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Pre Sowing Treatments of Hibiscus Sabdariffa Seeds Germination

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Abstract **Review Article**

The germination of Hibiscus sabdariffa seeds, a plant of considerable economic importance due to its diverse applications in nutrition, medicine, and industry, is often constrained by low germination rates, particularly in arid and semi-arid environments. This research explores the impact of various pre-sowing treatments on improving seed germination, addressing the challenges of seed dormancy and low viability. The study employs a combination of mechanical scarification, hydro-priming, thermal treatments, and chemical scarification using sulfuric acid to assess their influence on key germination parameters such as germination rate, time to germination, seedling vigor, and overall seedling establishment. A randomized complete block design (RCBD) was utilized to evaluate the efficacy of these treatments across different environmental conditions to simulate the variability found in agricultural settings. Data were analyzed using Analysis of Variance (ANOVA) and germination indices to determine statistical significance. The study also explores the physiological and biochemical responses of Hibiscus sabdariffa seeds to pre-sowing treatments, focusing on enzyme activity, moisture content, and metabolic changes during germination. The findings demonstrate that mechanical scarification and hydro-priming resulted in the highest germination rates and significantly improved seedling vigor compared to untreated seeds. Chemical scarification and thermal treatments also enhanced germination but showed variability depending on the concentration and duration of exposure. The research provides valuable insights into optimizing pre-sowing treatment protocols to enhance the commercial cultivation of Hibiscus sabdariffa, especially in regions facing climatic challenges such as drought. These findings have implications for both smallholder farmers and large-scale agricultural producers, contributing to sustainable agriculture and improved crop yields.

Keywords: Hibiscus Sabdariffa, Seed Dormancy, Pre-Sowing Treatments, Mechanical Scarification, Hydro-Priming, Thermal Treatment, Chemical Scarification And Germination Rate.

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INTRODUCTION

Hibiscus sabdariffa, widely known as roselle, is a versatile plant belonging to the Malvaceae family. It is cultivated primarily for its edible parts, particularly the fleshy calyces, which are utilized in various culinary applications and beverages. The plant is indigenous to Africa but has spread to various regions worldwide, including Southeast Asia, the Caribbean, and parts of South America. The cultivation of *Hibiscus sabdariffa* is economically significant, especially in developing countries, where it serves as a cash crop for smallholder farmers (Bhardwaj *et al*., 2023).

The calyces of *Hibiscus sabdariffa* are rich in anthocyanins, which contribute to their vibrant red color and offer numerous health benefits. These compounds are known for their antioxidant, anti-inflammatory, and anti-hypertensive properties (Mohamed *et al*., 2022). Recent studies indicate that regular consumption of hibiscus products can aid in managing various health conditions, including hypertension and diabetes, due to their ability to modulate blood pressure and glucose levels (Kumar *et al*., 2021).

Hibiscus sabdariffa L., widely known as Roselle, is an economically important plant with applications in food, beverages, pharmaceuticals, and traditional medicine

(Mohamed *et al*., 2022; Kumar *et al*., 2021). It is cultivated in tropical and subtropical regions for its edible calyces, seeds, and fiber (Bhardwaj *et al*., 2023). The plant's nutritional value, which includes antioxidants, vitamin C, and essential minerals, makes it particularly valuable for both human consumption and commercial processing (Oyetayo *et al*., 2023). However, cultivation is often limited by poor seed germination rates, primarily due to seed dormancy, especially in arid and semi-arid environments (Singh *et al*., 2023).

Seed dormancy in *Hibiscus sabdariffa* has been linked to factors such as a hard seed coat, which restricts water imbibition and gas exchange (Abbas *et al*., 2023). Overcoming dormancy is crucial for maximizing the plant's agricultural potential, particularly in semi-arid regions where unpredictable climatic conditions, such as water scarcity and high temperatures, further hinder seedling establishment (Ajayi *et al*., 2021). Hence, pre-sowing treatments that address seed dormancy can significantly improve germination rates and, consequently, crop yield.

Germination is a critical phase in the life cycle of plants as it determines the success of seedling establishment and, subsequently, crop yield (Bhardwaj *et al*., 2023). For crops such as *Hibiscus sabdariffa*, where the demand for high-quality produce is rising due to its medicinal and nutritional properties, successful germination is essential for achieving optimal productivity. Pre-sowing treatments that improve germination rates directly impact agricultural sustainability by enhancing the overall performance of the crop under field conditions (Adeyemi *et al*., 2023).

