability. The poor performance of seeds soaked in 60% H_2SO_4 for 5 min, with a lower germination percentage, indicates that prolonged exposure to the acid may have been detrimental, potentially damaging the seed embryos. This is consistent with studies that warrant against overexposure to acid treatments, which can lead to seedling death or poor vigor (Ikechukwu & Nwachukwu, 2018). In contrast, the highest germination percentage for roselle seeds was recorded in seeds soaked in hot water at 80°C for 5 min, followed by seeds soaked in hot water at 80°C for 3 min, this implies that heat treatment seems to have effectively softened the seed coats of *Hibiscus sabdariffa* L., making them more permeable to water and initiating faster germination. Studies on seed dormancy in *Hibiscus* species have demonstrated similar benefits of hot water treatment (Baskin & Baskin, 2014).

The peak value (PV) is an indicator of both the speed and uniformity of seeds germination. The highest peak value for okra seeds was observed in seeds soaked in 60% H_2SO_4 for 3 min, and the most uniform germination compared to other treatments. The untreated seeds (T0) had a significantly lower PV, this indicated the effectiveness of the acid treatment in promoting faster and more synchronized germination. According to Osemwota (2015), the peak value is crucial in predicting the field performance of seeds, as a higher PV indicates better seedling establishment potential. However, roselle seeds showed the highest peak values (9 seeds/day) in seeds soaked in hot water at 80°C for 3 and 5 min, indicating that these treatments led to quick and uniform germination. This result confirms the effectiveness of heat treatments in roselle seed viability improvement, a conclusion supported by Adebisi et al. (2018).

The mean daily germination (MDG) for okra was highest in seeds soaked in 60% H_2SO_4 for 3 min, which implies that acid scarification was effective in promoting consistent germination over time. In contrast, seeds soaked in 60% H_2SO_4 for 5 min resulted in the lowest MDG, showing that a prolonged exposure to acid can be harmful to seeds. The finding is in line with Shaban (2013) who reported that acid treatments enhance daily germination rates by accelerating seed coat degradation and improving water absorption. For roselle, the highest MDG was observed in seeds soaked in hot water at 80°C for 5 min, this showed the effectiveness of this treatment in promoting uniform and consistent germination over time. Similar findings were reported by Olowokere & Adedeji (2015), who demonstrated that hot water treatments improved the mean daily germination of *Hibiscus sabdarifa* L.

The germination value (GV), which integrates both the speed and uniformity of germination, showed that soaking okra seeds in 60% H_2SO_4 for 3 min was the most effective treatment. The results are in agreement with Anyanwu et al. (2020), who noted that seed treatments must be optimized for both duration and concentration to avoid negative impacts on germination value. For roselle, soaking the seeds in hot water at 80°C for 5 min resulted in the highest GV, indicating that heat treatments not only improved germination percentage but also ensured faster and more uniform germination. This conclusion is supported by research from Baskin & Baskin (2014), which highlights the importance of water temperature and exposure time in improving germination parameters in dormant seeds.

CONCLUSIONS

This study used a variety of seed treatments to compare the seed viability of roselle (*Hibiscus sabdariffa* L.) and okra (*Abelmoschus esculentus* L. Moench). The results showed that different treatments had a substantial impact on seed viability, as measured by parameters such as mean germination time, germination percentage, peak value, mean daily germination, and germination value. The H_2SO_4 treatment at 60% concentration for 3 minutes yielded the best results for okra across the majority of viability parameters measured, and this resulted in the highest germination rate. On the other hand, prolonged acid exposure, adversely affected seed viability, most likely as a result of tissue damage to the seeds. The findings imply that different species react differently to different seed treatments; for example, okra responds better to acid scarification, while roselle responds better to hot water treatments. The study showed the significance of refining seed treatment techniques in order to obtain enhanced germination. According to the findings of the research, farmers should treat okra seeds with H_2SO_4 at a 60% concentration for three minutes in order to maximize viability and increase germination rates. For roselle, hot water treatment at 80°C for five minutes is advised in order to boost seed performance. To guarantee both safety and efficacy, more study should examine scarification processes alternatives, such as mechanical approaches or chemical treatments which are more environmentally friendly.

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