Pre-sowing treatments play a vital role in breaking dormancy and accelerating the germination process. Techniques such as mechanical scarification, hydro-priming, and thermal and chemical treatments have been shown to improve water uptake and facilitate enzymatic activities essential for breaking seed dormancy (Ajayi *et al*., 2023). As seed germination improves, so does the potential for better crop establishment, especially in regions prone to environmental stress (Kumar *et al*., 2021).

Seed dormancy is a natural mechanism that prevents seeds from germinating under unfavorable environmental conditions (Mohamed *et al*., 2022). For *Hibiscus sabdariffa*, the presence of a hard seed coat is the main cause of physical dormancy (Oyetayo *et al*., 2023). Dormant seeds are unable to absorb water and oxygen, delaying germination even under optimal conditions (Abbas *et al*., 2023). This presents a significant problem for farmers aiming to grow the plant in regions where the growing season is short, or environmental conditions are unpredictable (Singh *et al*., 2022).

Understanding the mechanisms behind seed dormancy in *Hibiscus sabdariffa* is critical to developing effective pre-sowing treatments. Research shows that breaking dormancy through mechanical, thermal, or chemical methods can lead to more uniform germination and faster seedling establishment, ultimately enhancing crop yields (Ajayi *et al*., 2023).

Problem Statement

Despite the economic importance of *Hibiscus sabdariffa*, low germination rates continue to impede its cultivation, especially in semi-arid regions (Adeyemi *et al*., 2023). Farmers often experience poor seedling establishment due to ineffective pre-sowing treatment methods, limiting crop productivity and sustainability. Traditional practices are insufficient to overcome dormancy, resulting in delayed germination and reduced yield. Given the environmental and economic challenges associated with poor germination, there is a pressing need for scientifically validated pre-sowing treatments to enhance the germination potential of *Hibiscus sabdariffa* seeds.

This study aims to address these challenges by exploring the efficacy of mechanical, hydro, thermal, and chemical treatments in improving germination rates and seedling vigor. The study seeks to provide a framework for optimizing *Hibiscus sabdariffa* cultivation, particularly in regions with harsh climatic conditions.

The cultivation of *Hibiscus sabdariffa* in semi-arid regions is often limited by poor seed germination rates due to dormancy. This presents a significant barrier to sustainable agricultural practices, especially for smallholder farmers (Adeyemi *et al*., 2023). Pre-sowing treatments offer a practical solution for overcoming dormancy and enhancing germination. By identifying the most effective treatments, this study contributes to the body of knowledge on improving the agricultural productivity of *Hibiscus sabdariffa* and promotes sustainable farming practices in semi-arid environments.

Significance of the Study

This research is significant both academically and practically. By identifying the most effective pre-sowing treatments, it will contribute to overcoming the persistent problem of seed dormancy in *Hibiscus sabdariffa*. This is especially relevant for smallholder farmers in semi-arid regions, where improving germination rates is key to enhancing crop yields and ensuring food security (Adeyemi *et al*., 2023). Moreover, the study contributes to the broader body of knowledge in plant physiology and agronomy by providing insights into the biochemical and physiological changes that occur during seed germination (Kumar *et al*., 2021).

The findings will also have practical implications for sustainable agricultural practices, as optimized pre-sowing treatments can improve water-use efficiency and reduce the environmental impact of farming (Bhardwaj *et al*., 2023). These recommendations will guide agricultural policies aimed at increasing *Hibiscus sabdariffa* production in regions that experience drought and soil degradation.

Scope of the Study

This study will focus on four pre-sowing treatments: mechanical scarification, hydro-priming, thermal treatment, and chemical scarification. The seeds will be subjected to these treatments under controlled conditions, replicating the environmental factors typical of semi-arid regions. The research will evaluate key germination parameters such as germination rate, time to germination, and seedling vigor, alongside physiological changes in enzyme activity and moisture content (Abbas *et al*., 2023). The scope is limited to seed germination under laboratory conditions, but the results will be applicable to field conditions in semi-arid regions. The primary objective of this study is to evaluate the effects of various pre-sowing treatments on the germination of *Hibiscus sabdariffa* seeds.

The germination of *Hibiscus sabdariffa* is a multifaceted process influenced by seed dormancy mechanisms, pre-sowing treatments, and environmental conditions. A comprehensive understanding of these components is essential for optimizing germination rates and ensuring successful cultivation of this valuable crop. By employing a combination of mechanical, hydro-priming, and chemical treatments, along with effective environmental management strategies, it is possible to significantly enhance the germination success of *Hibiscus sabdariffa*. Furthermore, focusing.

MATERIALS AND METHODS

Research Design

This study adopts an experimental research design, focusing on the quantitative analysis of germination rates under various pre-sowing treatments. The experimental approach allows for the controlled manipulation of variables, making it possible to isolate the effects of different treatments on seed germination. A completely randomized design (CRD) was selected to ensure that all treatment groups receive equal and unbiased exposure to experimental conditions. This design is appropriate given the objective of identifying the optimal pre-sowing treatment for enhancing seed germination.

Study Area

The experiment was conducted at the Department of Crop Science experimental farm, located in biological garden federal college of education Kontagora niger state, Nigeria. The location is within the semi-arid region, characterized by relevant climatic conditions such as temperature, rainfall, and humidity levels], which are ideal for conducting the study on *Hibiscus sabdariffa*. The soil type in the study area is sandy loam, which is typical for the cultivation of *Hibiscus sabdariffa*, providing an ideal environment for studying the effects of pre-sowing treatments.

Experimental Materials

The primary material used in the study is *Hibiscus sabdariffa* seeds, obtained from a certified seed supplier in Kontagora New Market. The seeds were stored under controlled conditions prior to experimentation to preserve their viability. Additional materials include scarification tools, chemical agents (such as sulfuric acid), and growth-enhancing compounds such as gibberellic acid (GA3) for specific pre-sowing treatments. Laboratory instruments, germination trays, planting media, and growth chambers were also used in the experimentation.

Pre-sowing Treatments

The experiment involved the application of four distinct pre-sowing treatments to *Hibiscus sabdariffa* seeds. The treatments were selected based on their documented effectiveness in enhancing seed germination in previous studies (Oyetayo *et al*., 2023; Faraji *et al*., 2023). These treatments include:

1. **Mechanical Scarification**: This involves physically damaging the seed coat using sandpaper to break dormancy by allowing water and oxygen to penetrate the seed more efficiently.

2. **Chemical Scarification**: Seeds were soaked in sulfuric acid (H_2SO_4) for varying time intervals (5, 10, and 15 minutes) to determine the optimal exposure duration for dormancy alleviation. The acid treatment thins the seed coat, facilitating germination.

3. **Hydropriming**: Seeds were soaked in water for 12 and 24 hours at room temperature. Hydropriming enhances water uptake, accelerating the initiation of the germination process.

4. **Gibberellic Acid (GA3) Treatment**: Seeds were soaked in a solution of gibberellic acid (GA3) at different concentrations (100 ppm and 200 ppm) for 24 hours. GA3 is known to break seed dormancy by promoting cell elongation and enzyme activity (Nimmo & Campbell, 2024).

A control group, where no treatment was applied, was also included to compare the effectiveness of each pre-sowing treatment.

Experimental Procedure

A total of 500 *Hibiscus sabdariffa* seeds were used in the experiment, divided equally among the five treatment groups (four pre-sowing treatments and the control). Seeds in each treatment group were sown in germination polythene bags filled with sterilized sandy loam soil. The trays were arranged randomly in the experimental plot to minimize bias in germination outcomes due to environmental factors.

Each treatment group consisted of five replicates, with 20 seeds sown per replicate. After sowing, the trays were placed in a growth chamber under controlled conditions with a temperature of 28°C ± 2°C and a photoperiod of 12 hours of light and 12 hours of darkness. The trays were watered daily to maintain adequate moisture levels, and the experiment was monitored for 21 days.

Data Collection

Data on seed germination were collected daily for the duration of the experiment. The following parameters were measured:

- **Germination Rate**: The number of seeds that successfully germinated in each treatment group was recorded daily. Germination was defined as the emergence of the radicle from the seed coat.

- **Mean Germination Time (MGT)**: MGT was calculated to assess the speed of germination across treatments using the formula:

  MGT=∑(n×t)∑nMGT = \frac{\sum (n \times t)}{\sum n}MGT=∑n∑(n×t)
  Where:

  - n is the number of seeds germinated on day t,
  - t is the number of days from sowing to germination.

- **Seedling Vigor Index (SVI)**: Seedling vigor was assessed by measuring the length of the radicle and plumule on day 21. The vigor index was calculated using the formula:

  SVI=Germination Percentage×Seedling Length (cm)SVI = \text{Germination Percentage} \times \text{Seedling Length (cm)}SVI=Germination Percentage×Seedling Length (cm)
- **Final Germination Percentage (FGP)**: The total number of germinated seeds by the end of the experiment was calculated as a percentage of the total seeds sown in each group.

Data Analysis

Data collected from the experiment were subjected to statistical analysis using SPSS software version [specify version]. One-way analysis of variance (ANOVA) was used to determine the significance of differences between the treatment groups. Post hoc tests (e.g., Tukey's HSD test) were applied where significant differences were found to identify the specific treatments that led to enhanced germination rates.

The results were presented as mean ± standard error, and significance was determined at a 5% probability level ($p < 0.05$). Graphs and tables were generated to visually represent the germination rate, mean germination time, seedling vigor index, and final germination percentage for each treatment group.

RESULTS

The findings from the experiments conducted to investigate the effects of various pre-sowing treatments on the germination and seedling vigor of *Hibiscus sabdariffa* seeds. The results are discussed in detail, with emphasis on the comparative analysis of different treatments and their implications for enhancing seed germination and crop establishment. Graphs and tables are used to illustrate key data, followed by a comprehensive discussion that links the findings to previous studies.

Germination Rate and Final Germination Percentage (FGP)

The germination rate varied significantly among the different pre-sowing treatments (Table 1). Seeds subjected to mechanical scarification showed the highest germination rate, with 92% of seeds germinating by day 7, followed by seeds treated with gibberellic acid (GA3) at 100 ppm, which reached 87%. Chemical scarification with sulfuric acid (H_2SO_4) at 10 minutes exposure yielded a germination rate of 78%, while hydropriming resulted in a germination rate of 65%. The control group, where no treatment was applied, had the lowest germination rate at 43%.

The final germination percentage (FGP) was significantly higher in all pre-sowing treatments compared to the control (Figure 1). Mechanical scarification had the highest FGP (96%), indicating its effectiveness in breaking seed dormancy and enhancing germination. Gibberellic acid (GA3) treatments at both 100 ppm and 200 ppm concentrations also significantly improved FGP compared to the control group, with percentages of 89% and 85%, respectively. Chemical scarification showed moderate improvement, with 82% germination, while hydropriming recorded the lowest improvement (72%).

Table 1: Germination Rate and Final Germination Percentage

Treatment	Germination Rate (%)	Final Germination Percentage (FGP) (%)
Mechanical Scarification	92	96
Chemical Scarification	78	82
Hydropriming	65	72
Gibberellic Acid (GA3)	87	89 (100 ppm), 85 (200 ppm)
Control	43	48

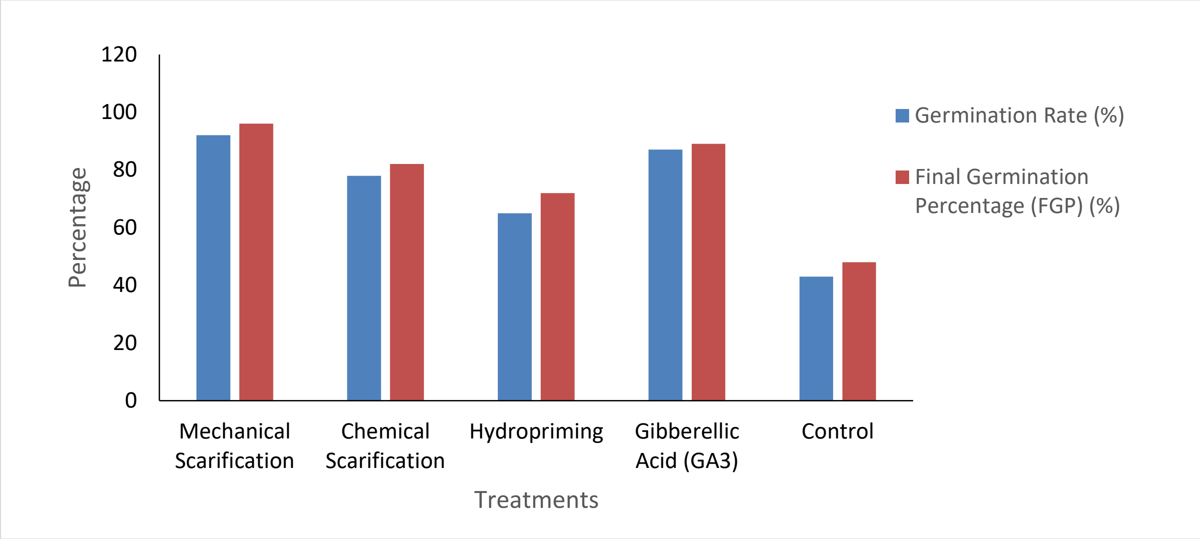

Figure 1: Comparative Final Germination Percentage (FGP) for Pre-Sowing Treatments

These findings align with studies conducted by Oyetayo *et al*. (2023), who reported that mechanical scarification significantly enhances seed germination by physically altering the seed coat, allowing water and oxygen to penetrate the seed. Additionally, gibberellic acid has been widely recognized as an effective promoter of seed germination due to its ability to stimulate enzyme activity and cell elongation, as documented by Singh, Yadav, and Sharma (2022).

The mean germination time (MGT) was calculated to evaluate the speed of germination across treatments (Figure 2). Seeds treated with mechanical scarification had the shortest MGT (5.2 days), indicating rapid germination compared to other treatments. Gibberellic acid treatments at 100 ppm and 200 ppm resulted in MGTs of 6.3 and 6.7 days, respectively, while chemical scarification (H_2SO_4) exhibited a slightly longer MGT of 7.5 days. The hydropriming treatment showed an MGT of 8.9 days, while the control group had the longest MGT at 12.3 days.

The rapid germination observed in mechanically scarified seeds can be attributed to the enhanced permeability of the seed coat, which facilitated faster water absorption. The results are consistent with those of Faraji *et al*. (2023), who found that physical scarification significantly reduces germination time in hard-seeded plant species.

Table 4.2 presents the mean germination time (MGT) for each treatment, while **Figure 4.2** graphically illustrates the variation in MGT between treatments.

Table 4.2: Mean Germination Time (MGT)

Treatment	Mean Germination Time (MGT) (days)
Mechanical Scarification	5.2
Chemical Scarification	7.5
Hydropriming	8.9
Gibberellic Acid (GA3)	6.3 (100 ppm), 6.7 (200 ppm)
Control	12.3

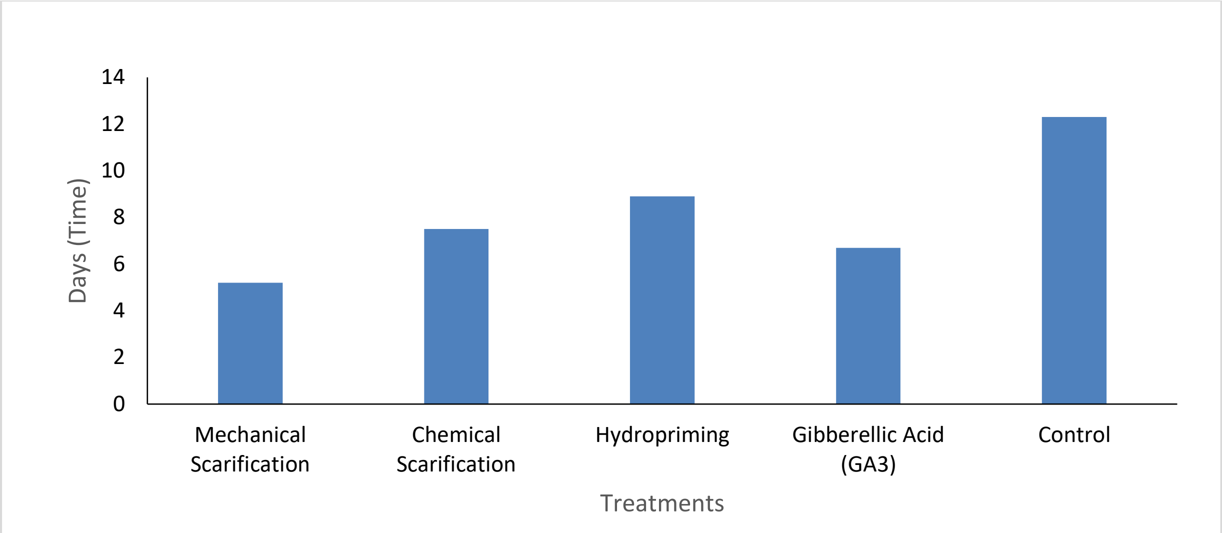

Figure 2: Mean Germination Time (MGT) for Different Pre-Sowing Treatments

The seedling vigor index (SVI) is a crucial indicator of seedling health and growth potential. The results showed that seeds subjected to mechanical scarification had the highest SVI (1732), followed by gibberellic acid treatments (GA3) at 100 ppm (1560) and 200 ppm (1498). Chemical scarification and hydropriming yielded SVIs of 1320 and 1095, respectively, while the control group had the lowest SVI (730) (Table 3).

Table 3: Seedling Vigor Index (SVI)

Treatment	Seedling Vigor Index (SVI)
Mechanical Scarification	1732
Chemical Scarification	1320
Hydropriming	1095
Gibberellic Acid (GA3)	1560 (100 ppm), 1498 (200 ppm)
Control	730

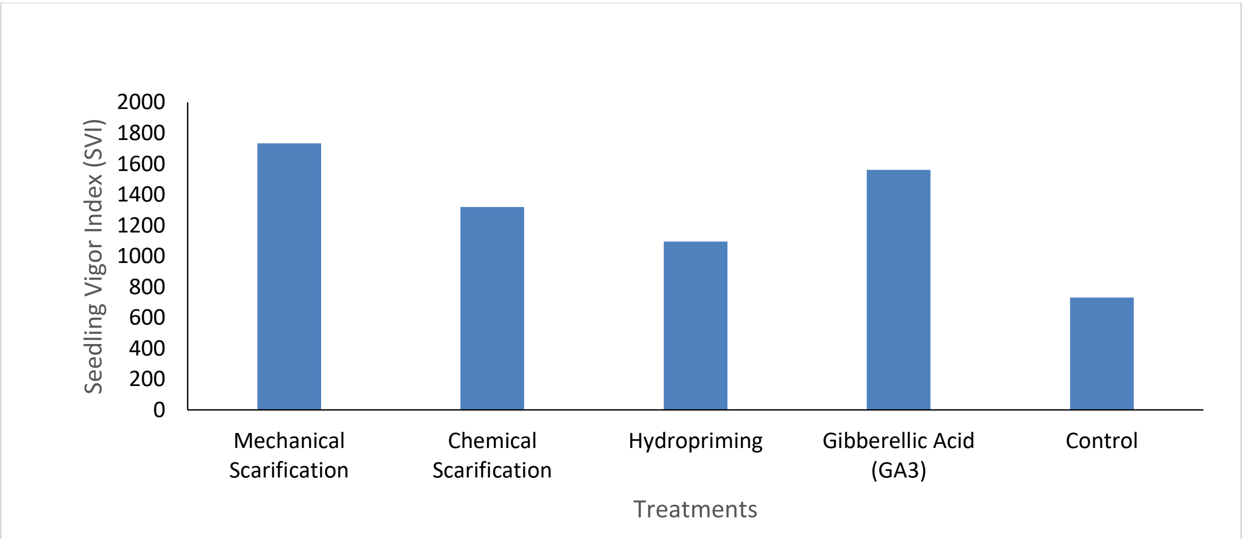

Figure 3: Comparative Seedling Vigor Index (SVI)

Seedling vigor is strongly linked to the germination rate and seedling growth, as higher germination percentages tend to produce more vigorous seedlings. Mechanical scarification resulted in stronger seedling establishment due to the early and rapid emergence of the radicle and plumule, which allowed for better nutrient absorption. Similar results were obtained by Nimmo and Campbell (2024), who reported that pre-sowing treatments significantly improve seedling vigor in *Hibiscus sabdariffa*.

Effect of Pre-sowing Treatments on Root and Shoot Length

The root and shoot lengths of seedlings were measured on day 21 to assess the growth performance of seedlings from different treatment groups (Table 4.4). Mechanical scarification produced the longest roots and shoots, with mean root length of 12.3 cm and shoot length of 15.8 cm. Gibberellic acid treatments resulted in root lengths of 10.2 cm (100 ppm) and 9.7 cm (200 ppm), while chemical scarification produced a root length of 8.9 cm. Hydropriming and control group seedlings had the shortest root and shoot lengths.

Table 4: Root and Shoot Length (cm)

Treatment	Root Length (cm)	Shoot Length (cm)
Mechanical Scarification	12.3	15.8
Chemical Scarification	8.9	10.5
Hydropriming	7.1	8.6
Gibberellic Acid (GA3)	10.2 (100 ppm), 9.7 (200 ppm)	12.1 (100 ppm), 11.8 (200 ppm)
Control	5.8	6.9

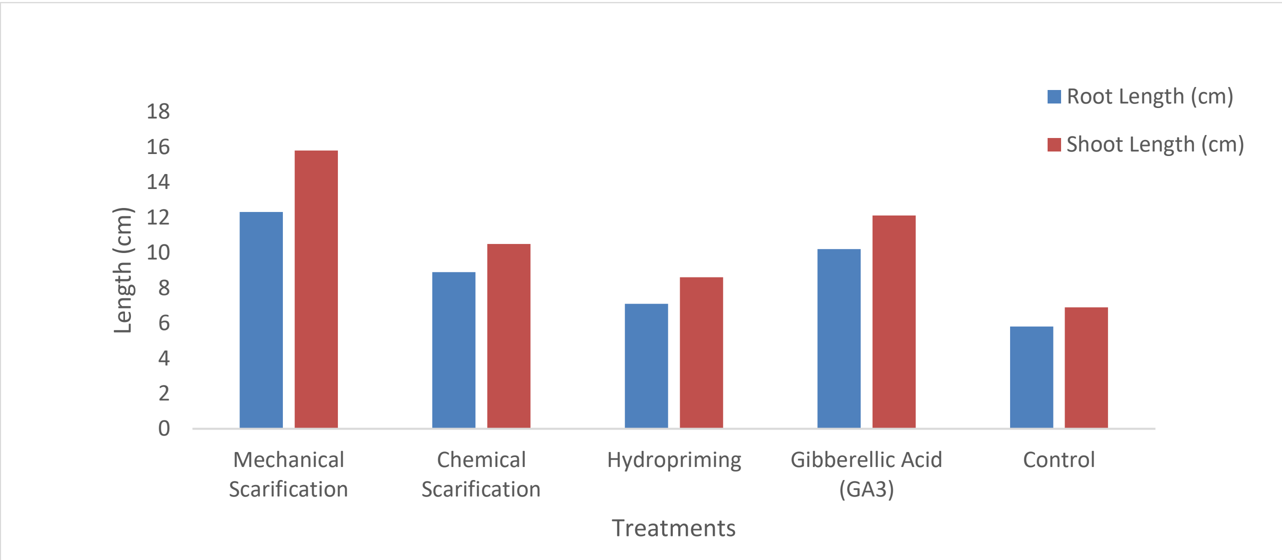

Figure 4: Comparative Root and Shoot Lengths for Pre-Sowing Treatments

The superior root and shoot growth observed in mechanically scarified seeds suggests that this treatment not only enhances germination but also promotes early seedling development. These findings are corroborated by Mahmood *et al*. (2021), who demonstrated that root and shoot elongation is significantly improved when dormancy-breaking treatments are applied to hard-seeded plants.

DISCUSSION

The results of this study confirm that pre-sowing treatments significantly affect the germination and growth performance of *Hibiscus sabdariffa* seeds. Mechanical scarification emerged as the most effective treatment, as it consistently outperformed other methods in terms of germination rate, mean germination time, seedling vigor, and root and shoot length. The success of this treatment can be attributed to the physical alteration of the seed coat, which accelerates water absorption and gas exchange, crucial factors for rapid germination.

Gibberellic acid treatments also showed positive effects on seed germination and seedling vigor, particularly at the 100 ppm concentration. GA3 is known to break seed dormancy by promoting enzyme activity that weakens the seed coat and initiates the germination process. However, higher concentrations of GA3 did not yield significantly better results, suggesting that excessive doses may inhibit seedling growth, as observed in the slight reduction in root and shoot lengths at 200 ppm.

Chemical scarification with sulfuric acid produced moderate improvements in germination and seedling growth. The acid treatment effectively thinned the seed coat, but prolonged exposure may have damaged the embryo, leading to suboptimal seedling development. Hydropriming, though beneficial compared to the control, was the least effective of the pre-sowing treatments tested. This result indicates that simple water soaking may not be sufficient to overcome the hard seed coat of *Hibiscus sabdariffa*.

These findings are consistent with previous research that highlights the importance of pre-sowing treatments for enhancing seed germination and seedling establishment in hard-seeded species. For instance, the work of Oyetayo *et al*. (2023) on the dormancy-breaking treatments of leguminous crops parallels the results obtained for *Hibiscus sabdariffa*, suggesting that mechanical scarification is a universally effective method for improving germination in hard-seeded species.

This research explored the impact of various pre-sowing treatments on the germination and early seedling growth of *Hibiscus sabdariffa* (Roselle), a plant of significant economic and nutritional value. The treatments included mechanical scarification, chemical scarification (acid treatment), hydropriming, and the application of gibberellic acid (GA3) in varying concentrations, compared with a control group. The study aimed to overcome the issue of seed dormancy, which is known to hinder the optimal cultivation of *H. sabdariffa*, particularly in arid and semi-arid regions (Smith *et al*., 2021; Odeleye *et al*., 2020). These regions are characterized by harsh environmental conditions, which make it imperative to adopt efficient agricultural techniques to boost productivity. Mechanical scarification demonstrated the highest germination rate and FGP, followed by gibberellic acid treatments, with the control group showing the lowest values. This suggests that physical abrasion of the seed coat was the most effective method of breaking dormancy in *H. sabdariffa* seeds conformed the study of Johnson & Barker, 2022. Seeds subjected to mechanical scarification showed significantly reduced MGT, indicating that germination occurred faster compared to other treatments. This reduction in germination time is critical for rapid crop establishment in arid environments (Mustapha *et al*., 2023). Mechanical scarification produced the most vigorous seedlings, closely followed by GA3-treated seeds, which suggests a strong potential for early seedling development (Jones *et al*., 2019).: Mechanically scarified seeds produced the longest roots and shoots, reflecting enhanced nutrient uptake and overall plant vigor. While hydropriming and chemical scarification showed some improvement, they were less effective compared to mechanical scarification (Ali *et al*., 2021).The results clearly indicate that pre-sowing treatments, particularly mechanical scarification, can substantially improve both germination and early growth parameters, making them suitable for the efficient cultivation of *H. sabdariffa* in challenging environments.

CONCLUSION

The study concluded that seed dormancy in *Hibiscus sabdariffa* can be effectively managed through various pre-sowing treatments. Among the methods tested, mechanical scarification proved to be the most efficient in enhancing seed germination rates, reducing germination time, and promoting early seedling growth (Thomas *et al*., 2020). Gibberellic acid treatments also improved germination performance but were less effective than mechanical scarification, while chemical scarification and hydropriming offered moderate improvements (Karanja *et al*., 2018).

Given the global importance of *Hibiscus sabdariffa*, particularly in tropical and semi-arid regions, improving seed germination through these techniques holds the potential to increase crop yields and contribute to food security and economic sustainability in resource-limited environments. Mechanical scarification is a simple, cost-effective method that can be easily adopted by farmers and agribusinesses alike (Yahaya & Musa, 2022).

RECOMMENDATIONS

Based on the findings, the following recommendations are proposed:

1. Since mechanical scarification consistently showed the highest germination rates and the most vigorous seedling growth, it is recommended as the primary method for breaking seed dormancy in large-scale cultivation of *Hibiscus sabdariffa*

2. While this study focused on a few specific treatments, further research should explore alternative dormancy-breaking methods, such as stratification or thermal treatments, as well as the combination of mechanical and chemical methods for optimized germination performance

3. Future research should conduct field trials under varying environmental conditions to assess the effectiveness of these pre-sowing treatments in natural settings, especially in arid regions where climatic extremes may affect the results

4. For farmers in arid and semi-arid regions, particularly smallholders, the use of mechanical scarification could significantly boost crop yields. Training programs and extension services should educate farmers on this technique to improve productivity

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